The imbalance netting mechanism is a form of cross-border exchange of balancing energy in automated secondary control (Automated Frequency Restoration, aFRR) and is recognized as one of the target models of the regional integration of electricity balancing markets by ENTSO-E network code on electricity balancing (Electricity Balancing Network Code – EB NC), which in the future could be potentially applicable to the countries in south-eastern Europe through fulfilling the obligations under the Energy Charter within the framework of the Energy Community.

The essence of imbalance netting is based on the ”offsetting” activation of secondary control in the opposite directions between participating transmission system operators. This concept involves central optimization of the transmission system operator’s real time imbalances, with the aim of minimizing the counter activations of balancing energy. The economic benefit of this approach is the avoided amount of balancing energy activation and lower costs in the regional electricity balancing market.

The integration of electricity balancing markets is one of the most important and challenging steps in the process of creating a single European energy market. The largest obstacles in this process are significant differences in the structure and organization of existing national balancing markets. The EB NC (ENTSO-E Electricity Balancing Network Code) network code developed by the ENTSO-E (an association of transmission system operators which regulates electricity balancing and whose proposal is presented to the European Commission for approval) deals with this issue. The aim of this document is to create a necessary framework for harmonization and integration of national balancing markets, first at regional level, and later at European level in order to form a single market. After the adoption, which is expected to happen in the near future, this document will become binding on the countries of South Eastern Europe based on the obligations under the Energy Community Treaty.

Regional cooperation between balancing markets aims to increase competition through cross-border trade in balancing products and consequently enables a more efficient process of system balancing, while maintaining/ensuring the necessary level of security of supply. A key element of the EB NC network code is to define target models for cross-border cooperation and integration of electricity balancing markets in Europe, which in the beginning should be set out as a regional initiative, and later merged into one integrated balancing market in Europe. The imbalance netting mechanism is recognized as one of the target models for the cross-border exchange of balancing energy.

IMBALANCE NETTING MECHANISM

The purpose of the imbalance netting mechanism is to prevent the activation of balancing energy in automated secondary control (Automated Frequency Restoration) in the opposite directions between participating transmission system operators. This concept involves central optimization of imbalance in control areas in real time, with the aim of minimizing

counter-activations of balancing energy.
The optimization of automated secondary control (aFRR) is accomplished by applying the imbalance netting mechanism through the participation of other control areas with the purpose of avoiding counter activations whenever possible. If one control area requires the delivery of balancing energy to compensate for the lack of energy, and at the same time another participating control area requires the withdrawal of balancing energy to compensate for the excess of energy, cross-border optimization takes place before the secondary regulation resource is activated in these control areas. A key part of any imbalance netting is the optimization module (Figure 1), which is used before the secondary regulation resource is activated. Control error of every participating control area ACE (Area Control Error) is transmitted to the central optimization module, in which netting of signals of opposite signs occurs, i.e. signals are “suppressed” in real time, taking into account constraints (such as current values of cross-border transmission capacity ATC after closing intraday capacity allocation, or other manually entered restrictions). As a result of this netting process, some correction signals are calculated and transmitted to a particular control system of each control area. After the completion of imbalance netting, the remaining imbalance is redistributed to the secondary control regulators of every control area, so that the necessary balancing energy is reduced.
The economic benefit of this approach is the reduced amount of balancing energy activated by the automated secondary control (aFRR), and hence lower costs of balancing on a regional electricity balancing market.
The limitation of the imbalance netting mechanism is available cross-border transmission capacity between two control areas, which remains after the closure of intraday transmission capacity auctions on the borders of all control areas participating in optimization. On the other hand, optimization can be manually limited, for example, according to the available and agreed amount of regulation resource in the secondary regulation of participants, so that imbalance netting interacts with other energy markets only to a certain desired amount of exchanges.
The economic value of energy supplied to a transmission system operator (TSO), which can be both energy recipient, and a balancing entity – a provider of energy in the imbalance netting process, will be determined based on the amount of costs saved by avoiding the activation of control energy in control areas (Opportunity Cost (OC) – “costs based on opportunities”). “Price based on opportunities” (Opportunity Price (OP)) is defined for each TSO:
– In case of a positive aFRR request from a control area (request for an increase in production) the OP within the accounting period corresponds to the quotient of the potential cost of upward activation of aFRR balancing energy, which is not activated due to the implementation of the imbalance netting mechanism and the amount of that energy

– In case of a negative aFRR request from a control area (request for a decrease in production) the OP within the accounting period corresponds to the quotient of the potential cost of downward activation of aFRR balancing energy, which is not activated due to the implementation of the imbalance netting mechanism and the amount of that energy
There are several most common pricing models for determination of prices and potential costs of aFRR balancing energy that is not activated, and, therefore, for the calculation of the OP:
– The price of aFRR energy activation is based on the principle of "pay as bid" (Germany, Austria) (see Figure 2, with a numerical example)
– The price of aFRR energy activation is based on the uniform marginal price and last accepted offer (Netherlands)
– The price of aFRR energy activation is uniform and determined by the energy regulator (Czech Republic)
– The price of aFRR energy activation is related to the price achieved at relevant spot market (Switzerland)
– The price of aFRR energy activation depends on the direction of activated aFRR and manually activated secondary / quick tertiary reserves mFRR (manual Frequency Restoration Reserve) and provided priority lists for the activation of aFRR and mFRR
– A hybrid model which combines several previously presented methods
Imbalance settlement price between different TSOs during accounting period is calculated as the mean value of all achieved opportunity prices within the respective cooperation, weighted with the respective exchanged volumes of balancing energy. In the context of cross border energy trading and imbalance netting, this price serves as a basis for making all calculations and payments.

IMBALANCE NETTING " – PROCESSES IN EUROPE

In Western Europe several cooperation programmes are underway in the form of regional integration of balancing markets governed by the principles of imbalance netting mechanism. The International Grid Control Cooperation (IGCC) encompasses seven European countries and ten transmission system operators. The initiators of this cooperation in 2008 were German transmission system operators involved in the GCC cooperation that have 4 modules and it is based on the common platform for system control and functioning of balancing markets in Germany. Within the IGCC cooperation, the first module, which is the imbalance netting mechanism between participating control, is currently in application. The transmission system operators from Belgium, Denmark, Netherlands, Czech Republic and Switzerland joined German transmission operators in 2012, while Austria entered the network in 2014. Annual savings that the IGCC cooperation participants can achieve is on the scale of 10 million euros. In addition to the IGCC cooperation, the INC cooperation (Imbalance Netting Cooperation) and the eGCC

cooperation have been implemented in continental Europe. Participants in the INC cooperation are Austria and Slovenia. Austria participates in both the IGCC and INC cooperation, and while the INC cooperation enables a signal to be sent to the central optimization module every 2 seconds, the IGCC makes this happen every 4 seconds. The EGCC cooperation consists of Slovakia, Hungary and the Czech Republic, which, like Austria, participates in two regional cooperation programmes.

IMPLEMENTATION OF IMBALANCE NETTING IN THE SMM CONTROL BLOCK

The implementation of imbalance netting requires minimum harmonization of national balancing markets, and therefore can be seen as one of the potential forms of regional cooperation in near future in the SMM block (control block consisting of Serbia, Montenegro and Macedonia). The basic preconditions for the implementation of "imbalance netting" include:

– Synchronization of area control error measurements (ACE) and harmonization of balancing energy products for the exchange between participants in the mechanism

– Development of an optimization software platform whose main tasks will be to receive requests for activation of aFRR energy in all control areas participating in the mechanism, net received requests for activation in the optimization process considering transmission network limitations, and send back optimized request for activation of aFRR energy in each control area

– Development of a financial algorithm for determining settlement price and invoicing between participating transmission system operators Besides energy effects, economic effects of the implementation of imbalance netting in this particular example have also been considered. Balancing markets in Montenegro and Macedonia are at an initial stage and still there is no market based mechanism for quantification of the amounts of balancing energy in use, while in Serbia balancing energy bids are not publicly available. For this reason, the indicators considered in this analysis provide insight into the potential benefits of establishing a market-based balancing mechanism in all SMM block countries and implementation of imbalance netting. Data from a study carried out for the Energy Community on the impact of regional balancing integration on electricity markets in Southeastern Europe will be used as a relevant source for the assessments of OP prices in a given region. The presumed OP price for upward regulation is 51.4 EUR / MWh, and for downward regulation amounts to 21.2 EUR / MWh.

Positive effects of imbalance netting implementation were observed in all the three simulations and the analyzed example. The savings observed for the SMM control block was in the range from 7.6% to 20%, depending on the scenario. In case of the cumulative calculation of activated balancing energy, the negative effect of imbalance netting implementation may be a cost increase for some of the participating transmission system operators; this is theoretically possible, but unlikely to happen. The possibility for this

occurrence can be decreased by introducing shorter settlement periods or totally avoided by running activated balancing energy separately depending on its direction. Setting up a regional cooperation between national balancing markets is one of the key current processes of development and more efficient functioning of electricity markets in Europe. As part of this process the ENTSO-E network code (EB NC) has been prepared, which deals with this issue, and aims to harmonize national balancing markets and subsequently brings about integration at a pan-European level.
The imbalance netting mechanism is one of the target models for balancing market integration, and has been successfully applied by 13 transmission system operators as part of three regional cooperation programmes in continental Europe (IGCC, INC EGCC). This mechanism is based on an exchange of unplanned “surplus” and “deficit” in control areas in order to prevent the counter activation of balancing energy. Imbalance netting requires a low level of harmonization of national balancing markets, and therefore represents one of the mechanisms of regional cooperation which can be applied first, considering its advantage over other existing target models for balancing market integration. Because of these benefits, this paper reviews the possibility of implementing imbalance netting inside the SMM control block. Analyses conducted using real data for a typical day revealed existence of practical benefits both in energy terms (reducing the engagement of production units for covering the imbalance of control areas), and in terms of economics, with evident monetary savings from implementing such a mechanism. Regarding economic indicators, one should keep in mind that the introduction of shorter settlement periods or separate direction-dependent runnings of activated balancing energy give greater benefits for all transmission system operators participating in the imbalance netting mechanism.