Energy Technology and Governance Program:

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

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

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

South East Cooperation Initiative Transmission System Planning Project

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1. INTRODUCTION

The term NTC values (Net Transfer Capacity values) was introduced at the beginning of electricity market opening process in Europe, in order to indicate possible cross-border transmission capacities between different countries to market players. Power systems were developed in the past 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 electricity market, comprising different market participants like power producers, power traders, suppliers, transmission and distribution system operators, power flows have been changed significantly, exposing transmission networks to different loadings and operational circumstances, comparing to former design parameters used for transmission networks planning and development. Cross border transmission capacities became limitation for power trading and exchanges often, leading to restricted market activities and thus limiting possibilities to increase electricity volumes which may be traded across wide geographical areas.

Observing the electricity market wholesale level, Transmission System Operators (TSOs) have been concerned about security of transmission networks operation and supply, having in mind that network under their responsibility has started to be exposed to different operational circumstances which may jeopardize its safe operation. Introduction of the NTC values allowed them to define possible cross-border exchanges under which transmission network will operate securely, thus keeping the security of supply at pre-defined level.

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

In order to harmonize NTC calculation methodologies between European Transmission System Operators, ENTSO-E published the document named "Procedures for cross-border transmission capacity assessments" in 2001. It defines basic assumptions and procedures for load flow calculations used to define the NTC values between different countries. Transmission system operators in the South-east Europe region follow this procedure while defining NTC values for transmission network under their responsibility.

This report analyzes transmission networks under responsibility of eleven SEE TSOs which participate in the SECI project of Regional Transmission System Planning (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, Serbia, Slovenia and Turkey – Figure 1.1) and possibilities to exchange electricity between their borders, identifying critical network elements which limit the NTC values. The main focus of interest is directed to existing transmission networks topology and operational conditions, with additional analysis of their expected future development.

The main goal of this Report is to analyze existing NTC values in the SEE region and to detect critical transmission network elements which restrict them. Further interest is focused on possible actions to increase existing NTC values excluding financially intensive projects (large investments) in the new interconnection lines, since their preparation and construction phases may last for ten years, thus restricting power trade and market activities in the region in the short and mid time frame.

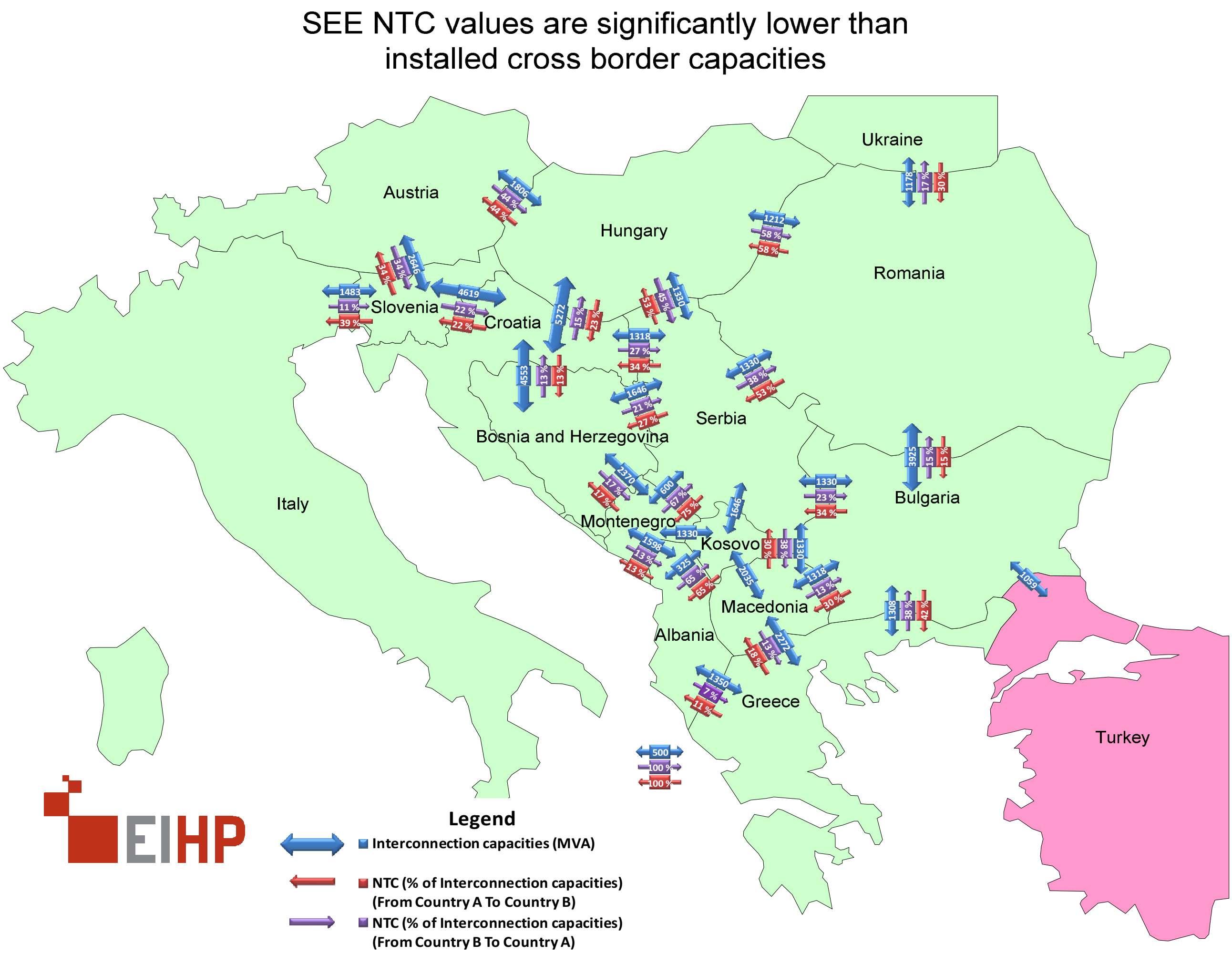


Figure 1.2 NTC values in the SEE region and total interconnected capacities

Cross-border capacities and interconnection lines between SEE countries were historically developed differently than those of central, western and northern Europe. Transmission network of seven countries (Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and Macedonia) was constructed under common power system of former Yugoslavia, with very strong interconnections between today independent countries and limited interconnections to surrounding countries but designed under the UCTE system. Romania and Bulgaria operated together within former eastern synchronous area with interconnections to Ukraine and Moldavia, but missing stronger interconnections to former UCTE synchronous area. Albanian transmission network was developed with poor interconnection capacities to neighboring power system, while Turkey has joint ENTSO-E in recent years by constructing new interconnection lines to Bulgaria and Greece but with limited cross border exchange limits during trial operation.

Typical NTC values related to different borders are significantly lower than total interconnection capacities between SEE countries – Figure 1.2. In relation to the sum of interconnection capacities of all transmission lines between countries in the SEE region, estimated and declared NTC values range between 10 % and 60 % of those values. For example, as an illustration one may notice that there are two 400 kV lines and seven 220 kV lines between Croatia and Bosnia and Herzegovina with total interconnection capacity of around 4000 MVA, but NTC values in both directions (Croatia to Bosnia and Herzegovina; Bosnia and Herzegovina to Croatia) are set to around 13 % of this value. Similar situations may be noticed on other borders too, and this was the main rationale why this study has been initiated and performed. Authors believe that is of the utmost importance to analyze restriction elements for NTC values and observe less-costly alternatives to increase NTC values in the SEE region comparing them with costly new interconnection line projects. This is more important having in mind that large transmission projects like interconnection ones usually consume significant time-scale, sometimes up to 10 or 15 years needed for project feasibility analysis, preparation works, permitting process, land acquisition and finally line construction. Relatively low NTC values between SEE countries in the meantime may become the most restrictive barrier in the electricity market opening process in the region, not allowing increase of the power trading volumes at the wholesale level.

In the preparation phase of this study questionnaire related to the NTC calculation, methodology, limitations, cross border congestions and revenues were prepared and responses by SEE TSOs were collected (Annex 2). All TSO in the region calculate NTC values annually and monthly, using ENTSO-E methodology. Some TSOs provided a list of limiting network elements, located in the 400 kV and most usually 220 kV voltage level. Some of the TSOs declaired that new interconnection capacities are the best way to increase NTC values.

Based on the calculated NTC values and ATC values (Available Transmission Capacity), annual, monthly and daily (intraday) auctions and allocation of cross border transmission capacities, SEE TSOs collect cross border congestion management revenues, shown in the following figures. Revenues were in a range between 3 million € to 61 million € in 2012 individually, and 177 million € for nine observed TSOs without Turkey.

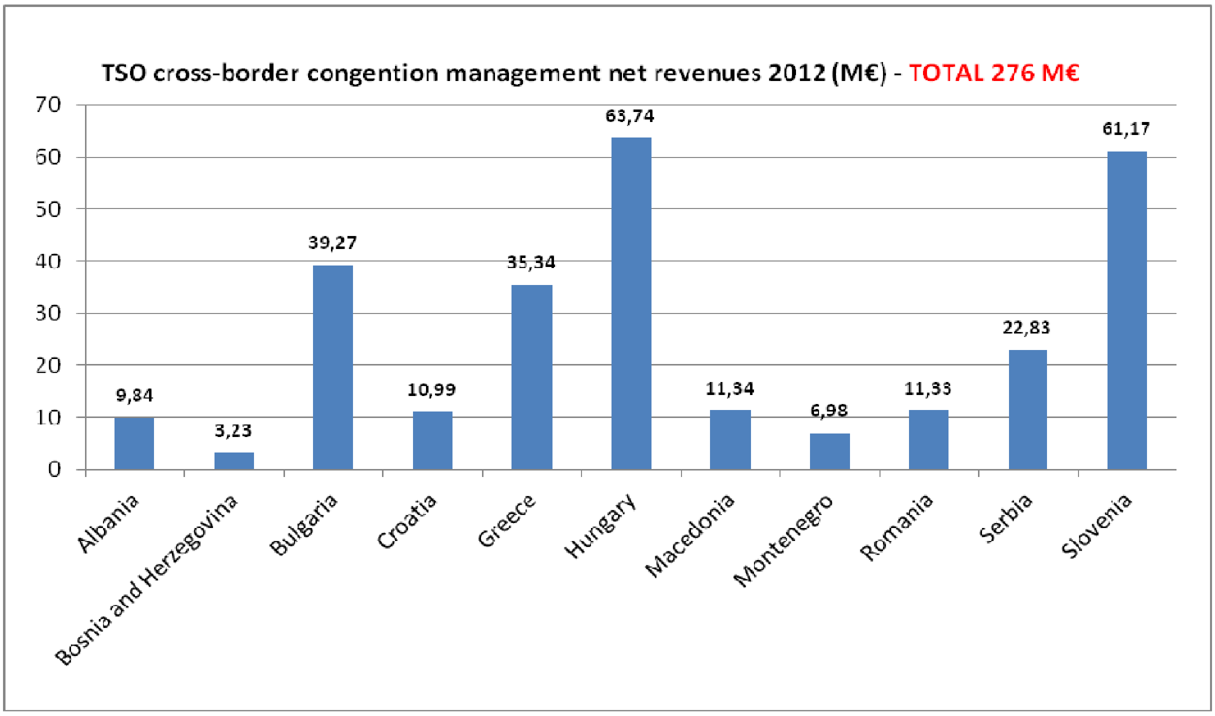


Figure 1.3 SEE and neighboring TSOs cross-border congestion management revenues in 2012

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

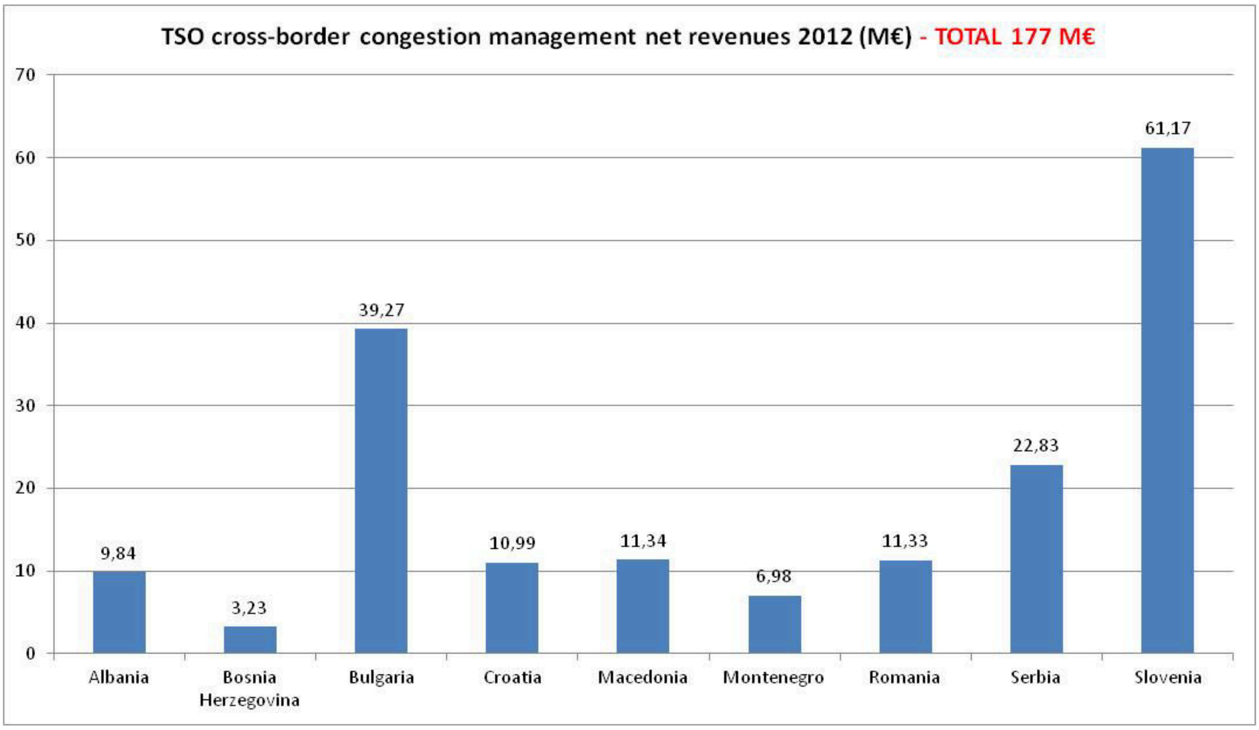


Figure 1.4 SEE TSOs cross-border congestion management revenues in 2012

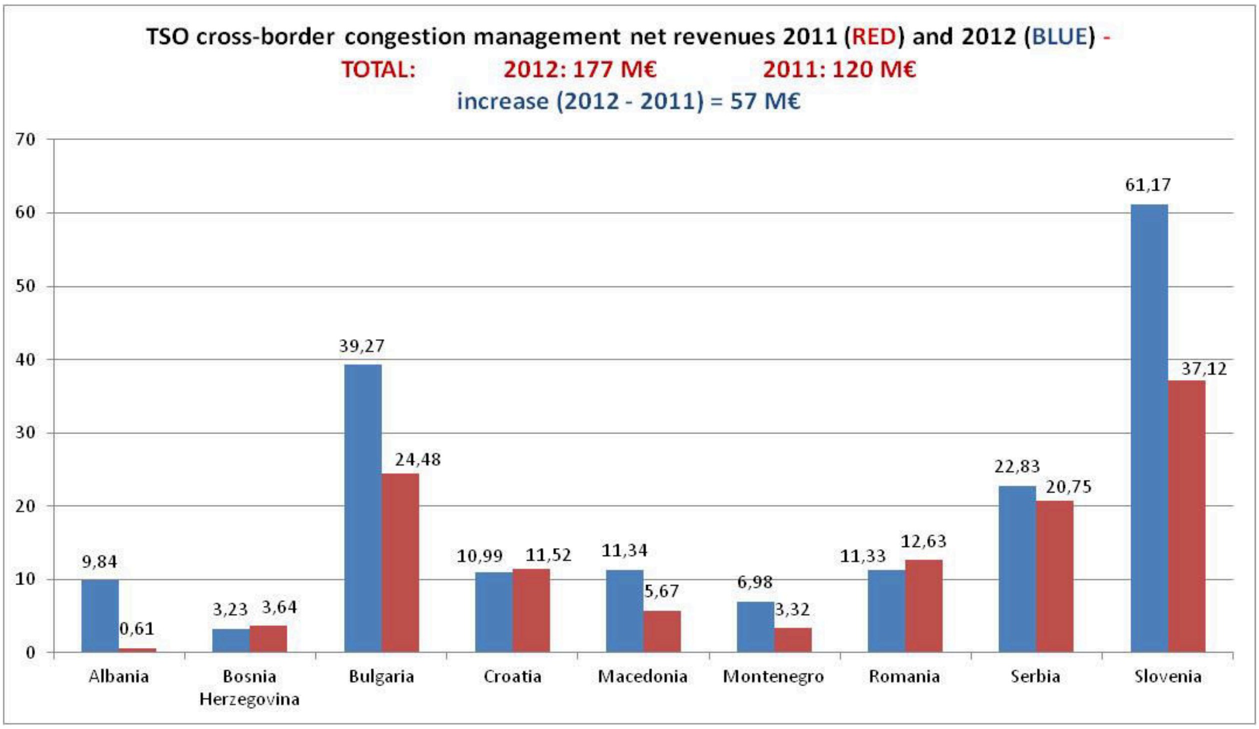


Figure 1.5 Comparison between cross-border congestion management revenues in 2011 and 2012

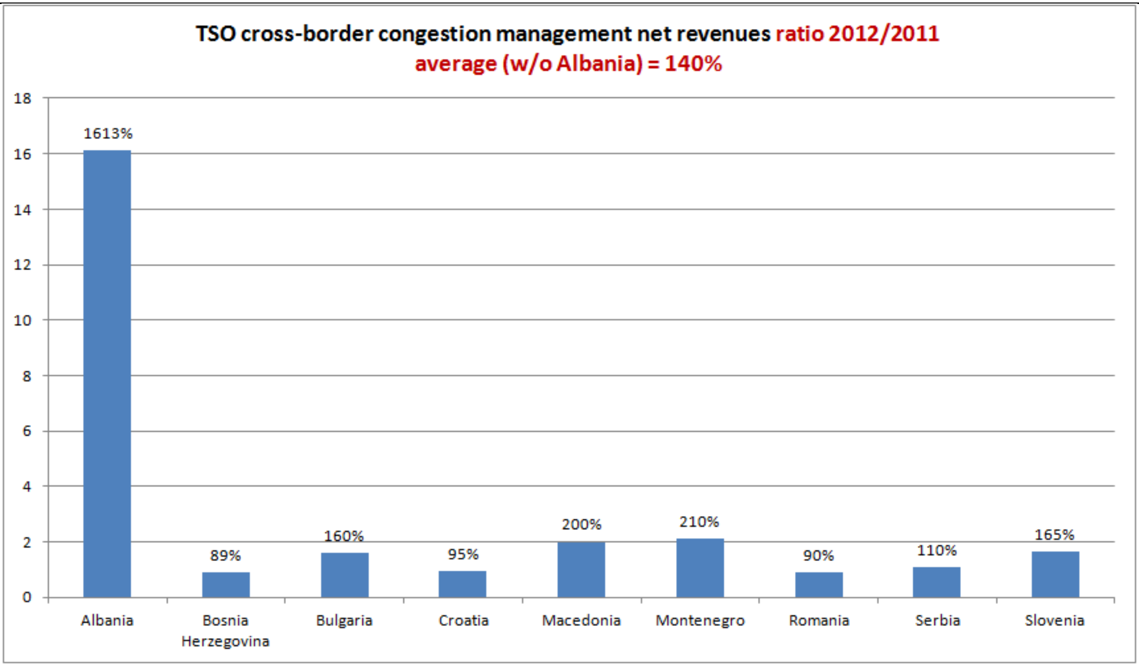


Figure 1.6 Ratio between cross-border congestion management revenues in 2012 and 2011

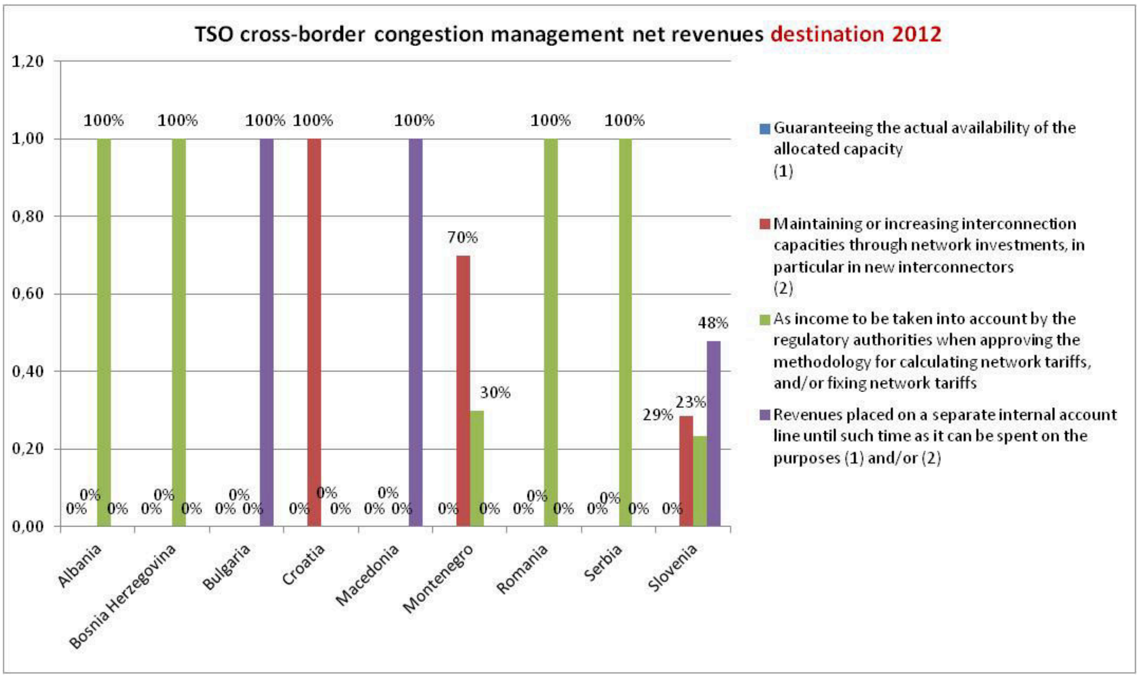


Figure 1.7 Usage of the cross-border congestion management revenues in 2012

This report is structured as follows. Current principles of NTC values calculation, allocation and revenue distribution are described in Chapter 2. Chapter 3 describes relevant ENTSO-E activities related to this topic. Expected development of the SEE transmission grid is explained in the following chapter, according to the SEE TSOs official development plans. By using SEE transmission network model in 2012 and 2015 load flow calculations were performed and NTC values were determined and described in Chapter 5. Critical network elements which limit NTC values on different borders were identified and described in Chapter 6. Chapter 7 investigates different actions in order to increase present NTC values, with special attention on low-cost actions. Due to expected large integration of intermittent power sources like wind and solar, impact of the NTC values on the future regional balancing market has been analyzed in Chapter 8. Report concludes with Chapter 9, after which relevant literature is given and appendices related to this report.

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

2.1 General description

Basic procedure for the NTC values calculation has been defined in the ENTSO-E document "Procedures for cross-border transmission capacity assessments", October 2001. This report tried to harmonize basis for NTC calculation between interconnected countries applicable to allocate commercial exchanges to market participants. Calculation methodology is also defined in the UCTE Operation Handbook, Policy 3 (Coordinated operational planning) and Chapter B: Capacity Assessment.

All SEE TSOs use this procedure defined by UCTE and ENTSO-E, in its original or modified form. Based on the questionnaire filled by all TSOs in the region, majority of them are satisfied with this procedure, but some of them had some remarks concerning its applicability and efficiency, especially in highly meshed but smaller power systems like the ones in the SEE.

NTC definition between interconnected countries is based on load flow calculations. It is prescribed that all TSOs have to model a network under their control using the best available input data. Modeling process is usually based on historic data and real operational situations from the past. TSOs usually model transmission network conditions when the most critical transmission elements were exposed to high loadings or some other operational difficulties.

The procedure defines that network representation should be as wide as possible and should contain full representation of the network elements. Secure operation of the networks should be validated based on national grid codes. All SEE TSOs as basic criterion to evaluate secure system operation use the N-1 criterion. TSOs also use quite wide contingency description defined in the UCTE Operational handbook. 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 should agree with the base case model representing analyzed wide area.

By using the base case model, the NTC values are calculated for each border between interconnected countries by increasing generation in one country and decreasing generation in another country. Increase/decrease of generation (generation shift) should be performed using predefined step and for each load flow calculation security criteria in both countries should be checked. Process ends when security criteria are not fulfilled in one country.

Load flow calculations are performed by both TSOs interested for their common border. Each of them calculate load flows for different generation shifts and check the security criteria. TSO should define network of its interest and decide which network elements will be taken into consideration (by defining contingency lists and monitored elements). TSO may observe 400 kV and 220 kV network only, but also it may observe important 110 (150) kV network elements. If two TSOs find different NTC values, they usually agree that 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:

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

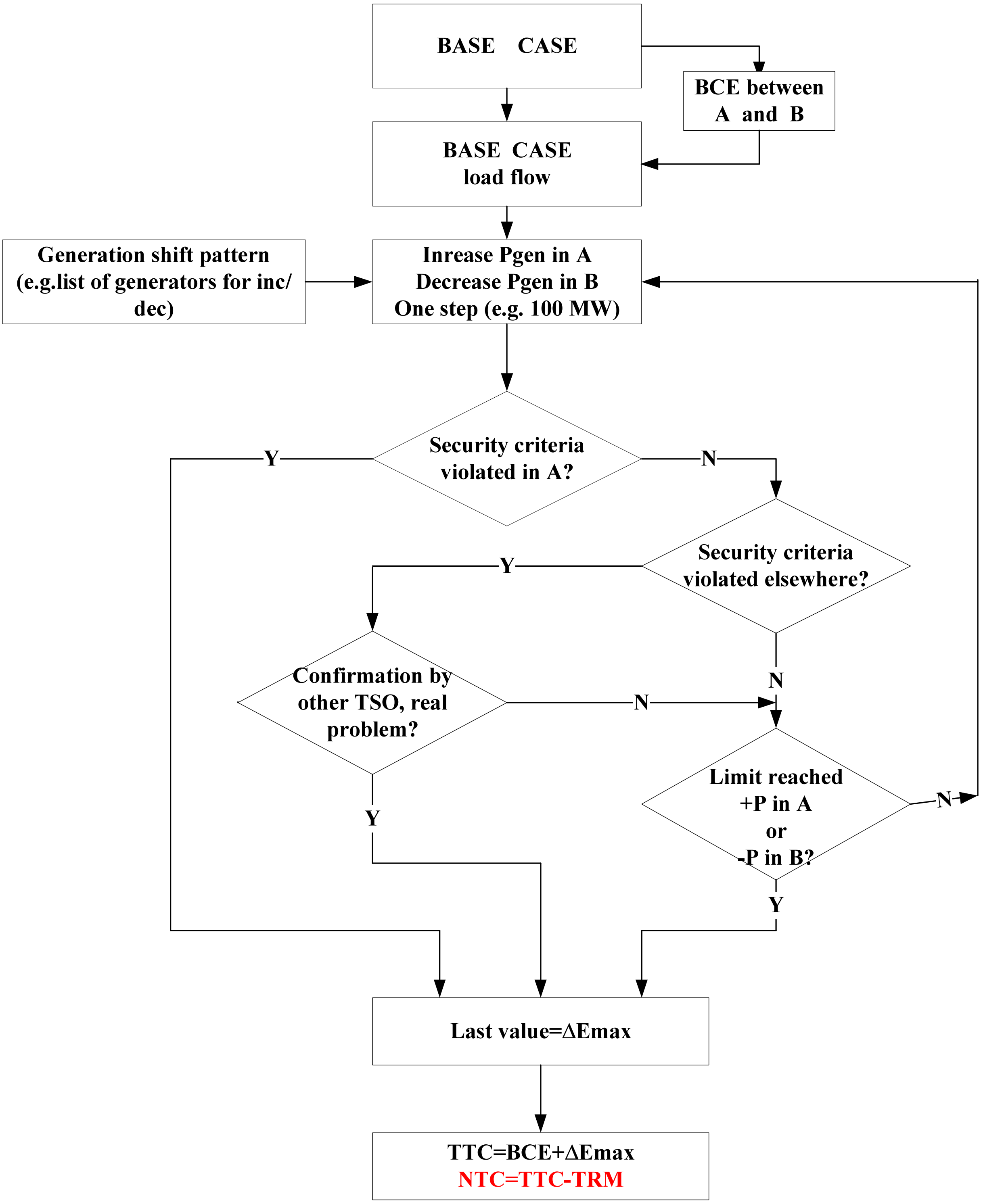


Figure 2.1 The NTC calculation procedure

Basic calculation values are described in the following chapters.

2.3 Base Case Exchange (BCE)

It is the basic exchange program, eventually existing in network model used for capacity calculation. Base case exchanges are determined from the base case load flow model, prepared by each TSO, merged together, and approved by TSOs. This model includes network model and input data describing load and generation patterns forecast and network topology at the studied time frame.

Input data for the base case model contain electrical parameters and thermal ratings of network elements (with possible use of seasonal values of thermal ratings), maximum and minimum values of generators engagement, 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)

Maximum additional exchange between the areas, 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. Generation shift should be performed stepwise until a network security is violated. Maximum generation shift for which network operation is still secure defines the value ΔE.

Generators which will be taken into account during generation shift are determined by each TSO. 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^{inc}_{new} : New increased injection
P^{dec}_{new} : New decreased injection
ΔE : Shift generation, negative for increasing and positive for decreasing
P^{max}_i : Maximum permissible generation (MW)
P^{min}_i : Minimum permissible generation (MW)

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

Generation shift must take into account maximum generator power output as well as its technical minimum, and other influential factors like expected hydrological situation, fuel availability etc.

2.5 Total Transfer Capacity (TTC)

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

$$TTC = BCE + \Delta Emax$$

Security assessment comprises 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 upper 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).

Sum of maximum generation shift for which security criteria are still satisfied in both interconnected countries and initial transaction values (base case exchange) gives the total transfer capacity between two countries or zones. ENTSO-E procedure defines that if the whole physical generation shift between the two concerned countries or zones is reached and no security rules breaching has occurred, no realistic limitation 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 the imperfection of the used network model (for example not modeled lower voltage network in one area, which actually mitigates the effect of the observed outage),
- if reasonable preventive & fast post-event measures can be made by the system operator of the network affected by the considered contingency (meshing of lower voltage network, generation restrictions and re-dispatching),
- if critical contingency is caused by the outage of an element with low failure probability according to 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 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 longer time period. It may be defined as 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 equitation's to determine the TRM values for different borders (in MW):

$$TRM = 100 \bullet N$$

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

where N is 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 procedure gives basic guidance for TRM determination, but state that TRM definition is a matter of 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, while TRM_{ii} value assumes that both uncertainty margins cannot happen simultaneously.

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)

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

$$NTC = TTC - TRM$$

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

The following figure presents schematic illustration of the NTC values determination. It defines two areas, A and B, with base case exchange BCE (or $BCE^{A>B}$) in the direction from A to B. For direction from A to B 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 direction from 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 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)

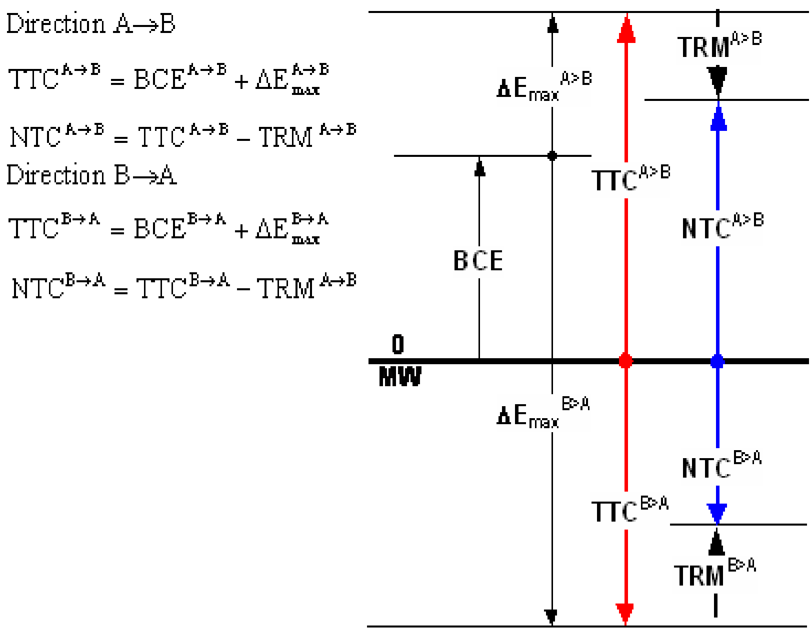


Figure 2.2 Net transfer capacities between two areas (A and B) and both directions

2.8 NTC results harmonization

Two neighboring TSOs typically should both calculate the NTCs for the same border/direction. The best practice is to harmonize the results and checking issues (especially for problems encountered in other TSO's area). If calculated NTC values are different and there is no agreement between TSOs involved, usual rule is to take the lower one as common NTC value.

2.9 Already Allocated Capacity (AAC)

Already allocated transmission rights are taken into account as Already Allocated Capacity values for specific direction. AAC values are part of NTC values which represents capacity rights given to market participants at previous auction rounds (annual, monthly and daily).

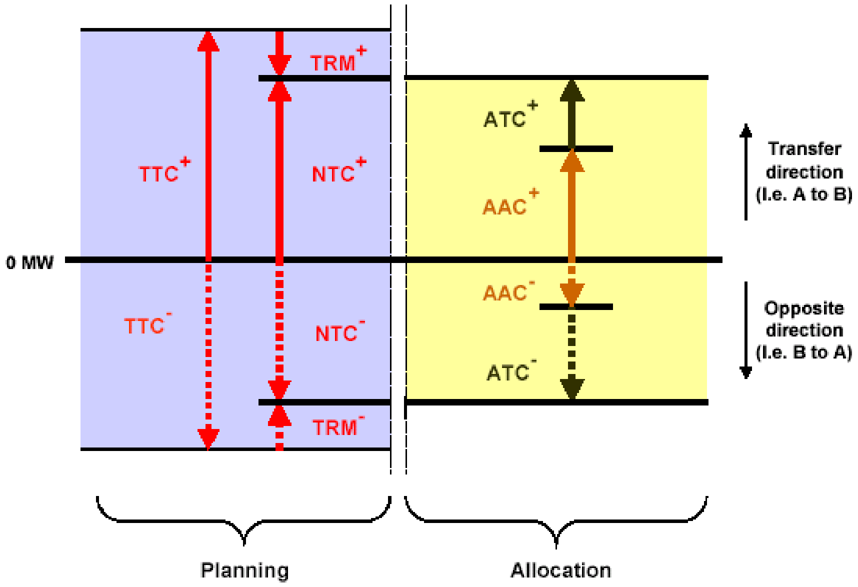


Figure 2.3 Net transfer capacities, already allocated capacities and available transmission capacity (*source ADMIE*)

2.10 Available Transmission Capacity (ATC)

A part of NTC that remains available, after each phase of the allocation procedure, for further commercial activity.

$$ATC = NTC- AAC$$

ATC is a subject for allocation procedure conducted by TSO's or auctions coordination offices. 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 allocates 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).

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

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

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

Cross-border capacity auctions are mostly conducted monthly by the SEE TSOs. TSOs agree for monthly reference network models, which are used for the monthly NTC calculation. The countries which 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.

The calculation of the NTC values is performed in a monthly basis with the complete network for 10:30 CET (high tariff) as well as an additional monthly NTC calculation and evaluation is performed when one of the critical lines is expected to be out of operation (forecasted monthly base case model takes into consideration maintenance plan for that period), as well as in cases when there is something unexpected in the region. The parties inform each other for any unplanned disconnection 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 security analysis and calculates the NTC values. Following the calculations, NTCs are exchanged and finally harmonized. If no agreement is taken then the lower value sets the NTC. 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 auction, $NTC_{MONTHLY}$ is the Net Transfer Capacity for monthly auction and $AAC_{YEARLY\ RIGHT}$ is the Already Allocated Capacity from the yearly auction.

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 models into regional SEE model, and send 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.

It is also possible, and applied by some TSO, to 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 cross-border capacities usage give their bids during auction process. If some 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. Cross-border congestion management revenue, collected by the TSOs, may be used only in a pre-defined manner. Under EU legislation the income derived from auctions must be used by the TSOs 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 their use this revenue to construct new network elements needed for NTC increasing (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, while 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 an NTC value calculated for a border between three or more TSOs. The composite NTC value is not necessarily the sum of bilateral NTC values. Using this approach of NTC calculation, especially to take into consideration the interdependency of the loop flows (suitable for smaller power systems which exist in the SEE region), one border between several countries is identified and generation shift is applied to all generators on both sides of the border.

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). In case the generation limit is reached in one area before violation of the N-1 criteria then additional generation will be taken into account though 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. It results 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

Identification of NTC values is performed using power transfer distribution factors (PTDF). PTDF represents the share of a power transfer that flows on a considered border. Power flow on the considered border may be calculated by multiplying PTDF and the amount of the power transfer:

$$\Delta F_{i,X} = PTDF_i * \Delta \mathrm{E}_X$$

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*

$\Delta \mathrm{E}_X$: 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:

$$\mathrm{TT}F_i = NTF_i + \Delta F_{i,TTC}$$

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

Having in mind that:

$$\Delta \mathrm{E}_{i,TTC} = \Delta F_{i,TTC}$$
$$TTC_i = \mathrm{BC}E_i + \Delta \mathrm{E}_{i,TTC}$$
$$TRM_{ALL} = 100\sqrt{N}$$
$$TRM_i = PTDF_i * TRM_{ALL}$$

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

$$\mathrm{NT}C_i = TTC_i - TRM_i$$

Total NTC value is defined as:

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

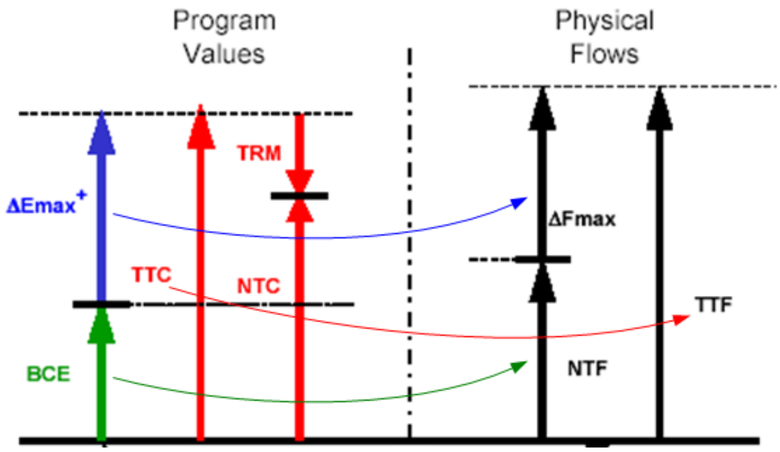


Figure 2.6 NTC calculation program base method and flow based method

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

The European Network of Transmission System Operators for Electricity (ENTSO-E) joins all TSOs in the EU and surroundings countries, dealing with technical and market aspects of transmission networks operation. All SEE TSOs are members of the ENTSO-E organization, except Albania and still unsolved position of Kosovo (KOSTT).

ENTSO-E has an important role in establishing of common electricity market in Europe. Relevant EU legislation gives the ENTSO-E obligations and rights to define planning and operational issues in power transmission business in order to support market-oriented and competitive European electricity market.

ENTSO-E has been included into main aspects of cross-border capacity allocation procedures and congestion management issues for years. ENTSO-E publishes the NTC values for different time-scales relevant for all European borders and agreed between TSOs.

ENTSO-E's activities are organized in the three Committees, including System development, System operations and Market Committees. System operation Committee deals with, among other tasks, security of supply issues. Market Committee has the main task to harmonize electricity market rules and promote competitive internal electricity market. Among other tasks, one key area of work is market integration and congestion management. This Committee also prepares market-related network codes like Capacity Allocation and Congestion Management code and Forwards Capacity Allocation network code.

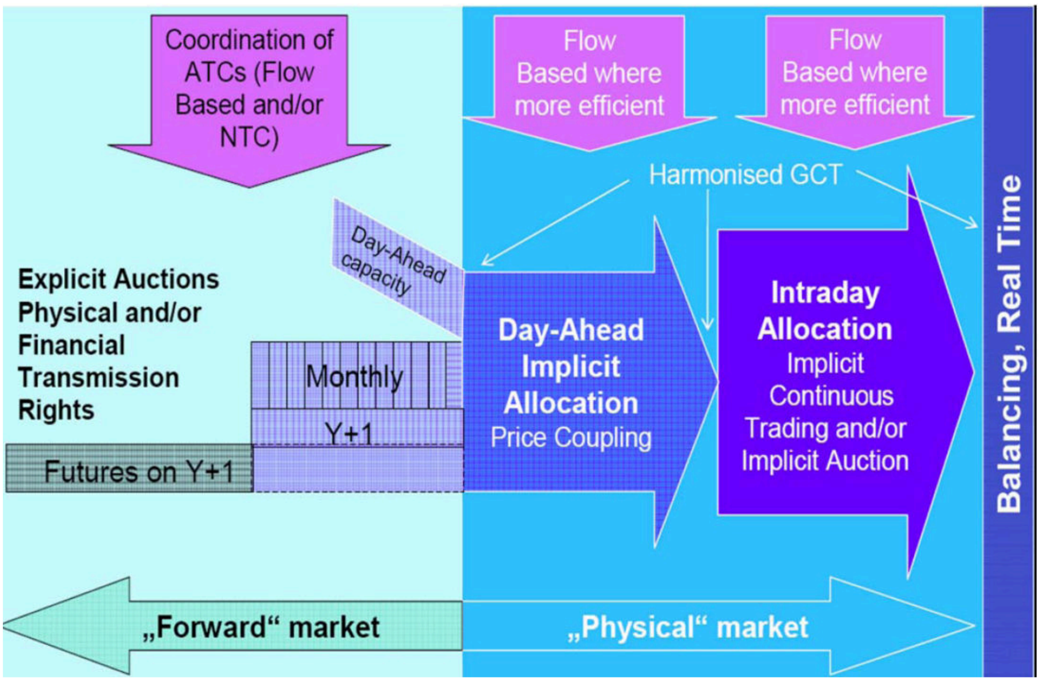


Figure 3.1 EU target model for the internal electricity market integration

ENTSO-E Market Committee tries to harmonize forwards, 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 now it is under 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.

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

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 obligation of TSOs to use common grid model and promotes flow based approach for capacity calculations. It also defines more specifically how to determine transmission reliability margins, treat operational security constraints, generation shift keys and remedial actions.

Both network codes will have significant impact on the SEE TSOs, concerning cross-border capacities calculations and capacity allocation. Regional, coordinated and flow based approach for capacity calculations seems appropriate for highly meshed and smaller systems like those of the SEE region, with large interdependency of the load flows across different borders caused by individual market transactions.

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

NTC values shown in tables and figures are indicative annual NTC values agreed between adjacent SEE TSOs, and refer to January values. Monthly indicative NTC values are usually the same as 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 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
- Conclusion is missing at the end of this chapter: why annual NTCs are changing/decreasing from year to year? There is no correlation with investments for sure. Probably it reflects TSOs strategy for market opening, to allocate more capacity on monthly and daily level.

3.1 Albania

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

Indicative annual NTC value for Albanian/Greek border was set to constant value of 250 MW in observed time period. The same amount 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

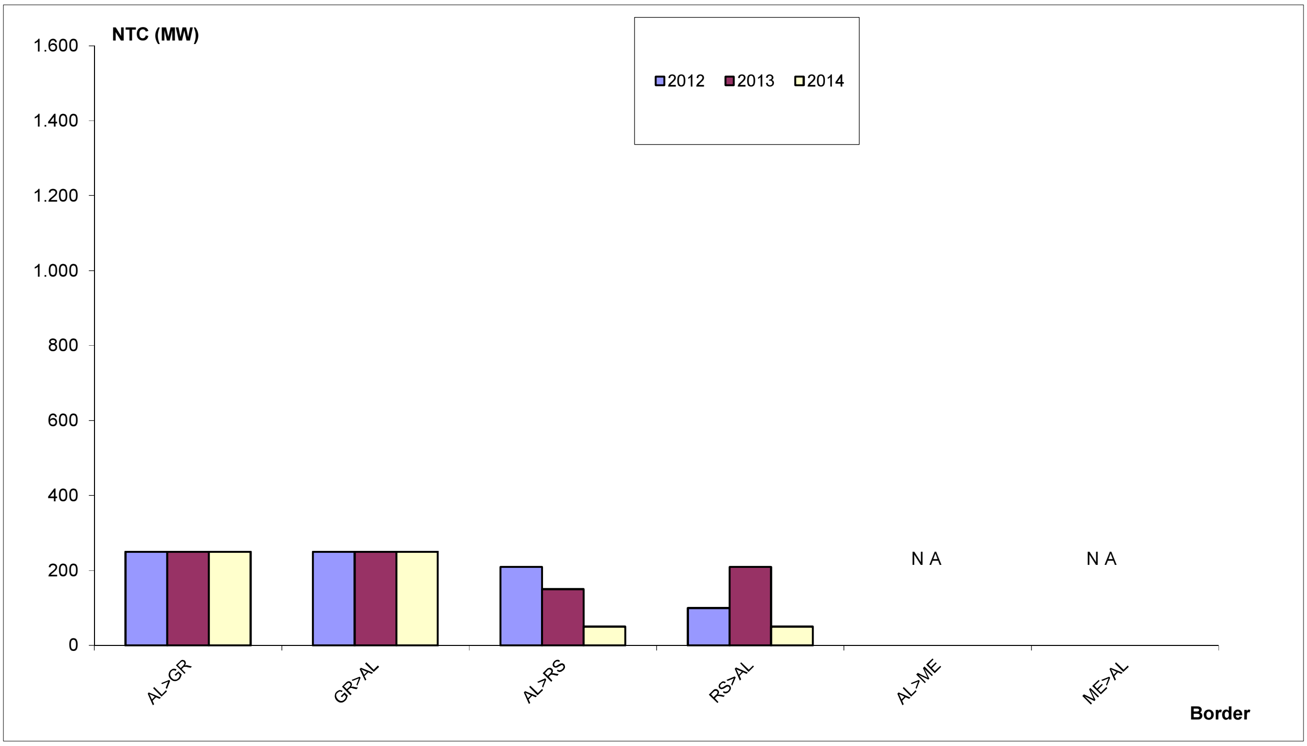


Figure 3.2 Indicative annual NTC values for Albania (2012-2014)

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

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

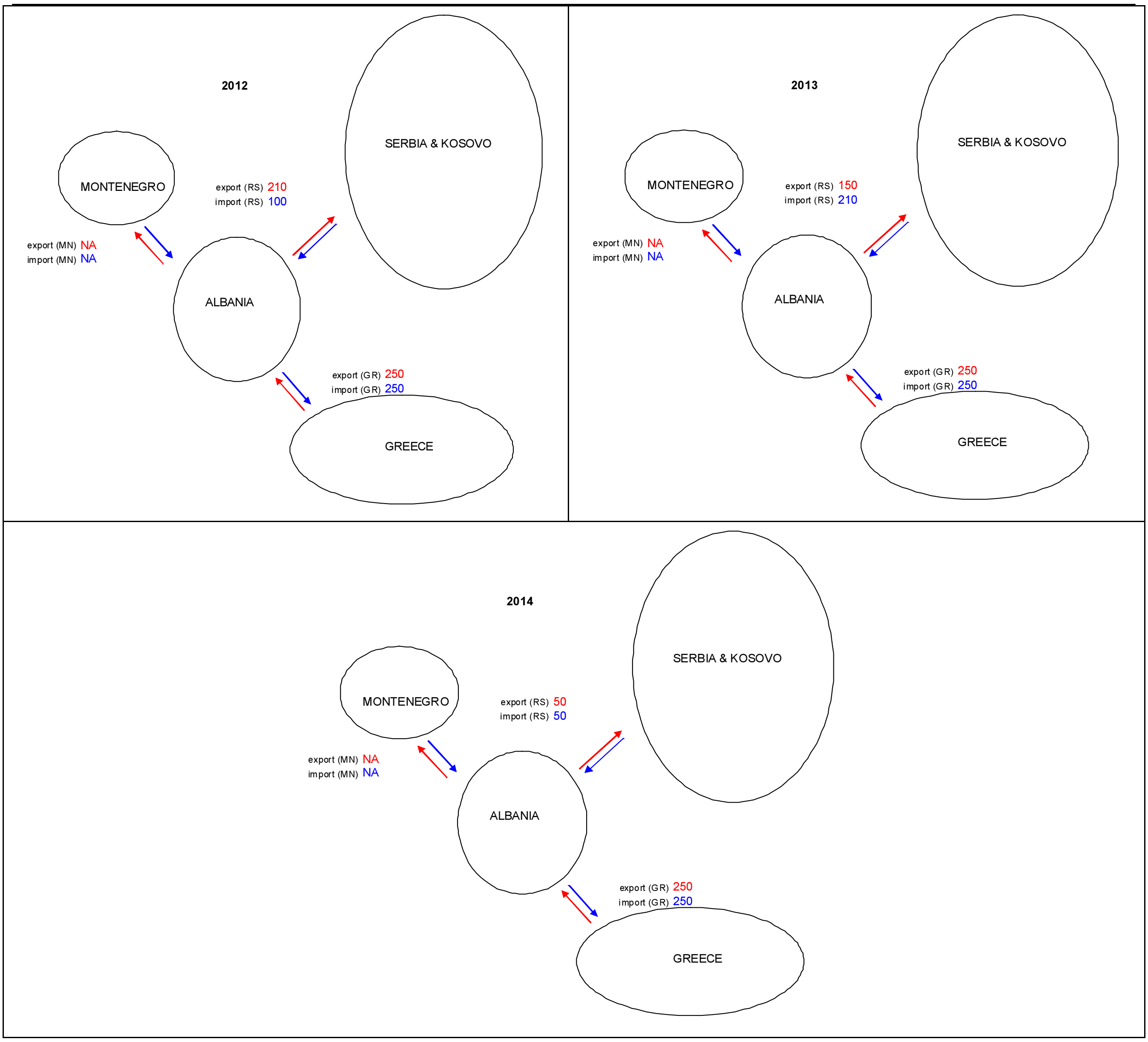


Figure 3.3 Graphical representation of the indicative annual NTC values for Albania

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

3.2 Bosnia and Herzegovina

Bosnia and Herzegovina ISO (NOS BiH) shares national borders with Croatia, Montenegro and Serbia. 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

Indicative annual NTC value for Bosnia and Herzegovina/Croatian border was set to constant value of 400 MW in 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

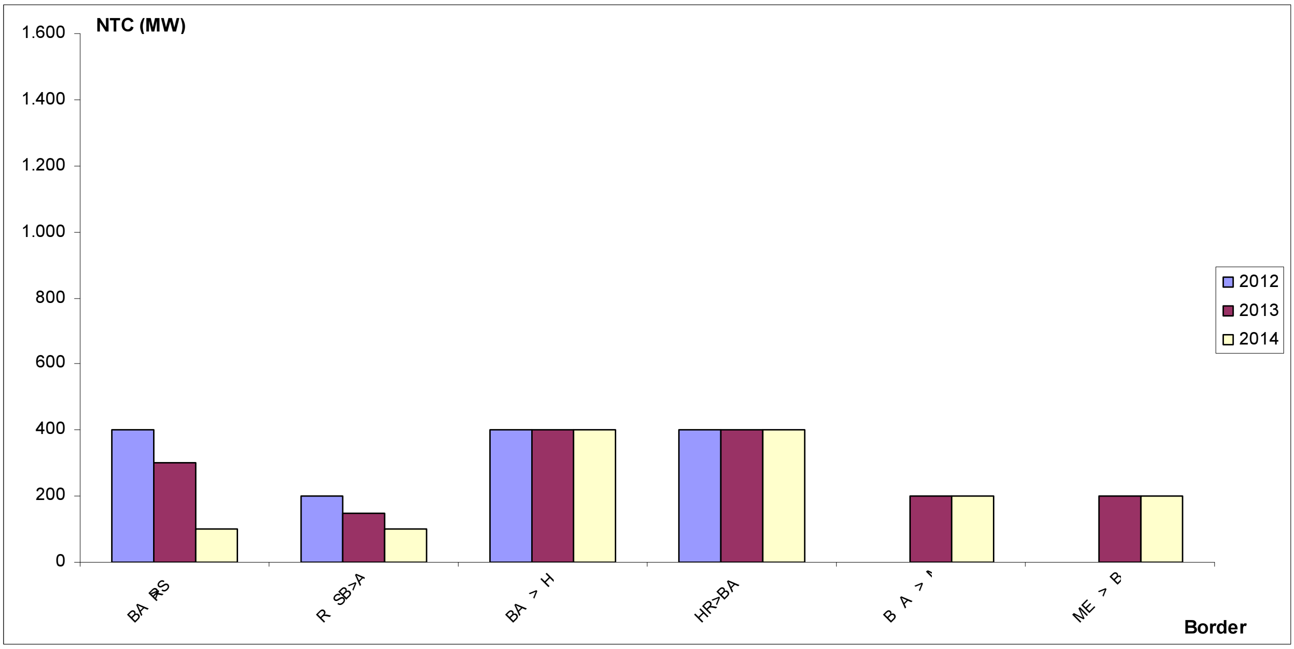


Figure 3.4 Indicative annual NTC values for Bosnia and Herzegovina (2012-2014)

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

Indicative annual NTC values for 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 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 BA/HR and BA/RS borders, while day-ahead values for BiH/Montenegro border were defined to 500 MW (from BiH to Montenegro) and 400 MW (from Montenegro to BiH).

Indicative NTC values for winter 2011 and summer 2010 were higher than annual values for time period 2012-2014, 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.

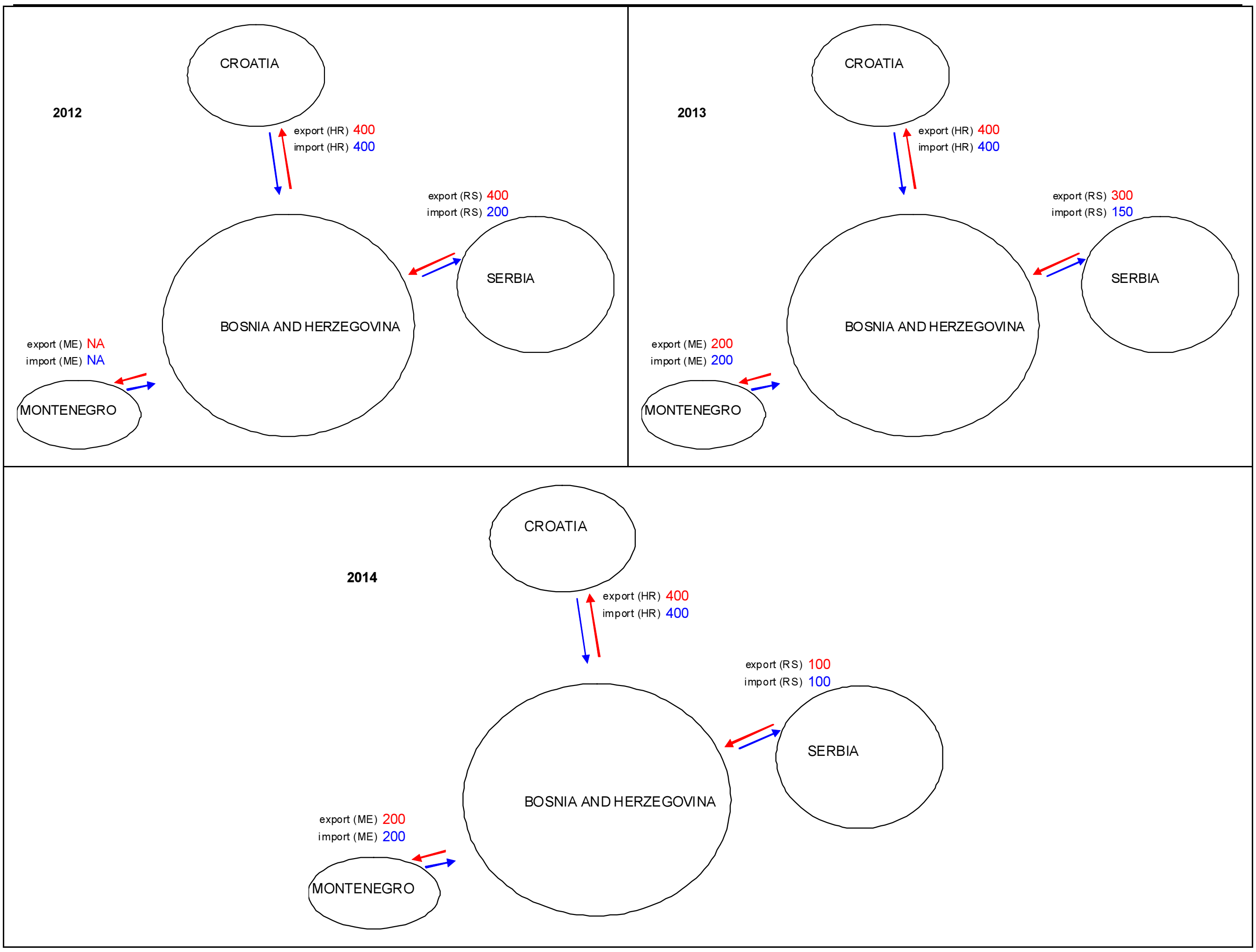


Figure 3.5 Graphical representation of the indicative annual NTC values for Bosnia and Herzegovina

3.3 Bulgaria

Bulgarian TSO (ESO) shares national borders with Serbia, Romania, Turkey, Greece and Macedonia. 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

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

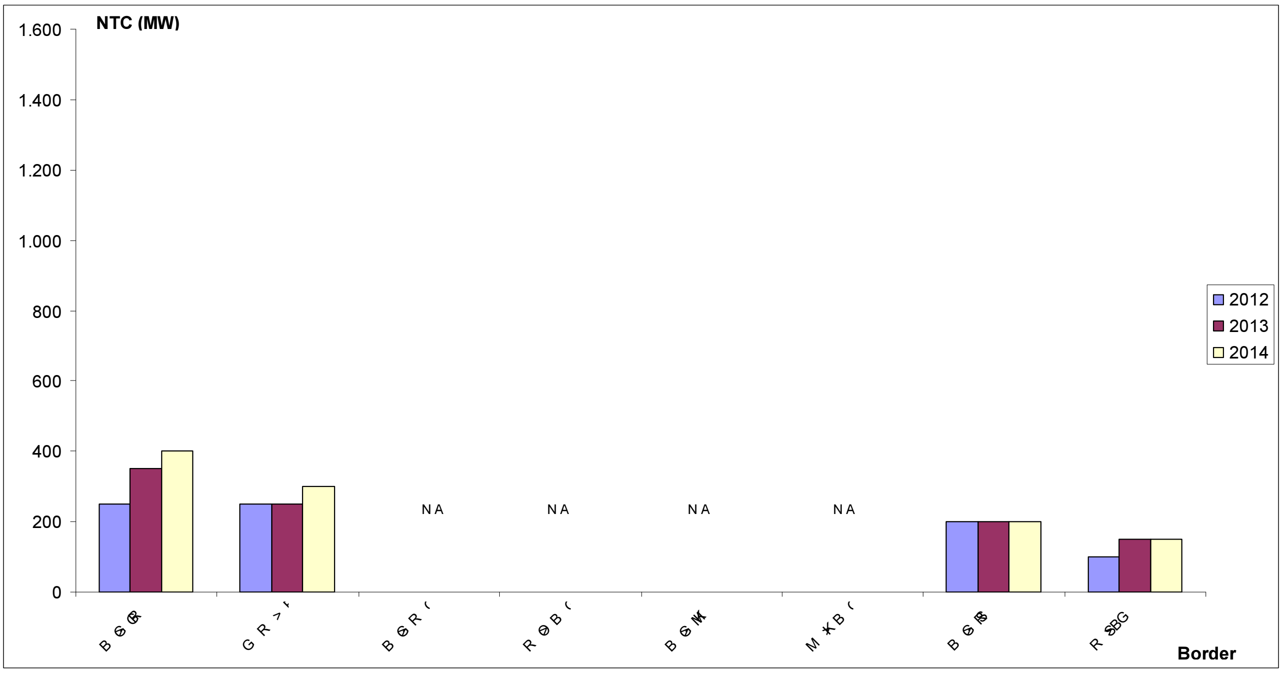


Figure 3.6 Indicative annual NTC values for Bulgaria (2012-2014)

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

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

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)

Indicative NTC values for winter 2011 and summer 2010 were generally higher than annual values for time period 2012-2014, 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.

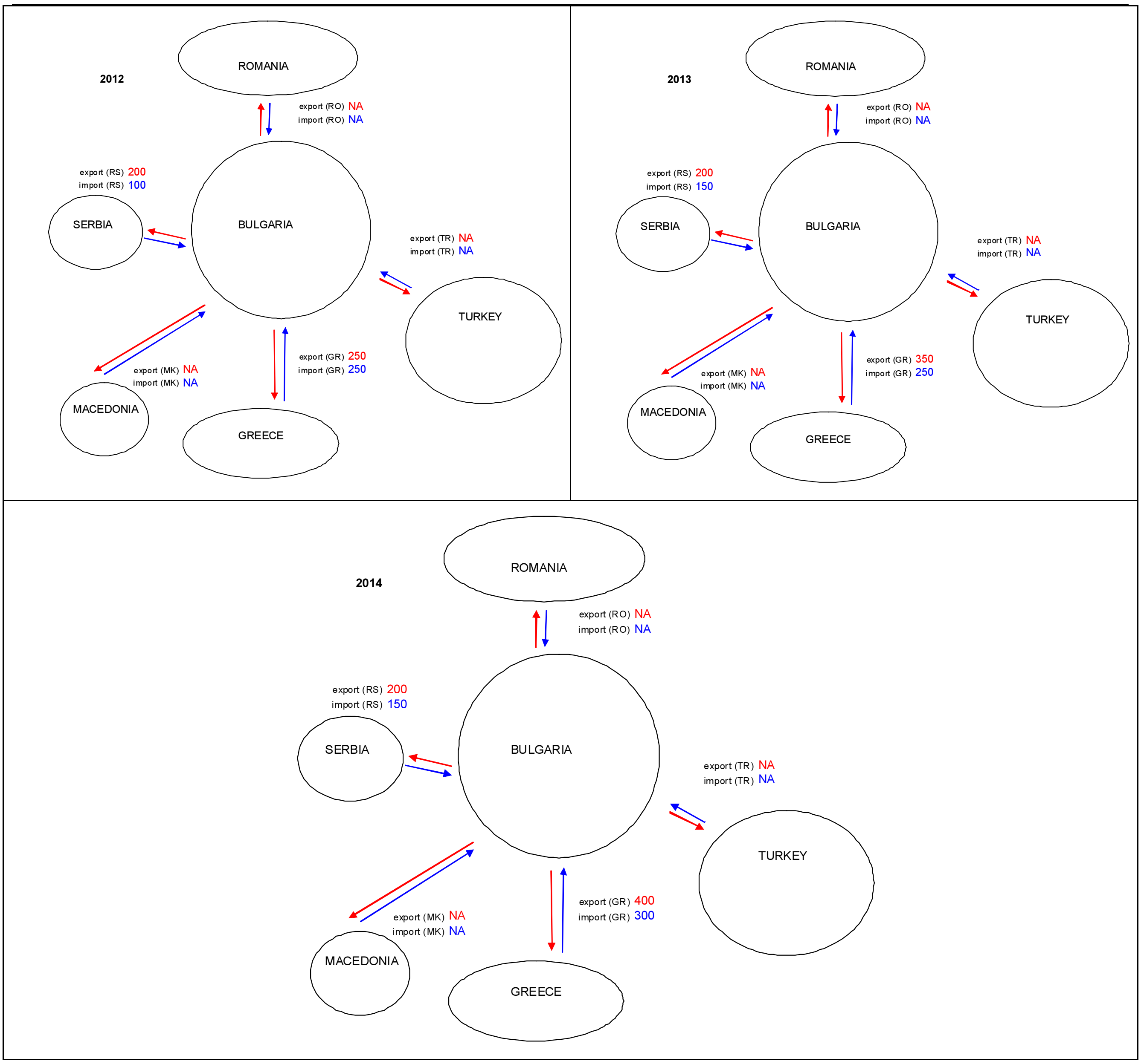


Figure 3.7 Graphical representation of the indicative annual NTC values for Bulgaria

3.4 Croatia

Croatian TSO (HOPS) shares national borders with Serbia, Hungary, Bosnia and Herzegovina and Slovenia. 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

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

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

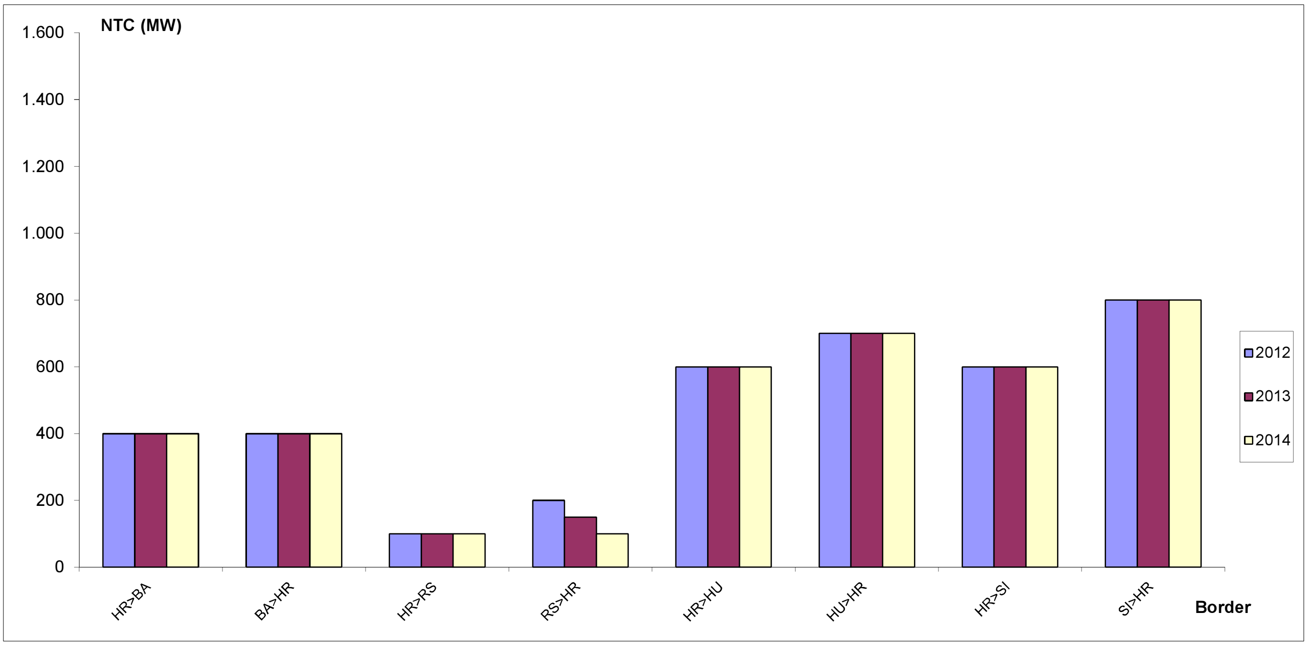


Figure 3.8 Indicative annual NTC values for Croatia (2012-2014)

Indicative annual NTC value for Croatian/Hungarian border was set to 600 MW for direction from Croatia to Hungary and 700 MW for the opposite direction, over 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)

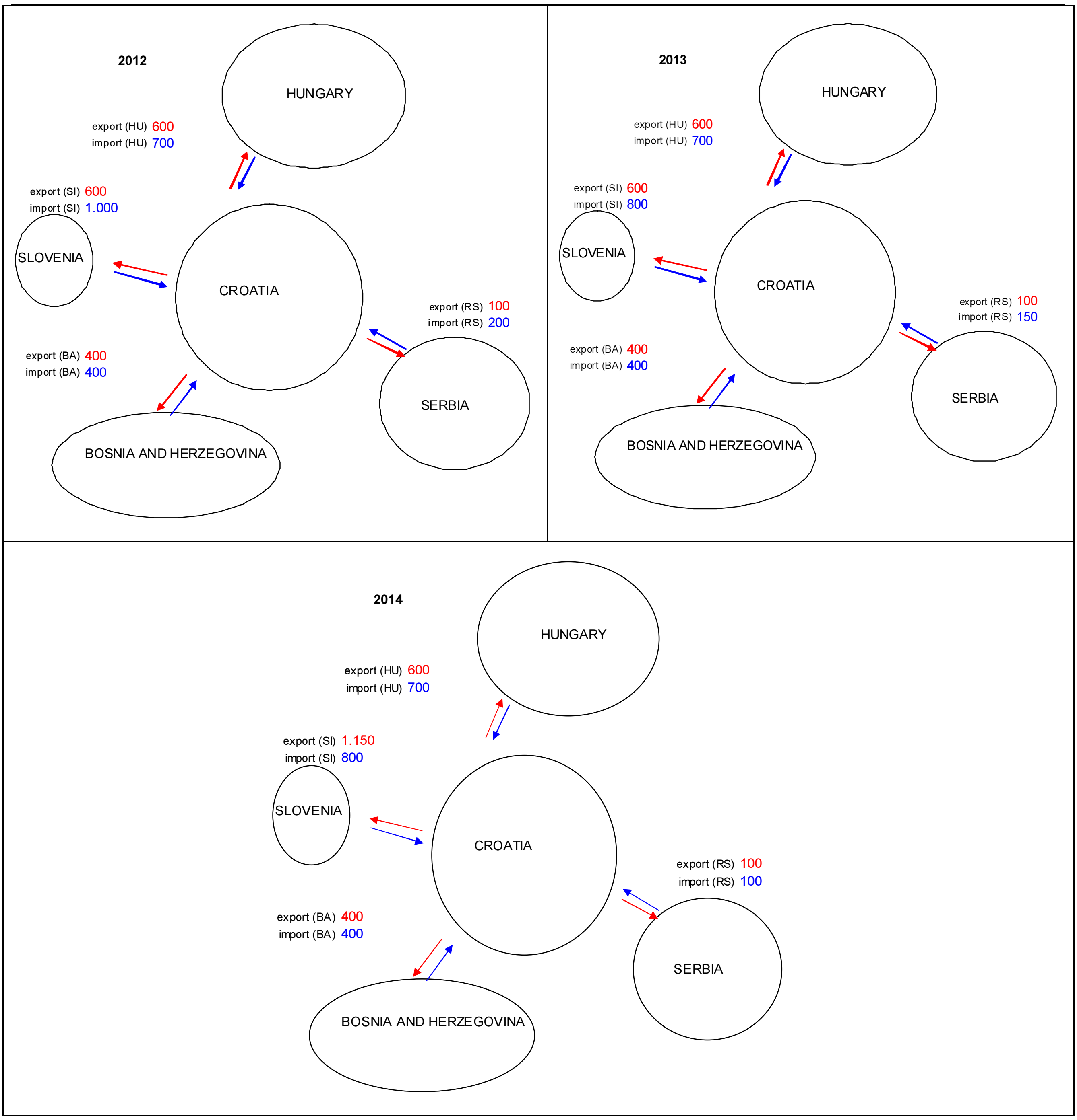


Figure 3.9 Graphical representation of the indicative annual NTC values for Croatia

3.5 Macedonia

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

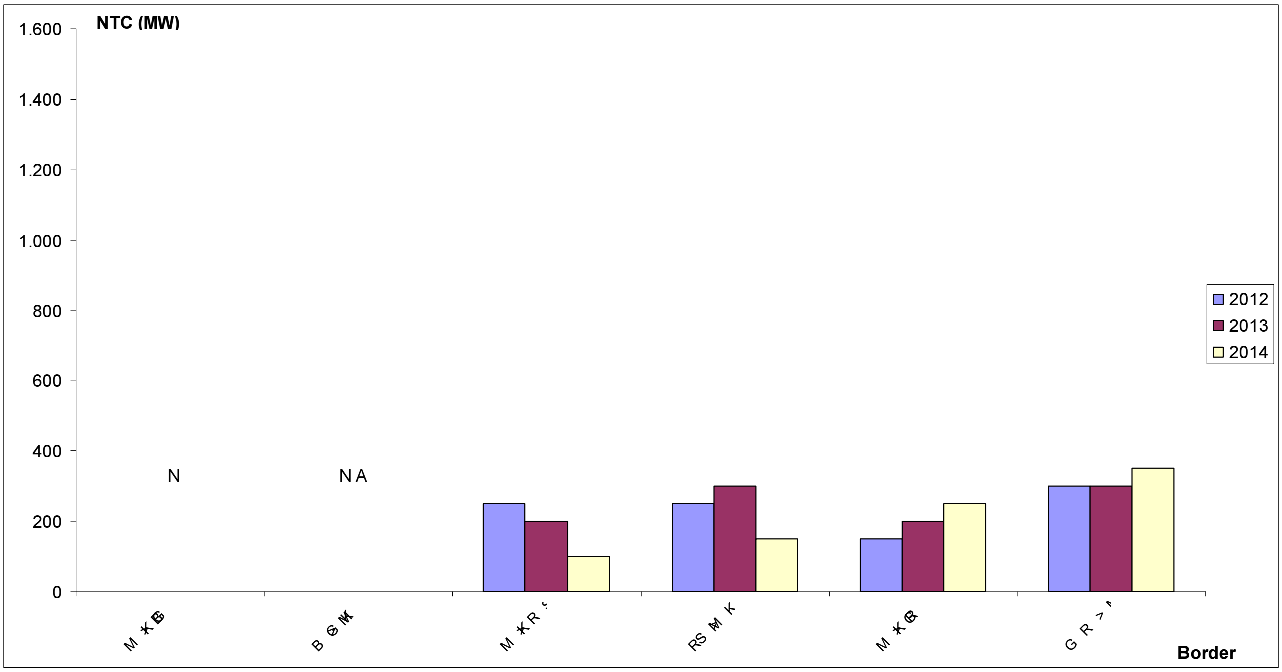


Figure 3.10 Indicative annual NTC values for Macedonia (2012-2014)

Indicative annual NTC value for Macedonian/Kosovo 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.

Indicative annual NTC value for Macedonian/Greek border was set to 150 MW for MK to GR direction and 300 MW for 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.

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

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)

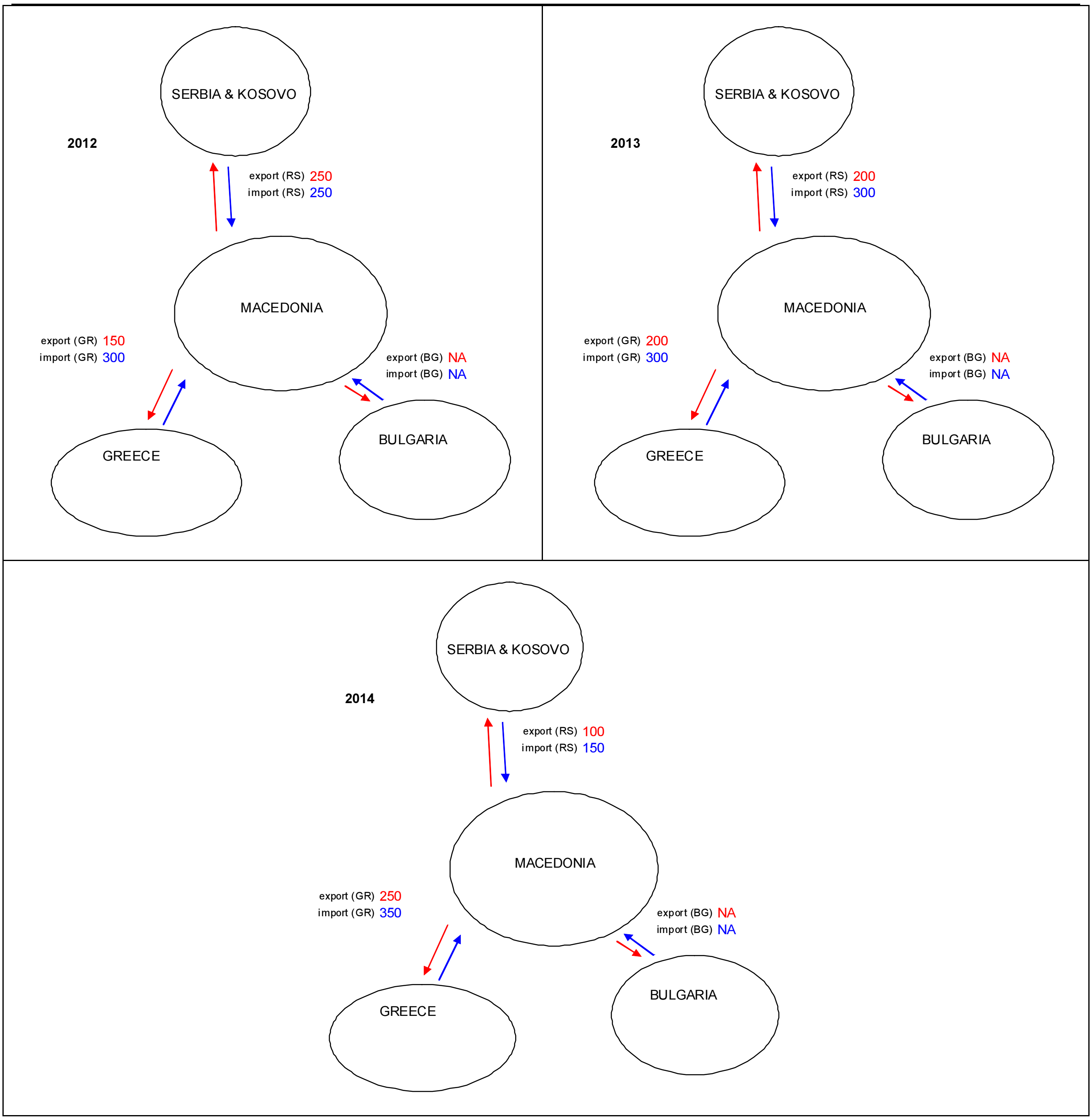


Figure 3.11 Graphical representation of the indicative annual NTC values for Macedonia

3.6 Montenegro

Montenegrin TSO (CGES) shares national borders with Kosovo, Serbia, Bosnia and Herzegovina and Albania. 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

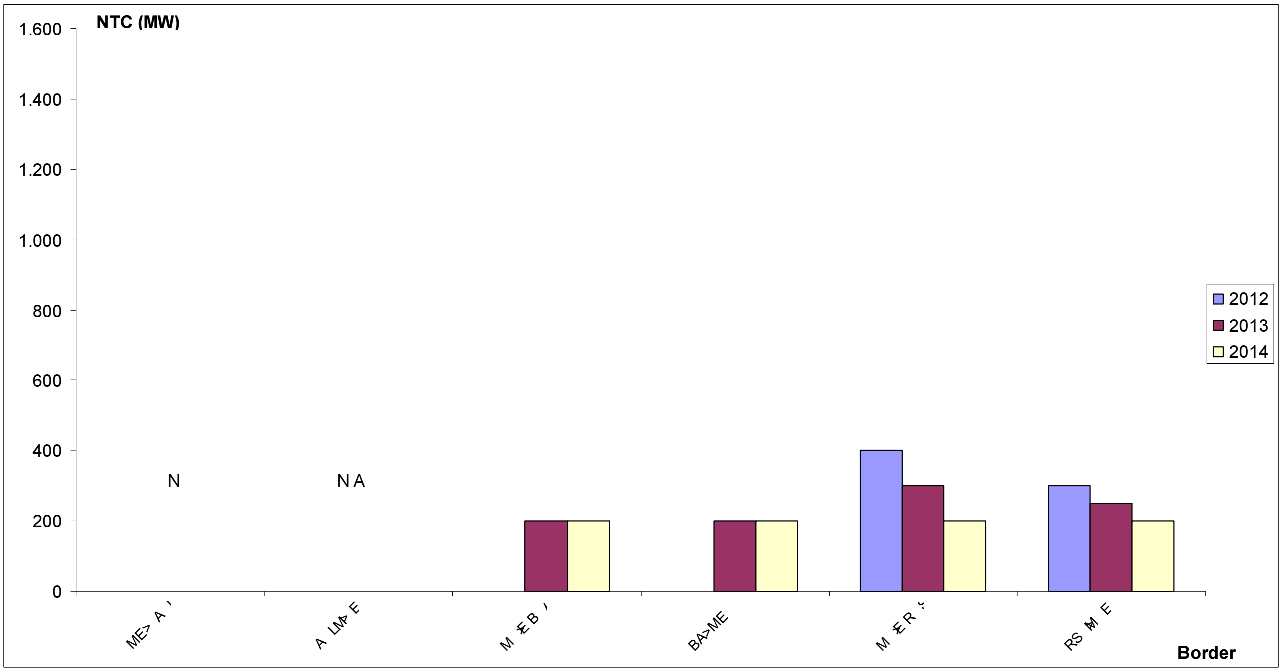


Figure 3.12 Indicative annual NTC values for Montenegro (2012-2014)

Indicative annual NTC value for Montenegrin/Kosovo and Serbian border was set to 400 MW for 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.

Indicative annual NTC value for Montenegro/Bosnia and Herzegovina border was set to 200 MW for both directions in 2013 and 2014

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

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)

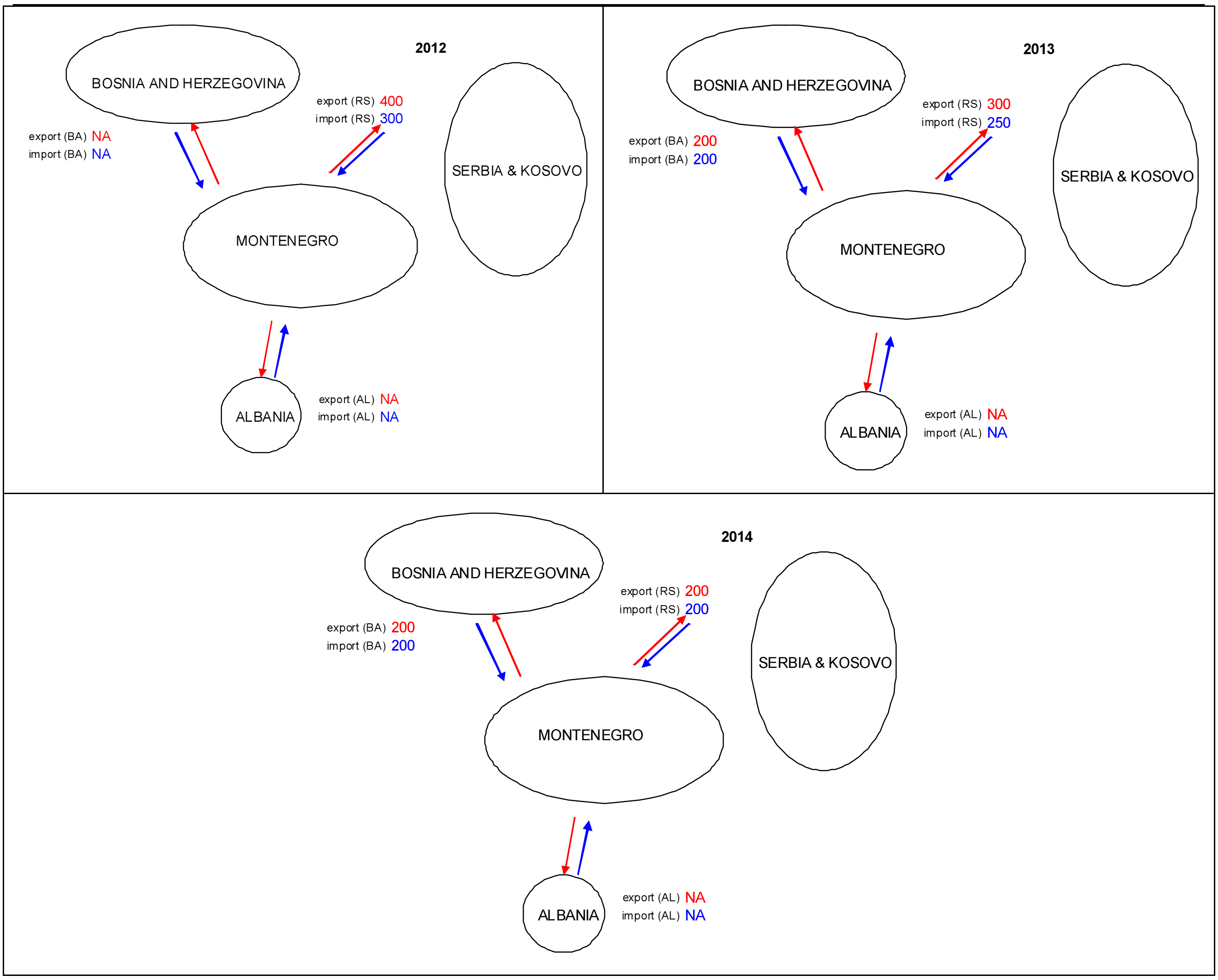


Figure 3.13 Graphical representation of the indicative annual NTC values for Montenegro

3.7 Romania

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

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

Indicative annual NTC value for Romanian/Serbian border was set to 250 MW for 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

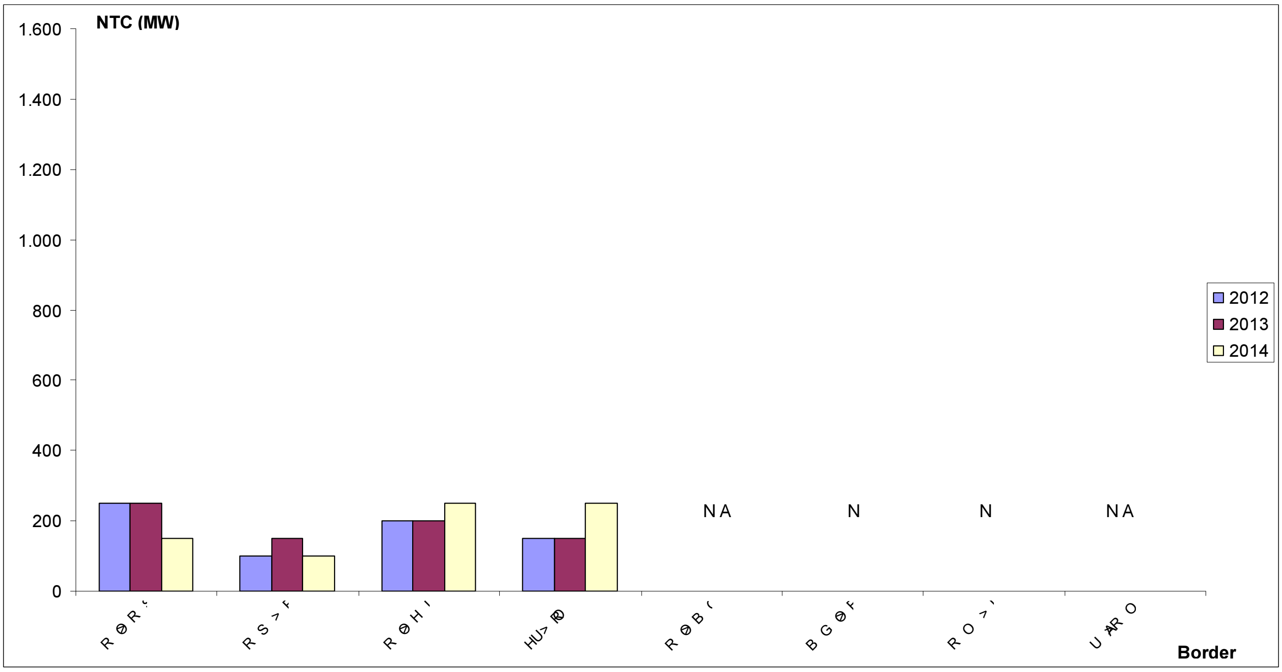


Figure 3.14 Indicative annual NTC values for Romania (2012-2014)

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

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

Day-ahead NTC values in January 2014 were published for Romania/Serbia border only, and set to 600 MW for Romania to Serbia direction and 300 MW for 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 NTCs 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 most of the time significantly higher.

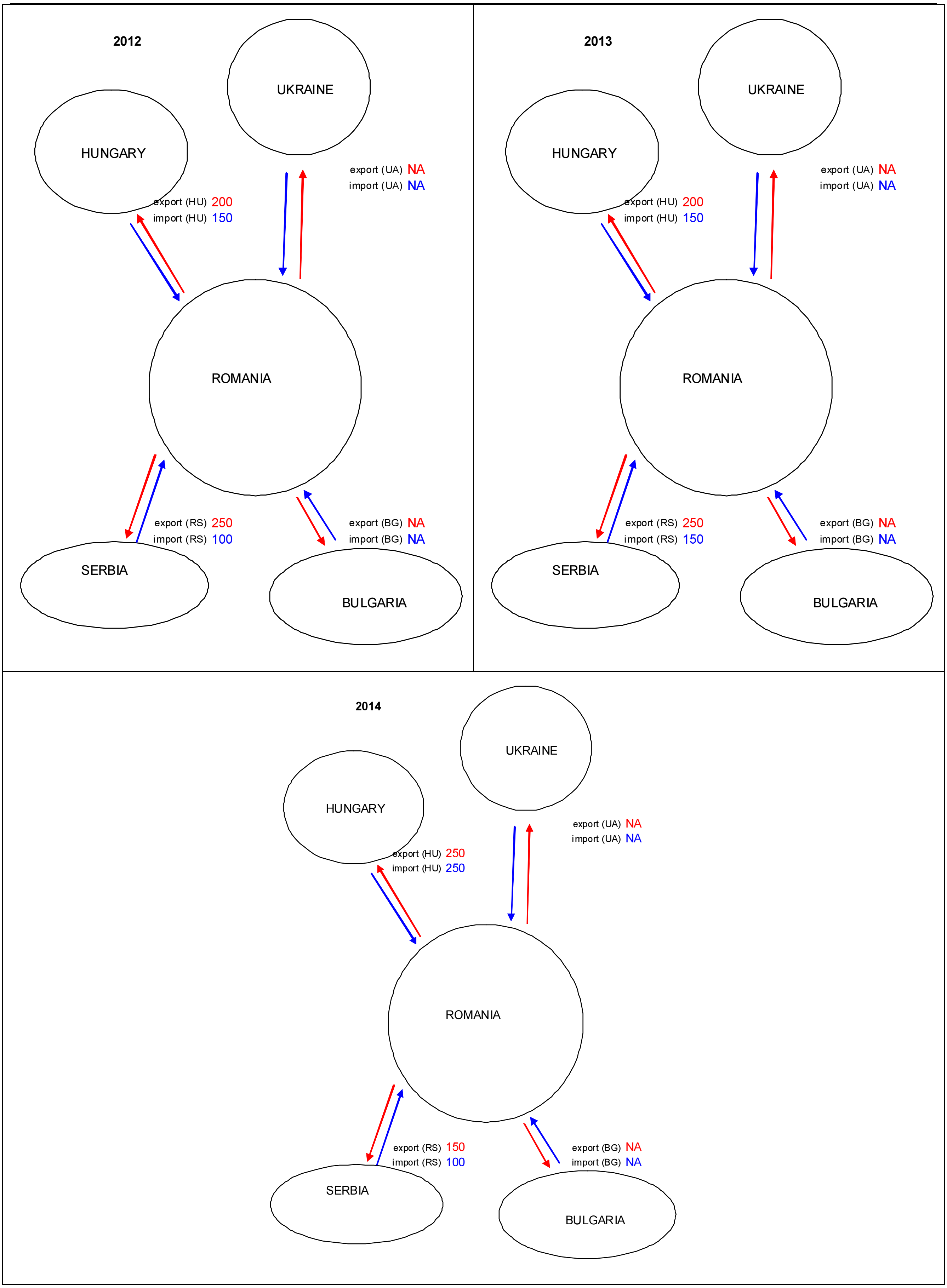


Figure 3.15 Graphical representation of the indicative annual NTC values for Romania

3.8 Serbia & Kosovo

Serbian TSO (EMS) and Kosovo TSO (KOSTT) share national borders with Albania, Bosnia and Herzegovina, Croatia, Hungary, Romania, Bulgaria, Macedonia and Montenegro. 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

Indicative annual NTC value for Kosovo/Albanian border for 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.

Indicative annual NTC values for Serbia&Kosovo/Montenegrin border have been gradually decreased for Serbia&Kosovo direction to Montenegro, from 300 MW in 2012, 250 MW in 2013 to 200 MW in 2014. The same is valid for Montenegro to Serbia&Kosovo direction, where the NTC values have been 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 Serbia/Bosnia and Herzegovina border, indicative annual NTC values were set to 200 MW, 150 MW and 100 MW in observed time frame for direction from Serbia to Bosnia and Herzegovina, and 400 MW, 300 MW and 100 MW for the opposite direction.

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

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

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

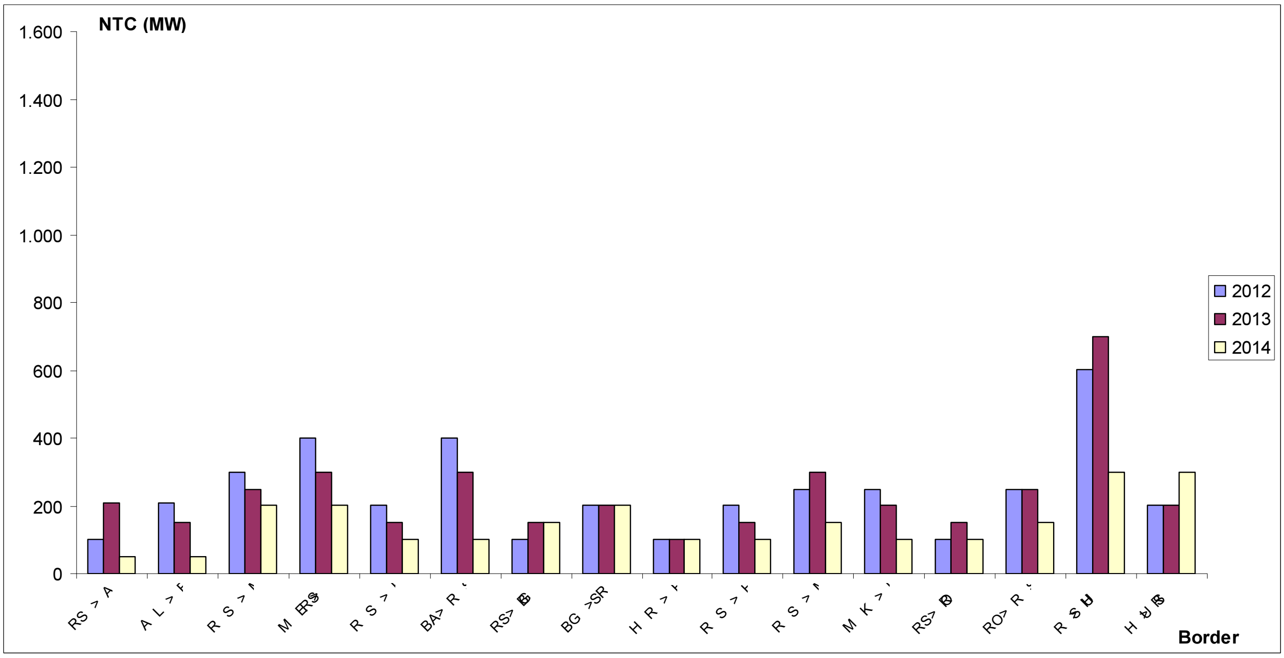


Figure 3.16 Indicative annual NTC values for Serbia&Kosovo (2012-2014)

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

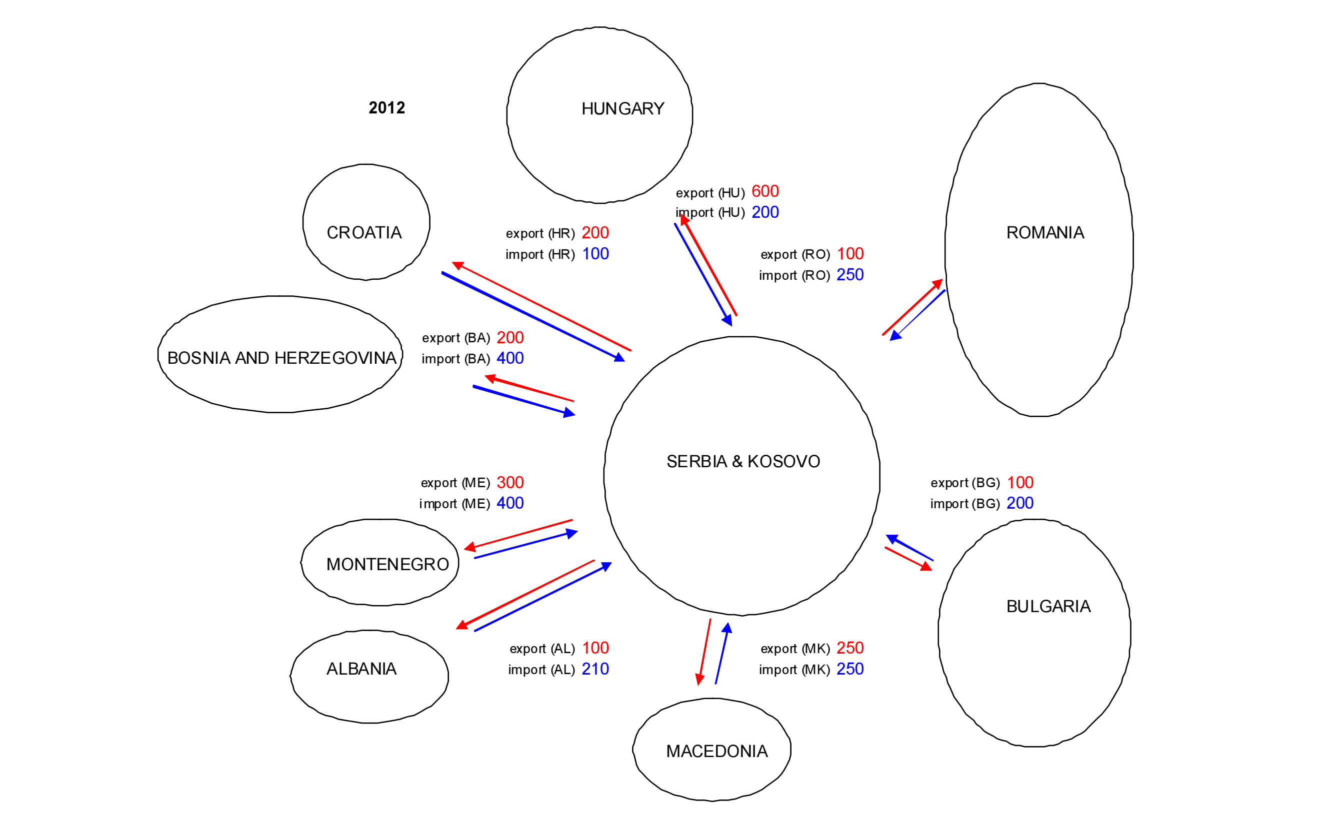
RS/BiH border	600 MW (for both directions)
RS/HR border	500 MW - 600 MW (for both directions)
RS/HU border	700 MW to 1000 MW (for Hungary to Serbia direction) and 800 MW – 1000 MW (for Serbia to Hungary direction)
RS/AL border	250 MW (for both directions)
RS/MK border	250 MW (for MK to RS direction)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

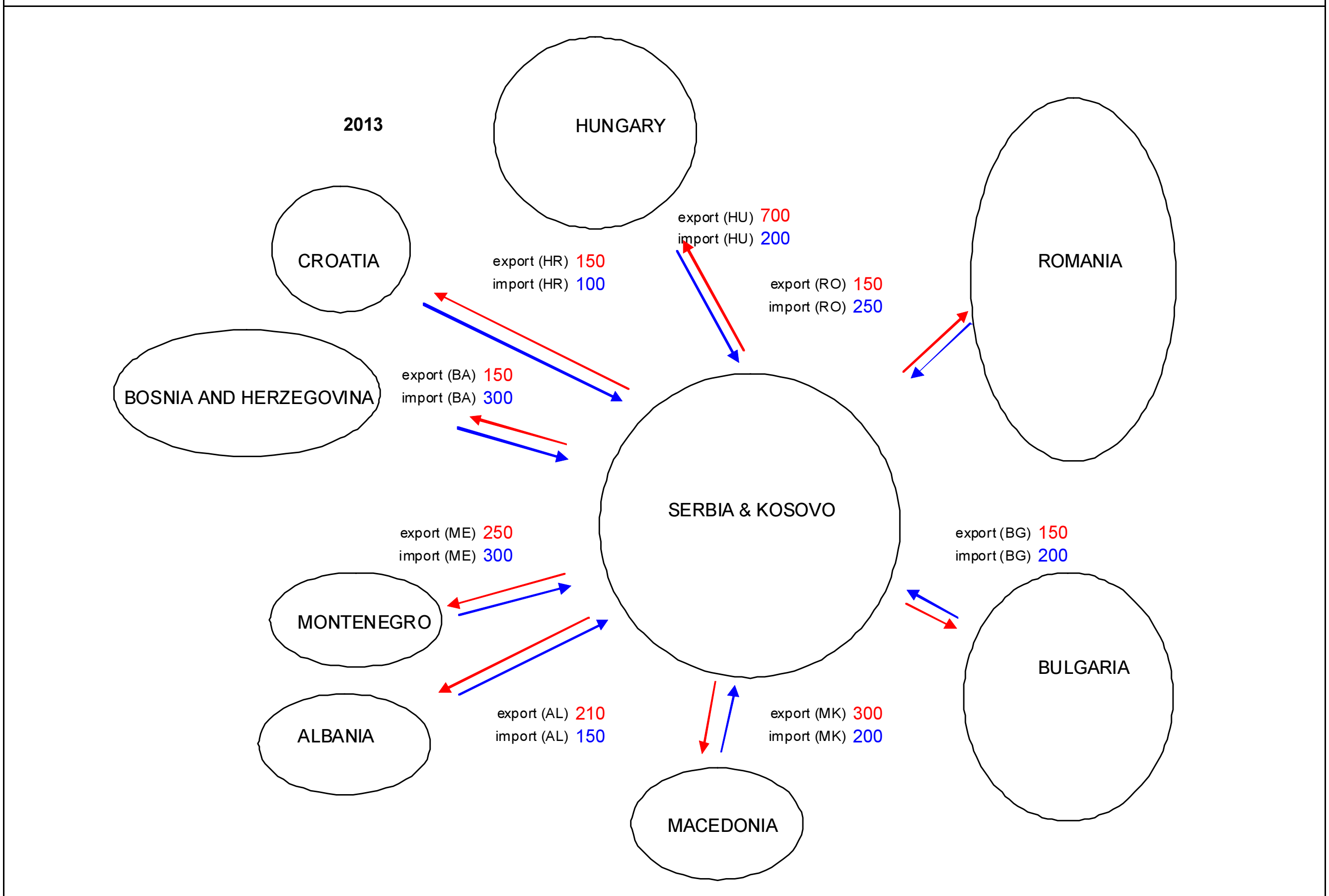
Day-ahead NTC values in January 2014 were also published for all Serbia&Kosovo borders:

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
BULGARIA
ALBANIA
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
BULGARIA
ALBANIA
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

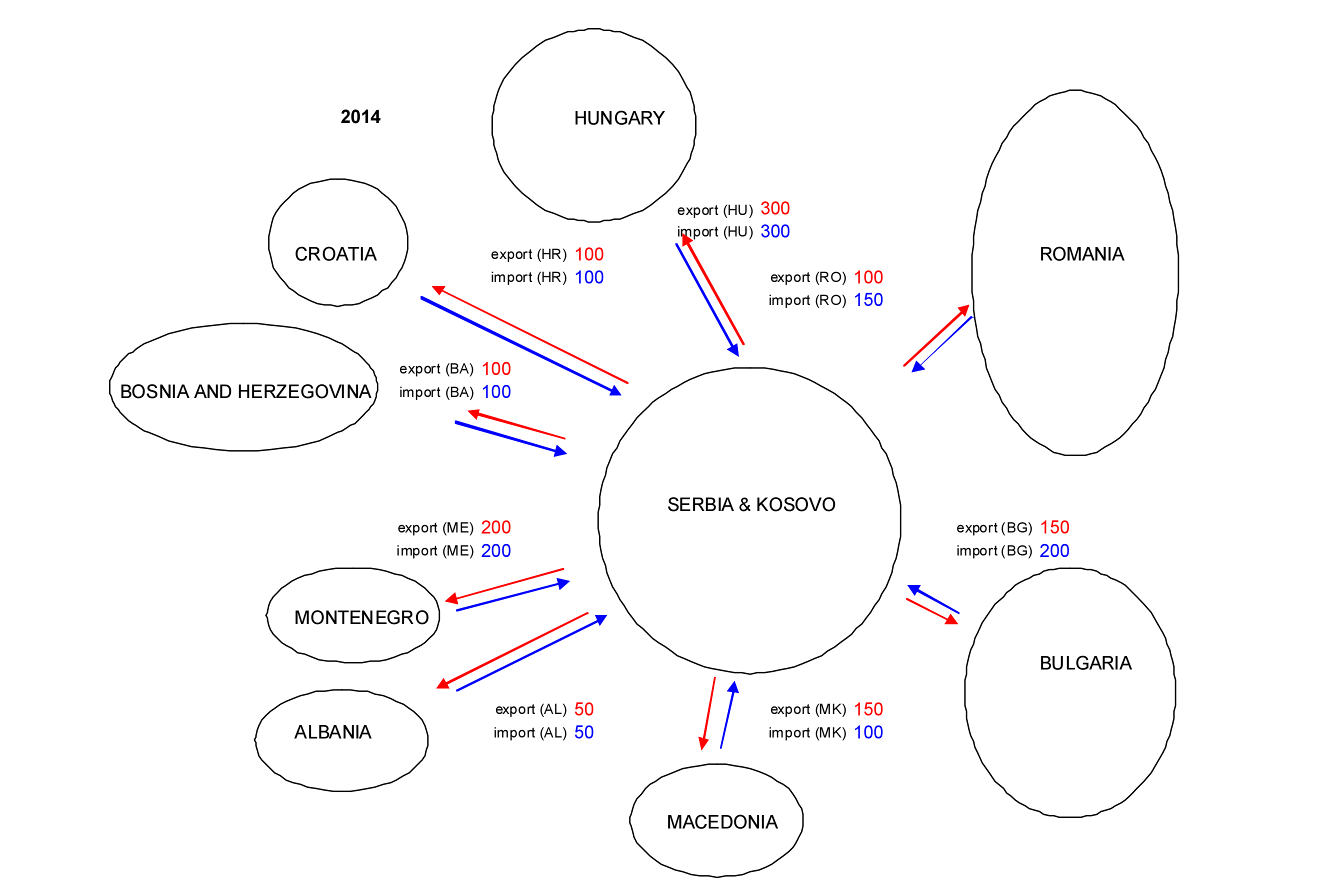


Figure 3.17 Graphical representation of the indicative annual NTC values for Serbia&Kosovo

3.9 Slovenia

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

Indicative annual NTC value for Slovenia/Austrian border was set to 950 MW for both directions in observed time frame.

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

Indicative annual NTC values for Slovenia/Italy border were around 80 MW for Slovenia to Italy direction, and 120 MW to 620 MW for 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).

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.

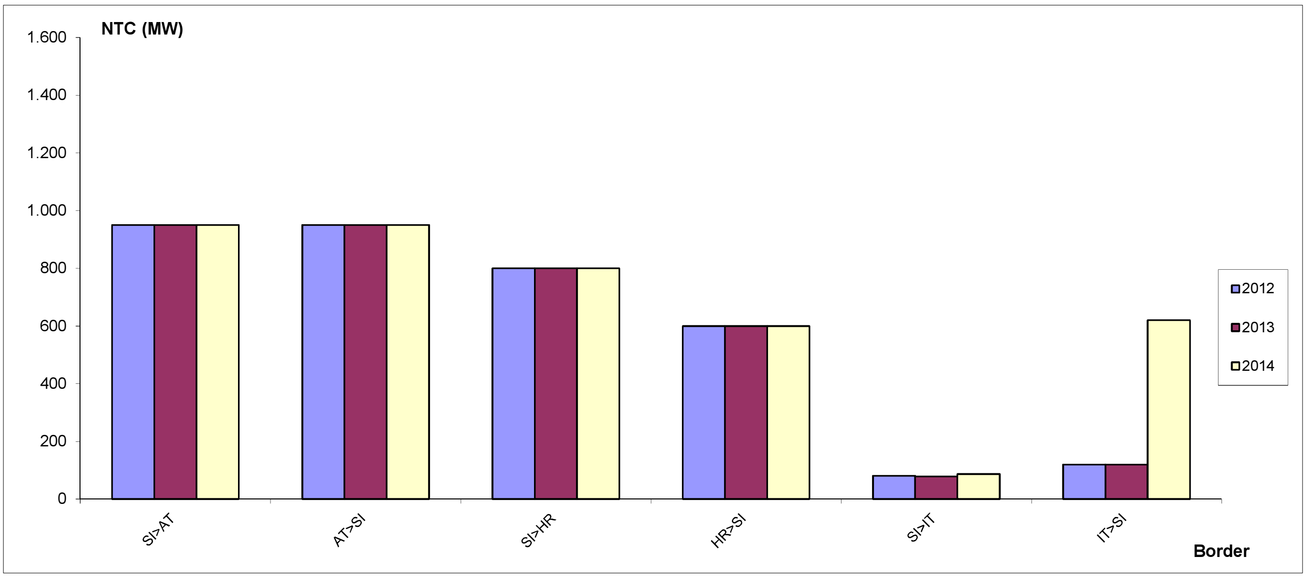


Figure 3.18 Indicative annual NTC values for Slovenia (2012-2014)

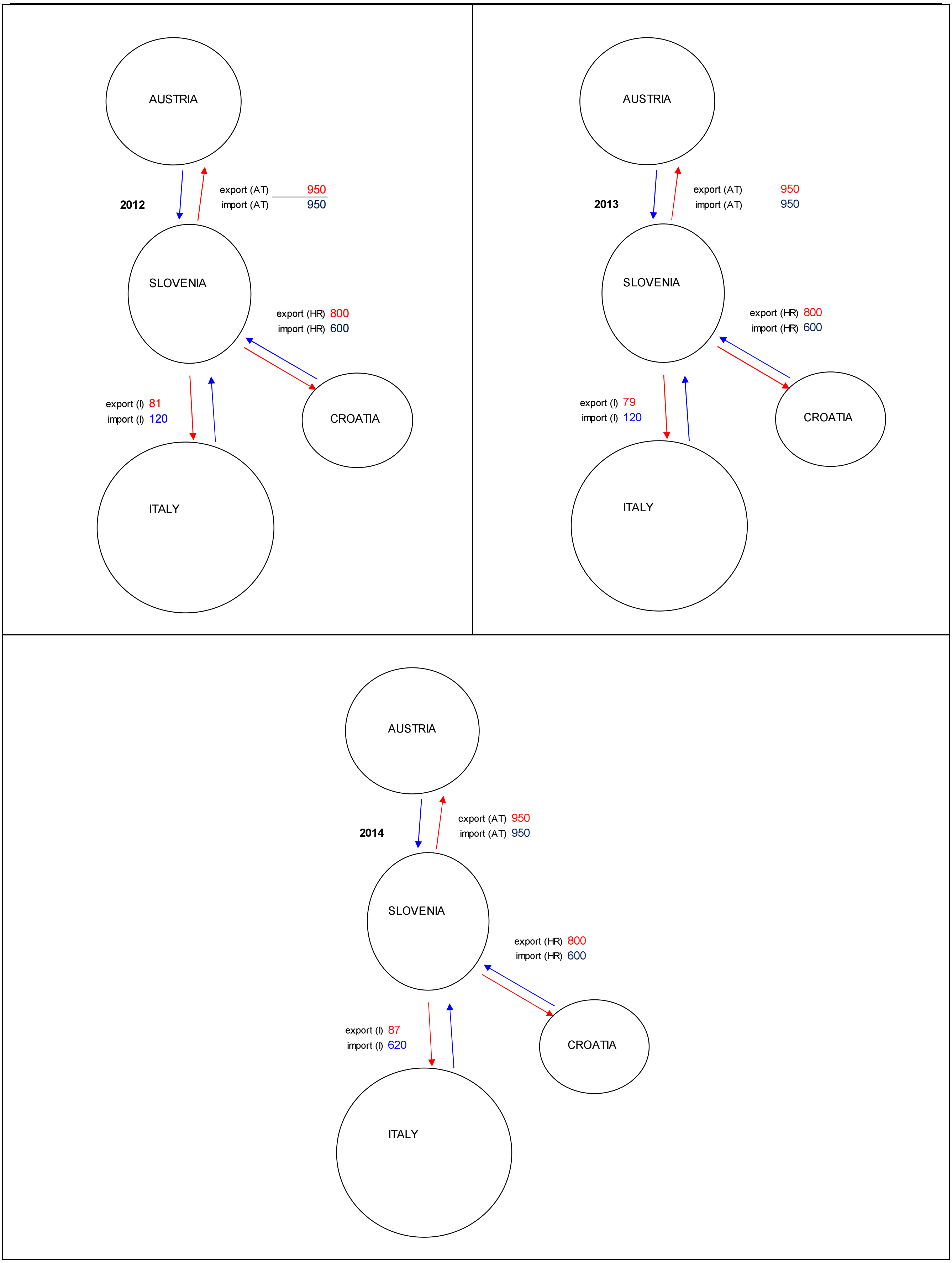


Figure 3.19 Graphical representation of the indicative annual NTC values for Slovenia

4. REGIONAL TRANSMISSION NETWORK MODEL

Existing topology and operational conditions in the SEE region have been presented by the common model of all power systems related to actual situation on January 14, 2012, in 12:40 pm. Model was prepared by the EKC – Belgrade in the PSS/E format, and it was later used as the base case model for the NTC values computation.

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
Italia.

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

Total load of observed countries at 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 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). Countries generation also varies between 0,25 GW (Montenegro) to 6,4 GW (Romania) and 31 GW (Turkey).

Importing countries at the model 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 at the model are Bulgaria (exports 846 MW), Romania (113 MW) and Turkey (81 MW).

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

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.

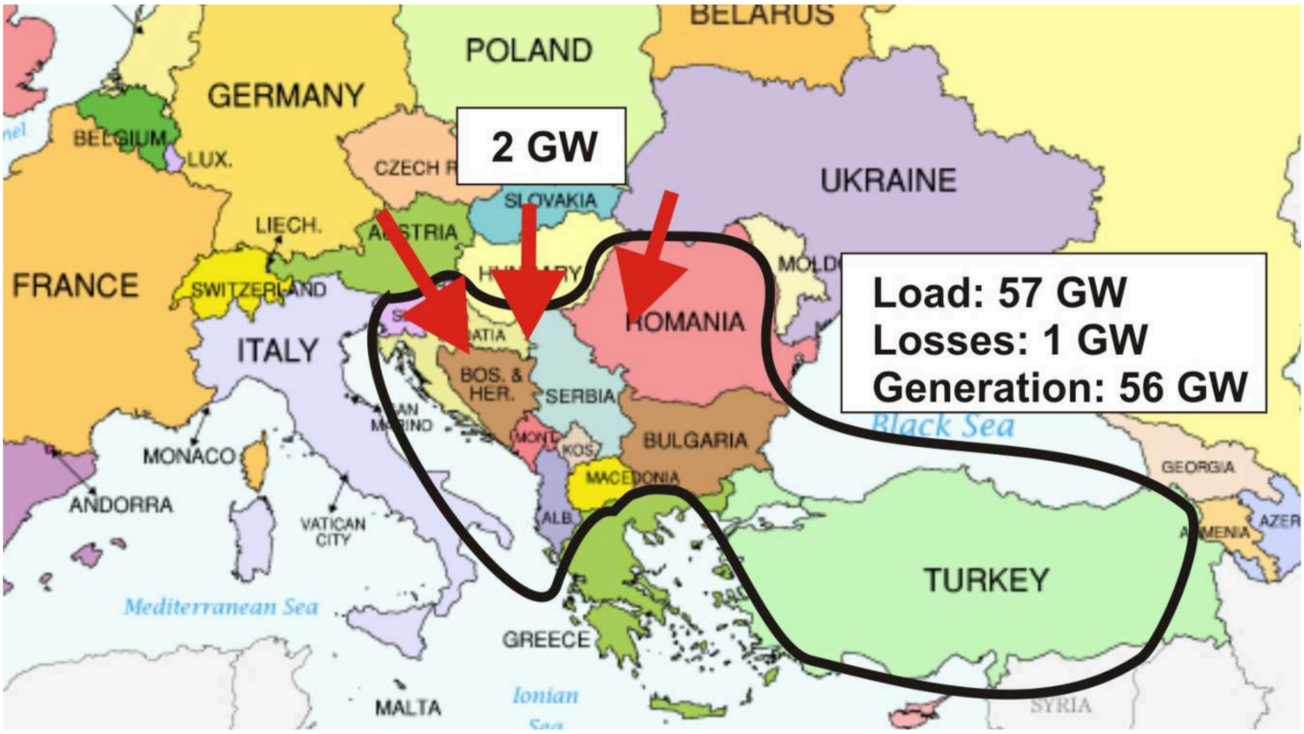


Figure 4.1 Power balance for the SEE region at the base case model in 2012

X-- AREA --X	FROM ------AT AREA BUSES------- 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

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 Albanian network. Critical contingences comprise some transformers 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 overloadings due to security criterion N-1 in the Albanian transmission network

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

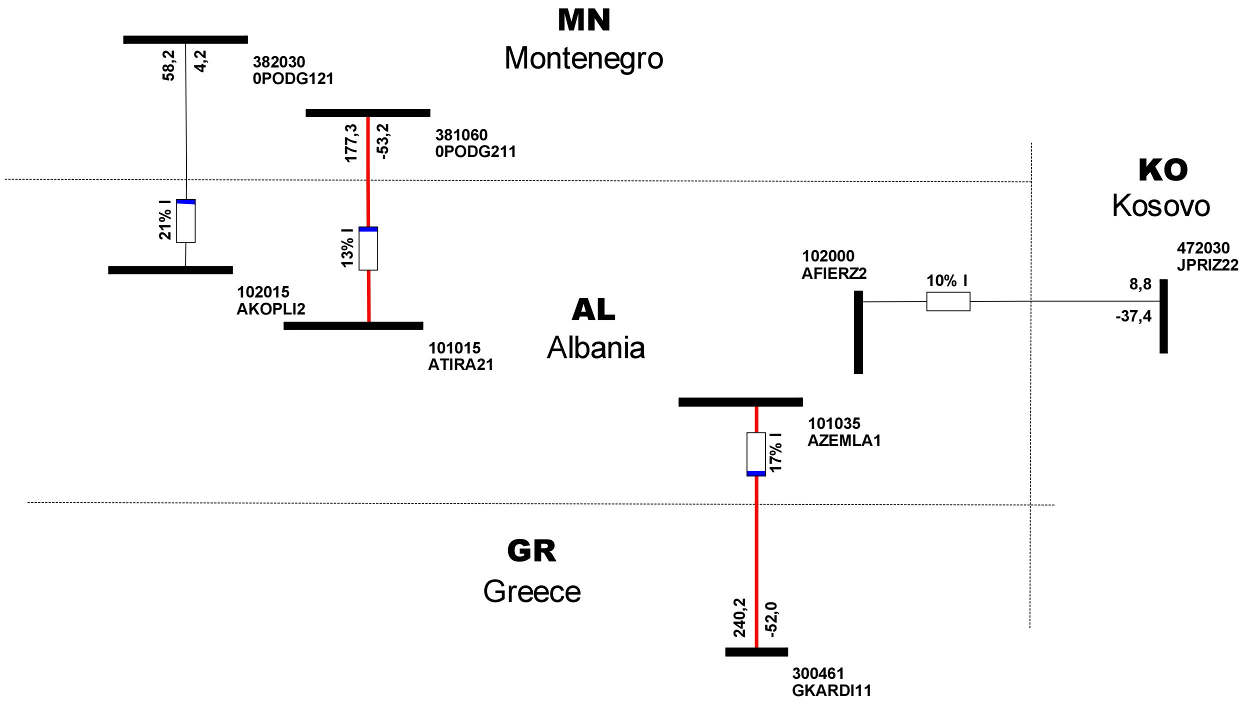


Figure 4.4 Albanian interconnection lines loading and percentage of loading in the base case

In the present situation 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*

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

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 declared indicative annual NTC values in time period 2012 – 2014, one may notice that interconnection capacities at Albania/Greek border could be poorly used, while interconnection capacity at Albanian/Kosovo border could be used more significantly in 2012 and 2013, but poorly in 2014.

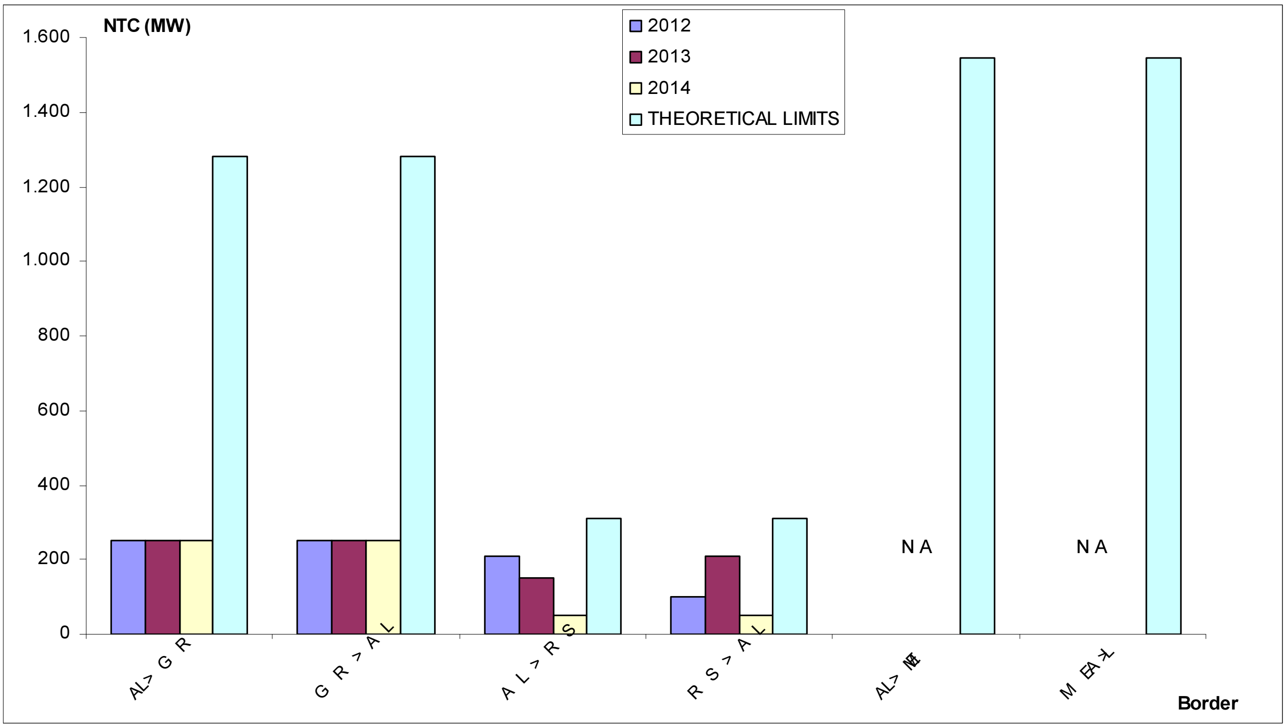


Figure 4.5 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Albania

4.2 Bosnia and Herzegovina

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 Bosnian network.

The following figure presents Bosnia and Herzegovina interconnection lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 39 % of their thermal ratings.

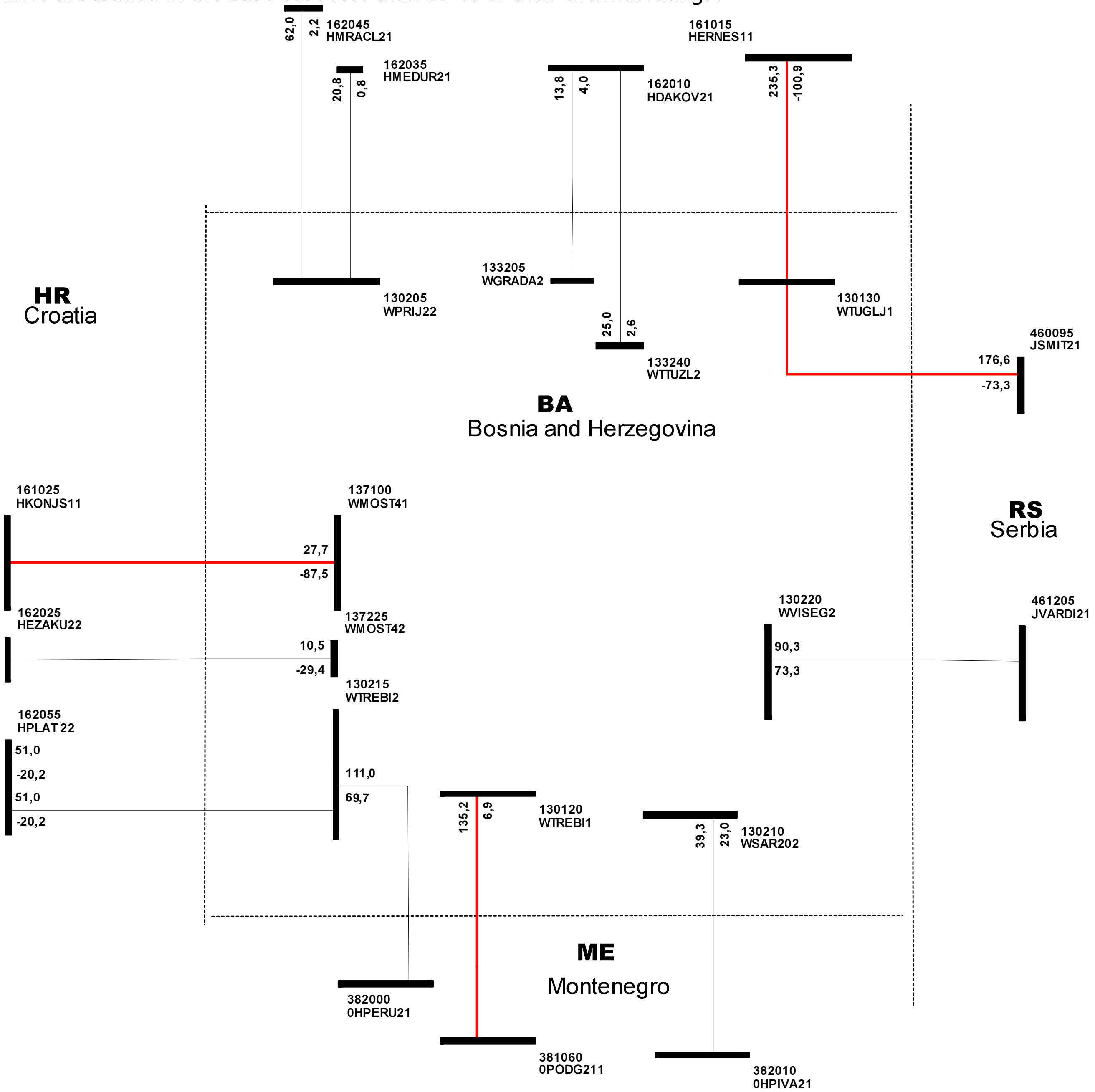


Figure 4.6 Bosnian interconnection lines loading and percentage of loading in the base case

In the present situation Bosnian transmission network is interconnected with neighboring power systems by four 400 kV and ten 220 kV lines. The sum of their thermal ratings is 9652 MVA (around 9200 MW). 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*

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

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 lines ratings and declared indicative NTC values in time period 2012 – 2014, one may notice that interconnection capacities at all Bosnia and Herzegovina borders could be poorly used, up to 8 % of theoretical limits in 2012, 19 % in 2013 and 8 % only in 2014.

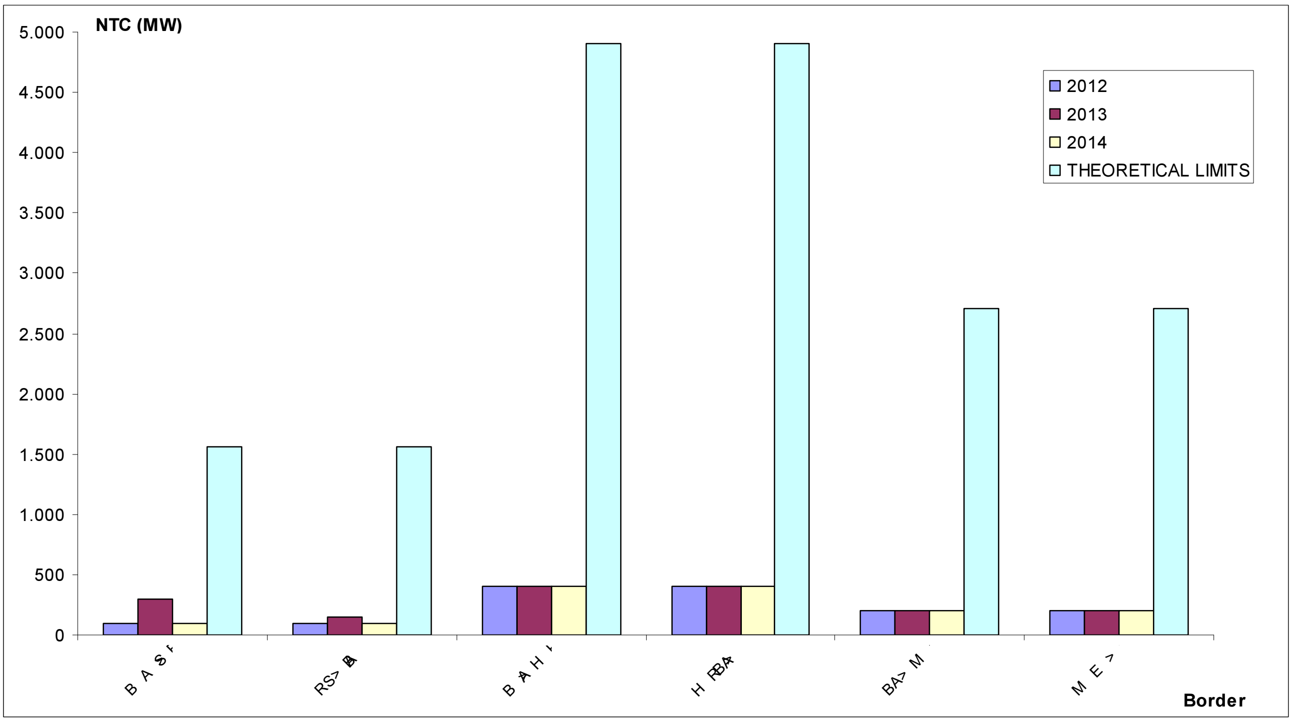


Figure 4.7 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Bosnia and Herzegovina

4.3 Bulgaria

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
```

Security criterion N-1 is not fulfilled in the base case for Bulgarian network. Critical contingences comprise some lines 400 kV and 110 kV. 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 overloadings due to security criterion N-1 in the Bulgarian transmission network

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

In the present situation 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 time period 2012 – 2014, one may notice that interconnection capacities at all Bulgarian borders could be poorly used, up to 20 % of theoretical limits in 2012, 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

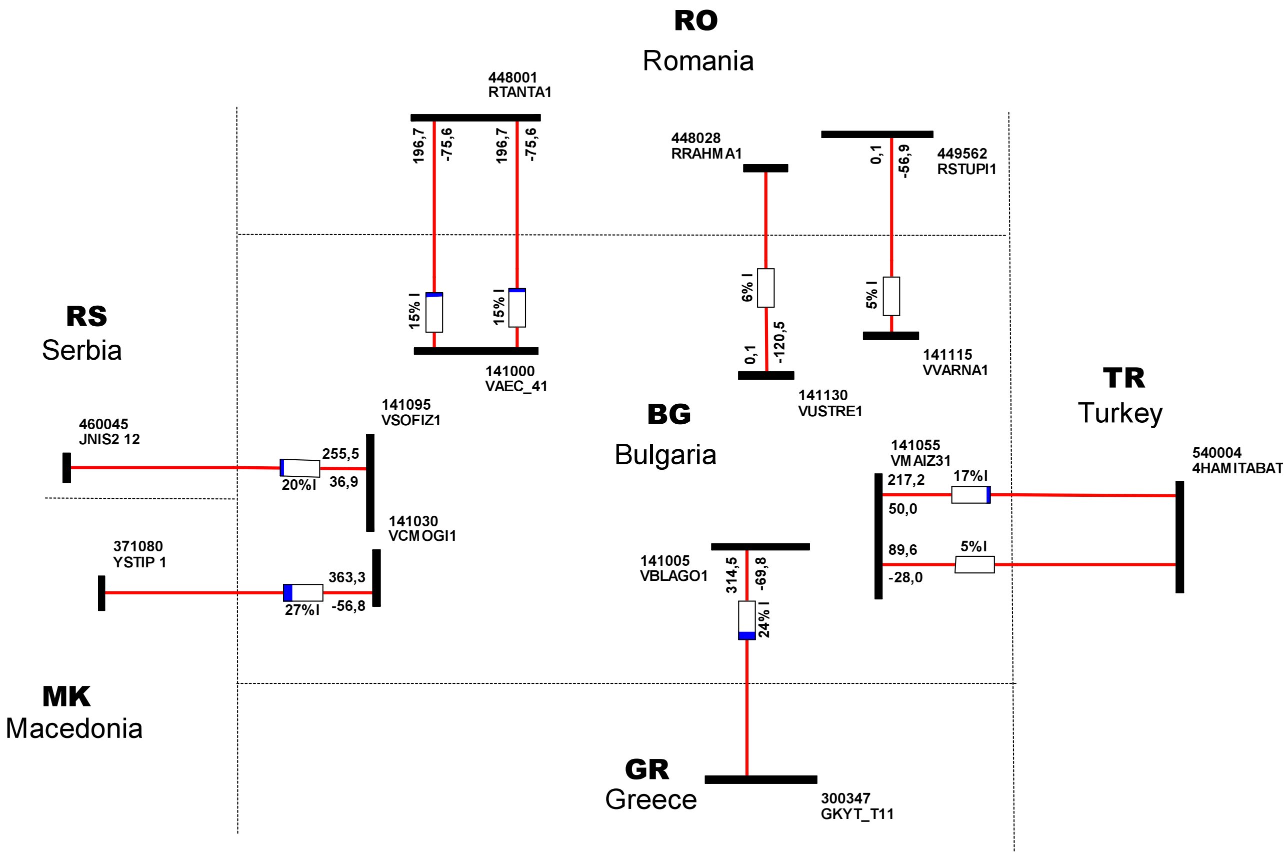


Figure 4.9 Bulgarian interconnection lines loading and percentage of loading in the base case

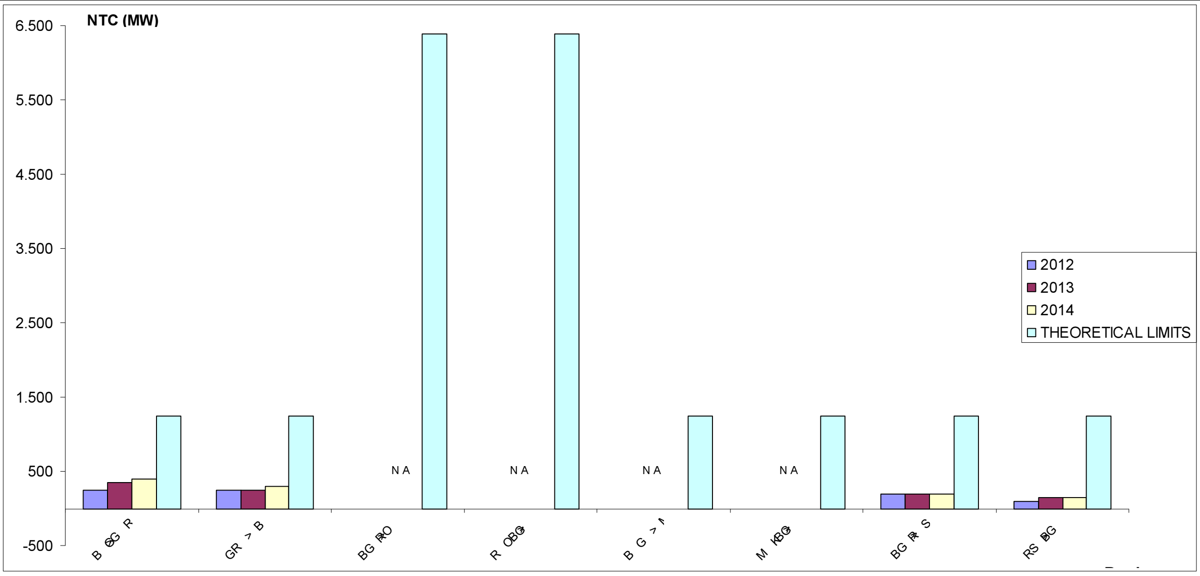


Figure 4.10 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Bulgaria

4.4 Croatia

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)

In 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 lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 51 % of their thermal ratings.

In the present situation 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 lines ratings and declared indicative NTC values in time period 2012 – 2014, one may notice that interconnection capacities at all Croatian borders could be poorly used, up to 28 % of theoretical limits in 2012, 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

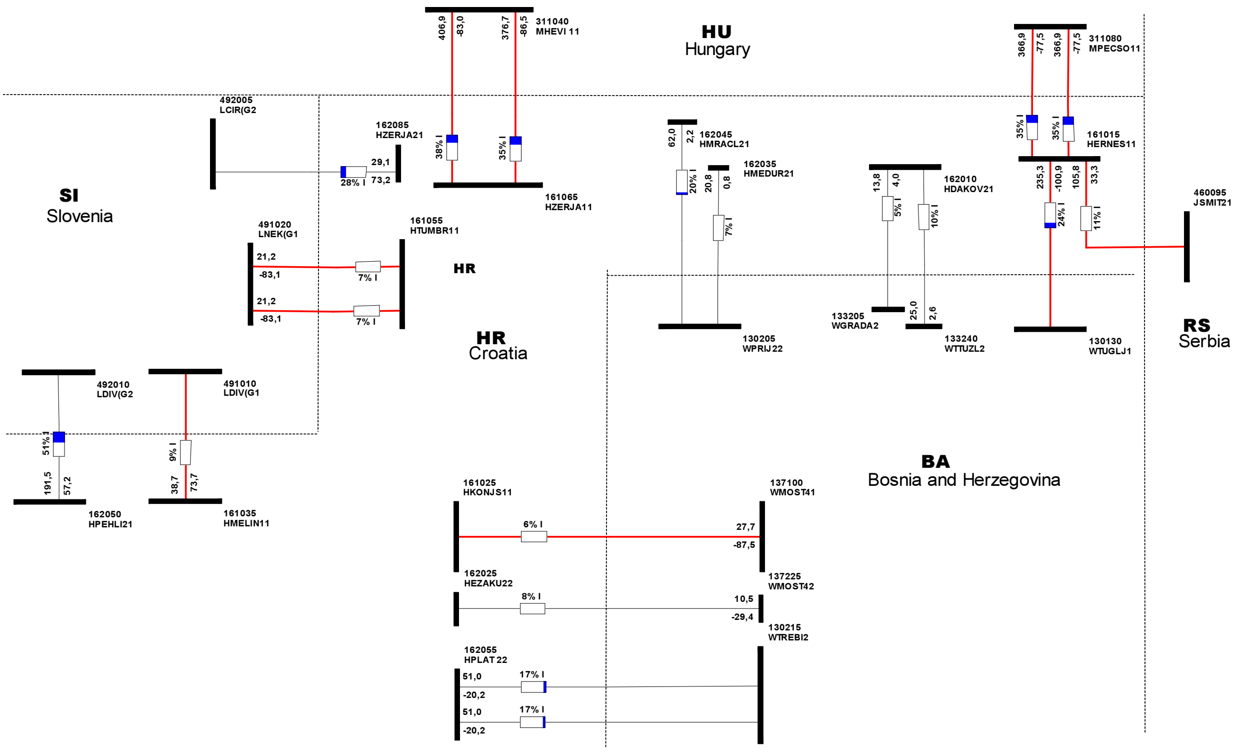


Figure 4.11 Croatian interconnection lines loading and percentage of loading in the base case

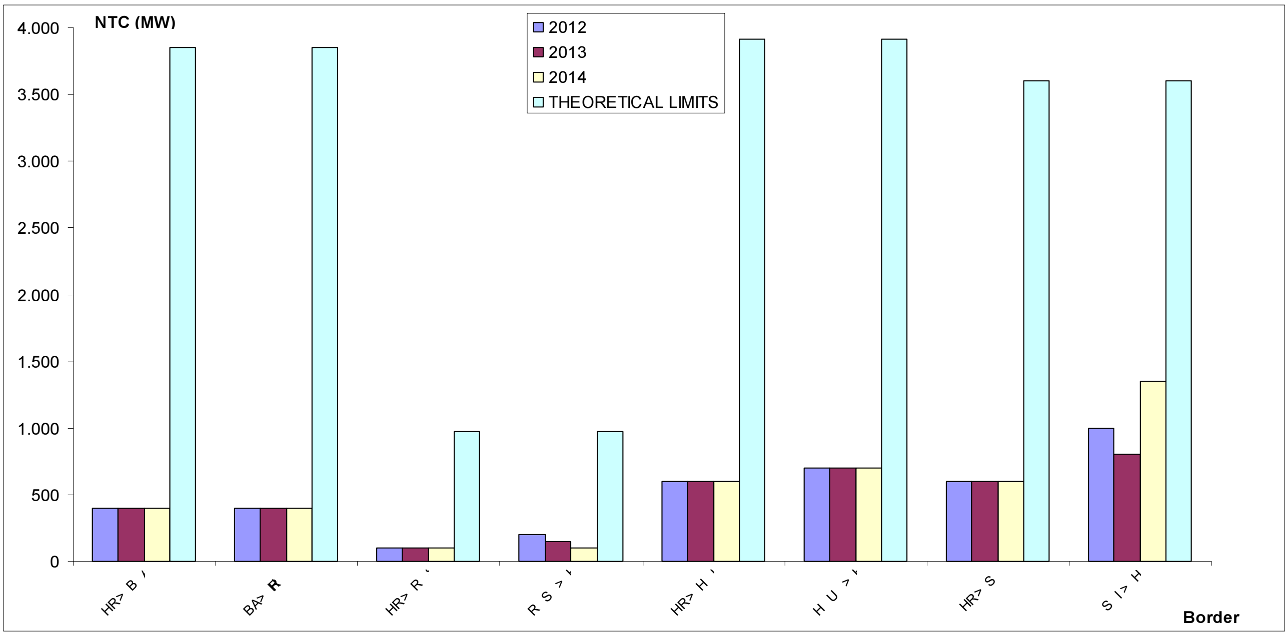


Figure 4.12 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Croatia

4.5 Macedonia

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. Critical contingences comprise some lines 110 kV, 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 overloadings due to security criterion N-1 in the Macedonian transmission network

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

In the present situation 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

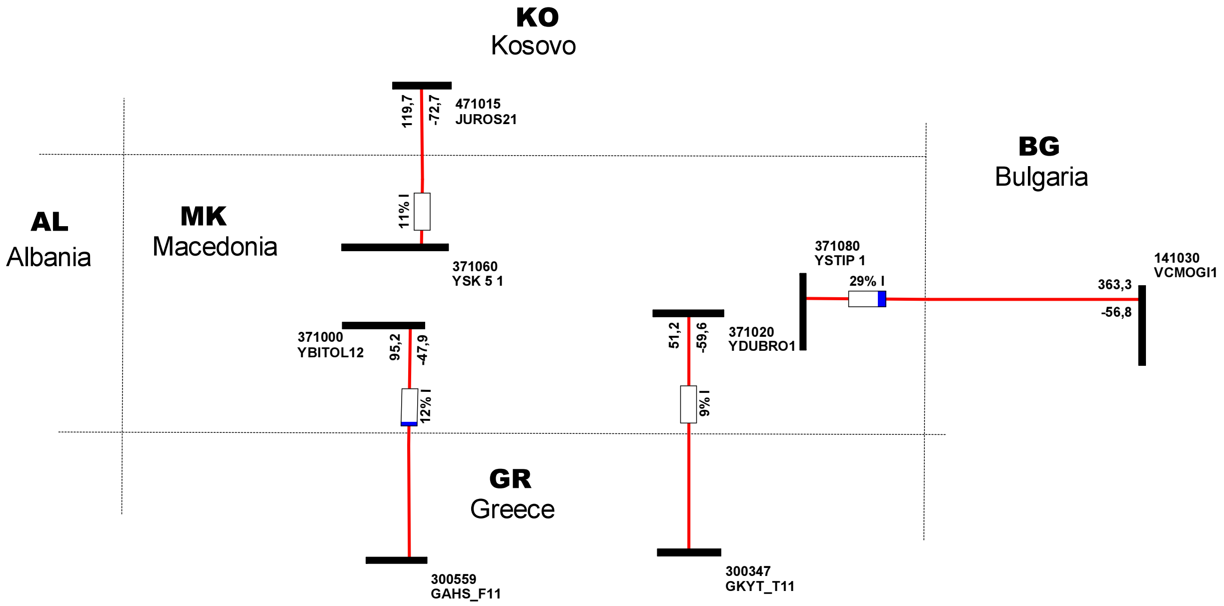


Figure 4.14 Macedonian interconnection lines loading and percentage of loading in the base case

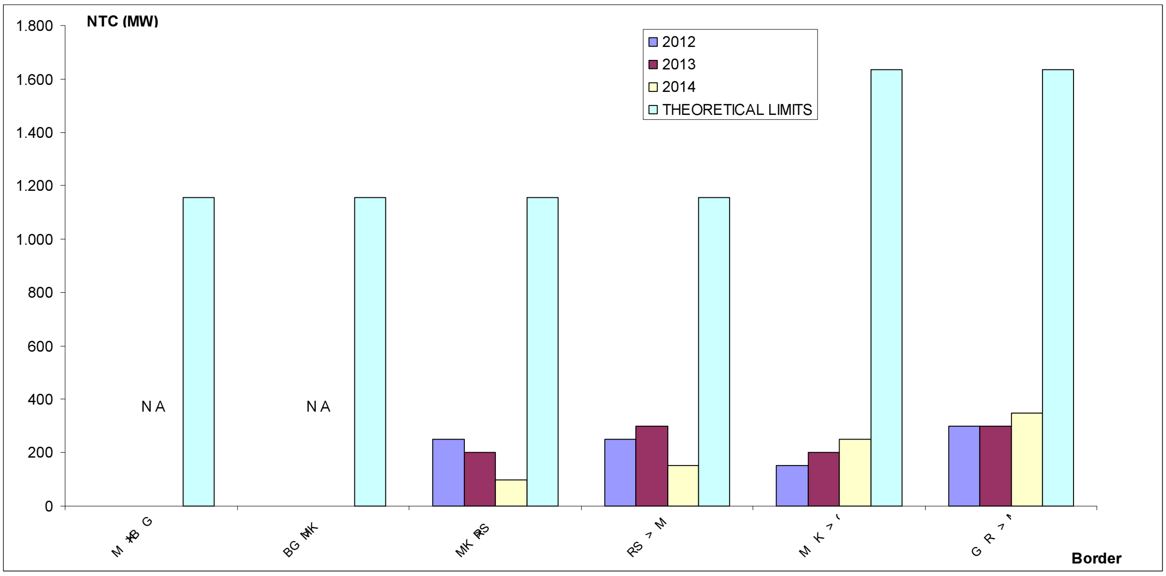


Figure 4.15 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Macedonia

Comparing Macedonian interconnection lines ratings and declared indicative NTC values in time period 2012 – 2014, one may notice that interconnection capacities at all Macedonian borders could be poorly used, up to 22 % of theoretical limits in 2012, 26 % in 2013 and up to 21 % in 2014.

4.6 Montenegro

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 lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 46 % of their thermal ratings.

In the present situation 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 time period 2012 – 2014, one may notice that interconnection capacities at all Montenegrin borders could be poorly used, up to 21 % of theoretical limits in 2012, 15 % in 2013 and up to 10 % in 2014.

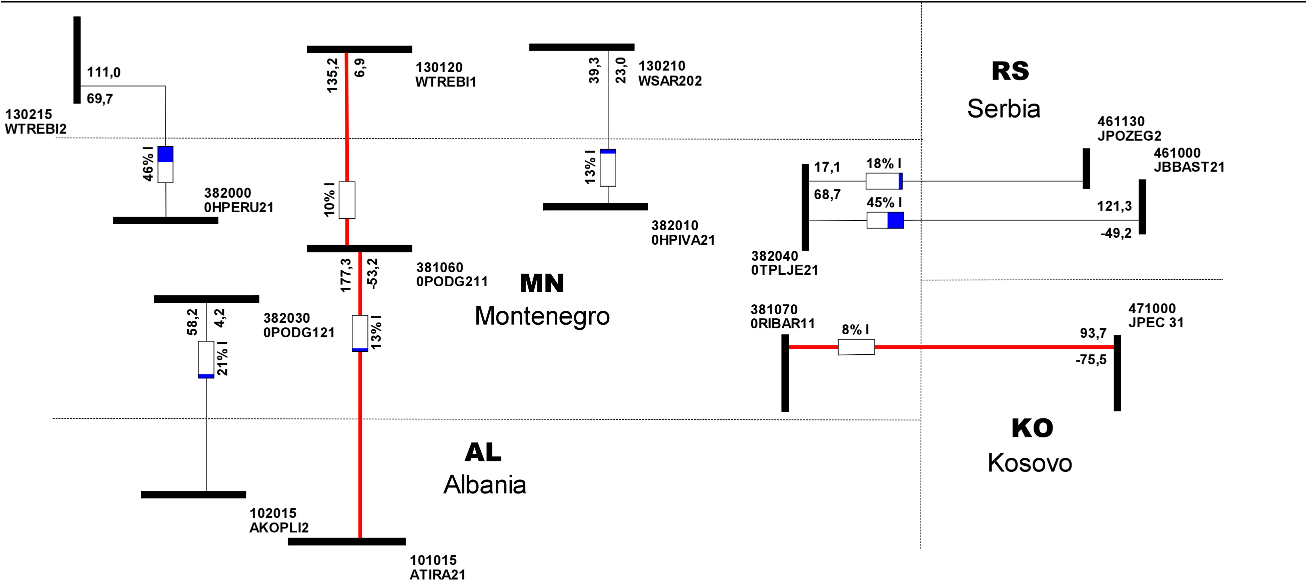


Figure 4.16 Montenegrin interconnection lines loading and percentage of loading in the base case

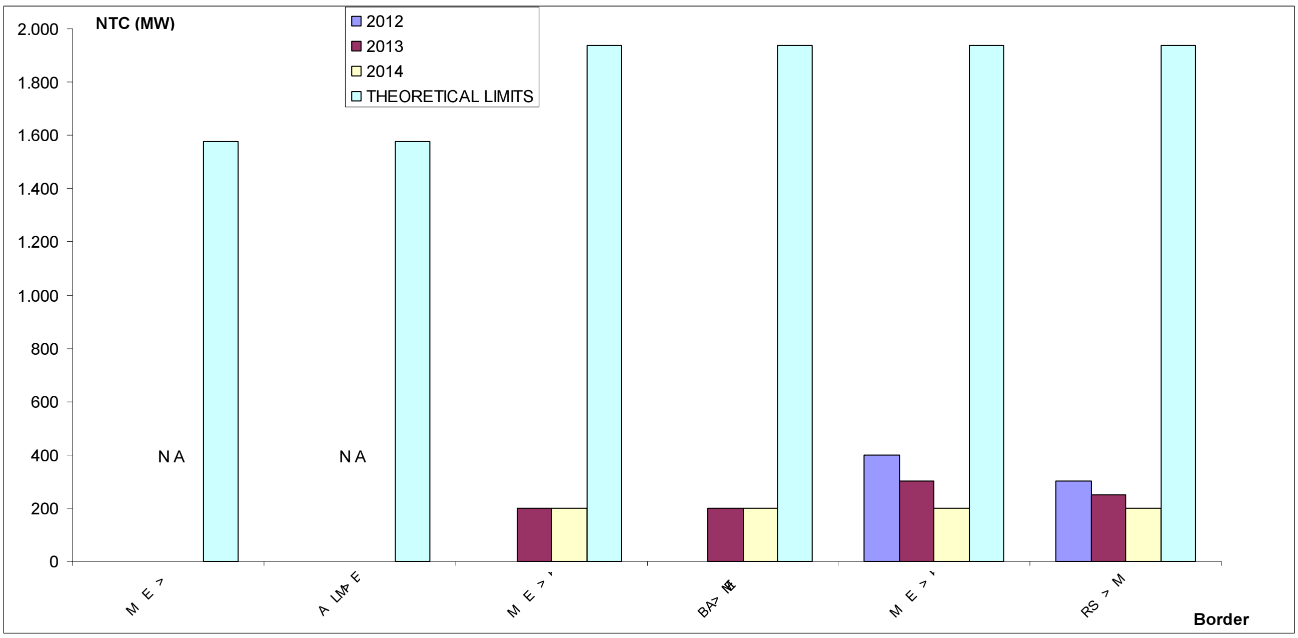


Figure 4.17 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Montenegro

4.7 Romania

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. Critical contingences comprise two transformers 220/110 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 overloadings due to security criterion N-1 in the Romanian transmission network

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

In the present situation 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 thermal ratings, which are in operation, 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 time period 2012 – 2014, one may notice that interconnection capacities at all Romanian borders could be poorly used, up to 22 % of theoretical limits in 2012 and 2013, and up to 13 % in 2014.

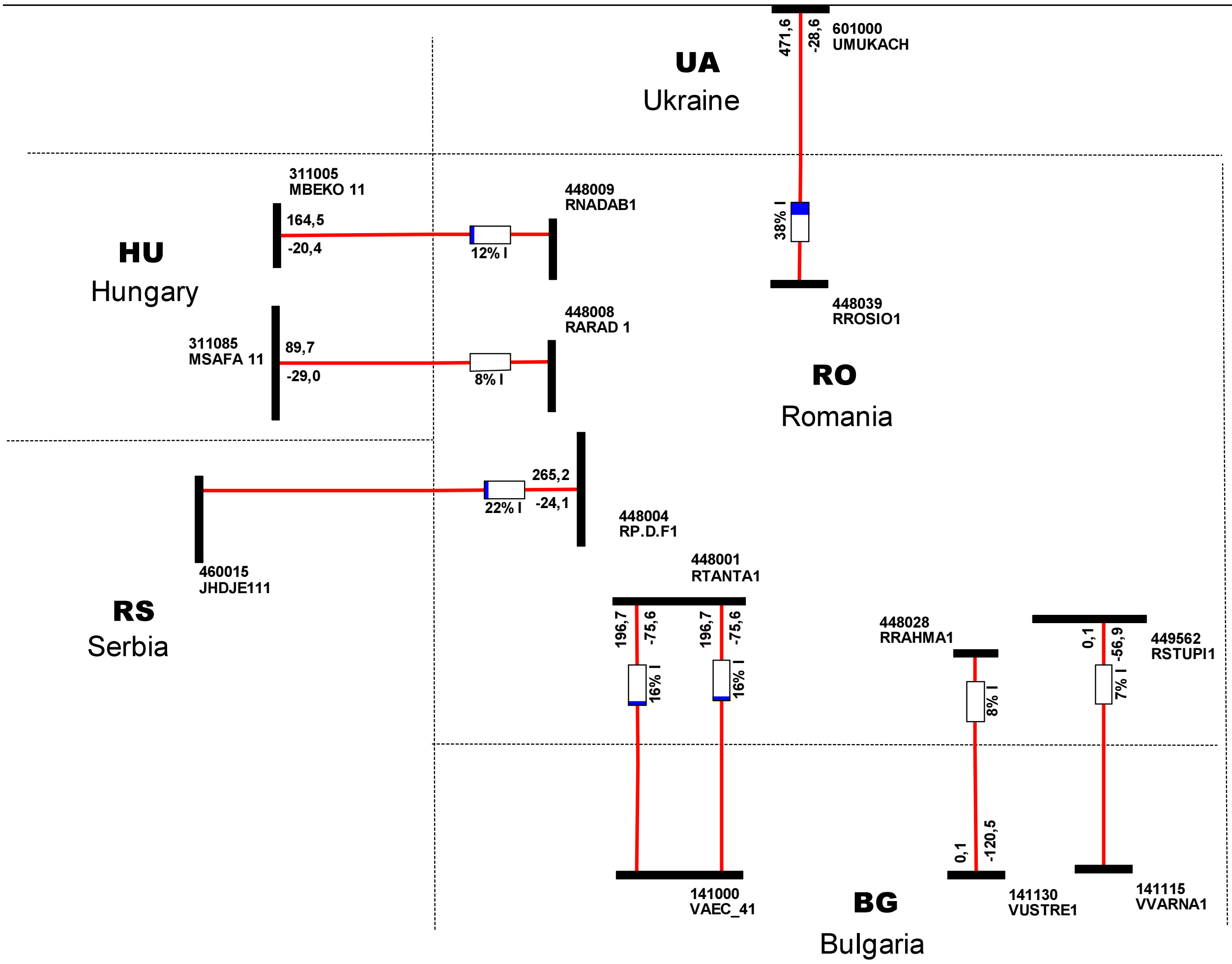


Figure 4.19 Romanian interconnection lines loading and percentage of loading in the base case

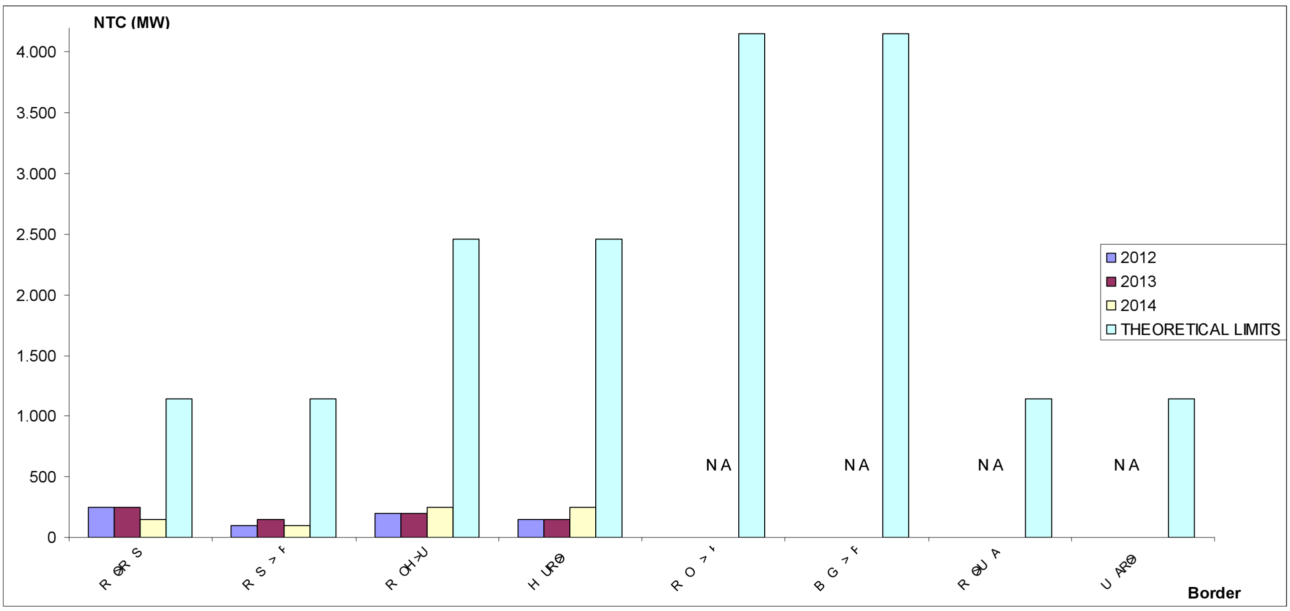


Figure 4.20 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Romania

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

4.8 Serbia & Kosovo

Serbian & Kosovo 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. Critical contingences comprise transformers 400/110 kV and 220/110 kV, and lines 220 kV and 110 kV within the Serbian internal network, as well as lines 110 kV in the network of Kosovo.

The following figure presents Serbian and Kosovo interconnection lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 37 % of their thermal ratings.

In the present situation Serbian & Kosovo transmission networks are interconnected with neighboring power systems by seven 400 kV lines and four lines 220 kV. 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 time period 2012 – 2014, one may notice that interconnection capacities at Kosovo/Albanian border could be used significantly in 2013 but poorly in 2014, while interconnection capacities at other borders could be used in very low amount of their theoretical values, except 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 as well.

```
<----------- 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 overloadings 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

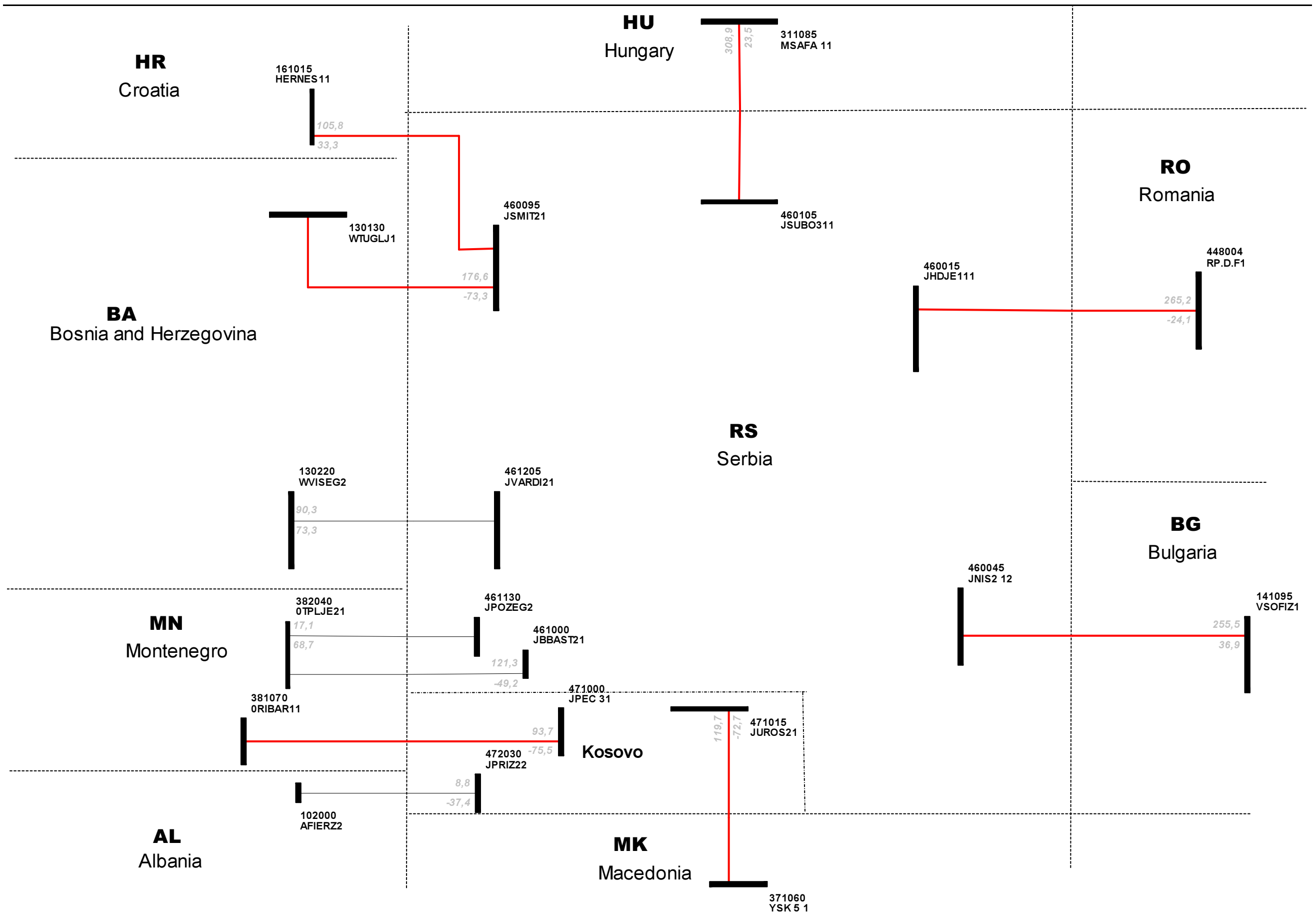


Figure 4.22 Serbian&Kosovo interconnection lines loading and percentage of loading in the base case

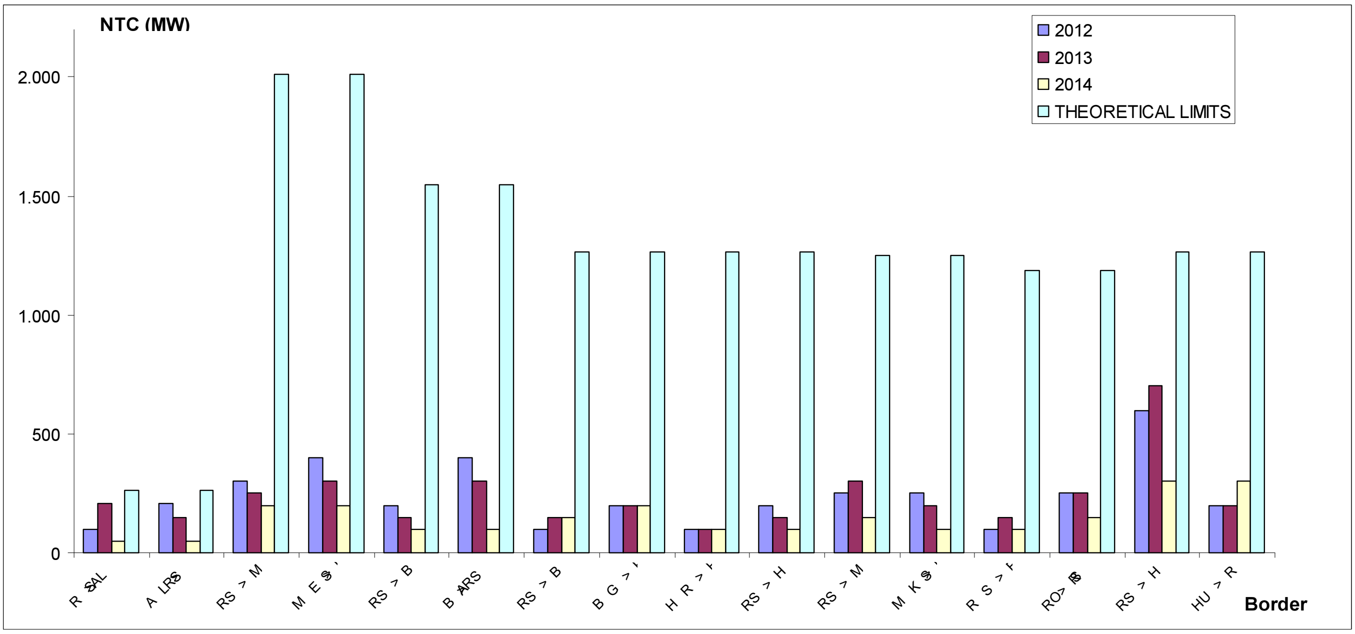


Figure 4.23 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Serbia&Kosovo

4.9 Slovenia

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 lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 81 % of their thermal ratings.

In the present situation 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 time period 2012 – 2014, one may notice that interconnection capacities at all Slovenian borders could be poorly or moderately used, up to 34 % of theoretical limits in time period 2012-2014.

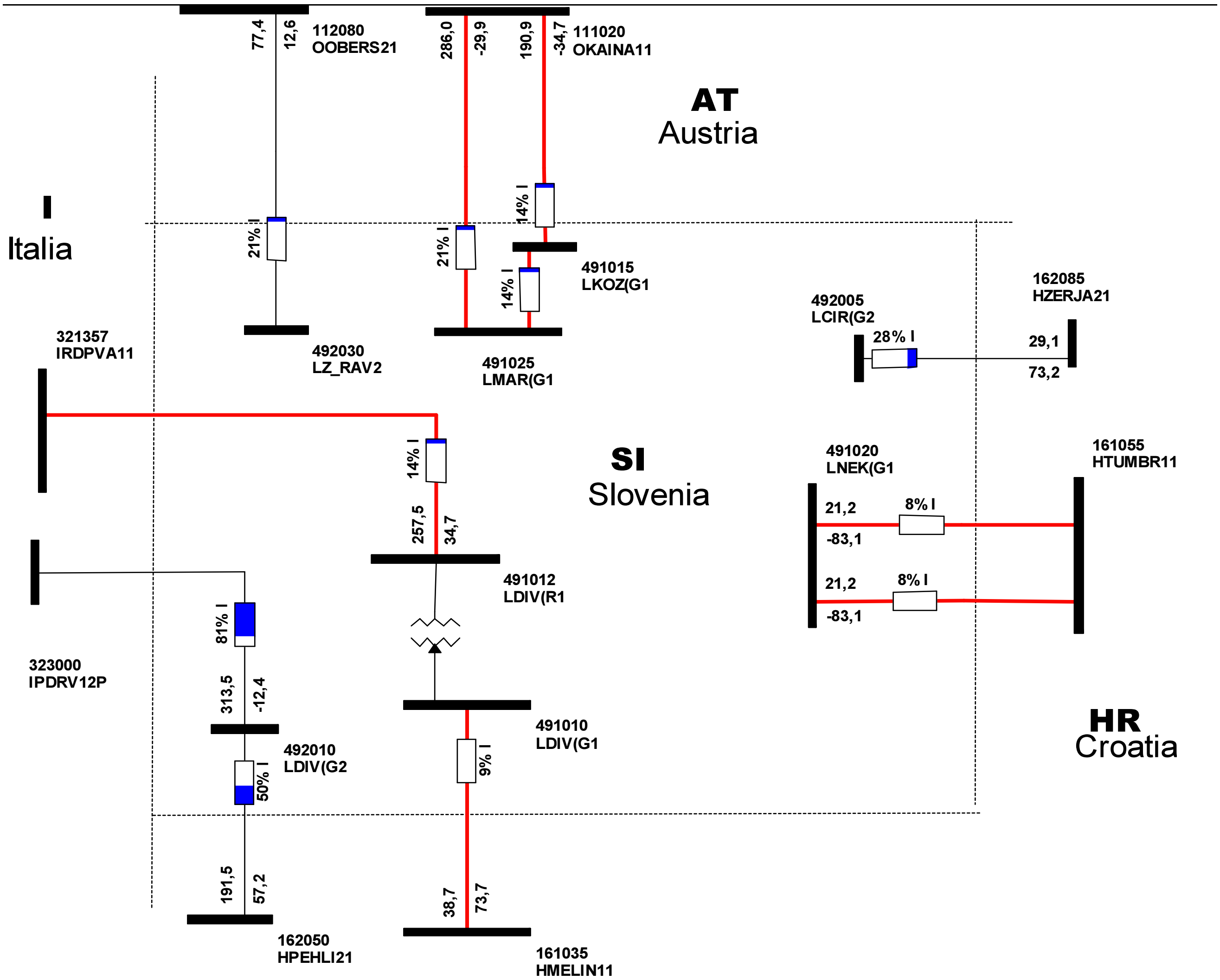


Figure 4.24 Slovenian interconnection lines loading and percentage of loading in the base case

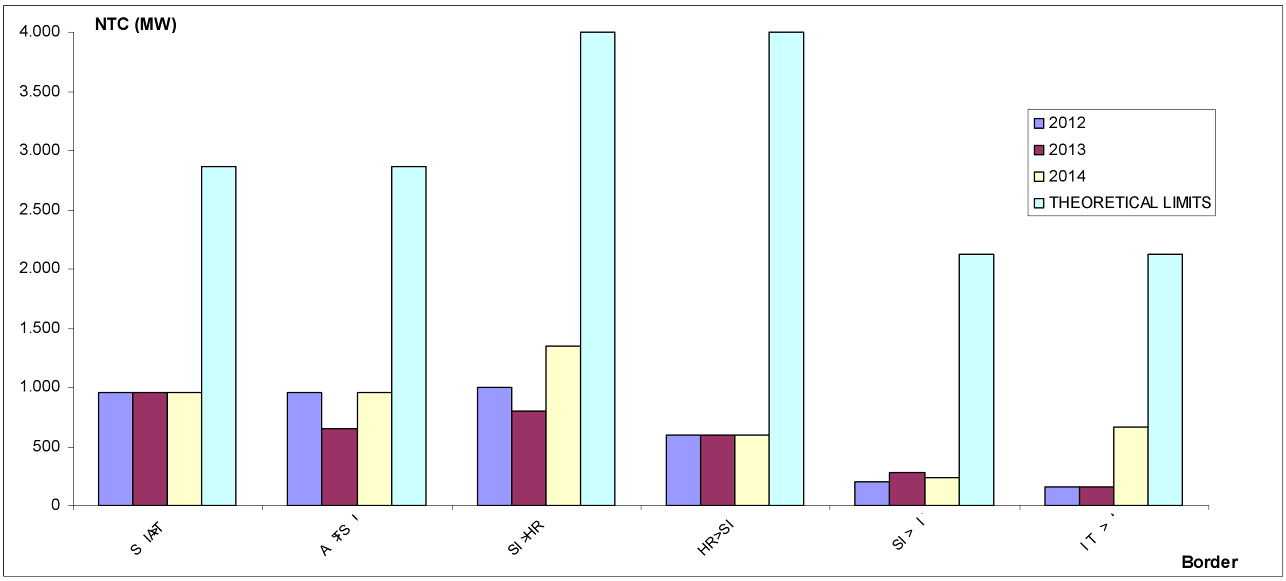


Figure 4.25 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Slovenia

4.10 Turkey

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 transformers 400/154 kV and two lines 154 kV 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 lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and percentage of loading comparing with a line rating. It is visible that interconnection lines are loaded in the base case less than 18 % of their thermal ratings.

In the present situation 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.

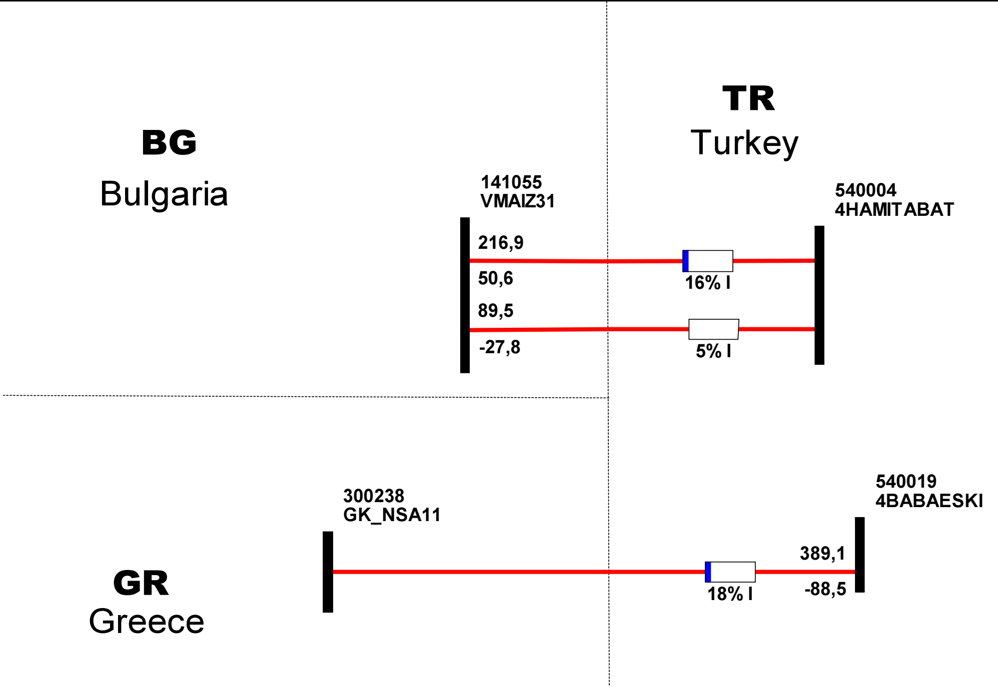


Figure 4.26 Turkish interconnection lines loading and percentage of loading in the base case

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

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

For power systems (countries) with small amount of possible generation increase, additional generators which 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, Python program was prepared in order to automatically give final results based on proportional increase of production in one area and proportional decrease of production in another area. Program initially uses the generation shift step of 200 MW, but when transmission limits are found (network overloadings), program automatically decrease generation shift steps until final result is reached with 1 MW precision.

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

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

The usual practice of TSOs is to perform the NTC calculations observing network elements 400 kV and 220 kV 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 be also stressed that some TSOs in the region take into consideration network elements 110 kV while performing the NTC calculations. The NTC computation with tie-lines monitored only (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 overloadings in the base case were neglected and TTC computation will stop when contingency causing first new overloading in a network is detected. Overloadings in the base case were 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 so it should be stressed that results may be different for these countries because of different NTC computation methodology (EMS latter stated that it's 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 related to one border, observing contingencies and monitor network elements in one area, then observing contingences and monitor network elements in another area. Final NTC value is defined as the lower one, between these two values.

NTC values were computed as TTC minus TRM values. TRM values for all SEE borders were determined by multiplying 100 with the second square-root of number of interconnection lines 400 kV and 220 kV related to an observed border (EMS latter stated that they determine the TRM value in another way so this is another reason why results obtained from this study can not be compared to values calculated by EMS in previous period).

For borders consisted 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), the NTC values are related to contingencies in observed country only (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

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

The next table (Table 5.2) summarizes 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, and reasons may be as follows:

1. Computed values refer to only one operational situation and there are other more restrictive operational situation which 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 could be additionally decreased related to computation results in order to take into account different uncertainties.
4. Security criterion or contingency lists were defined differently by TSOs, probably including exceptional type of contingencies (loss of double circuit line, single busbar, several generation units etc.).
5. TRM values were somewhere probably defined on a higher level than assumed here.
6. Different methodology was used.
7. Some NTC values were probably additionally decreased because of contingencies and critical network elements in surrounding countries, etc.

If we define NTC < 300 MW to identify borders with relatively small cross-border capacity, the following figure presents them on the map of the SEE region using results of our computations. According to the PSS/E model and calculations, NTC values below 300 MW, observing all network elements 400 kV, 220 kV and 110 (154) kV as possible limiting elements for cross-border transactions, could be expected at 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 observing 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

Import	Export														
	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

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 observed, and all network elements of the voltage levels 400 kV and 220 kV were monitored (lines 400 kV, lines 220 kV, transformers 400/220 kV, 400/110 kV, 220/110 kV, tie-lines). Networks 110 kV and 154 kV were excluded from observations, meaning that eventual overloadings in the network 110 (154) kV were neglected. Computed NTC values don't include potentially critical elements in the networks 110 (154) kV, 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 difference between 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). One may notice that computed NTC values are higher in many cases if we exclude network 110 (154) kV from our observations.

Significantly higher NTC values observing networks 400 kV and 220 kV and neglecting network 110 (154) kV 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 high difference 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)

If we define NTC < 300 MW to identify borders with small cross-border capacity but monitor only elements 400 kV and 220 kV as potentially critical ones, the following figure presents them on the map of the SEE region using results of the PSS/E computations.

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

High difference (>500 MW) between indicative annual NTC values published by the ENTSO-E and 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)

Import	Export															
	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

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

The following table (Table 5.6) presents difference between computed NTC values using 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 computed NTC values are higher in many cases if we exclude internal networks 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)

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

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

High difference (>500 MW) between 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 may lead to conclusion that many limitations which decrease the NTC values and possibilities for power trading at the wholesale market are located within internal national transmission systems. This gives a strong signal to the SEE TSOs to additionally plan 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. Other important factor is expected time period needed to realize transmission projects. Internal network reinforcements are generally well prepared in advance and need significantly less time from decision making till full operation.

Appropriate internal network reinforcements may increase the NTC values in a short period of time, thus leaving the TSOs enough time to well 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

Import	Export															
	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)

	Export															
Import	**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 which limit the NTC values for all SEE borders have been analyzed and described in this chapter, observing networks from both sides of a border. Monitored elements were all network elements 400 kV, 220 kV and 110 (154) kV, then 400 kV and 220 kV only (ignoring network 110-154 kV), and finally interconnection lines 400 kV and 220 kV only. The NTC values were calculated with respect to the first network overloading among monitored elements, neglecting N-1 situation overloadings in the base case. By monitoring different voltage levels of network elements, set of critical elements in each SEE national transmission system and location of critical branches (interconnection lines or internal networks) are defined using this procedure.

Observing 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 lower value is used to be declared as the final NTC value, dispatching actions or network reinforcements may be prioritized observing both countries which 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, and observing all network elements 400 kV, 220 kV and 110 kV on Albanian side, the NTC value is set to 386 MW, limited by internal line 220 kV V.Dejes – Koman that gets overloaded as a consequence of the OHL 220 kV Tirana – Kolac outage. For the same direction of power flow and observing only tie-lines on 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 observing all network elements 400 kV, 220 kV and 110 kV on Montenegrin side, the NTC value is set to 383 MW, limited by interconnection line 220 kV Podgorica – V.Dejes that gets overloaded as a consequence of the OHL 400 kV Podgorica – Tirana outage.

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

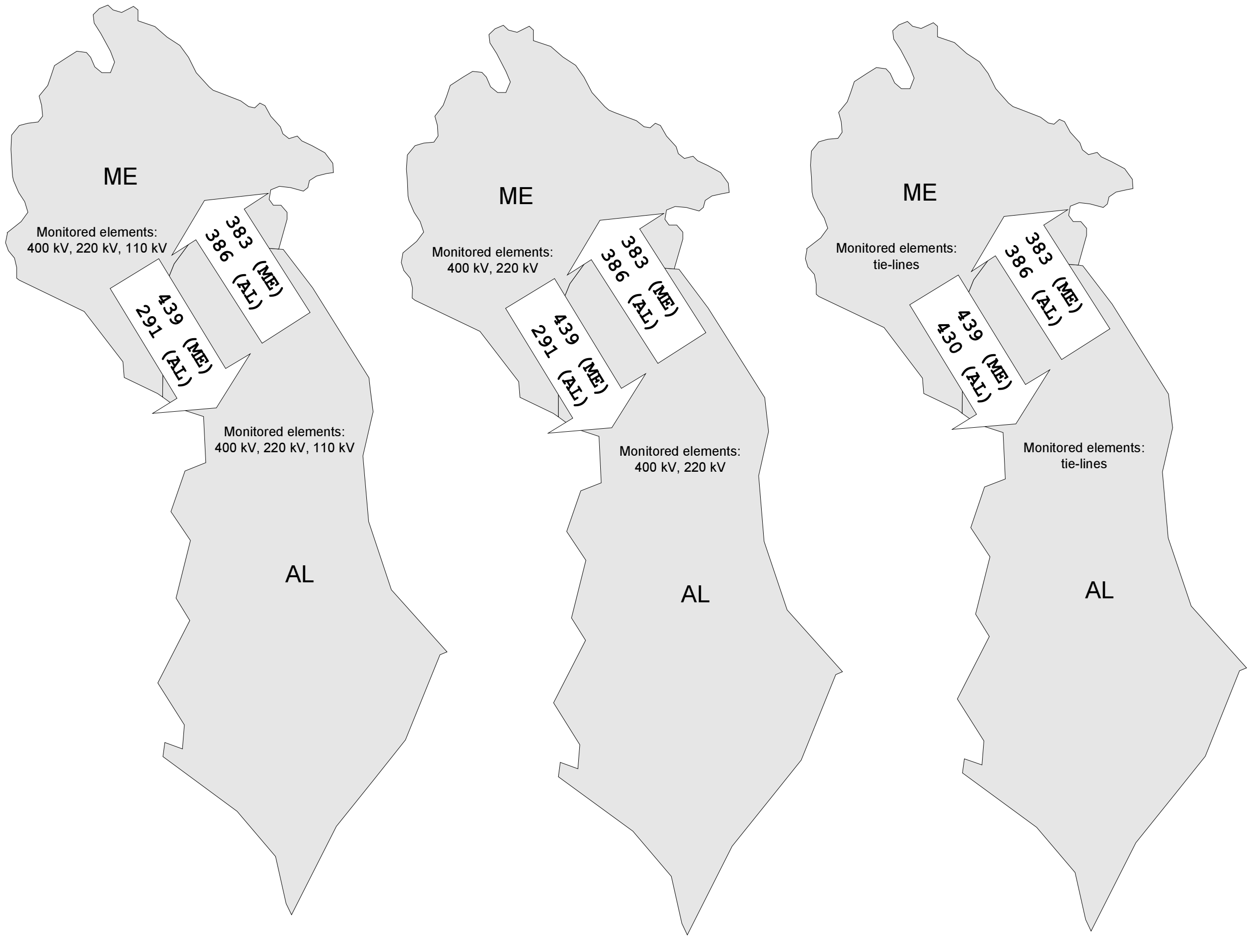


Figure 6.1 Calculated NTC values for Albania/Montenegro border depending on the monitored elements (model 2012)

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

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

The final NTC value for Montenegro to Albania direction of power exchange, as the lower value observing both sides of the border, is set to 291 MW if we observe internal Albanian network and is limited by the number and rating of transformers in Elbassan (defined as 2x300 MVA), or 430 MW if we observe tie-lines only and is limited by the interconnection line 220 kV 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: 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 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 observing all network elements 400 kV, 220 kV and 110 kV on Albanian side, the NTC value would be set to 641 MW, limited by transformers 220/110 kV in the SS Tirana which get overloaded if one of them goes out of operation. For the same direction of power flow and observing 400 kV and 220 kV Albanian network or tie-lines on Albanian side only, the NTC value would be increased up to 671 MW without any critical network element but due to maximum generation shift in Albania at the model.

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

The final NTC value for Albania to Kosovo direction of power exchange, as the lower value observing both sides of the border, is set to 178 MW if we observe internal transmission systems of Albania, Kosovo and Serbia, limited by high loading of transformers 220/110 kV 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 transformers 220/110 kV in the SS Tirana and up to 671 MW observing tie-lines only, due to maximum generation shift in Albania at the model. Excluding Serbia from the NTC calculations, meaning that generation shift in Kosovo is performed only (with constant generation in Serbia), the NTC value for Albania/Kosovo border and Albania to Kosovo direction of power exchange will be set to 127 MW, not limited by any network element but limited due to maximum generation shift in Kosovo.

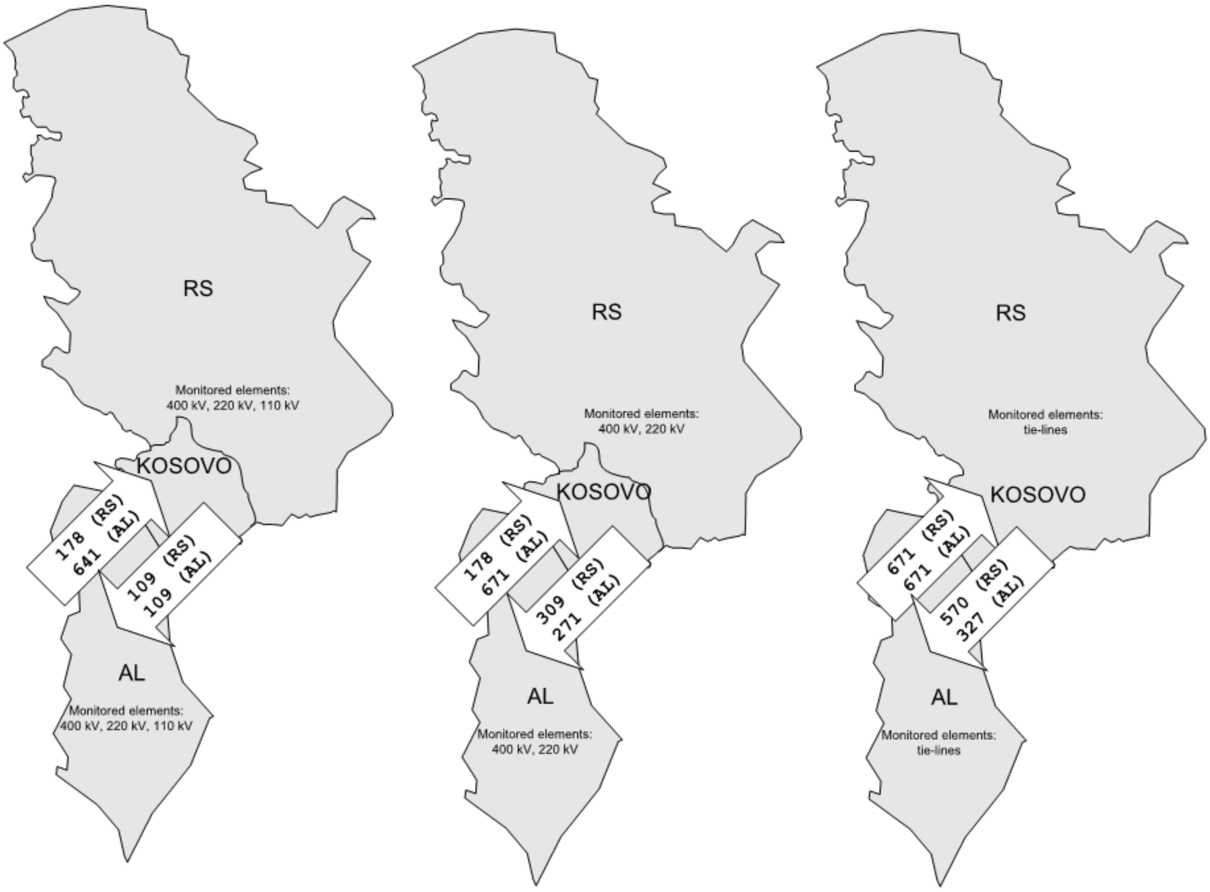


Figure 6.2 Calculated NTC values for Albania/Kosovo border depending on the monitored elements (model 2012)

For the direction of power flows from Kosovo and Serbia to Albania, and observing all network elements 400 kV, 220 kV and 110 kV on Albanian side, the NTC value is set to 109 MW, limited by the OHL 110 kV Tirana – Selite that gets overloaded as a consequence of the OHL 220 kV Tirana – Rrashbull outage. For the same direction of power flow and observing 400 kV and 220 kV network on Albanian side, the NTC value is increased up to 271 MW, limited by transformers 400/220/30 kV 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 observe tie-lines only, the NTC values rises up to 327 MW, limited by the OHL 220 kV Podgorica – Vau Dejes that 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 observing all network elements 400 kV, 220 kV and 110 kV on Kosovo and Serbia side, the NTC value is set to 109 MW, limited by lines 110 kV Prizren – Theranda and Theranda – Ferizaji (ratings 83,8 MVA at the model) which get overloaded in a case of the OHL 220 kV Prizren – Drenas outage. Monitoring networks 400 kV and 220 kV on Kosovo and Serbian side, the NTC value rises up to 309 MW limited by the transformer 400/110/35 kV in the SS Niš that gets overloaded caused by the transformer 400/220/20 kV Niš outage. If we observe tie-lines only, the NTC value is calculated as 570 MW due to maximum generation shift in Albania.

The final NTC value for Kosovo and Serbia to Albania direction of power exchange, as the lower value observing both sides of the border, is set to 109 MW if we observe internal networks including 110 kV, 271 MW if we observe 400 kV and 220 kV networks and 327 MW if we observe 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. Overloadings of transformers in the Tirana substation are 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 overlodings of transformers 400/110 kV and 220/110 kV, together with possible overloadings 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 Albania/Greece border were computed with respect to security criterion in Albanian network only, so they may be additionally reduced by possible limitations in Greek transmission system.

For the direction of power flows from Albania to Greece, and observing all network elements 400 kV, 220 kV and 110 kV on Albanian side, the NTC value is set to 360 MW, limited by transformers 220/110 kV 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 observing tie-lines on Albanian side only, the NTC value would rises up to 440 MW and be limited due to maximum generation shift in Albania at the model.

For the direction of power flows from Greece to Albania, and observing all network elements 400 kV, 220 kV and 110 kV on Albanian side, the NTC value is set to 340 MW, limited by the OHL 110 kV Tirana – Selite that gets overloaded as a consequence of the OHL 220 kV Tirana – Rrashbull outage. For the same direction of power flow and monitoring Albanian network elements 400 kV and 220 kV only the NTC value would be set up to 427 MW, limited by transformers 400/220/30 kV in the SS Elbassan (rating of 2x300 MVA at the model) which could be overloaded if one of them trips off. Repeating a calculation but observing tie-lines on Albanian side only, the NTC value is increased to 683 MW, limited by the OHL 220 kV Fierza – Prizren (thermal rating 325,4 MVA on Albanian side at the model) that 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. Overloadings of transformers in the Tirana substation are 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 overloadings 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 observing all network elements 400 kV, 220 kV and 110 kV on BiH side, the NTC value is set to 650 MW, not limited by any network element on Bosnian side but due to maximum generation shift in Croatia.

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

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

For the direction of power flows from Croatia to Bosnia and Herzegovina, and observing all network elements 400 kV, 220 kV and 110 kV on BiH side, the NTC value is set to 775 MW, limited by transformer 400/110 kV in the SS Ugljevik that is jeopardized due to the OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and observing tie-lines only (on Bosnian side), the NTC value is increased to 1584 MW, limited by the interconnection line 220 kV Zakučac – Mostar that gets overloaded as a consequence of the 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, and observing all network elements 400 kV, 220 kV and 110 kV on Croatian side, the NTC value is set to 1076 MW, limited by interconnection line 220 kV Zakučac – Mostar.

The final NTC value for Croatia to BiH direction of power exchange, as the lower value observing both sides of the border, is set to 775 MW if we observe internal networks and is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik, or 1076 MW if we observe only tie-lines 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 overloadings 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 observing all network elements 400 kV, 220 kV and 110 kV on the BiH side, the NTC value is set to 494 MW, limited by possible overloading of the OHL 110 kV Trebinje – Herceg Novi as a consequence of the OHL 400 kV Trebinje – Podgorica outage. Ignoring network 110 kV in Bosnia increased NTC has been achieved up to 731 MW, limited by possible overloading of the interconnection line 220 kV Trebinje – Perućica as a consequence of the OHL 400 kV Trebinje – Podgorica outage.

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

The final NTC value for BiH to Serbia direction of power exchange, as the lower value observing both sides of the border, is set to 0 MW and is limited by transformers (2x150 MVA) in Sremska Mitrovica because of their high loading in the base case, while the NTC value could be set to 731 MW if Bosnian and Serbian tie-lines only are observed, 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 observing all network elements 400 kV, 220 kV and 110 kV on BiH side, the NTC value is set to 473 MW, limited by transformer 400/110 kV in the SS Ugljevik that is jeopardized due to the OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and observing tie-lines on Bosnian side only, the NTC value is increased to 1597 MW, limited by the interconnection line 220 kV Višegrad – Vardište that gets overloaded as a consequence of the OHL 400 kV Tuzla – Ugljevik outage.

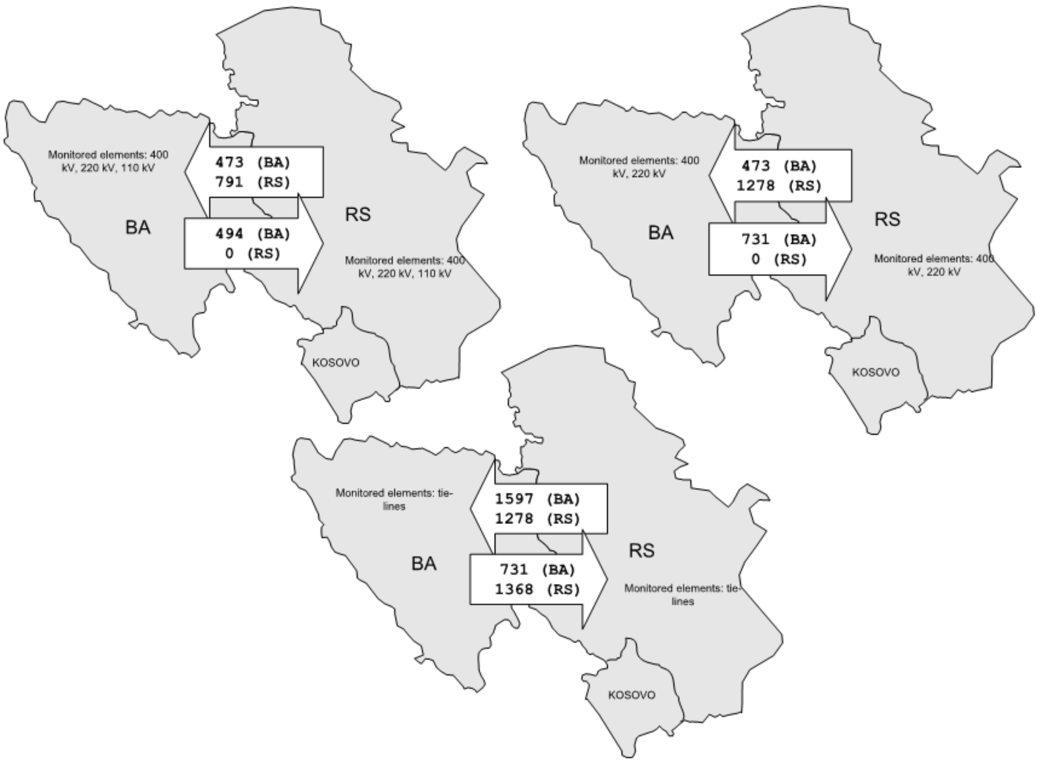


Figure 6.5 Calculated NTC values for BiH/Serbia border depending on the monitored elements (model 2012)

For the direction of power flows from Serbia to BiH, and observing all network elements 400 kV, 220 kV and 110 kV on Serbian side, the NTC value is set to 791 MW, limited by the OHL 110 kV Đerdap – Negotin that is jeopardized when the OHL 110 kV Đerdap – Prahovo goes out of operation. This limitation is obviously caused by increase of the HPP Đerdap production while applying generation shift key. Ignoring the network 110 kV in Serbia, and also complete Serbian internal network, the NTC value could be increased up to 1278 MW with limitation 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 the OHL 220 kV Bajina Bašta – Požega outage.

The final NTC value for Serbia to BiH direction of power exchange, as the lower value observing both sides of the border, is set to 473 MW if we observe internal networks and is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik, or 1278 MW if we observe only tie-lines 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 overloadings 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 overlodings 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 - Perućica
BiH side (monitored elements: tie-lines)	872	141	731	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Perućica
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 observing all network elements 400 kV, 220 kV and 110 kV on the BiH side, the NTC value is set to 639 MW, limited by possible overloading of the OHL 110 kV Trebinje – Herceg Novi as a consequence of the OHL 400 kV Trebinje – Podgorica outage. Ignoring the network 110 kV in Bosnia, or complete internal Bosnian network, increased NTC has been achieved up to 751 MW, limited by possible overloading of the interconnection line 220 kV Trebinje – Peručica as a consequence of the OHL 400 kV Trebinje – Podgorica outage.

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

The final NTC value for BiH to Montenegro direction of power exchange, as the lower value observing both sides of the border, is set to 639 MW and is limited by the OHL 110 kV Trebinje – Herceg Novi with thermal rating of 90 MVA on Bosnian side (89,5 MVA on Montenegrin side), while the NTC value could be set to 746 MW if only Bosnian and Montenegrin 400 kV and 220 kV network or tie-lines only are observed, limited by the OHL 220 kV Trebinje – Peručica with thermal rating defined to 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, and observing all network elements 400 kV, 220 kV and 110 kV on the BiH side, the NTC value is set to 789 MW, limited by transformer 400/110 kV in the SS Ugljevik that is jeopardized due to the OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and observing tie-lines on Bosnian side only, the NTC value is increased 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 of network elements which are observed on Montenegrin side of the border, the NTC value is set to 1088 MW, due to maximum generation shift at the model.

The final NTC value for Montenegro to BiH direction of power exchange, as the lower value observing both sides of the border, is set to 789 MW if we observe internal networks and is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik, or 1088 MW if we observe only tie-lines, 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 overloadings 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 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 observing internal transmission network of Bulgaria there are no possibilities for power exchange across the border because of the 110 kV network weaknesses in Dobrudzha area. There are several lines 110 kV which will be overloaded in case of several 110 kV lines outages if power exchange is increased over transmission reliability margin for this border. If we ignore these limitations, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to the OHL 400 kV Maritza East 1 – Plovdiv outage. Plovdiv – Aleko line thermal rating is set to 228,6 MVA at the model.

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

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

Analyzing direction of power flows from Romania to Bulgaria, no matter of internal network elements which are observed on Romanian side of the border, the NTC value is set to 1220 MW, due to transformers 400/110 kV 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)

The final NTC value for Romania to Bulgaria direction of power exchange, as the lower value observing both sides of the border, is set to 1014 MW if we observe internal networks and is limited by the transformer 400/110 kV (250 MVA) in the SS Plovdiv, or 1814 MW if we observe 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 overloadings 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 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 observing internal transmission network of Bulgaria the NTC value would be limited to 161 MW due to 110 kV network weaknesses in Dobrudzha area. Ignoring limitations in the network 110 kV of Bulgaria, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to the OHL 400 kV Maritza East 1 – Plovdiv outage, and limits the NTC value up to 386 MW. Monitoring interconnection lines only and ignoring the problems in 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 observing network elements on 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 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.

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

For the direction of power flows from Serbia to Bulgaria, and observing all network elements 400 kV, 220 kV and 110 kV on Bulgarian side, the NTC value is set to 445 MW, limited by transformer 400/110 kV in the SS Plovdiv that is jeopardized due to outage of parallel transformer. For the same direction of power flow and observing 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 network 400 kV, 220 kV and 110 kV of Serbia limitation appears due to OHL 110 kV Valjevo – Kosjerić overloading when the NTC values is 132 MW as a consequence of the OHL 220 kV Bajina Bašta – Požega outage. Thermal rating of this 110 kV line is set to 68,6 MVA at the model. The NTC value would be increased to 745 MW if limitations in the network 110 kV of Serbia are ignored, limited by the OHL 220 kV Bajina Bašta – Pljevlja (thermal rating 388,7 MVA on Serbian side at the model) that is jeopardized due to possible OHL 220 kV Bajina Bašta – Požega outage.

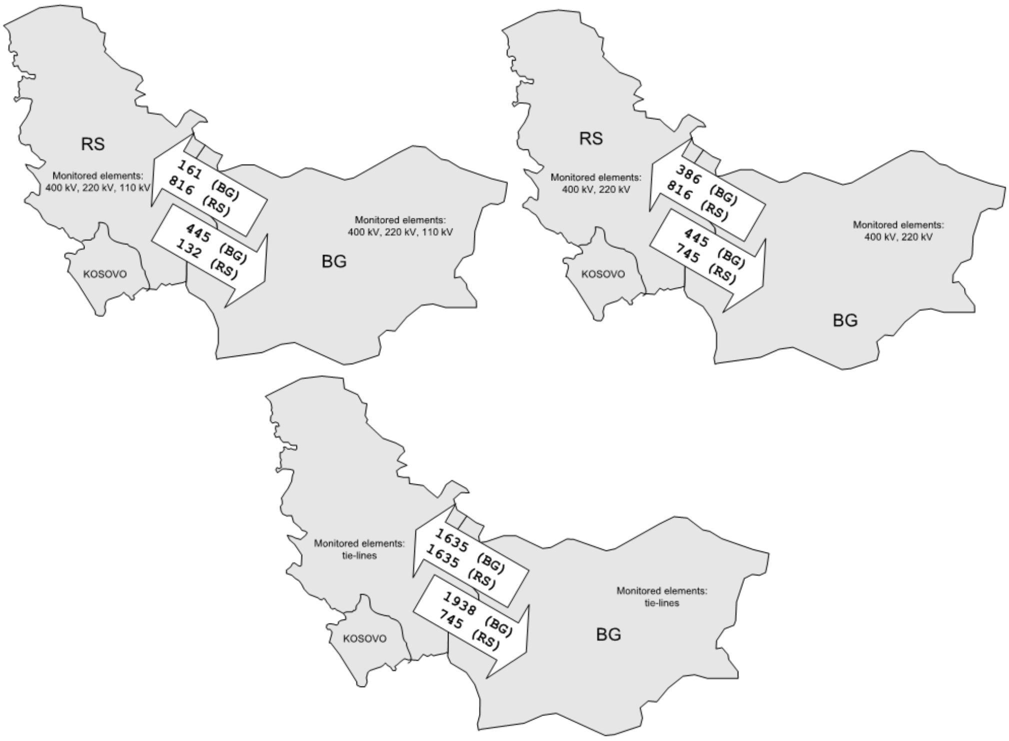


Figure 6.8 Calculated NTC values for Bulgaria/Serbia border depending on the monitored elements (model 2012)

The final NTC value for Serbia to Bulgaria direction of power exchange, as the lower value observing both sides of the border, is set to 132 MW if we observe internal networks and is limited by the OHL 110 kV around Valjevo in Serbia, 445 MW if we ignore networks 110 kV and limited by transformers 400/110 kV in the SS Plovdiv in Bulgaria, and finally 745 MW if we observe 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 overloadings 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 overlodings 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 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 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 observing internal transmission network of Bulgaria the NTC value would be limited to 267 MW due to 110 kV network weaknesses in Dobrudzha area. Ignoring limitations in the network 110 kV of Bulgaria, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to the OHL 400 kV Maritza East 1 – Plovdiv outage, and limits the NTC value up to 523 MW. Monitoring interconnection lines only and ignoring the problems in 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 observing network elements on Macedonian side, the NTC values could be increased up to 855 MW, limited by possible overloading of the OHL 110 kV Skopje 3 – Skopje 4 as a consequence of the OHL 110 kV G.Petrov – Skopje 1 outage. Further increase is possible up to 1074 MW if we ignore Macedonian network 110 kV and new critical element becomes transformer 400/110 kV 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.

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

For the direction of power flows from Macedonia to Bulgaria, and observing all network elements 400 kV, 220 kV and 110 kV on Bulgarian side, the NTC value is set to 282 MW, limited by transformer 400/110 kV in the SS Plovdiv that is jeopardized due to outage of the parallel transformer. For the same direction of power flow and observing tie-lines on 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 and monitoring the network 400 kV, 220 kV and 110 kV of Macedonia limitation appears due to OHL 110 kV TETO – Skopje 4 overloading when the NTC values is 288 MW as a consequence of the OHL 110 kV Skopje 1 – Kumanovo 1 outage. Thermal rating of this 110 kV line is set to 157 MVA at the model. The NTC value would be increased up to 412 MW if limitations in the network 110 kV of Macedonia are ignored, due to maximum generation shift in Macedonia.

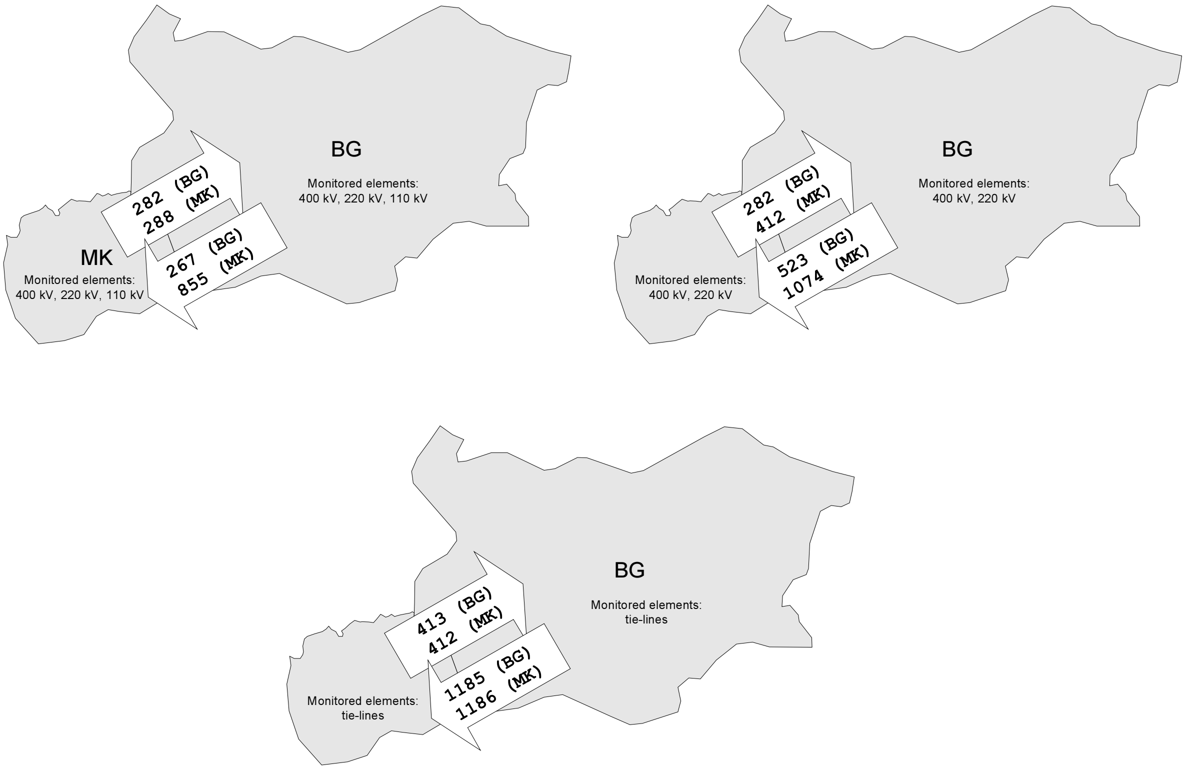


Figure 6.9 Calculated NTC values for Bulgaria/Macedonia border depending on the monitored elements (model 2012)

The final NTC value for Macedonia to Bulgaria direction of power exchange, as the lower value observing both sides of the border, is set to 282 MW if we observe internal networks and limited by the transformers in the SS Plovdiv, and finally 412 MW if we observe tie-lines only 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 overloadings 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 observing internal transmission network of Bulgaria the NTC value would be limited to 219 MW due to 110 kV network weaknesses in Dobrudzha area. Ignoring the network 110 kV NTC would rise up to 512 MW limited by the OHL 220 kV Plovdiv – Aleko, or up to 1693 MW if we ignore internal network of Bulgaria and take into observation only 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 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 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 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 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 observing internal transmission network of Bulgaria the NTC value would be limited to 170 MW due to 110 kV network weaknesses in Dobrudzha area. Ignoring limitations in the network 110 kV of Bulgaria, the NTC could be increased up to 1457 MW, limited by the OHL 400 kV Maritza East – Babaesku that is jeopardized by the 400 kV line Maritza East – Hamitabad outage. For the same direction of power flows but observing network elements on Turkish side, the NTC values could be increased up to 1457 MW due to OHL 400 kV Maritza East – Babaesku limitation.

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

All values have been calculated using load flow calculations observing the (n-1) criterion, without any dynamic analyzes 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.

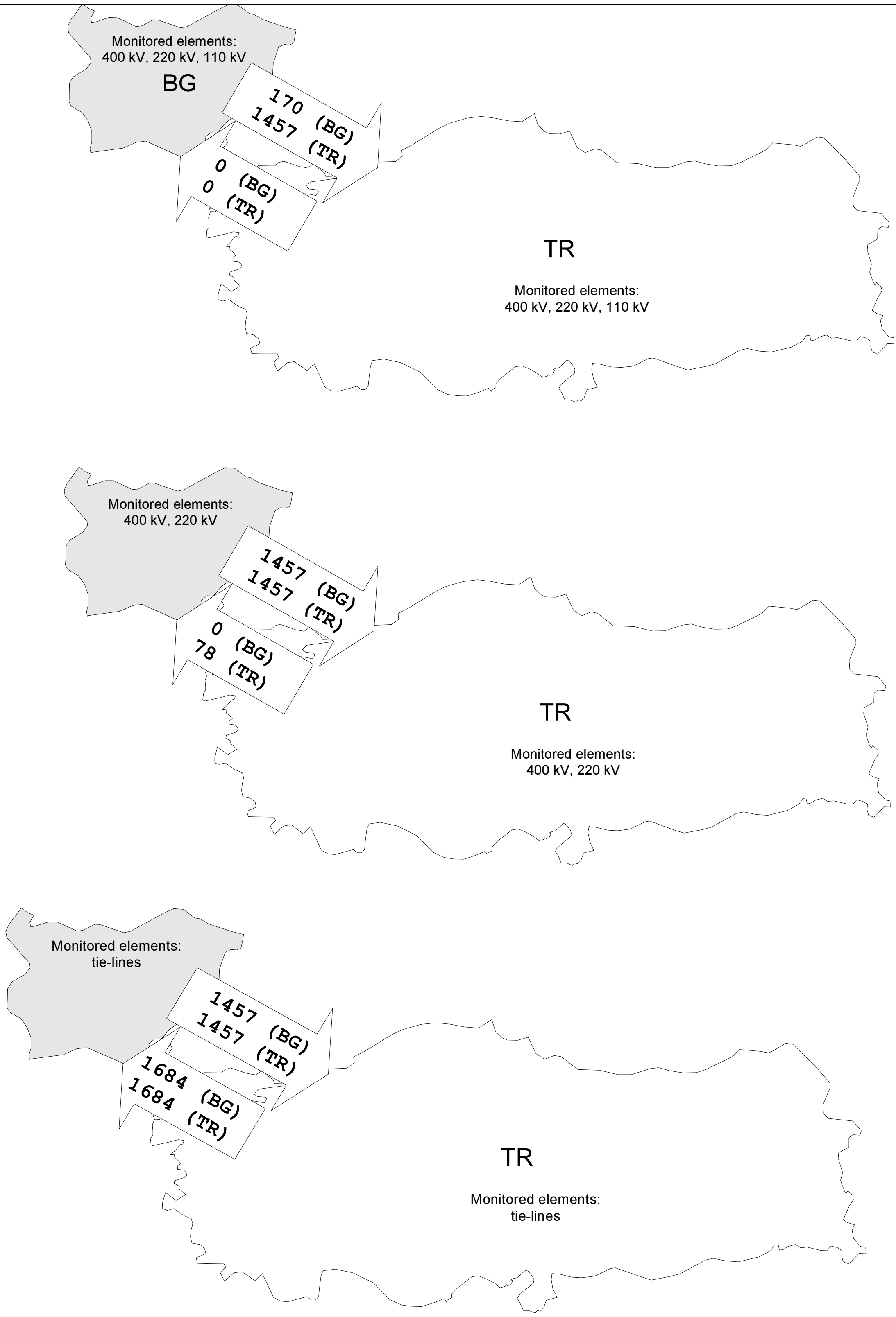


Figure 6.11 Calculated NTC values for Bulgaria/Turkey border depending on the monitored elements (model 2012)

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 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 and observing all network elements 400 kV, 220 kV and 110 kV the NTC value would be 1009 MW from Croatian side and 1259 MW from Slovenian side. The NTC value is limited because of the OHL 110 kV Crikvenica – Krk that is jeopardized by the OHL 110 kV Melina – Vinodol – Crikvenica outage. This contingency gives lower NTC value observing both sides of the border. The critical line has thermal rating of 70 MVA at the model and consists of submarine cable and overhead line sections. Submarine cable has low cross-section that reduce thermal capacity of the line. The NTC value would be limited by 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 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 network elements 400 kV and 220 kV of Croatian and Slovenian transmission system and ignoring the networks 110 kV, the NTC value would be limited by the tie-line 220 kV Pehlin – Divača, with thermal capacity of 360 MVA on Croatian side and 365,8 MVA on Slovenian side at the model. Critical contingences in Croatia and Slovenia are different. The OHL 220 kV Pehlin – Divača is jeopardized by outage of the tie-line 400 kV Melina (HR) – Divača (SI) observing Croatian side and outage of the tie-line Divača (SI) – Redipuglia (I) observing Slovenian side. The NTC values would be defined up to 1471 MW on Croatian side and 1402 MW on 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 that gets overloaded as a consequence of the OHL 110 kV Žerjavinec – Jertovec outage on Croatian side (NTC is 344 MW) or the OHL 400 kV NPP Krško – Maribor on Slovenian side (NTC is 594 MW). Ignoring the network 110 kV and monitoring network elements 400 kV and 220 kV, the NTC values would be increased to 487 MW on Croatian and 631 MW on Slovenian side, limited by the transformers 400/110 kV 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). Observing 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 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 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 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, observing 400 kV, 220 kV and 110 kV voltage levels, but due to maximum generation shift in Croatia.

For the direction of power flows from Hungary to Croatia, and observing all network elements 400 kV, 220 kV and 110 kV on Croatian side, limitation appears when NTC values is set to 1811 MW, concerning the line 110 kV Žerjavinec – Jertovac (thermal capacity 110 MVA at the model), jeopardized by the OHL 400 kV Tumbri – Žerjavinec outage. Ignoring the network 110 kV in Croatia, the NTC value could be increased above 2000 MW, limited by transformers 400/110 kV 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 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 Croatia/Serbia border have been calculated using the model for 2012 as follows:

Table 6.40 The NTC values for 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 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 and observing 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 observed border, one may assume that this critical contingency may be neglected. Ignoring network 110 kV on Croatian side, the NTC value could be increased up to 1738 MW when critical line becomes tie-line between Croatia and Bosnia and Herzegovina, OHL 220 kV Zakučac – Mostar.

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

For the direction of power flows from Serbia to Croatia, and observing all network elements 400 kV, 220 kV and 110 kV on Croatian side, limiting network elements are OHL 110 kV Žerjavinec – Jertovec, transformers 400/110 kV 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 observe only tie-lines.

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

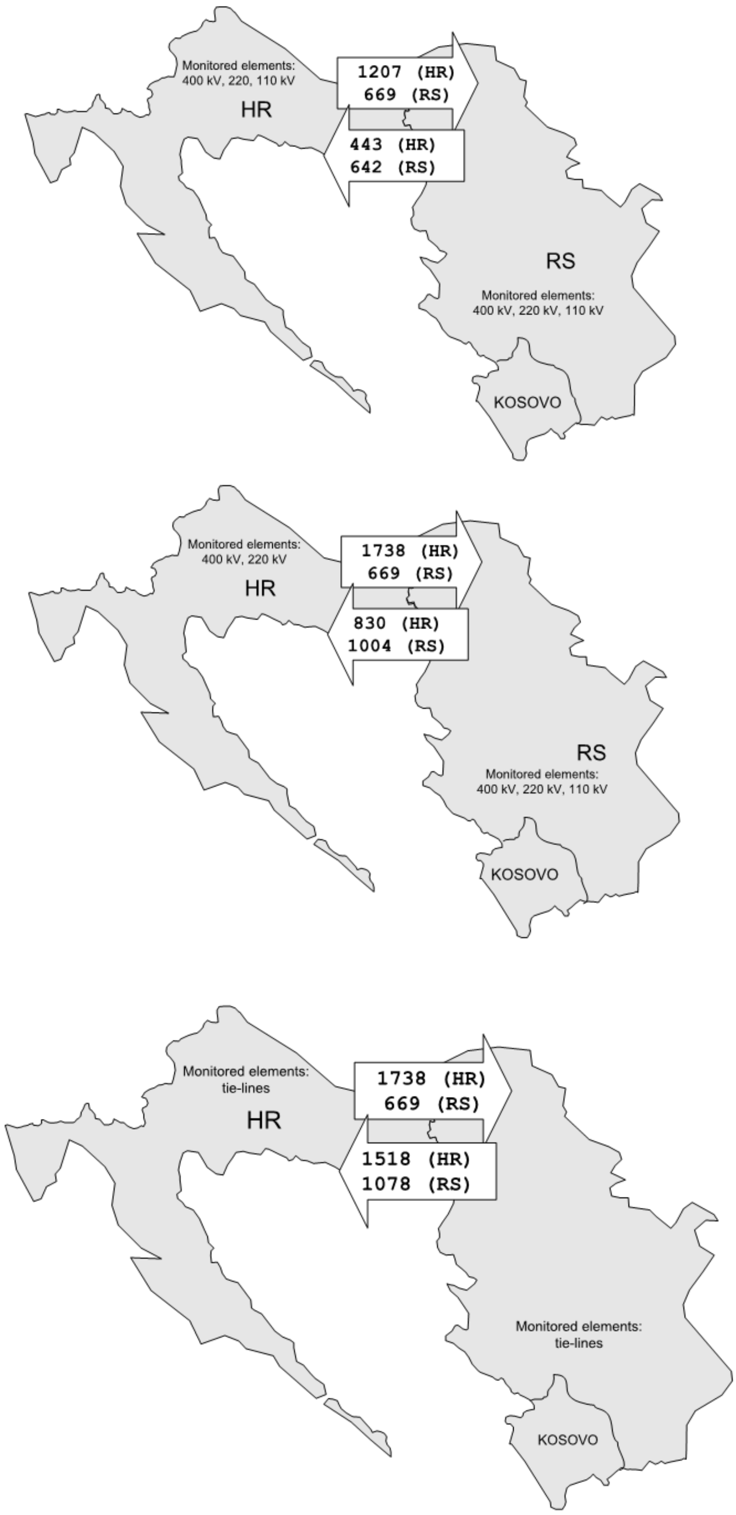


Figure 6.14 Calculated NTC values for Croatia/Serbia border depending on the monitored elements (model 2012)

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

Table 6.43 The NTC values for 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 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 Montenegro and Serbia&Kosovo area to 788 MW, observing Montenegrin side, and 311 MW observing Serbian and Kosovo 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, and observing all network elements 400 kV, 220 kV and 110 kV on Montenegrin side, the NTC value is set to 583 MW, limited by the OHL 220 kV Pljevlja – Bajina Bašta that gets overloaded as a consequence of the OHL 400 kV Ribarevine – Peć outage. Observing Serbian side and network 400 kV, 220 kV and 110 kV limitation appears concerning the line 110 kV 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, and new limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of the OHL 220 kV Bajina Bašta – Požega outage. Thermal rating of this line is set to 274,4 MVA on Montenegrin side and 388,7 MVA on Serbian side at the model.

Remark: Serbian TSO (EMS) stated that overlodings 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 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 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 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 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 Macedonia and Serbia&Kosovo area to 681 MW observing Macedonian side and 441 MW observing Serbian and Kosovo side. Network limitations in Macedonia, Serbia and Kosovo for these ranges of power exchanges are not visible at the model, except one network limitation in the network 110 kV of Macedonia related to the OHL 110 kV TETO – Skopje 4 that gets overloaded in a case of the OHL 400 kV Skopje 5 – Kosovo B outage.

For the direction of power flows from Kosovo and Serbia to Macedonia, and observing all network elements 400 kV, 220 kV and 110 kV on Macedonian side, the NTC value is set to 600 MW, limited by the OHL 110 kV Skopje 3 – Skopje 4 that gets overloaded as a consequence of the OHL 110 kV G. Petrov – Skopje 1 outage. Observing Kosovo and Serbian side and network 400 kV, 220 kV and 110 kV limitation appears concerning the line 110 kV 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, and new limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of the 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 overloadings 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 overlodings 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.

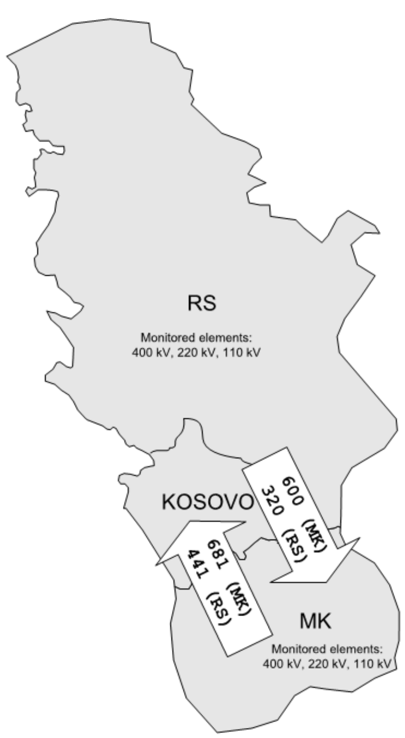


Figure 6.16 Calculated NTC values for Macedonia/ Kosovo border depending on the monitored elements (model 2012)

Table 6.48 Critical network elements for a power exchange on 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 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 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 network 400 kV, 220 kV and 110 kV on Macedonian side the NTC values is set to 755 MW, limited by the OHL 110 kV TETO – Skopje 4 that is jeopardized by outage of the OHL 110 kV Skopje 1 – Kumanovo 1. Ignoring the network 110 kV 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, and observing all network elements 400 kV, 220 kV and 110 kV on Macedonian side, the NTC value is set to 212 MW, limited by the OHL 110 kV Skopje 3 – Skopje 4 that gets overloaded as a consequence of the OHL 110 kV G. Petrov – Skopje 1 outage. The NTC values 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 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 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 Romania/Serbia border have been calculated using the model for 2012 as follows:

Table 6.52 The NTC values for 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 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 because of that, no matter of the monitored network elements. For this value of power exchange from Romania to Serbia no network limitations in Romania and Serbia, including the networks 110 kV, have been detected at the model. Increasing possible generation shift in downward direction in Serbia, network limitations have been detected in Romanian network concerning the transformers 220/110 kV in Targoviste substation and the OHL 400 kV P.D.Fier – Đerdap that is jeopardized in a case of the 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 observing all network elements 400 kV, 220 kV and 110 kV on Romanian side, the NTC value is set to 1266 MW due to maximum generation shift in Romania. Observing Serbian side and network 400 kV, 220 kV and 110 kV limitations appears concerning the line 110 kV Đerdap – Prahovo. The NTC value for this direction of power exchanges may be increased up to 999 MW if we ignore 110 kV network elements in Romania and Serbia. New limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of the 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 network.

Remark: Serbian TSO (EMS) stated that overlodings 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.

Romanian TSO (Transelectrica) confirmed critical elements on their side of the border which appear when generation shift in both countries is increased. Critial 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.

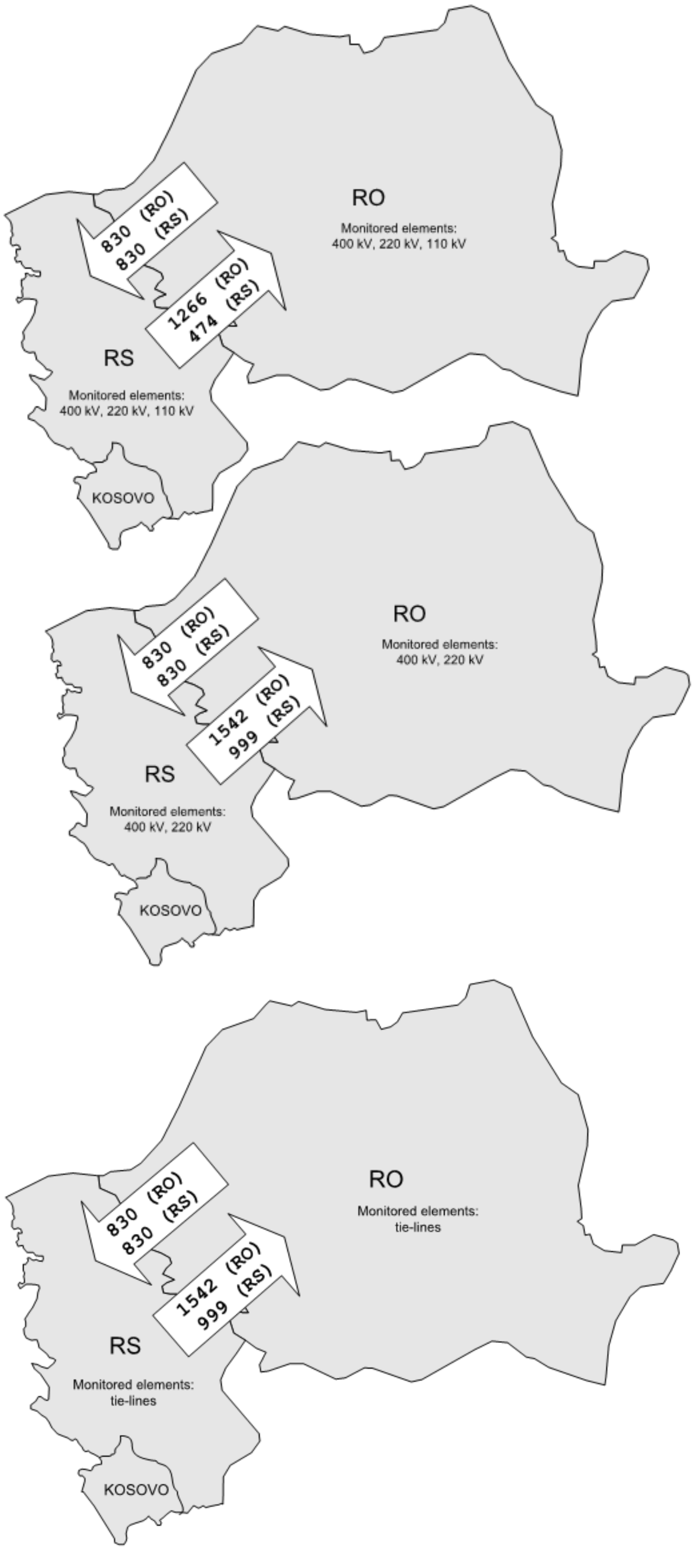


Figure 6.18 Calculated NTC values for Romania/ Serbia border depending on the monitored elements (model 2012)

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

Table 6.55 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Romania the NTC value is set to 681 MW, limited by possible overloading of the transformers 400/110 kV Tariverde in a case when one transformer goes out of operation. Rating of these transformers is defined to 2x250 MVA at the model. If we ignore Romanian internal transmission system and observe tie-lines only, the NTC value could be increased up to 2006 MW, limited by the OHL 400 kV P.D.Fier – Đerdap that is jeopardized in a case of the OHL 400 kV Tantareni – Urechesti outage.

For the direction of power flows from Hungary to Romania, and observing all network elements 400 kV, 220 kV and 110 kV on Romanian side, the NTC value is set to 1256 MW and limited by transformer 400/220 kV in the Rosiori substation, jeopardized by outage of the OHL 400 kV Gadalin – Rosiori. Rating of critical transformer is 400 MVA at the model. Ignoring 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 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 Romania/Ukraine border have been calculated using the model for 2012 as follows:

Table 6.58 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Romania the NTC value is set to 442 MW due to maximum generation shift in Ukraine. Network limitations in Romanian network can not be found for this level of power exchange across analyzed border.

For the direction of power flows from Ukraine to Romania, and observing all network elements 400 kV, 220 kV and 110 kV on Romanian side, the NTC value is set to 1119 MW and limited by transformer 400/220 kV in the Rosiori substation, jeopardized by outage of the OHL 400 kV Gadalin – Rosiori. Ignoring 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.

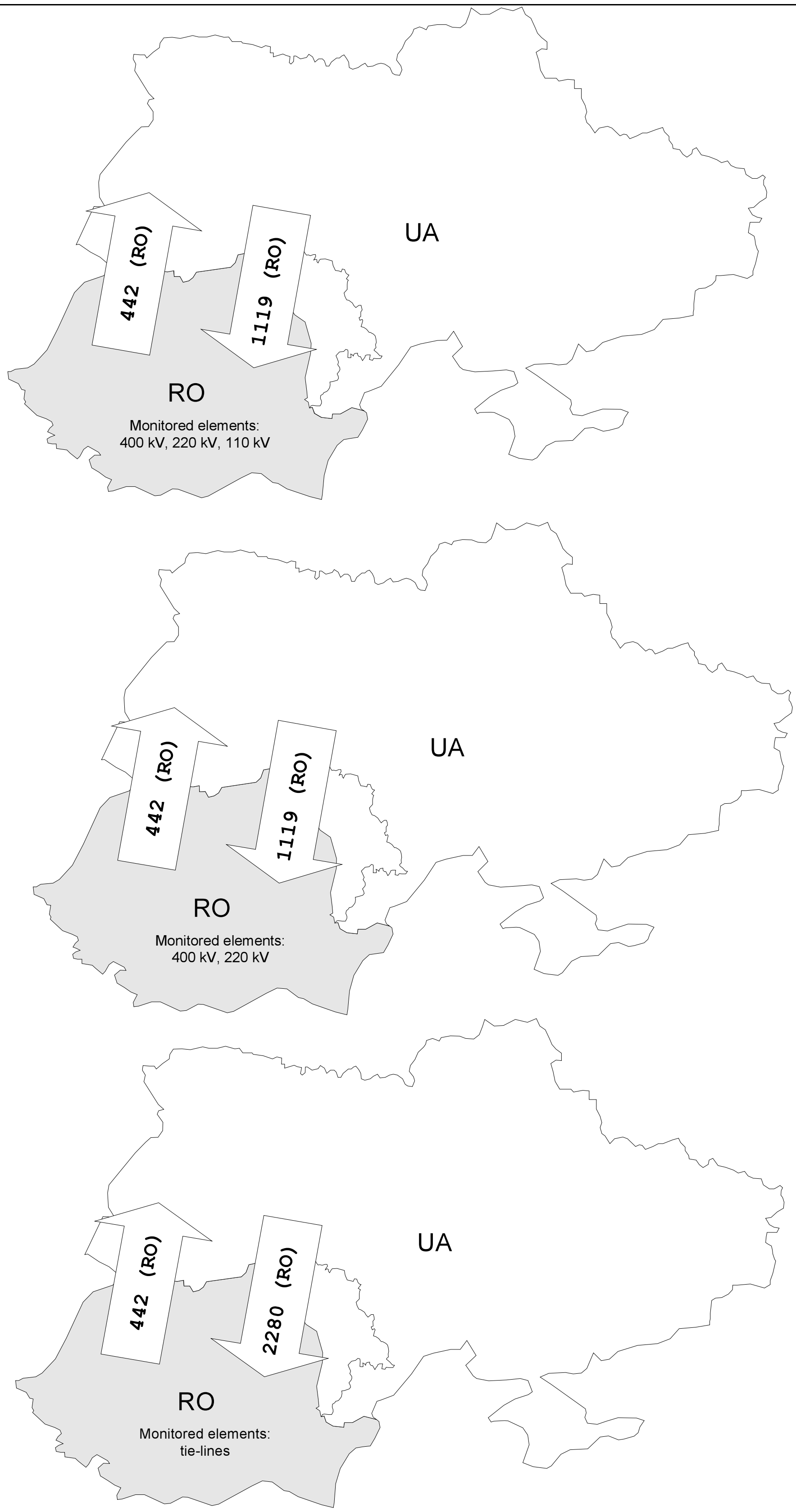


Figure 6.20 Calculated NTC values for Romania/ Ukraine border depending on the monitored elements (model 2012)

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

Table 6.61 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Serbia the NTC value is set to 489 MW, limited by possible overloading of the OHL 110 kV Đerdap – Prahovo after the OHL 110 kV Đerdap – Negotin went out of operation. Ignoring network 110 kV limitations and monitoring 400 kV and 220 kV network elements in Serbia, calculated NTC value is increased to 1051 MW and become limited due to OHL 220 kV Bajina Bašta – Vardište overloading as a consequence of the OHL 220 kV Bajina Bašta – Požega outage. Monitoring tie-lines only, the NTC value may be further increased up to 1401 MW, when limiting element becomes the OHL 220 kV Bajina Bašta – Pljevlja. Both lines are located in the south-western part of Serbia and the OHL 220 kV Bajina Bašta – Pljevlja is interconnection line between Serbia and Montenegro, located far away from the Serbia/Hungary border. It is obvious that 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 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 Hungarian border.

For the direction of power flows from Hungary to Serbia, and observing all network elements 400 kV, 220 kV and 110 kV on Serbian side, the NTC value is set to 872 MW, 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) onfirmed 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 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 Slovenia/Italy border have been calculated using the model for 2012 as follows:

Table 6.64 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Slovenia the NTC value is set to 674 MW, limited by possible overloading of the transformers 220/110 kV in the Divača substation. There are two transformers there with rating of 143,5 MVA at the model for each. Ignoring 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 outage of 400 kV line between Divača and Redipuglia.

For the direction of power flows from Italy to Slovenia, and observing all network elements 400 kV, 220 kV and 110 kV on 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.

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

Figure 6.22 Calculated NTC values for 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 Slovenia/Austria border have been calculated using the model for 2012 as follows:

Table 6.67 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Slovenia the NTC value is set to 482 MW, limited by possible overloading of the OHL 110 kV Plave – Gorica in a case of the OHL 110 kV Maribor – RTP Pekre 2 outage. Ignoring network 110 kV limitations, the NTC value could be increased up to 519 MW, now limited by the transformers 220/110 kV in Divača substation. Monitoring tie-lines only, maximum power exchange of 1162 MW could be reached without any network limitation but due to maximum generation shift in Austria ate the model.

For the direction of power flows from Austria to Slovenia, and observing all network elements 400 kV, 220 kV and 110 kV on Slovenian side, the NTC value is set to 1502 MW, limited by transformer 220/110 kV in the substation Podlog, jeopardized when transformer 400/220 kV in the same substation goes out of operation. Maximum NTC of 1645 MW fore this power flow direction could be achieved due to maximum generation shift in Austria, without any tie-lines limitation.

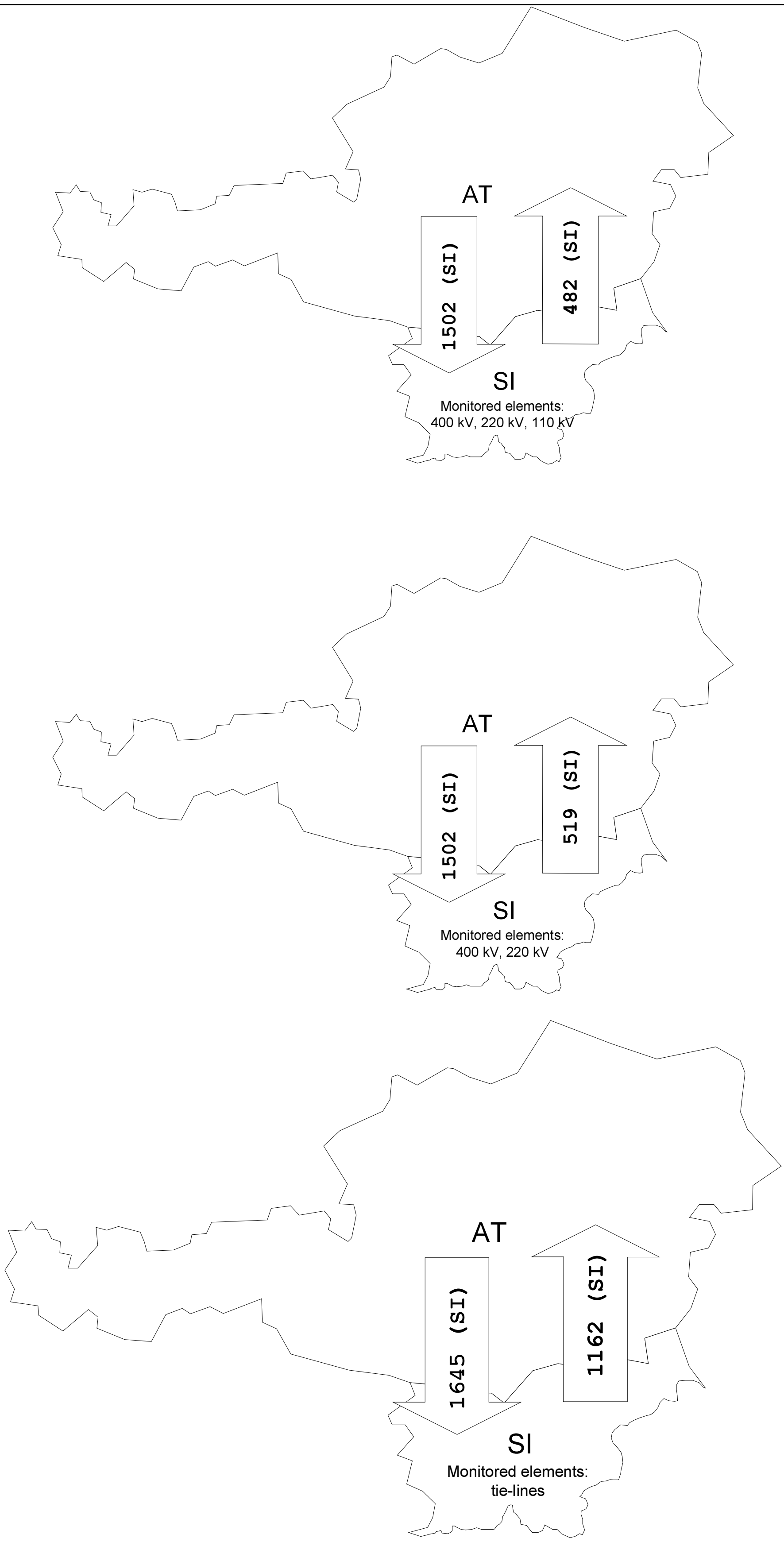


Figure 6.23 Calculated NTC values for Slovenia/ Austria border depending on the monitored elements (model 2012)

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 Turkey/Greece border have been calculated using the model for 2012 as follows:

Table 6.70 The NTC values for 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 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 and observing network elements 400 kV, 220 kV and 110 kV in Turkey the NTC value is set to 410 MW, limited by possible overloadings of several 154 kV lines following the contingency (outage) of one 400 kV line. If we ignore the network 154 kV, the NTC value could be increased to 804 MW, limited by the transformers 400/154 kV in the Adapazari substation. Maximum NTC value may be reached by ignoring 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 observing all network elements 400 kV, 220 kV and 110 kV on 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.

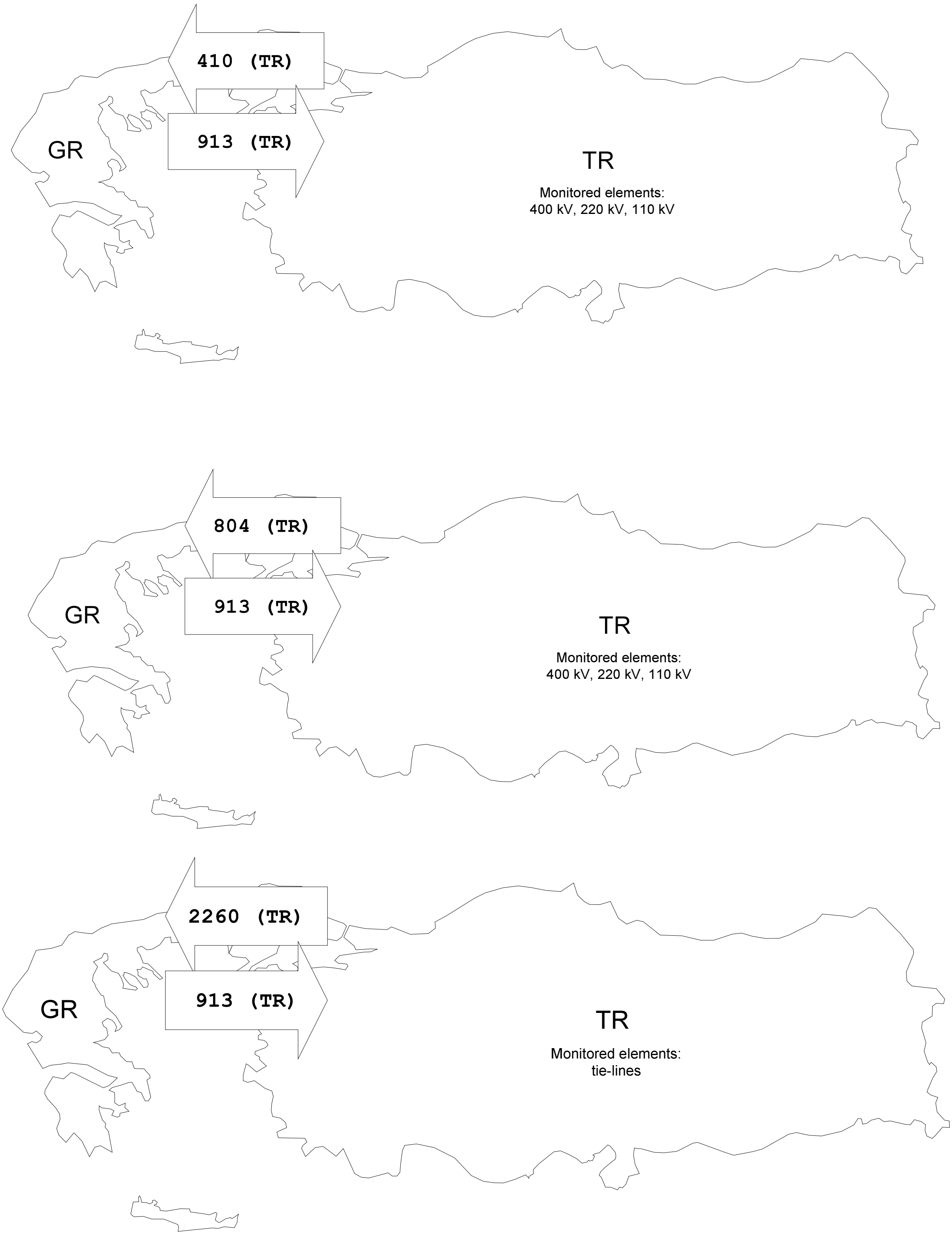


Figure 6.24 Calculated NTC values for Turkey/ Greece border depending on the monitored elements (model 2012)

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 the Chapter 2, SEE TSOs use the NTC computation methodology defined by the ENTSO-E, having in mind the UCTE Operational Handbook, Policy 3 and 4.

ENTSO-E methodology is related to the base case network modeling in studied time frame, increase of generation in one area while simultaneously decreasing generation in another area, load flow calculations with respect to predefined contingency list and network security checking, which all give the Total Transfer Capacity (TTC) over individual borders that has to be decreased for the Transmission Reliability Margin (TRM) in order to define the Net Transfer Capacity (NTC) value.

Experience shows that results of the NTC calculation are dependent on the methodology that is used for a NTC computation. The ENTSO-E methodology seems well defined for larger power systems, not mutually very well meshed and especially not very well meshed over third neighboring transmission systems. SEE regional transmission system is very well meshed, with many smaller transmission networks under control of many Transmission System Operators, resulting in large number of borders for which the NTC values are calculated. Power exchanges between two countries in reality go over several other countries which is not taken into consideration by the basic ENTSO-E methodology in the best manner. 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 Programmed exchanges 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 like Albanian, Macedonian, Kosovo and Montenegrin one (followed by other like Bosnian, Croatian, Slovenian etc.). Observing these transmission systems individually, the ENTSO-E methodology may give inaccurate results concerning cross-border transmission capacities. One example is maximum possible generation shift in one country that 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 value will not give real possibilities for power exchanges over considered border, because larger usage of that border is possible in reality. Observation of several national transmission systems as one area increases maximum possible generation shift ("upwards" and downwards"), giving more realistic NTC values due to network limitations and not due to maximum possible generation shift. In fact, many of the interconnections of small system are more loaded because of transits rather than because of imported power. In order to simulate such case, it is better to consider in calculation large exporting systems as Source area, and large importing system as Sink area. While simulating maximal power transfer in such way, calculated physical flows on interconnection of interest should determine TTC value.

Observing the NTC calculations using 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, meaning that there are no network limitations for power exchanges over these borders and power directions but the NTC values may be still 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. ENTSO-E methodology prescribes calculation of the TTC value as sum of the Base Case Exchange (BCE, based on programmed exchange) and the maximum generation shift (ΔE_{max}). With BCE quite different that physical exchange for studied base case, large inaccuracy of the TTC may be introduced, giving latter smaller NTC values. For example, if the BCE value between two areas (countries) is defined to 500 MW, only portion of this base case exchange will load interconnection lines between these two areas, while significant load flow will go over third transmission systems. By increasing generation in one area and decreasing in another area, when security criterion is not fulfilled somewhere, the TTC value will be determined as sum of the largest generation shift for which security criterion is still fulfilled and the base case exchange that may be significantly larger then physical load flow between two areas. If the BCE is defined in opposite direction than studied power exchange over a border, resulting TTC value will be smaller than it should be. Additional inaccuracy in this methodology is going to be introduced if there are many different market transactions in reality which will flow over different borders, causing large difference between programmed exchange and physical exchange over studied border. In reality, load flows over the SEE borders may be quite different than programmed values, not only in volumes but in direction also. Because all of this, coordinated flow-based approach seems the most appropriate way for the NTC calculations in well-meshed SEE transmission system, consisted of many smaller national transmission networks with large number of borders for which the NTC values have to be defined. Coordination office should use common network model for studied time-period and model all expected market transactions in the SEE transmission system, check network security by applying the pre-defined contingency list, and determine congested transmission systems and congested borders together with the NTC values for each border.

It should be stressed that some SEE TSOs use similar methodology based on composite load-flow approach, but further expansion and methodological improvements would be welcomed.

Furthermore, ENTSO-E methodology and resulting TTC values are very dependent on the studied base case. Methodology recognizes this fact and suggests that base case should be defined according to real observed operation situations or TSO's forecasts. Observing the SEE region and its transmission system, 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 countries balance in base case is extreme (high import/export), this base case is adequate for NTC calculation in one "dominant" direction only. Opposite direction could be problematic for calculation because in order to revert flows in interconnection, a big generation shift should be made. Recommendation is to use base cases with more balanced systems.

** NOS BiH comment: NTC calculation has to be done before daily auction which is performed day ahead, what means that NTC calculation cannot be in the same day. Because of fact that NTC/ATC value is used as a part of offered capacity on auction, NTC calculation has to be done in D-2. Thus, term *day ahead* in this sense should be changed to D-2 or define *day ahead* as day before day of daily auction process.

SEE TSOs usually use snapshots of real operational conditions in the network under their control which seems 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 TSO will plan and perform regular maintenance activities during high load period.

By decreasing the observed time frame for the NTC calculations TSO may decrease an influence of different uncertainties, no matter if it take them into analysis or not. More realistic operational conditions will be analyzed if time period for calculations is closer which will result in higher accuracy and TSO's reliance on the calculated NTC values. In existing conditions SEE TSOs are primarily concerned about network security, and this may be a reason why quite low NTC values are declared as indicative values for year ahead time frame. Month-ahead and specially day-ahead NTC values are always much larger than annual NTC values, which may be explained with TSO's concern about network security, giving much lower attention to increase possibilities for market participants to trade across national borders under TSO's control (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).

Published indicative annual NTC values so far prove that TSOs are mostly concerned about network operational security. It seems that generally low NTC values don't appear as a consequence of real network limitations, but appear as consequence of TSO concerns about network security that will be probably introduced through network modeling. TSO may model unrealistic load growth or 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 daily basis and organize yearly cross-border capacity auctions based on minimum day-ahead or intraday NTC values from 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, taking into analyses possible influential future circumstances).

Other important issue related to the ENTSO-E methodology is that results of the NTC computations are dependant on the generation-shift method. Because of that, the following recommendations may be given:

1. Merit order list is preferable (more realistic, unrealistic overloadings are 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, 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 generation shift method that is used during calculation. SEE TSOs usually use generation shift proportional to the power reserve and thus introduce important parameters for a calculation, maximum power generation P_{max} and minimum power generation P_{min}. Maximum possible generation shift "upwards" or "downwards" strongly depends on modeled generators engagement during the base case and those two generator parameters. Direct negative influence of this approach may be visible through small maximum generation shift that may be introduced, resulting in small NTC values not restricted by any network element. At the model for 2012 one may notice many hydro power plants in the region with quite high minimum possible power (P_{min}) parameter. Because of this, 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 range. TSOs should not be concerned on hydro power plants efficiency during the NTC calculations and minimum capacity for such production facilities should be modeled using lower values because TSO's interest is on power exchanges over the network, not on efficient usage of production facilities. On the other hand, low difference between power engagement of generators at the model and maximum possible power of these generators, with other generators out of operation and disconnected from the network, gives low maximum possible generation shift in "upwards" direction, decreasing the NTC values without any real network limitations.

Usage of generators merit order list may give the most realistic values for the NTC calculation, and bring additional realistic approach in this process. If there are some generators within a national system which are rarely engaged due to extremely high production costs, it's obvious that their inclusion into generator shift key may cause unrealistic and not-expected situation in the network. On the other hand, engagement of generators according to merit order list, modeling different possible hydrological situations and appropriate expected hydro power plants engagement, is more probable from market point of view, 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 scale down for the TRM value to get the NTC value. Simple conclusion follows, that NTC values would be higher if TRM values are lower. ENTSO-E methodology also prescribes general terms in TRM values definition but leaving TSOs to determine appropriate values for its transmission system.

Concerning the TRM values 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)

Determination of 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 comparing with real operational conditions in a transmission system. Each power system and related transmission system has specific operational conditions, the largest generators for which tertiary control is defined, power balance, ancillary services availability and engagement, load predictions, renewable sources integration etc. may differ a lot from one to other transmission system. TSOs have large knowledge on unintentional deviations which may occur over their borders and they may define the TRM value according to their past experience, minimizing it while keeping operational security and thus increasing cross-border exchange (trading) possibilities. Probability of different events line simultaneous large internal deviations and loss of the largest generator should be evaluated, and in a case of very low probability (very close to zero) TRM margin should be defined in order to maximize the NTC values.

Introduction of well-defined, efficient, market-based and cost effective approach in ancillary services provision should be helpful in order to minimize internal deviations, thus increasing possible cross-border transactions due to lower TRM value. SEE TSOs still experience large internal and cross-border deviations due to lack of appropriate ancillary services procurement mechanism and balancing energy provision. Establishment of the 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 but still take 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. Approach based on the PTDF factors may be used in this purpose.

7.1.3. Security criteria

SEE TSOs generally analyze the (N-1) criterion during the NTC calculation, according to national grid codes. Some of them behave according to the UCTE OH, Policy 3, that defines different types of contingences which have to be analyzed, but without critical TSO overview those contingences may become unrealistic cause of the NTC values decreasing. Policy 3 defines that:

- 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.

- Normal type of contingency. 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.

- Exceptional type of contingency. The exceptional type of contingency is defined as the uncommon loss of the following particular elements based on the one hand on the design of the network structure and on the other hand on 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 have to be defined according to the likelihood of occurrence and respective risk assessment.

Furthermore, UCTE OH defines that the N-1 situation is applied on the N situation which may comprise some network elements out of operation in advance due to maintenance activities or long lasting outages. It is the TSOs responsibility to determine realistic scenarios concerning a network topology for a studied time frame, but some unrealistic situations may happen, for example if TSO consider simultaneous N-1-1 outages of two or more branches, one due to forced and unpredictable cause and second due to planned activities like maintenance during high-level loads in a studied system (usually during winter months).

If TSO consider and include some exceptional types of contingencies into the contingency list, like double-system line or bus-bar outage, it's unclear does he take into account probability of such events because probability related to such event is usually extra low. Recent study on the SEE transmission system reliability shows that all Southeast European countries have very reliable 400 kV networks where forced outages are very rare and not-lasting event. Deterministic N-1 approach in system security analysis ignores this knowledge.

NTC values are strongly dependent on the security criteria which are used (N-1) and recommendations related to this topic are:

1. TSOs should consider to take into account probabilities of line outages during the NTC computations.
2. TSOs should consider to take 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 to take into account effects of individual contingences (for example, minor overloadings 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 amplitude 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

TSOs concerns about security of supply are taken into account during the NTC calculations through the contingency list and monitored elements defined by them. Calculations conducted within this study show that the NTC values are lower if network 110 kV in the region is observed 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 which are observed and 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 mainly observe 400 kV and 220 kV network, it is mostly influenced by cross-border transactions.
4. Network 110 (154) kV 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 possibilities to allow 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. In 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 TSO should be aware about consequence of each contingency that is observed and influence of power exchanges over a border on critical network element. 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 so dependent on a power exchange over the borders. Example of this may be given through the transformers 220/110 kV in the Sremska Mitrovica substation, which are highly loaded in the base case model for 2012. By increasing/decreasing generation shift in Serbia and neighboring countries these transformers became overloaded, which may be a trigger for the NTC value computation to stop. Fortunately, Serbian TSO stated that such overloading will not be considered during the NTC calculation, but if it was considered, it would represent unrealistic case of the NTC values limitation over Serbian border. According to this, TSO should define such contingences and limiting network elements which 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. That's the reason why these network elements should be mainly monitored during the NTC calculations. Differences in the NTC values calculated within this study in two scenarios, by monitoring network elements 400 kV-110 kV in one scenario, and by monitoring network elements 400-220 kV in other scenario, clearly show that much larger NTC values may be expected if network 110 kV is ignored. Network 110 kV monitoring should be exceptional and conducted only if some network elements 110 kV are significantly influenced by cross-border transactions.

PSS/E network model for 2012 shows that majority of the SEE TSOs don't consider different ratings of transmission lines and transformers. Usually there is one rating defined only, meaning that TSOs don't take into account possible temporary overloadings 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 network model for 2012 that was used in this study is Macedonia, with two possible ratings of transmission lines (RATE A and RATE B in the PSS/E model), but according to information received from MEPSO they don't consider possibilities for temporary overloadings or different seasonal values of transmission lines ratings. Bosnian and Turkish transmission system model also have different ratings defined, but with second value lower than the first one (RATE A > RATE B), probably meaning that economic line loadings are considered by them, not temporary overloading or seasonal values.

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 network model in 2012 for Bosnia/Montenegro border and Bosnia to Montenegro direction of power exchange, monitoring network elements 400 kV and 220 kV on Bosnian side (ignoring the network 110 kV), is 751 MW (TTC = 925 MW, TRM = 173 MW). Critical contingency in the network is outage of the OHL 400 kV Trebinje – Podgorica and critical network element is the OHL 220 kV Trebinje – Perućica with rating of 316 MVA defined on Bosnian side and 274,4 MVA defined on 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 for 143 MW (NTC = 894 MW, TTC = 1068 MW). Practically, without jeopardizing network security possibilities for cross-border power exchanges over 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 which 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 - Perućica
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 doesn't 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 – Perućica 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 Perućica 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 Bulgarian power system 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

Critical 110 kV 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.

Transformers 400/110 kV 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 400/220 kV transformer in the same substation (certain range of active load flow control is possible).

Transformers 400/110 kV in the Ernestinovo may be partially relieved by increase of production of local generators in Osijek, connected to the network 110 kV.

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 110 kV network as limiting elements for the NTC values, but observe limitations in the network 400 kV 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 – Skoppje 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 Peručica – Trebinje
220 kV Pljevlja – Bajina Bašta

Possible dispatching actions in order to relieve the OHL 110 kV Herceg Novi – Trebinje and Peručica – Trebinje are previously described (under the Bosnia and Herzegovina section).

Dispatching actions related to the OHL 220 kV Pljevlja – Bajina Bašta will be decribed under 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).

Overloadings of transformer 400/220 kV in the Rosiori substation occur 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 decrease of 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 to construct the network 400 kV 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 stared that for Turkish transmission network, only tie lines between Turkey and Bulgaria&Greece must be taken as 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.

Observing the PSS/E 2012 model one may notice quite different ratings for the same lines between Turkey and Bulgaria. For the line Maritsa East – Hamitabad ratings are defined to 1715 MVA for Bulgarian side and 2178 MVA for Turkish side. For the line Maritsa East – Babaesku ratings are defined to 1310 MVA for Bulgarian side and 1431 MVA for Turkish side. Similar situation may be noticed for the line between Greece and Turkey. For the OHL 400 kV Babesku – N. Santa rating on Greek side has been defined to 2000 MVA while for Turkish side amount is 2178 MVA. 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 overloadings.
2. If TSO practices remedial dispatching actions in order to efficiently relieve critical network element overloadings, 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

Observing 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 technically correct if a line material, cross-section and other defined parameters like permitted sag or related current-metering transformers in appropriate line bays of adjacent substations are different in each country, but usually this could be inaccuracy that may restrict the NTC values.

Example of possible different tie-line ratings (depending on an observed side of a border) influence on the calculated NTC value is given here. The NTC value on the network model in 2012 for Bosnia/Montenegro border and Bosnia to Montenegro direction of power exchange, monitoring network elements 400 kV and 220 kV on Bosnian side (ignoring the network 110 kV), is 751 MW (TTC = 925 MW, TRM = 173 MW). Critical contingency in the network is outage of the OHL 400 kV Trebinje – Podgorica and critical network element is the OHL 220 kV Trebinje – Peručica with rating of 316 MVA defined on Bosnian side and 274,4 MVA defined on Montenegrin side. If we equalize tie-line ratings from both side of the border to higher value (316 MVA in this case), the NTC value will be increased for 218 MW (NTC = 970 MW, TTC = 1143 MW). Practically, without jeopardizing network security possibilities 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 of both TSOs concerned and equalize to unique value if 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 PSS/E model in 2012 with inequalities in transmission capacity depending on a side of a border 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.

Concerning significant transmission capacities difference for the same tie-line, and number of tie-lines in the region with different values of transmission capacity depending on a side of a border, one may assume that the NTC values may be significantly increased for a number of borders if transmission capacities are equalized on the same value (higher one).

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

Transmission System Operators should operate transmission systems and plan their development to support market transactions in the region and restrict market power of individual electricity producers. In other words, low NTC values prevent those tasks to be sufficiently conducted. TSOs should balance between market transactions through their transmission networks and security of supply of the transmission consumers.

It seems that SEE TSOs are nowadays mostly occupied with security of supply issues, which may result in unnecessary restrictions of the market activities on the wholesale market level. Market participants are obviously interested to increase volumes of electricity trading but they are restricted with limited cross-border transmission capacities, with strong negative influence of large number of TSOs and national borders. Final result of this is large amount of congestion revenues collected by the SEE TSOs on an annual basis. Generally, it is unsatisfactory how these congestion revenues are spent for. According to the questionnaire provided within this study, the majority of SEE TSOs spend congestion revenue in order to guarantee cross-border transmission capacity or to decrease transmission tariffs, rarely to increase the NTC values by network investments or in some other ways. With such practice, the NTC values are not going to be significantly increased in the near future.

Authors of this study believe that larger portion of congestion revenues should be directed to increase existing possibilities of the cross-border transmission capacities in order to support market transactions in the region at the wholesale level. The region of the Southeast Europe should operate under internal regional electricity market according to the Energy Community Treaty that will become a part of unique European electricity market. This task will not be achieved with cross-border trading possibilities kept to present values.

Beside simple and mostly methodological and organizational interventions in the NTC calculation practice described in previous chapters, SEE TSOs should plan network investments in order to support larger possibilities of cross-border trading 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 ones should be considered by the SEE TSOs where applicable:

- replacement of the current measuring transformers which limit transmission capacity of important transmission lines,
- investments in the lines 110 kV 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) which will relieve the existing and limiting ones,
- investments related to increase of critical 220 kV transmission lines transmission capacities, where such measure is applicable,
- removal of internal transmission network limitations.

Important recommendations concerning this topic and described in the following chapters, are the following ones:

NTC values may be increased by network reinforcements:

1. Low-cost investments should have the highest priority (replacements of current-measuring transformers, 110 kV network reinforcements etc.).
2. Adjacent TSOs should closely cooperate concerning investments for the NTC values increasing (NTCs are determined concerning 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 lines construction!

7.3.2 Internal network investments

NTC values calculations using PSS/E network models for 2012 and 2015 indicate that large number of limiting network elements concerning cross-border transmission capacities are located within national internal transmission systems. Calculations also indicate that possible limitations for the NTC values are almost never caused by the 400 kV transmission lines overlodings, especially not caused by the 400 kV interconnection lines overloadings.

The NTC calculations also indicate the following:

1. In many cases by ignoring network 110 (154) kV and observing network 400 kV and 220 kV 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 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 lines 220 kV, almost never to the lines 400 kV.

These three basic findings of calculations conducted within this study lead to logical conclusions and recommendations:

1. If TSO considers network 110 kV as limiting part of a transmission system concerning the NTC values, it should plan actions or investments to remove limitations there.
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, regulatory approval is more probable.
3. Some TSOs should reevaluate a significance of 220 kV interconnection lines and consider operational practice related to them.

Network elements 110 kV (lines and transformers) are the lowest expensive part of transmission systems. Unit investment in the lines 110 kV are around four times lower than unit investments in the lines 400 kV. Furthermore, lines 110 kV are shorter than 400 kV lines resulting in much smaller total investments related to their construction and comparing them with total costs of the new 400 kV lines. Right-of-ways for 110 kV lines could be assured much more easily than the same for the lines 400 kV. It is clear that investments in the lines 110 kV, if some of them are considered as limiting elements to the cross-border transmission capacities, are more probable, feasible and easily economically justified.

Similar arguments are valid for internal network investments comparing them with new interconnection lines investments. The SEE transmission system is well meshed even today and there are existing 36 tie-lines operated under 400 kV and 18 tie-lines operated under 220 kV voltage level in-between the observed countries and between the observed and surrounding countries (Table 7.2, Figure 7.1, additionally see Chapter 4). It should be stressed that Regulatory approval for internal network investments could be provided more easily, assuming that TSO will be able to prove necessity of network reinforcements to a Regulatory Authority.

While first two recommendations are clear enough and don't need any further explanations, third one should be explained in more details.

Tie-lines 220 kV were constructed in former Yugoslavia due to historic reasons, during 60-ties when transmission facilities 400 kV were still expensive and unnecessary for the level of generation and load at that time. Important factor is that these lines were considered as internal network lines, not interconnection ones, since today independent countries (seven of them among eleven countries observed in this Report) were part of Yugoslavia. Result of this is existence of large number of 220 kV interconnection lines at this moment (total number is 18), operated in parallel with 400 kV interconnection lines although 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). Consequence of this is possible 220 kV interconnection lines overloadings following the outages of the parallel 400 kV interconnection lines where larger power exchange goes from one country to another one. SEE TSOs, especially Slovenian, Bosnian, Croatian, Montenegrin and Serbian, should reconsidered operational practice to operate 220 kV tie-lines in parallel with 400 kV tie-lines, and if necessary, study possibilities to use 220 kV transmission lines corridors in order to reinforce those lines to the 400 kV voltage level. Other alternative is to abandon some old lines 220 kV, when significant funds will be needed for their revitalization, together with internal network reinforcements where this is necessary.

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

Calculations conducted within this study show that cross-border possibilities related to the same border and the same direction of power exchange may be significantly different depending on a side of a border that was observed.

According to the ENTSO-E methodology for cross-border transmission capacity assessments security criterion (criteria) has to be satisfied on both sides of a border and in third parties transmission system if they are significantly influenced by power exchanges related to observed border. If related NTC values are different TSOs usually agree that the lower one is declared as the final NTC value related to observed border and direction of power exchange.

If we observe two areas and calculate related NTC values observing security criteria in the transmission network in Area 1 (related NTC may be defined as NTC_{area1}) and then observing 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 which 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 contingency list that includes single element outages only, while other TSO uses contingency list with double-circuit lines outages or bus-bars outages, significantly different NTC values may be expected for the same border, resulting in lower NTC value finally defined for this border.

The same conclusion is valid in relation to monitored elements during the NTC values calculations. Significantly different values may be expected if one TSO observe 400 and 220 kV network elements only, while other TSO includes 110 kV network in 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 related to internal network investments which 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 common border have no importance and will not result in higher NTC value for observed border. This is because limitation will still exist due to internal network limitations in Area 1 that limits the final NTC value for 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 element in both transmission networks. Transmission development plans will have to be coordinated and internal network investments should be planned in order to achieve maximum positive influence on the NTC values for their common border. TSO in Area 1 will have to plan its internal network reinforcements first, and then 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 network monitored in both countries which 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 network monitored in both countries which 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

SEE TSOs often declare a necessity 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 SECI PSS/E models for 2015 and 2020 there are lot of new interconnection lines 400 kV planned by TSO to be operational in a short, mid and long-time frame.

There are 11 new interconnection projects which 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 volumes of market transactions in the region have to be increased soon (2015 is expected year of market establishment on retail level). Authors of this study suggest that TSOs should consider all recommendations given here in order to increase NTC values in a short period of time.

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

SECI TSP study "Preparation for large scale wind integration in South East European power system" has clearly shown that the regional approach to WPP balancing would decrease total reserves need to balance intermittent WPP by a range of -2,600 MW and +2,000 MW. In other words, the regional approach would decrease 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 mechanism.

But, current practice is still far away 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

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 of 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 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 which would increase transparency and decrease costs in line with ERGEG GGP.
5. Before a regional mechanism is established, either throughout 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 treatment of cross - border capacities, as a part of 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 to commonly develop a detailed methodology on TRM calculation based on the principles and approach set by 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.

But, besides cross - border capacity issues, there are another three areas needed 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 out 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 energy portions
6. Centralized and harmonized data collection, data analysis and results reporting under ECRB's management
7. Adopt regulations in view of 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 follow 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 about 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 this process for balancing and reserves monitoring
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 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). Cross-border transmission capacities are generally restricted because of tie-lines transmission capacities and security of supply issues which are the matter of Transmission System Operators concern. The main task of this report is to analyze the NTC values in the Southeast Europe region, identify critical network elements and define recommendations in order to increase cross-border trading possibilities in the SEE region.

Analyses conducted within this study were mainly based on the SECI PSS/E regional transmission system models for 2012. PSS/E model for 2012 represents snapshot of real operating conditions during January 14, 2012 at 12:40 pm.

The NTC values for the SEE countries are published at the ENTSO-E web site, and relate to indicative annual NTC values for specific borders and direction of power exchanges, month-ahead NTC values and day-ahead NTC values. Published NTC values show that market trading possibilities at the wholesale level are quite restricted in the region today and one of the main reasons for this is low NTC values for a number of borders, especially concerning indicative annual values. Direct consequences of this are low volumes of electricity trading in the region, large congestion revenues collected by the SEE TSOs and existence of market power of national electricity producers. Economically efficient electricity market is also disturbed by the existence of large number of TSOs and national borders in the region. It should be stressed that indicative annual NTC values do not show the market trading possibilities during the year, but they show only the NTC values that are reliable for any topology and therefore could be transacted in 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. Computed NTC values in this study could not be considered as exact indicators of cross-border trading possibilities in the region since only one operational condition has been analyzed, but they should be considered as indicative values used to define specific recommendations to the SEE TSOs on possible actions in order to increase cross-border trading possibilities in the near future (Transelectrica comment: 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 by all 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 values increase are directed mainly to the new interconnection lines construction. It has to be stressed that there are 36 tie-lines 400 kV and 18 tie-lines in the region today which make regional transmission system extremely well-meshed comparing it with other European regions. Because of that, Authors of this report believe that 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 exchanges method.
- Coordinated flow-based approach seems the most suitable methodology for the NTC values computation in the SEE region.
- Realistic base cases should be used.
- 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).
- Merit order list for generation shift definition is preferable (more realistic, unrealistic overloadings are 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 probabilities of simultaneous events which influence cross-border flows deviations.
- One value of TRM should be defined and then allocated to different borders.
- TSOs should consider to take into account probabilities of line outages during the NTC computations.
- TSOs should consider to take into account 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 to take into account effects of individual contingences (for example, minor overloadings may be neglected).
- TSOs should take into account possible dispatching actions (remedial actions).
- 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 400 kV and 220 kV network, it is mostly influenced by cross-border transactions.
- Network 110 (154) kV 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 possibilities to allow 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 overloadings.
- If TSO practices remedial dispatching actions in order to efficiently relieve critical network element overloadings, especially on regular basis and without any serious consequences on a system security, this critical element should be neglected during the NTC calculations.
- Tie-lines ratings should be defined in coordination of both TSOs concerned and equalize to unique value if 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 TSO considers network 110 kV as limiting part of a transmission system concerning the NTC values, it should plan actions or investments to remove limitations there.
- 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, regulatory approval is more probable.
- Internal network investments have to be conducted before new interconnection lines construction!
- Some TSOs should reevaluate a significance of the 220 kV interconnection lines and consider operational practice 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.
- 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.

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 involved more actively by controlling congestion management revenues usage and direct them to low-cost measures and investments. First step may be initiation and establishment of internal dialog between SEE Regulation agencies and TSOs in the region, possible under the umbrella of the Energy Community Secretariat, in order to coordinate common activities with the main goal to increase 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.

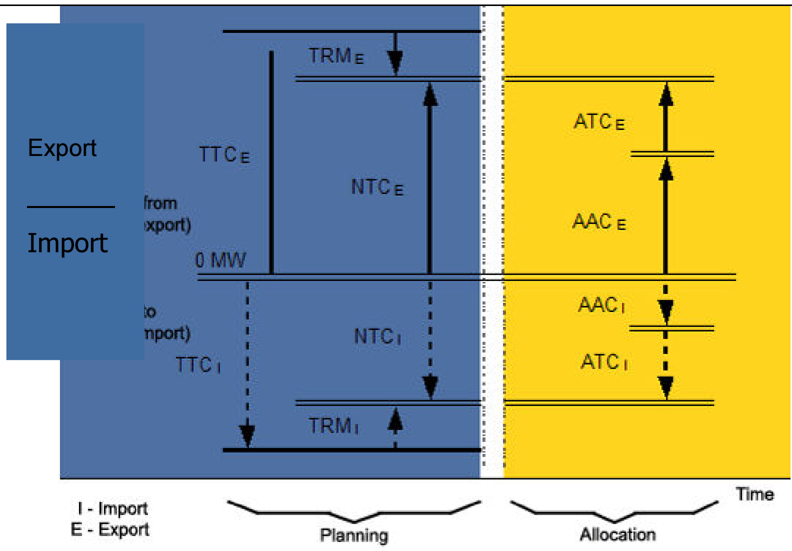

Figure 1 Technical volumes of the cross-border exchange transmission capacity

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.

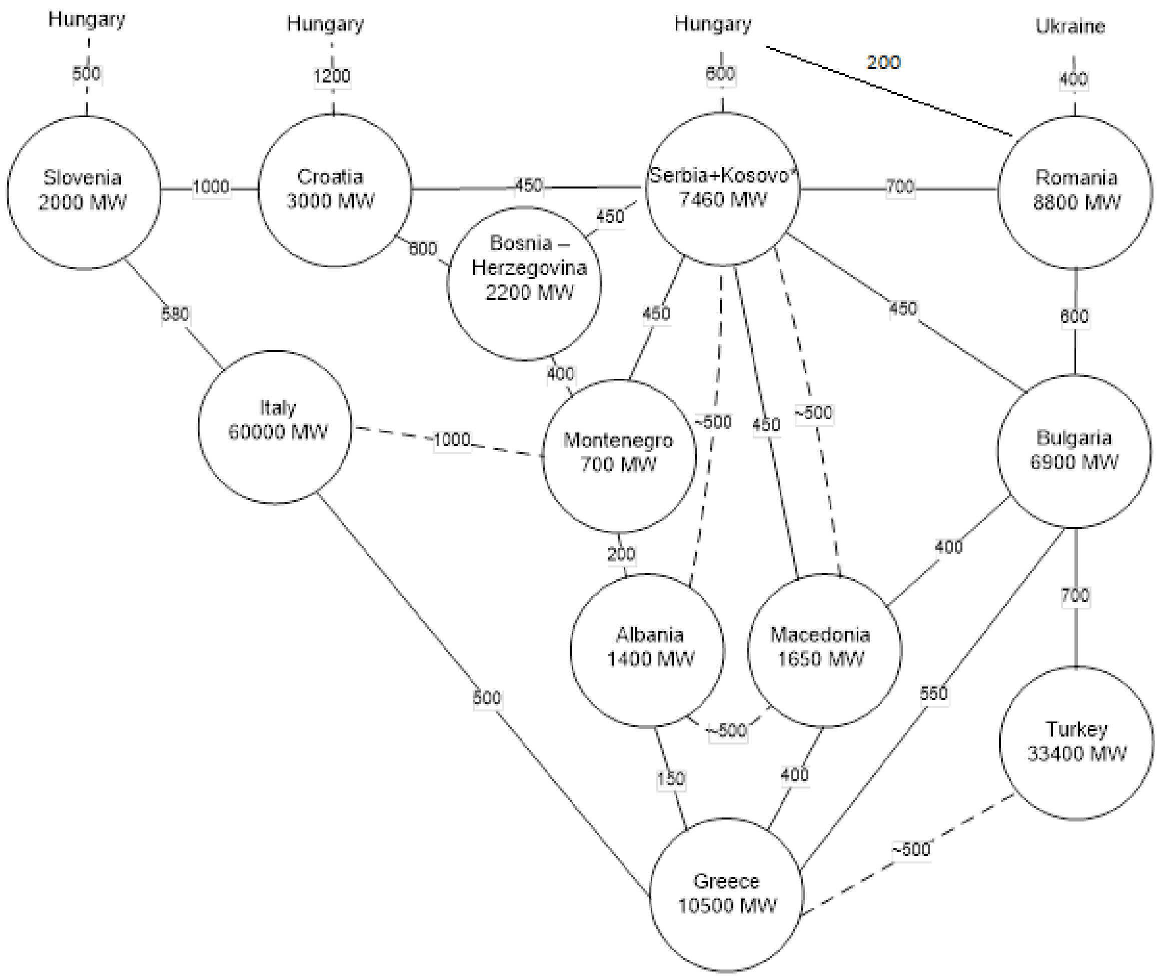

Figure 2 Current system peak loads and net transfer capacities for winter in between SEE countries (MW) (new transmission projects are given in dashed lines) (Source: ENTSO-E)

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: (Increase of part of network capacities, specified in Section 6.)

■ New internal lines construction
(specify which ones: (Increase of part of network capacities, specified in Section 6.)

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: 3.450.000,00 (€)

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: Transmission Company in B&H, not ISO B&H)

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:<u>25 million (€)</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:____)

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: <u>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.</u>

<u>On the other side this is the best method which we have.</u>

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):

- Different value settings of overlaod protection at both ends of interconctor
- TRM value are to high
- No transparency
- Discrepancies between calculated and nominated values of NTC,

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 acces 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 concideced

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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