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Optimizing Net Transfer Capacity Calculation in Albania and the Shift Towards Coordinated Approaches between Western Balkans Transmission System Operators

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ABSTRACT

Following evolving electricity markets, Transmission System Operators face challenges in processes of Net Transfer Capacity calculations. Increasing uncertainties stemming from growing electricity trade exchanges, make traditional monthly calculations obsolete. To enhance system stability, the paper proposes an implementation of a fast capacity calculation method aligned with day-ahead market principles. The study discusses capacity calculation regions aligning with European Legislation, particularly examining the Albanian Power System as a case study and introduces an improved approach to net transfer capacity calculations. The paper proposes and implements a Python algorithm to automate the net transfer capacity calculation process, obtaining improved efficiency in the calculation process. The paper emphasizes the importance of ensuring power system security, promoting cross-border trade, and easing market developments, offering a practical solution to the problem of net transfer capacity calculation.

KEYWORDS

NTC, Implicit auction, Power exchange, Control area, Day ahead market.

INTRODUCTION

The primary objective of Transmission Operators is to ensure power system security while facilitating cross-border trade with neighbouring systems [1]. The link between power system security and cross-border trade lies in the shared reliance on interconnected electrical power

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systems. Power systems must guarantee a stable and secure provision of electricity, ensuring it meets consumer demand while maintaining a satisfactory level of electricity quality [2]. Interconnection lines provide the required cross border capability to exchange electricity between systems, i.e., an importing and exporting system, with different energy sources or in case one of the systems is lacking completely generation capacity. The importance of interconnection lines and cross-border trade is paramount in guaranteeing a stable and secure power supply [3]. Transmission Operators have the specific responsibility of ensuring adequate transmission capacity, both internally and cross border, to accommodate market trade schedules according to Mohammed *et al.* [4]. Concurrently, they must ensure that security standards are consistently met to always safeguard the power system.

Insufficient transmission capacity necessitates the operator to limit electricity demand or power generation, resulting in a notable decrease in social welfare [5]. The capacity calculation problem aims to identify the optimal cross border allowed exchange to meet market participants needs for transactions [6]. A satisfactory capacity calculation process in a power system is crucial to ensure open and non-discriminatory access for all market players to the transmission network. Consequently, enhancing capacity calculation becomes imperative, offering benefits to both suppliers and consumers by minimizing congestion and improving power system security [5].

The increase of cross-border trade places high loading on interconnection lines, leading to a situation called network congestion [7]. This congestion, in turn, constrains the flow of electricity trade. In the electricity market, congestion in the transmission systems can significantly limit power flows [8], [9]. Congestion occurs when the demand for transferring electrical power surpasses the transmission system's available transmission capacity, indicating situations where unrestricted network utilization would pose a risk to the system's security [10]. To mitigate the risk of overloading the transmission system due to cross-border energy transfers and the associated threats to network security, there is a need for a well-coordinated capacity calculation and allocation mechanism [11]. A coordinated capacity calculation mechanism ensures the efficient allocation of transmission capacity, striking a balance between the cross-border capacity introduced into the market and the security of power supply. Besselink *et al.* [12] explain that Transmission System Operators (TSOs) will encounter increased volatility and intermittent generation, along with increased liquidity, which requires fast calculation and novel methodologies, necessitating the implementation of advanced procedures.

Cartaxo *et al.* [13] state TSOs collaborate to determine the available interconnection capacity for day-ahead and intraday markets, facilitating price-based market coupling across countries and regions. The coordination of capacity calculation is crucial for optimizing the utilization of electricity from renewable sources and ensuring the effective distribution of renewable energy benefits throughout Europe, in the same time achieving clean energy targets 42.5% set in the latest European Union (EU) directive [14].

The current practice among the 6 Western Balkan Transmission System Operators is to perform this calculation on a monthly period and apply the results throughout the entire month. This process is executed using a predefined scenario for the third Wednesday of each month in simulation tools in “Union for the Coordination of Transmission of Electricity” (UCTE) format [15]. While historically robust, the evolving electricity markets present new challenges, which need to be addressed [16]. In today's electricity market, each country is developing its power exchange for electricity, with the common objective of joining the “Single Day Ahead Coupling” (SDAC) initiative in Europe [17], [18]. With numerous evolving trades and schedules, the number of uncertainties for the TSOs has already increased, rendering the monthly calculation of Net Transfer Capacity (NTC) obsolete, and putting the power system stability at risk [4]. To mitigate the risk, a more dynamic method of NTC calculation is needed, aligning with the methodology for the day-ahead market timeframe outlined in Article 21 of

"Commission Regulation (EU) 2015/1222" [19]. There are two problems that arise and need to be defined:

- Capacity Calculation Region (CCR) definition [20].
- The shift from the current method for NTC calculation, from bilateral to composite NTC calculation and further to coordinated NTC.

In this paper, the second problem will be analysed in detail, by comparing both cases of application of the method, bilateral NTC vs composite NTC.

The paper is structured into the following subtopics: introduction of the topic, discussion about Capacity Calculation Regions (CCRs), a general overview with relevant information for the Albanian Power System, followed by problem formulation and the method used to perform calculations and address the problem. Finally, the discussion is presented, and conclusions are outlined.

Based on the decision of the Agency for the Cooperation of Energy Regulators No 06/2016 of 17 November 2016, on the electricity transmission system operator's proposal for the determination of capacity calculation regions CCR 10 is the official SEE capacity calculation region, consisting of EU TSOs: ADMIE, TRANSELECTRICA and ESO EAD [20]. To include Non-EU TSOs from the SEE region in the coordinated capacity calculation process, Shadow CCR 10 region is defined in the decision of D/2022/03/MC-EnC decision of the Ministerial Council of the Energy Community on 15 December 2022 as shown in Figure 1. Shadow CCR 10 includes the WB6 TSOs (CGES, EMS, KOSTT, MEPSO, NOS BiH, and OST) and CCR 10 TSOs, as well as borders to neighbouring TSOs MAVIR, HOPS, and TERNA.

Figure 1. Capacity Calculation Regions (CCRs) in SEE [20]

METHOD

Net Transfer Capacity (NTC) is a crucial factor in ensuring the reliability and security of the electricity market. According to the current practice in the SEE region, the method based on NTC is used by all SEE TSOs. The basic definitions of NTC [27], [28] and related parameters is as follows.

Net Transfer Capacity [NTC], is the maximum exchange program between two neighbouring TSOs considering the security standards applicable in all control areas of the synchronous area, as well as considering the technical uncertainty associated with the prediction of the operational conditions of the network, it is calculated according to the formula:

$$\mathrm{NTC} = \mathrm{TTC} - \mathrm{TRM} \tag{1}$$

Total Transfer Capacity [TTC], is the program of the maximum exchange between the control areas accompanied by the safety standards of operation in both systems, based on the available information on the expected operation of the network, including the generation and load:

$$\mathrm{TTC} = \mathrm{BCE} + \Delta E_{\max} \tag{2}$$

Transmission Reliability Margin [TRM], is a part of the cross-border transmission capacity, necessary for the safe operation of the transmission system considering the inaccuracy of the calculation of the transmission capacities and the schedules that are based on them. This inaccuracy results from secondary adjustment operations, the need for emergency exchanges, and real-time deviations from schedule. Neighbouring TSOs jointly reconcile the TRM value [29].

The NTC methodology [20] is designed for computing cross-border capacities in a bilateral manner, wherein the power flow is directed from one export area to one import area. However, this approach may result in loop flows in highly interconnected grids (the case is Albania, Kosova, and Montenegro), thereby decreasing the quality of calculations. The classical bilateral approach is heavily reliant on the interdependence of borders within the meshed grid, which can significantly undermine its effectiveness. To address this, a composite approach can be used wherein several bidding zones are treated as one import/export area, dropping the drawbacks of the bilateral NTC calculation. Depending on the network interdependence of each border and direction with other borders, it is figured out whether to perform a composite or bilateral calculation. The CCR 10 method proposal and SEE TSOs' current practices dictate that composite NTC will be conducted on specific borders. The concept of composite NTC will be evaluated for the north borders of Albania. The calculation will be performed in Albania vs (Montenegro, and Kosova) power systems.

The current NTC procedure mandates that the network representation should be as comprehensive as possible, encompassing all network elements. The N-1 criterion is currently employed by all SEE TSOs to evaluate system security.

To start the procedure, individual transmission models are shared and merged to form the base case model, including estimates of generation and load patterns for cross-border exchanges. All TSOs must use the base case model representing the analysed power system [30], [31]. The NTC values for each border are calculated using the base case model. This involves incrementing the generation in one country while simultaneously reducing it in another, following a predetermined step. Security criteria must be checked for both countries during each load flow calculation (N-1 criterion for each control area) [32], [33] . The process concludes when a security violation occurs in one country. The load flow calculations are performed by neighbouring TSOs interested in their shared border. Each TSO computes load flows for different generation shifts and verifies the security criterion N-1. TSOs determine the network they intend to analyse and which network elements to concentrate on by defining contingency lists and monitoring elements. While a TSO may evaluate only the 400 kV and 220 kV networks, it may also examine critical 110 (150) kV network elements. In case two TSOs derive different NTC values, they agree that the lower value will be used as the final one.

Capacity calculation in principle, is a process of defining the maximum transfer between Control Areas (CA) [34] , considering operational limits and system operation conditions. Firstly, a power system model is needed which includes several control areas, with enough modelling details for power system elements, to represent the static behaviour of the System. The next step is to shift the generation pattern by increasing generation in one control area and decreasing in the adjacent control area for which it has been defined the border where will perform the capacity calculation. The change in generation is done according to the following equations [35]:

$$P_{\mathrm{new}}^{\mathrm{inc}} = P_{\mathrm{i}} + \Delta E \frac{P_{\mathrm{i}}^{\max} - P_{\mathrm{i}}}{\sum(P_{\mathrm{i}}^{\max} - P_{\mathrm{i}})} \quad (3)$$

$$P_{\mathrm{new}}^{\mathrm{dec}} = P_{\mathrm{i}} + \Delta E \frac{P_{\mathrm{i}}^{\min} - P_{\mathrm{i}}}{\sum(P_{\mathrm{i}}^{\min} - P_{\mathrm{i}})} \quad (4)$$

Additional condition:

$$|\Delta E| \leq |P_{\mathrm{i}}^{\max} - P_{\mathrm{i}}| \quad (5)$$

$$|\Delta E| \leq |P_{\mathrm{i}}^{\min} - P_{\mathrm{i}}| \quad (6)$$

The calculation will continue until all generation has been exhausted and there is no more available generation in the power system where the increase of generation, or reciprocally in case there is no more generation to decrease in the adjacent area.

ALBANIAN TRANSMISION SYSTEM

Albania has a key location in the Balkans referring to the power system topology and next plans for integration of Energy markets. The transmission network of OST plays a significant role in the transfer of energy [21] from the direction of Greece and Macedonia/Bulgaria to Kosovo, Montenegro, and Italy. Besides the sea cable connection between Greece and Italy, a new cable connection is in operation between Montenegro and Italy.

The OST power system [22], [23], [24] consists of 400 kV, 220 kV, 110 kV voltage levels. OST network topology has a vertical profile, with the biggest power generation sources found in the north of the country and consumption centres located in the centre and the south of the country. In the north, the country has large hydro's which are owned by the public power corporation KESH sh.a. The large hydro plant owned by KESH has an installed capacity of 1350 MW [25]. Besides the large hydro's KESH also owns TPP Vlora. In the 220 kV network, there are also private HPP owned by AYEN, namely Peshqesh (28 MW) and Fang (72 MW) and Statkraft Moglica (180 MW), and Banja (70 MW). In recent years there have been many run-of-river hydropower plants connected to the Albanian power system, while most of them have been connected to 110 kV and distribution systems. All these exploitations of Albanian rivers and so an increase in installed generation capacity have led to a less dependent situation on imports for country adequacy. **Figure 2** shows that the installed capacity in the year 2022 is 2352 MW.

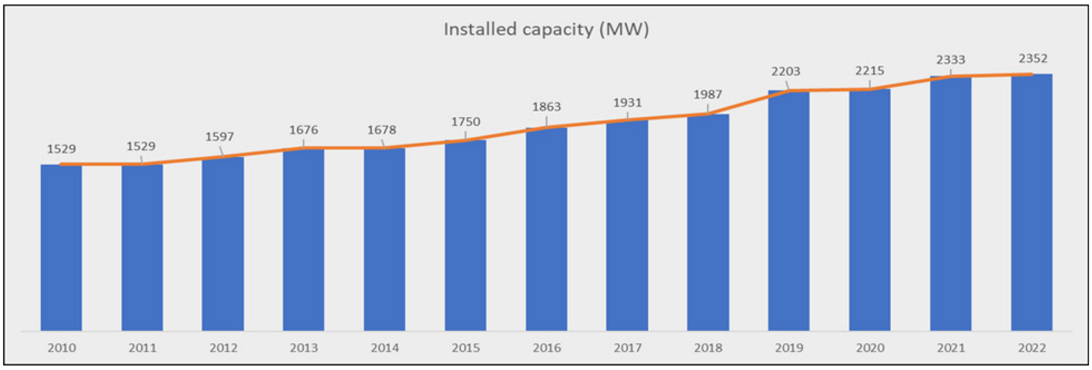

Figure 2. Installed Generation capacity (OST Yearly Report)

OST power system up to now has the following Net Transfer Capacities [26] with neighbouring countries:

Table 1. Current NTC values for OST borders

Control Areas	Net Transfer Capacity [MW]	
	NTC	TRM
Albania-Montenegro	300	100
Montenegro-Albania	300	100
Albania-Kosovo	400	100
Kosovo-Albania	400	100
Greece -Albania	400	100
Albania-Greece	400	100

The current NTC values in Table 1 show that the existing network can accommodate approximately 1100 MW in the export direction and 1100 MW in the import direction, which is sufficient for the needs to cover demand or in cases high production from hydropower plants in periods of high inflows.

Based on the information collected from the transmission operator OST, the major bottleneck in the network which affects the values of the Net Transfer Capacities, leading to the above-mentioned NTC values are the following elements:

a) OHL 220kV tie line Koplik-Podgorica1.
b) OHL 220kV tie-line Fierza-Prizren.
c) OHL 220 kV Vau Dejes – Koplik.

RESULTS AND DISCUSSION

Optimizing the NTC calculation process can be a challenging task, given its time-consuming nature and the multitude of actions involved in simulation tools. To enhance efficiency, an algorithm has been proposed and implemented in the Python programming language, utilizing a PSS/E simulation engine (version 33.10) to execute simulations and obtain NTC calculation results. The proposed method underwent testing using data provided by the Albanian TSO in .raw format, which was verified for plausible power flow convergence in PSS/E compared to actual values measured in the SCADA System. However, the models obtained from the TSO exhibited inaccuracies in element modelling and total active and reactive power flow balance. To proceed with assessing the developed NTC calculation algorithm, it became imperative to achieve a "good" quality of power flow convergence in the base case scenario. This means, to achieve the solution in very few iterations in Newton Raphson iterative method implemented in PSS/E software, whereas the recommended setting [36] in PSS/E is to limit 20 iterations to the power flow solution. If the base case scenario lacks quality, there is a possibility that, during the iterations in N-1 scenarios throughout NTC calculation, the calculation may halt at a low power transfer value between control areas. Such conditions could lead to the failure of the entire calculation and yield undesirable results. Therefore, obtaining a good convergent solution in such an extensive network is crucial for assessing the NTC algorithm. Once a convergent solution was achieved in the base case scenario, efforts were made to assess the NTC algorithm.

Since the electrical power system operates in synchronous parallel, power system models of nine countries were used in the simulation to obtain dependencies between power systems and represent in detail all flow between control areas. These countries include Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo, North Macedonia, Serbia, and Montenegro. The chosen base case scenario is assumed to be representing each country the most common operating conditions based on historical data. The use of an automation algorithm in the NTC calculation process has proven to be a valuable tool in optimizing the process and improving efficiency.

With this new method, the number of calculations required for NTC calculation has been reduced, and the time required for the process has been significantly decreased. The implementation of the proposed algorithm in the Python programming language, with the PSS/E simulation engine, has made the process of NTC calculation more accessible to engineers and researchers in the field. By automating the process, engineers can spend less time on manual calculations and more time analysing the results to optimize the electrical power system. Overall, the proposed method of NTC calculation through an automation algorithm in the Python programming language with a PSS/E simulation engine has proven to be an efficient and valuable tool in the field of electrical power system optimization. The scenario chosen to test the developed algorithm, in the base case scenario, has operating conditions and balance for each control area represented in **Table 2** (the minus sign means import, positive number in exchange means export). **Table 2**, represents the operating conditions of the model used in the analysis, showing the total generation of electricity in each Control Area (including renewable energy sources), the sum of electricity exchange in all interconnection lines and the total load of each power system.

Table 2. Power System Model Balance

Control Areas	Balance data		
	Generation [MW]	Exchange [MW]	Consumption [MW]
Albania (OST)	832	-391	1189
Bosnia (NosBiH)	1726	400	1320
Bulgaria (ESO)	4345	400	3899
Croatia (HOPS)	592	-715	1292
Greece (IPTO)	7565	-700	8014
Kosovo (KOSTT)	860	-425	1258
Montenegro (CGES)	703	482	209
N. Macedonia (MEPSO)	529	-414	928
Serbia (EMS)	5038	100	4938

Using the Python script shown in the Appendix, with the PSS/E software engine, it was possible to perform bilateral and composite NTC. It can be observed in **Table 3**, that in the case of the border Albania-Montenegro, the results obtained from the script are the same as the current official values used by the TSO. In the case of Albania-Kosovo, the obtained values average 400 MW. On the contrary in the border Albania-Greece, the obtained values are much higher compared to the values used by the TSO. The explanation for the high values on the border with Greece is that the TSO of Greece uses composite calculation, while bilateral calculation has been done and reported in **Table 3**. The TSO of Greece performs the composite calculation for the borders of Greece vs (N. Macedonia, Albania, Bulgaria, and Turkey); hence different values have been obtained. **Table 4**, shows the results of the composite calculation for the north borders of the

Albanian Network. It can be observed that the values are lower than bilateral NTC because the calculation considers simultaneously operational limits in three power systems.

Table 3. Bilateral NTC Calculation Results

Control Areas	NTC [MW]
Albania-Montenegro	324
Albania-Greece	843
Albania-Kosovo	605
Montenegro-Albania	292
Greece -Albania	802
Kosovo -Albania	268

Table 4. Composite NTC Calculation Results

Control Areas	Direction	NTC (MW)
Albania - (Montenegro, Kosova)	Export	405
(Montenegro, Kosova) - Albania	Import	405

Comparing the analysis results, it is evident that the bilateral NTC calculation fails to account for loop flows, which are clearly present in the model. These loop flows pose a risk to the safe operation of the power system, and their existence, along with unaccounted loop flows, can jeopardize system security [37]. Unaccounted loop flows may result in congestion, voltage instability, and thermal overloads, posing operational challenges and increasing the risk of cascading failures. In contrast, the composite NTC method considers loop flows in its calculations, resulting in lower values compared to the bilateral methodology. The use of composite NTC estimates cross-border capacity under safer conditions for system operation and reduces the likelihood of grid disturbances. However, the effectiveness of the composite NTC method hinges on the accuracy of the input data and model parameters. Each element within the power system, including generators, transformers, and transmission lines, must be correctly modelled to obtain reliable power flow solutions and accurately detect loop flows. Any discrepancies or inaccuracies in the modelling process can compromise the validity of the NTC estimates and undermine the effectiveness of the composite method. In summary, correct modelling is essential for ensuring the reliability, security, and efficiency of power system operations. By accurately representing the system's components and behaviours, engineers can mitigate risks, optimize performance, and make informed decisions to support the reliable supply of electricity to consumers.

CONCLUSION

Calculating the transmission capacity is a crucial process for the Transmission Operator, ensuring that the transmission systems adhere to security criteria [38]. The significance of NTC calculation extends to the efficient functioning of the electricity market, providing precise and dependable information regarding the quantity of electricity transferable through interconnection lines connecting different power systems. Additionally, Net Transfer Capacity calculation plays a pivotal role in fostering cross-border electricity trade, particularly considering market developments in Albania with the establishment of ALPEX.

By supplying accurate information about the amount of electricity that can be transferred between countries or regions, NTC calculation helps to facilitate the buying and selling of energy across national borders. This has the potential to enhance competition in the electricity market, resulting in decreased prices and improved overall efficiency. To ensure the security of the power system, this paper introduces an efficient method for conducting complex NTC calculations swiftly. The algorithm developed in Python and PSS/E holds the potential to assist the Albanian Transmission Operator in managing its daily business processes.

This paper demonstrates that the bilateral method for NTC calculation yields higher values in comparison to the composite method. This observation is in line with common understanding, as the bilateral NTC calculation concentrates on individual power systems, resulting in higher values. Conversely, the composite NTC method combines multiple power systems into one, resulting in reduced Net Transfer Capacity (NTC) values. In the Albanian context, it has been confirmed that the composite NTC approach produces lower NTC values. However, it provides the advantage of meeting security criteria by considering loop flows from neighbouring systems, addressing a limitation of the bilateral NTC calculation. The shift toward coordinated NTC calculation requires collaboration with other Transmission System Operators (TSOs), and this progression should be carried out in distinct phases.

Conducting coordinated Net Transfer Capacity calculation necessitates the exchange of Individual Grid Models (IGMs) between Transmission System Operators (TSOs) during the D-2 timeframe. This allows ample time for NTC calculation, which will then be utilized in the D-1 phase for market allocation. As outlined in the introduction, the existing monthly process is insufficient to support the demands of D-2 NTC calculation. Therefore, TSOs should collaborate and engage in IGM exchange and merging, particularly in the D-2 timeframe, considering the evolving landscape of electricity markets, including the presence of power exchanges and the establishment of ALPEX in Albania.

NOMENCLATURE

P_{i}	Actual active power injection	[MW]
$P_{\mathrm{new}}^{\mathrm{inc}}$	New increased injection, in next iteration it will be P_i	[MW]
$P_{\mathrm{new}}^{\mathrm{dec}}$	New increased injection, in next iteration it will be P_i	[MW]
ΔE	Shift generation, negative for increasing and positive for decreasing.	[MW]
$P_{\mathrm{i}}^{\mathrm{max}}$	Maximum permissible generation	[MW]
$P_{\mathrm{i}}^{\mathrm{min}}$	Minimum permissible generation	[MW]

Abbreviations

ALPEX	Albanian Power Exchange
BCE	Base Case Exchange
CCR	Capacity Calculation Region
DAM	Day Ahead Market
KESH	Albania Power Generation Corporation
NTC	Net Transfer Capacity
PSS/E	Power System Simulator for Engineers
SDAC	Single Day Ahead Market
SEE	Southeast Europe
TSO	Transmission System Operator
TRM	Transmission Reliability Margin
TTC	Total Transmission Capacity
UCT	Standard for Model Data Exchange between TSOs
WB6	Western Balkan 6

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APPENDIX

Extract of python script used for the study:

```
# Python script for NTC Calculation in PSSE
from itertools import groupby
from operator import itemgetter
attr_type = itemgetter(0)
#-------------------------------------------------USER INPUTS-------------------------------------
#User Input - UI_01
area_1_UI = 10
#User Input - UI_02              # area_1, area_2 -> Area Num
area_2_UI = 38                   #        -> 10 - AL
                        #        -> 11 - AT
                        #        -> 13 - BA
                        #        -> 14 - BG
                        #        -> 16 - HR
                        #        -> 30 - GR
                        #        -> 31 - HU
                        #        -> 37 - MK
                        #        -> 38 - ME
                        #        -> 44 - RO
                        #        -> 46 - RS
                        #        -> 47 - KS
                        #        -> 48 - SK
                        #        -> 49 - SI
                        #        -> 54 - TR
                        #        -> 60 - UA
#User Input - UI_03
# area_crossborder -> Area Num area_crossborder_UI = 1038
#        -> 1030 - AL--GR
                        #        -> 1032 - AL--IT
                        #        -> 1037 - AL--MK
                        #        -> 1038 - AL--ME
                        #        -> 1047 - AL--KS
                        #        -> 1126 - AT--DE
                        #        -> 1131 - AT--HU
                        #        -> 1149 - AT--SI
                        #        -> 1316 - BA--HR
                        #        -> 1338 - BA--ME
                        #        -> 1346 - BA--RS
                        #        -> 1430 - BG--GR
                        #        -> 1437 - BG--MK
```

```
#           -> 1444 - BG--RO
#           -> 1446 - BG--RS
#           -> 1454 - BG--TR
#           -> 1631 - HR--HU
#           -> 1632 - HR--IT
#           -> 1646 - HR--RS
#           -> 1649 - HR--SI
#           -> 3032 - GR--IT
#           -> 3037 - GR--MK
#           -> 3054 - GR--TR
#           -> 3144 - HU--RO
#           -> 3146 - HU--RS
#           -> 3148 - HU--SK
#           -> 3149 - HU--SI
#           -> 3160 - HU--UA
#           -> 3238 - IT--ME
#           -> 3249 - IT--SI
#           -> 3746 - MK--RS
#           -> 3747 - MK--KS
#           -> 3846 - ME--RS
#           -> 3847 - HU--KS
#           -> 4446 - RO--RS
#           -> 4460 - RO--UA
#           -> 4463 - RO--MD
#           -> 4647 - RS--KS
#           -> 4860 - SK--UA

#User Input - UI_04
country_code_UI = "AL"

#User Input - UI_05
accc_tolerance_UI = 1.0
# Default convergence tolerance = 1.0MW
#------------------------------------------------Step-----------------------------------------------------
#User Input - UI_06
deltaE_step_UI = 100
#---------------------------------WORKING .sav file, PATH----------------------------------------
#User Input - UI_07
sav_filename_UI = "AL-ME-KS-BA1.sav"
#User Input - UI_08
Active_user = "e.voshtina"
case_directory_UI = r"G:\\My Drive\\Fakulteti\\PhD-Elio\\05.PaperSDEWES\\SIM" %
Active_user
# directory for other input files (.mon, .con,...)
input_files_dir_UI = case_directory_UI
# output directory
output_files_dir_UI = case_directory_UI
```

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