TYNDP 2022

Regional Investment Plan

Continental South East

Final Version · May 2023

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ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association for the cooperation of the European transmission system operators (TSOs). The 39 member TSOs, representing 35 countries, are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E brings together the unique expertise of TSOs for the benefit of European citizens by keeping the lights on, enabling the energy transition and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

As the European TSO community, ENTSO-E and its members fulfil a common mission: ensuring the security of the inter-connected power system in all timeframes at the pan-European level, promoting the optimal functioning and development of the European interconnected electricity markets and enabling the integration of renewable energy sources and emerging technologies.

Our vision

ENTSO-E will play a central role in enabling Europe to become the first climate-neutral continent by 2050. It will create a system that is secure, sustainable and affordable and that integrates the expected amount of renewable energy, thereby making an essential contribution to the European Green Deal. This endeavour requires sector integration and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system that combines centralised and distributed resources. ENTSO-E acts to ensure that this energy system keeps consumers at its centre and is operated and developed with climate objectives and social welfare in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap toward a climate-neutral Europe.

Our values

ENTSO-E acts in solidarity as a community of TSOs united by a shared responsibility.

As a professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by optimising social welfare in its dimensions of safety, economy, environment and performance.

ENTSO-E is committed to working with the highest technical rigour, developing sustainable and innovative responses to prepare for the future and overcoming the challenges of power system security in a climate-neutral Europe. In all its activities, ENTSO-E acts with transparency and in trustworthy dialogue with legislative and regulatory decision-makers and stakeholders.

Our contributions

ENTSO-E supports cooperation among its members at the European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, successfully contributing to the achievement of EU climate and energy targets.

To carry out its legally mandated tasks, ENTSO-E's key responsibilities include the following:

› Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as the integration of renewable energy;

› Assessment of the adequacy of the system in different timeframes;

› Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);

› Coordination of research, development and innovation activities of TSOs;

› Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the implementation and monitoring of the agreed-upon common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This section of the Regional Investment Plan serves as an introduction to the document itself by providing an overview of its contents and conclusions. The document is divided into seven chapters, each with its own subject and purpose. These are followed by the three Appendices found near the end of the Regional Investment Plan.

Chapter 1 can be considered a continuation of this Executive Summary. While the Summary contains the overview of the plan's contents and the goals of each of its sections, the first chapter includes the key messages of the region. It highlights the challenges that the region is bound to face in the upcoming period, as well as the main improvements and changes that are foreseen by the results of the TYNDP process; the IoSN plays a particularly important role in this step.

Chapter 2 explains the motivation for this document by underlining both the legal obligations governing the Regional Investment Plans in the context of the TYNDP package and the benefits that the TSOs gain from these plans. Indeed, the plans are a unique opportunity for the TSOs to provide their view on the development of the CSE region and to emphasise the importance of projects and investments that would otherwise be completely overlooked from an international perspective.

Chapter 3 describes the present situation in the CSE region, including both a description and a comprehensive map of the region itself. It presents a list of the main changes that have occurred in the region since the publication of the previous edition of the Regional Investment Plan. These changes are portrayed in both tabular form and graphical form on a map that was specifically designed for this role. The chapter demonstrates the activities that the TSOs have undertaken in the last two years to move towards the commonly set goals of the European transmission system operators, including integrating the electricity market, integrating massive renewable energy capacities and increasing the security of the energy supply for consumers.

Next, Chapter 4 gives an overview of the outcomes of the IoSN process relevant to the CSE region. The two sections within this chapter are dedicated to the two time horizons considered in the IoSN procedure. Hence, the first section focuses on the year 2030, beginning with a map showing the recommended increases in NTC values in the region through 2030 and continuing with diagrams containing the values of several indicators relevant to the operation of the systems. These diagrams show the same indicators – including CO_2 emissions, the generation mix and the annual exports and imports of energy for the countries in the region – for three separate cases: 'no grid' (no reinforcements of the grid compared to the current state), 'TYNDP portfolio' (the projects assessed in TYNDP with the commissioning year before 2030 are considered completed) and 'IoSN grid' (all of the recommended grid reinforcements are operational by 2030), enabling straightforward comparisons. The second section of Chapter 3 provides the same set of maps and indicators for the year 2040.

Chapters 5 and 6 are somewhat connected to each other. Chapter 5 shows the future challenges that the region will face in the upcoming period, based both on the results of the IoSN process and the information obtained from the TSOs themselves. It discusses how the results of the IoSN process are used in the individual TSOs, with a particular focus on the studies that the TSOs have initiated to explore how the suggested grid improvements may be achieved in a timely way. To build upon this, Chapter 6 focuses on each of the regional studies that is in process or has been completed. The first section discusses the UA/MD connection sensitivity study, the second and third are dedicated to one cycle of the SECI TSP (a regional initiative for coordinated system planning) and the fourth and final section describes the main outcomes of the SINCRO.GRID project.

Finally, Chapter 7 provides a list of the infrastructure projects in the CSE region. The first part of the chapter includes a comprehensive list of projects in the region that were submitted for assessment within the scope of TYNDP. The second part (which also concludes the main text of this Regional Investment Plan) lists the projects in the region that were not submitted for presentation in the TYNDP but were nonetheless seen by the TSOs as sufficiently important to be included in the Regional Investment Plan. These projects' inclusion allows them to gain at least some international recognition and may, in the future, aid their completion by making it much faster and less complicated to secure finances for the projects.

There are three Appendices to this plan: the glossary, which can clarify the document for readers unfamiliar with the TYNDP process, a list of links to the Network Development Plans of the TSOs in the CSE region and, finally, a link to the simulation results that were used as the basis of both this document and the entire TYNDP package.

1. Key messages of the CSE region

The key messages of the CSE region are listed below. Readers who are particularly interested in any of these topics can turn to the appropriate section of the Regional Investment Plan for more detail. The list is as follows:

- *Increase of transfer capacities and market integration facilitation*: As is rather well known, the transmission network of the CSE region is somewhat sparse compared to the transmission grids of other regions under the ENTSO-E umbrella. For operational regimes that require high energy transits across the region, this can cause problems related to insufficient transfer capacities. Therefore, increasing the existing transfer capacities (both at the inter- and intra-system levels) is the highest priority for the TSOs in the CSE region. This effort is also important because market integration has been set as one of the goals for the development of the entire European grid; as a result, increasing the NTCs is a matter of vital importance as a prerequisite for the integration of the energy market. This is supported by the IoSN results shown in Chapter 4.

- *Massive renewable energy source integration*: Although there has been considerable progress in the process of integrating renewable sources in the CSE region compared to the state described in the previous Regional Plan, the exploitation of this type of generation unit could be enhanced even further if the appropriate extensive grid development is finalised. This necessitates major investments from the point of view of system operators, among other issues related to the need to decommission previously used thermal units. This type of new project may be a necessary precondition for certain countries to reach the set targets; regional insight into the topic is given in Chapter 5.

- *Necessity of stronger connection between the EU and West Balkan countries:* The West Balkans' location means that the countries belonging to it are surrounded by EU states. As a result, West Balkan countries represent a natural part of one of the main PCI electricity transmission corridors (NSI East Corridor). A number of analyses (primarily market simulations) have confirmed the need to increase transfer capacity between the West Balkan countries and the EU countries, both in the CSE region and some of the neighbouring regions. This is also visible in the IoSN results, shown in Chapter 4 of this document. For instance, increasing NTC on nearly all the borders of Serbia (which has common boundaries with EU countries including Bulgaria, Romania, Hungary and Croatia) would be economically justified (or cost-effective, as the commonly used term goes).

- *The effects of the stronger connection of the members of the CSE region to observers and other countries:* This point is seen in the large number of studies that were envisaged to analyse the topic. They include several studies related to the connection of Ukrainian and Moldovan power systems to the system of the CSE region. This connection would not only affect the state of the system in the region but would also change the benefits that could be expected from commissioning the planned projects in the CSE area. This could also be said, for example, for increasing the NTCs towards Turkey, as identified in IoSN.

2. Introduction to the Regional Investment Plan

As already stated in the Executive Summary, Chapter 2 contains basic information related to the motivation for drafting the Regional Investment Plans in general. Along with that, this chapter will provide a brief overview of the structure and scope of this document.

2.1. Legal requirements and link to the TYNDP package

The Regional Investments Plans are part of the TYNDP package and comply with Regulation (EU) 2019/943 (Articles 34 and 48), which requests TSOs to establish regional cooperation within ENTSO-E and publish a Regional Investment Plan biennially. In addition, TSOs may take investment decisions based on the Plans. Each Regional Investment Plan corresponds to one of the ENTSO-E SDC regions (shown in detail in Fig. 2-1).

Regional Investment Plans are part of the TYNDP 2022 package, which also includes the Scenario report and the System Needs study. The **Scenario Report** describes possible European energy futures up to 2050. It is used to test potential electricity and gas infrastructure needs and projects; the scenarios serve as a basis for the Regional Investment Plans to describe the future challenges of the region. The System Needs study investigates system gaps in the mid- and long-term time horizons (2030 and 2040) in the National Trends scenario. The present Plan further analyses, at both the regional and country levels, the capacity increases identified in the System Needs study.

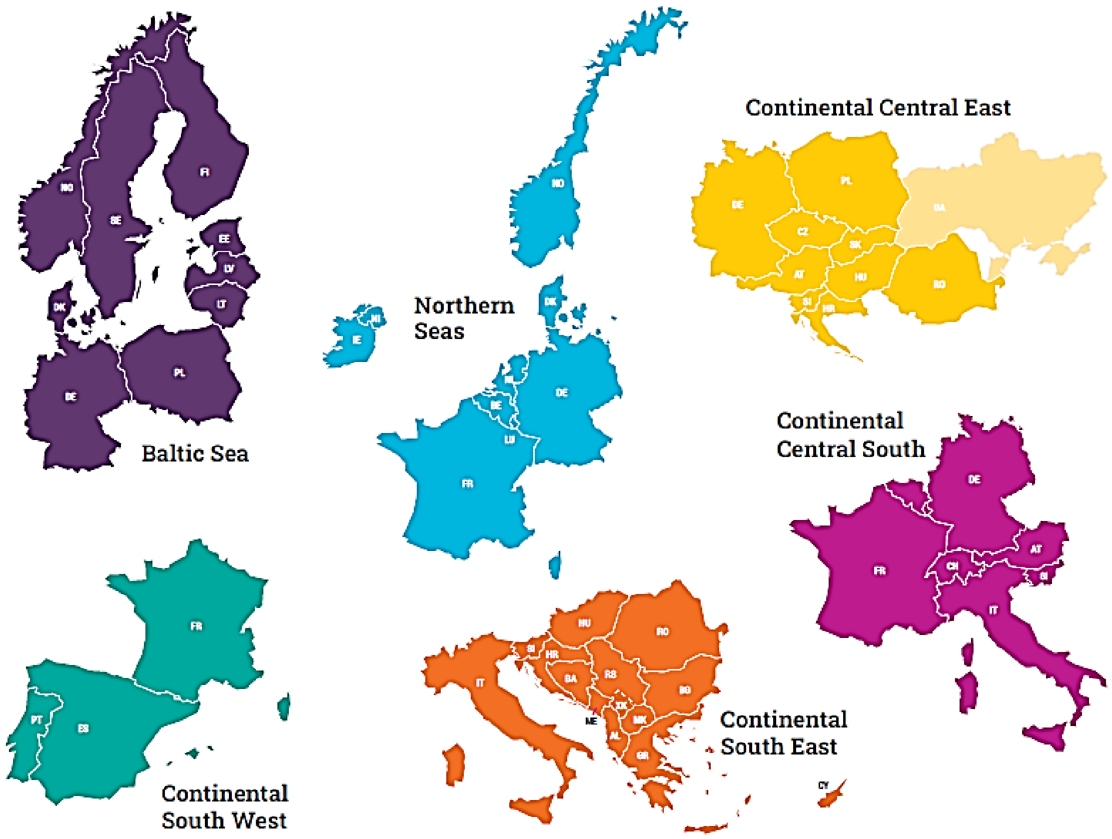

Figure 2-1: ENTSO-E's System Development regions.

2.2. Scope of the RegIP CSE 2022

Regional Investment Plans describe the present situation in each region and the future regional challenges for both the 2030 and 2040 time horizons. The Regional Investment Plans 2022 also investigate solutions to mitigate future challenges as well as the projections for necessary internal network reinforcements. In addition, this edition of the Plan includes a study roadmap for each of the regions, including ongoing and future studies that cover the priorities stemming from the 2040 System Needs analysis.

This document contains the following chapters:

- **Chapter 1** gathers the key messages of the region.
- **Chapter 2** outlines the legal requirements and scope of the Regional Investment Plans.
- **Chapter 3** provides insights into the present situation of the region.
- **Chapter 4** describes the identified regional system needs depending on the regional challenges.
- **Chapter 5** presents the future challenges facing the region, the necessary mitigation steps and the projections in terms of internal reinforcements. The study roadmap for the region is also included.
- **Chapter 6** is dedicated to additional region-specific analyses. For the CSE region, these analyses and studies include both cycles of the SECI TSP project (the completed one and the ongoing one), some information related to the UA/MD connection study and a description of the SINCRO.GRID project and its main achievements.
- **Chapter 7** contains a list of projects in the CSE region that were submitted for evaluation within the scope of the TYNDP 2022 package, a list of the PECI/PMI projects in the CSE region and, finally, a list of projects in the region that were not submitted for assessment in the TYNDP package but which the CSE TSOs deemed important to underline.

Finally, the Appendix includes the abbreviations and terminology used in the report, as well as links to the valid editions of the TSO's Development Plans and to the simulation results.

3. Overview of the CSE region

As noted near the beginning of Chapter 2 and graphically shown in Figure 2-1, ENTSO-E SDC includes six geographically determined regions. Each region corresponds to one of the Regional Investment Plans included in the TYNDP package. The regions are as follows:

- North Sea;
- Baltic Sea;
- Continental Central East;
- Continental South West;
- Continental Central South; and
- Continental South East.

The Continental South East (CSE) region covers the Balkan area and Italy. The members of the Regional Group CSE include the transmission system operators (TSOs) of Albania (AL), Bosnia and Herzegovina (BA), Bulgaria (BG), Croatia (HR), Cyprus (CY), Greece (GR), Hungary (HU), Italy (IT), Montenegro (ME), North Macedonia (MK), Romania (RO), Serbia (RS) and Slovenia (SI); Figure 3-1 shows these TSO's grids. Along with those, Operator Sistemi, Transmisioni dhe Tregu Sh.A - KOSTT (XK) also participate in the work of RG CSE, holding the observer status. Due to the importance that the development of the Turkish transmission grid holds for the CSE region, the TSO of Türkiye (TR), TEIAS, participates in the RG activities, including the drafting of this Regional Investment Plan.

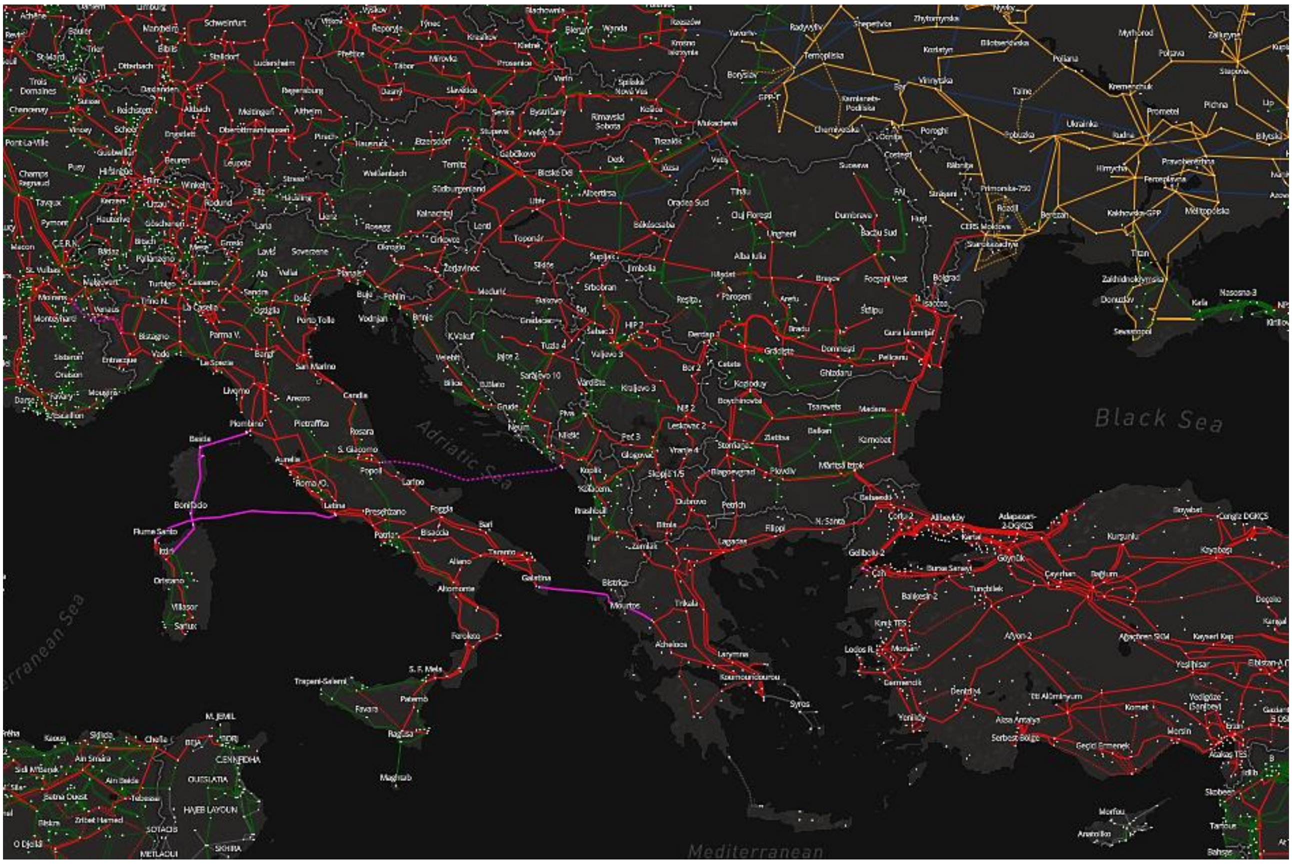

Figure 3-1: Map of the CSE region's grid.

Table 3-1 shows the identifiers of the TSOs with RG CSE membership status from each of the countries listed above. The left column contains the names of the countries in the region and the right one includes the respective TSOs of those countries.

Table 3-1: ENTSO-E SDC Regional Group CSE members.

Country	Company/TSO
Albania	OST
Bosnia and Herzegovina	NOS BiH
Bulgaria	ESO-EAD
Croatia	HOPS
Cyprus	TSOC
Greece	IPTO
Hungary	MAVIR
Italy	TERNA
Montenegro	CGES
North Macedonia	MEPSO
Romania	CN Transelectrica SA
Serbia	JSC EMS
Slovenia	ELES

The TSOs that were named in Table 3-1 are all involved in the functioning of the RG CSE, the selection of representatives to participate in the RG's meetings and the continuous realisation of the information and experience exchange mechanism, which was initiated in the scope of the RG's work.

3.1. Evolution of the region since RegIP CSE 2020

The previous edition of the Regional Investment Plan was published in 2020. As such, it was based on and aligned with the information and results given in TYNDP 2020. However, as is well known, two years can represent quite a long time in the environment of the constantly evolving system planning process. This is why this section, first introduced in RegIP 2020, gives an overview of the changes that have occurred in the CSE region in those two years. To do so, it will primarily focus on the projects that were either commissioned or have entered the construction phase during the timeframe of interest.

First of all, a number of significant projects have been completed in the region during the two years, strongly affecting load flows and increasing transfer capacities. These efforts have intensified market integration and enhanced the inclusion of renewable sources in the region's generation mix. The complete list of these projects, sorted by completion year and indicating the TSOs that benefitted, is provided in Table 3-2.

Table 3-2: List of the completed projects in the CSE region in the last two years.

Project name	Affected TSO in the region
Investment 1716 – Interconnection between Crete and Peloponnese (Phase I) – Part of Project 1055 – Interconnection of Crete to the Mainland System of Greece	IPTO
New SK–HU interconnection	MAVIR
The HU terminal of the 750 kV line to Zakhidnoukrainska (UA) was moved to new substation Szabolcsbáka	MAVIR
110 kV line Podgorica 4 – Podgorica 1	CGES
Project 227: Transbalkan Corridor (investment: 400 kV OHL SS Kragujevac 2 – SS Kraljevo 3, with upgrading SS Kraljevo 3 to 400 kV level)	CGES, JSC EMS, NOS BiH
New 220/110 kV SS Bistrica	JSC EMS
Upgrade of existing SS 220/110 kV Srbobran to 400 kV level	JSC EMS
Variable shunt reactor (VSR) with installed capacity of 100 MVAR in substation 220/110 kV Mraclin	HOPS
Variable shunt reactor (VSR) with installed capacity of 200 MVAR in substation 400/220/110 kV Melina	HOPS
Static var compensator (SVC) with installed capacity of 250 MVAR in substation 400/220/110 kV Konjsko	HOPS
400 kV OHL Oradea Sud (RO) – Nadab (RO)	Transelectrica, MAVIR
Variable shunt reactor (VSR) with installed capacity of 150 MVAR in substation 400/110 kV Cirkovce	ELES
Variable shunt reactor (VSR) with installed capacity of 150 MVAR in substation 400/220/110 kV Divaca	ELES
Mechanically switched capacity device (MSCDN) with installed capacity of 100 MVAR in 400/220/110 kV Divaca	ELES

Project name	Affected TSO in the region
STATCOM with installed capacity of 150 MVAR in substation 400/220/110 kV Bericevo	ELES

To accompany this, Table 3-3 lists the projects in the CSE region that reached the construction phase in the previous two years.

Table 3-3: List of the projects that reached the construction phase in the CSE region in the last two years.

Project name	Affected TSOs in the region
Project 138: Black Sea corridor	ESO-EAD, Transelectrica
Project 142: CSE4 (Investment 256 – New line between Maritsa East (BG) and Nea Santa (GR))	ESO-EAD, IPTO
Central Northern Italy	TERNA
South Balkan Corridor (construction of new 400 kV interconnection line Elbasan (AL) – Bitola (MK))	MEPSO, OST
Construction of 220 kV double-circuit line Tirana2 – Rashbull and reinforcement of 220/110 kV Rashbull substation	OST
Construction of new 400/110 kV Tirana3 substation and reinforcement of 110 kV Tirana ring	OST
Construction of new 220/110 kV Substation Shumat and 220 kV OHTL Shumat-Burrel	OST
Construction of new 400 kV line Elbasan – Fier and extension of 220/110 kV Fier substation	OST
Installation of new shunt reactor at 400 kV SS Tirana2	OST
Slovenia-Hungary/Croatia interconnection (Double 400 kV OHL Cirkovce – Heviz (HU)/Zerjavinec (HR))	ELES, HOPS, MAVIR
Investment 1717 – Interconnection between Crete and Attica (Phase II) – Part of Project 1055 – Interconnection of Crete to the Mainland System of Greece	IPTO
Project 227: Transbalkan Corridor (investment: 400 kV OHL SS Lastva – SS Pljevlja 2)	CGES, JSC EMS, NOS BiH
Increasing transmission capacity by replacing the wires on the 220kV OHL Stejaru (RO) – Gheorghieni (RO) with a higher thermal capacity	Transelectrica
Increasing transmission capacity by replacing the wires on the 220kV OHL Fântânele (RO) – Gheorghieni (RO) with a higher thermal capacity	Transelectrica

Project name	Affected TSOs in the region
New 400 kV substation Resita (T400/220 kV 400 MVA + T 400/110 kV 250 MVA), as development of the existing 220/110 kV substation	**Transelectrica**
Completion of 220 kV substation Timisoara and partial replacement with 400 kV substation	**Transelectrica**

3.2. Present situation in the CSE region

Following the practice established in some previous editions of the RegIPs, this part of the document describes the current situation in the CSE region. This will both provide the reader with a better comprehension of the regional situation and establish a basis for comparisons with the state of the system foreseen in the encompassed time horizons.

First, Figure 3-2 shows the number of interconnections on each of the borders in the region. As can be seen, the AC voltage levels present in the CSE region are 400 kV, 220 kV and 110 (to 150) kV. The DC is represented by two lines connecting Italy to the Balkan Peninsula (specifically, to Greece and Montenegro).

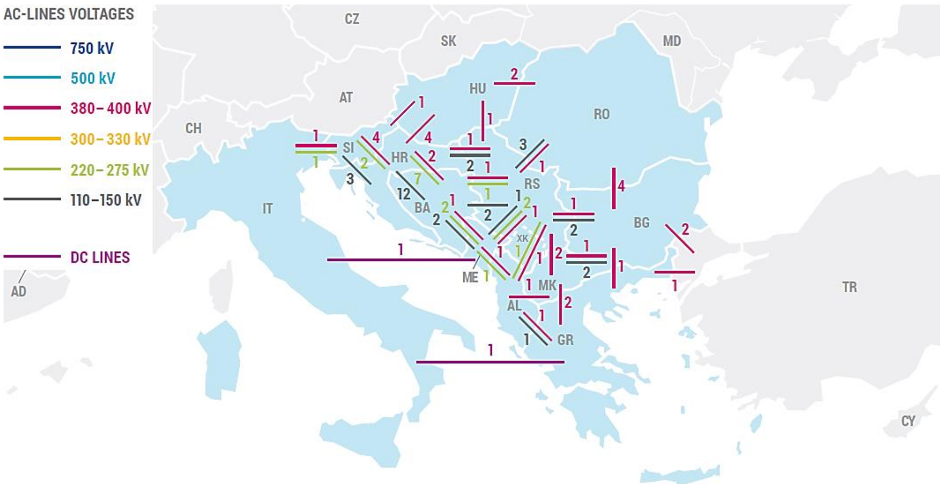

Figure 3-2: Number of interconnectors on borders in the CSE region.

The next parameter is the values of NTCs on the borders in the CSE region (Fig. 3-3). These NTC values take 2020 as the reference year and, for unification purposes, use data corresponding to the Mid-Term Adequacy Forecast (MAF) 2018. Hence, there may be some discrepancies between the values shown below and the measured NTC values for this year.

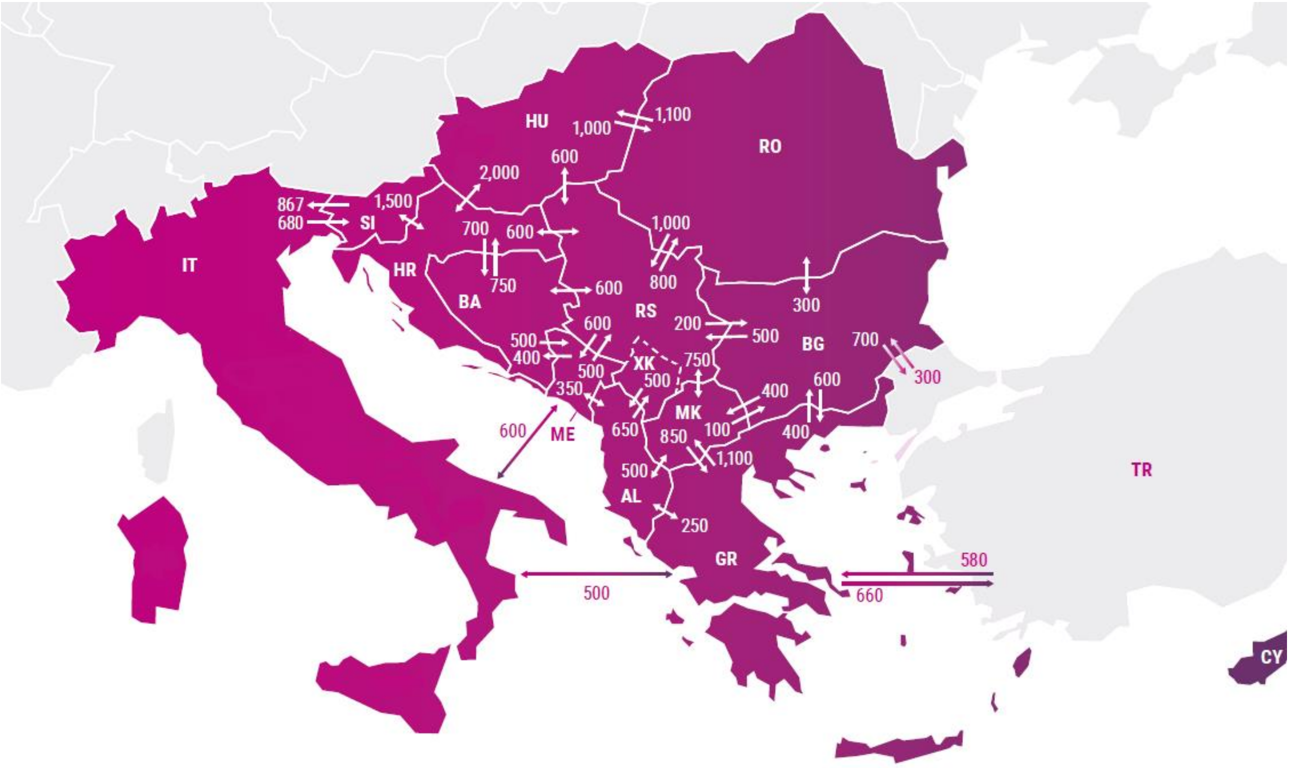

Figure 3-3: NTC values on borders in the CSE region.

With the values of the NTCs known, the next logical step is to illustrate the cross-border physical energy flows corresponding to those values. This is done in the bar diagram in Fig. 3-4; to allow parallel analysis, three different colours mark the values relevant for each of the included years (2010, 2019 and 2020). Comparing the 2010 values and the values for the remaining years provides an overview of the evolution of energy exchange in the CSE region in the past decade, whereas comparing the 2019 and 2020 values illustrates the effects of the COVID-19 pandemic on energy exchange in the region.

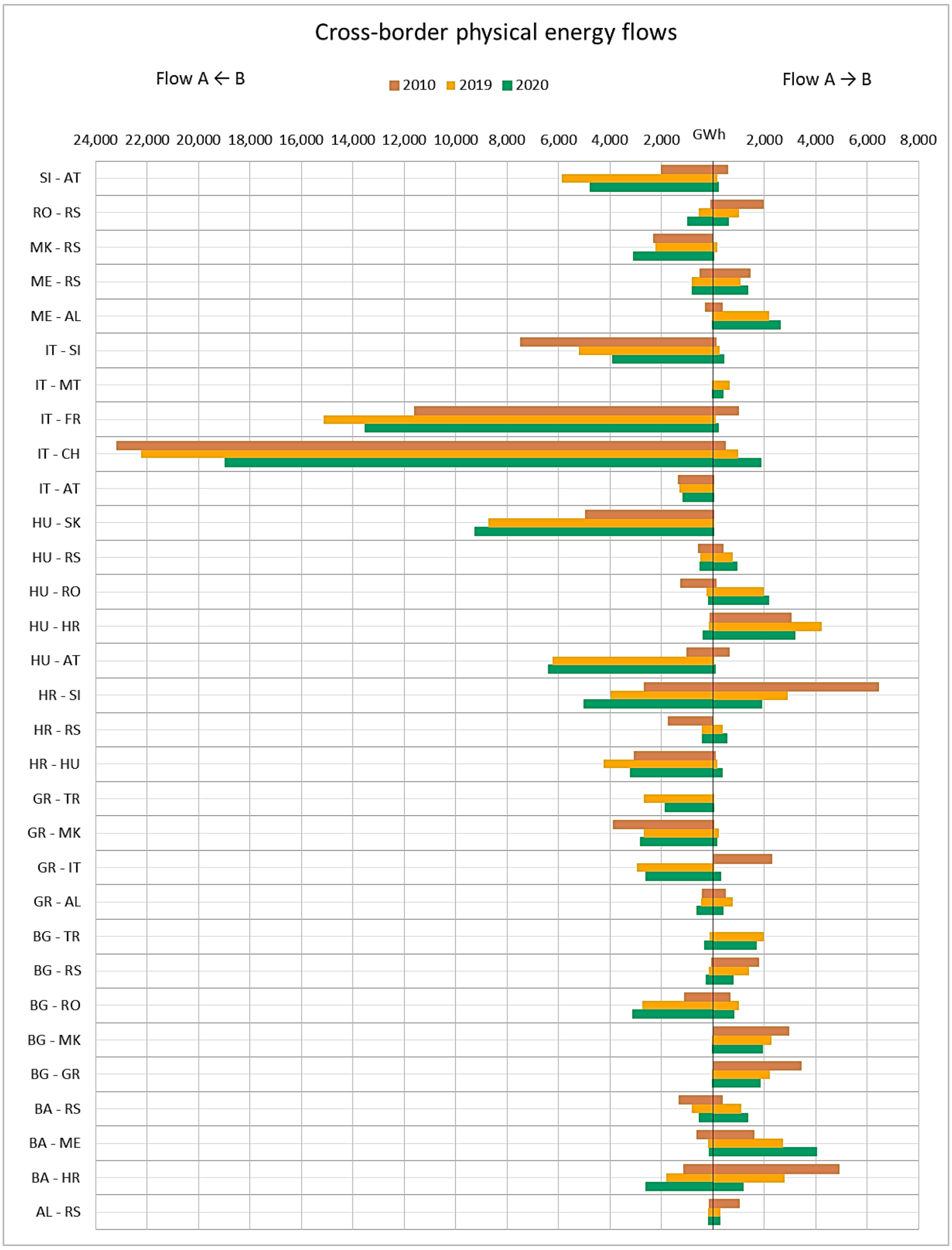

Figure 3-4: Cross-border energy flows in the CSE region.

This analysis shows that even though the timeframe covered by the diagram given above is ten years long, the energy exchanges in the CSE region did not undergo major modifications during that interval. Indeed, most flows that were prominent in 2010 remain so both in 2019 and 2020. Exceptions to this rule can, of course, be found, such as the doubling of the flows from Romania to Bulgaria in 2020 compared to 2010. Nevertheless, most cross-border energy exchanges behaved in accordance with this general conclusion.

In addition, changes in the direction of flows across the same border are somewhat interesting, especially in cases where the total amount of energy exchanged remained almost unchanged. One such case is found on the border between Bosnia and Herzegovina and Croatia. In 2010, energy flowed overwhelmingly away from Bosnia and Herzegovina towards Croatia, but the direction had almost completely reversed by 2020. A similar situation can also be observed for the Croatian border with Slovenia, with the flows turning towards Croatia over time. Also, it is particularly remarkable that there was no substantial difference in the energy flows (both in terms of direction and intensity) between 2019 and 2020. This means that the COVID-19 pandemic did not have any relevant impact on the values of this indicator in the CSE region. Fig. 3-5 provides a map of the energy flows for 2020 shown in the previous table.

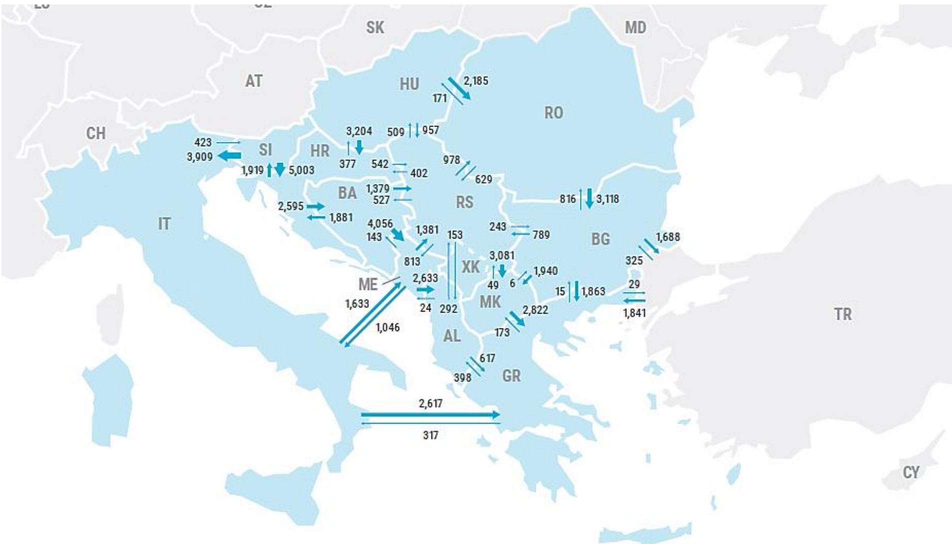

Figure 3-5: Energy flows in 2020 in the CSE region [GWh].

After this brief explanation of the transmission capacities in the region, it is necessary to turn to the region's generation capacities. Fig. 3-6 shows the total installed capacities of the region categorised by fuel type. Each of the categories is assigned a certain colour in the bars of the figure. The upper half of the figure shows values for all of the countries in the region and the bottom half is dedicated to the detailed illustration of the values for all the countries except for Italy and Türkiye, which were excluded for the sake of the graphs' readability.

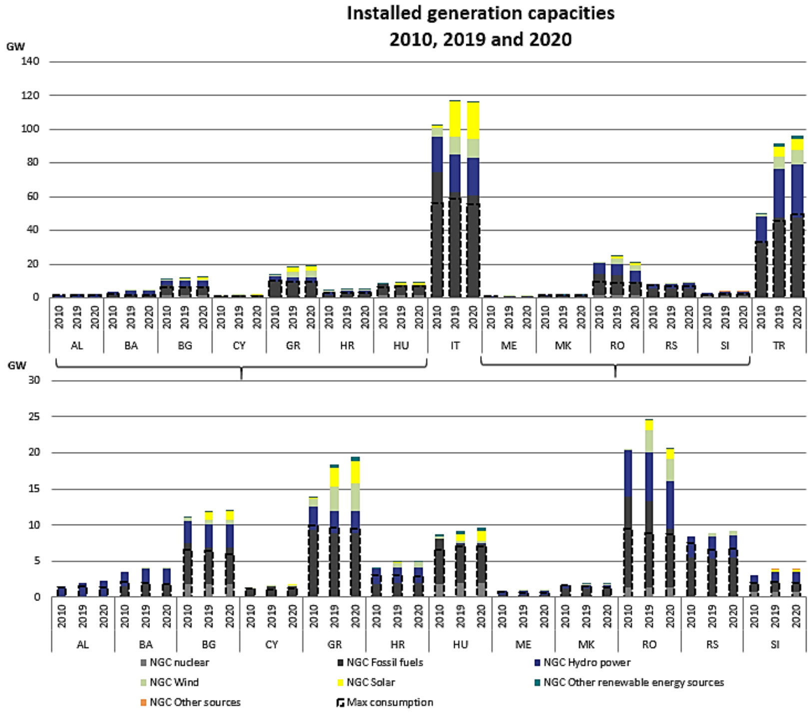

Figure 3-6: Installed capacities in the CSE region [GW].

This diagram clearly shows that the total value of the installed capacities in the region has gone up in the previous ten years, and the same trend applies to most of the countries in the region. A slight exception to this can be found in Romania, in which the generation capacities rose in 2019 only to fall nearly back to their 2010 level in 2020. This happened in line with energy transition plans: the rise in capacity was mostly due to the commissioning of new renewables, whereas the drop was due to the decommissioning of thermal units. Accordingly, the share of different fuel types in the total generation capacities of the region can be found below (Fig. 3-7).

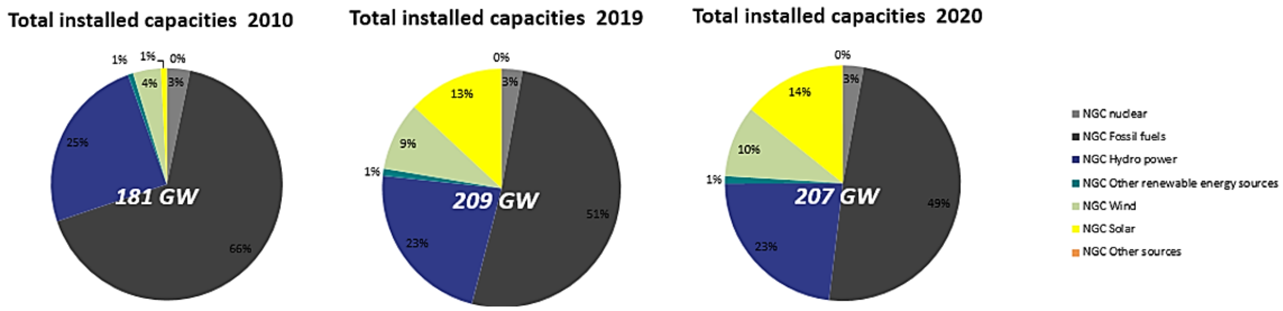

Figure 3-7: Installed capacities in the CSE region [share].

Fig. 3-7 shows that the share of renewable sources significantly rose in 2019 and 2020 compared to their 2010 level, whereas the share of thermal units went down. This is perfectly in line with the expectations set by the goals of the ongoing energy transitions, especially the turn towards sustainable energy sources such as wind plants (10% share in 2020) and solar plants (14% share in 2020). It should also be noted that the share of hydro units remained almost the same in all three observed years. The total energy production per country in the CSE region can be seen in the bar diagram in Fig. 3-8, divided in the manner already used in Fig. 3-6.

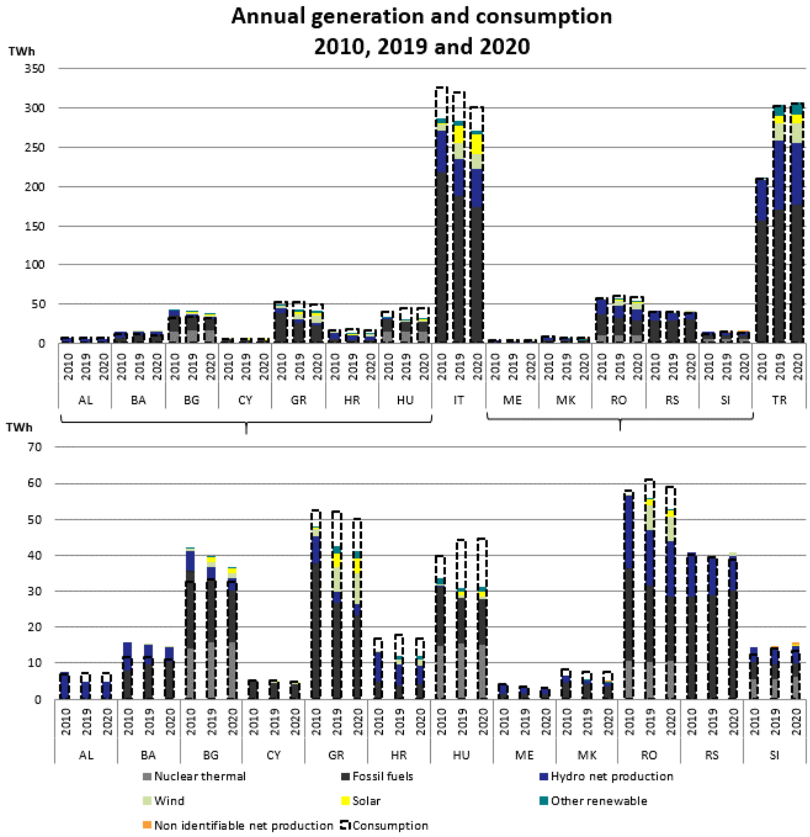

Figure 3-8: Energy production in the CSE region [TWh].

Analysing the enclosed production values and comparing them to the consumption levels for each of the countries (Fig. 3-8, dashed lines) shows that some countries in the region behaved as energy importers, such as Greece and Romania. Other countries, such as Bulgaria, produced more energy than what was used in their systems and became overall exporters. Finally, the share of different fuel types in the generation of energy shown in the previous diagram can be seen in Fig. 3-9.

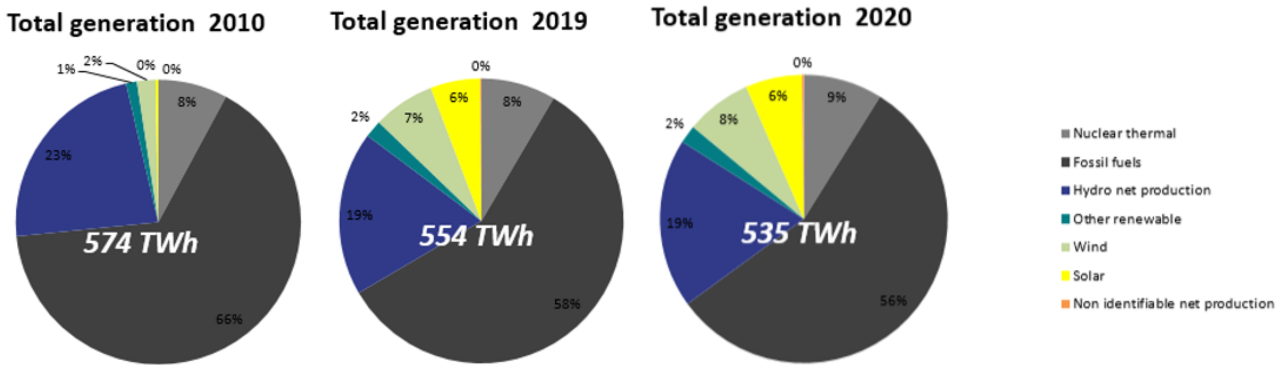

Figure 3-9: Energy production in the CSE region [share].

In accordance with their increasing share of the region's total installed capacities, the renewable sources also achieved an increase in the share of energy production between 2010 and the latter two analysed years. This growth was 6% for both wind (2% to 8%) and solar (0% to 6%) power plants in the CSE region.

4. Identified system needs in the CSE region

This chapter provides basic information regarding the results of the calculations performed during the TYNDP 2022 creation process, as well as detailed explanations that underline the most relevant points for the region. The chapter will be divided into two sections, one for each time horizon. The first section will provide insights into the identified system needs in the CSE region for 2030, whereas the second will do the same for 2040. The chapter will also discuss some of the more prominent parameters of system operation for both observed horizons.

4.1. Overview of system needs in 2030

Fig. 4-1 provides a map showing the NTC increases seen as desirable through 2030. The colour of the arrows connecting the countries depends on the size of the needed NTC increase for the time horizon of interest. Two shades of blue (light and dark), purple and pink arrows mark the recommended NTC increases in the region in increasing size order.

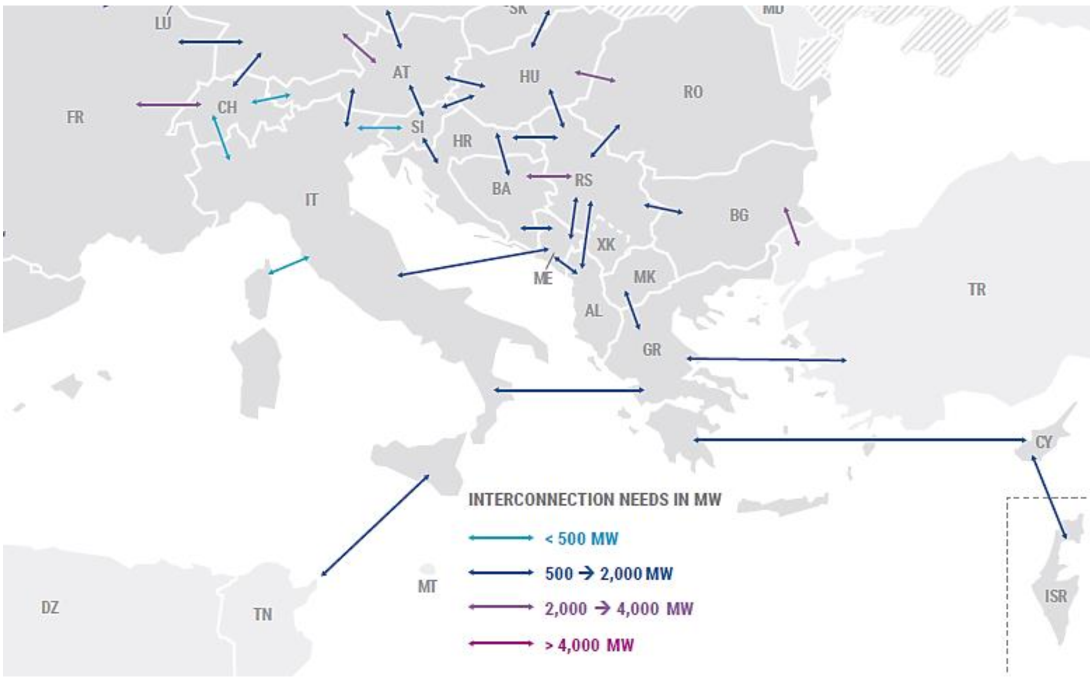

Figure 4-1: Map of the recommended NTC increases in the CSE region for 2030.

Here it can be seen that the performed optimisation process advised increasing the NTC values on nearly every border in the CSE region. This may reflect the ever-rising need for stronger interconnective cooperation in the region, especially as energy transits between the systems are set to grow following the foreseen level of integration of renewable sources in the CSE countries' production portfolios. Some notable examples of borders where major NTC increases were proposed are those between Serbia and Bosnia and Herzegovina and between Romania and Hungary (both exceeding 2,000 MW). Overall, the region appears to be in need of further investments to increase NTCs.

The first indicator of market operation in the region that will be analysed here is the calculated net annual balances of the region's countries for 2030. This indicator includes three different cases: the case in which the market results match the ones for 2030 but the grid remains on the current level, the case in which only the submitted project portfolio is taken into account and the case in which all increases that were obtained from the IoSN process are completed by 2030. The indicator is depicted in Fig. 4-2.

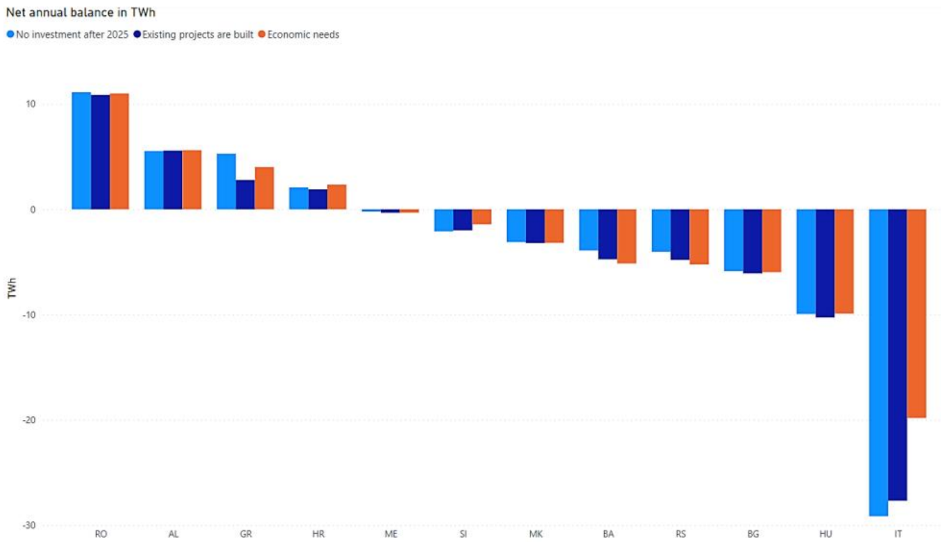

Figure 4-2: Net annual balances [TWh] in the CSE region for 2030.

Here, although the values of exports and imports vary depending on the type of the observed grid, the nature of the flows remains similar; countries are either exporters in all three cases or importers in all cases.

The next indicator to be discussed is the generation mix in the region, which is provided in the diagrams in Fig. 4-3.

Figure 4-3: Annual generation mix [TWh] in the CSE region for 2030.

Several conclusions may be drawn from this diagram. The most relevant are, first, that the total amount of energy production in individual countries varies slightly from case to case and, second, that changing the absolute production values in the countries does not affect the relative shares of different fuel types in the countries' energy generation mixes.

In addition to the generation mix, it is only natural to cover some of the other indicators related to energy production in the countries of the CSE region. The first of these will be the estimated level of curtailment of the renewable energy sources in each country (Fig. 4-4).

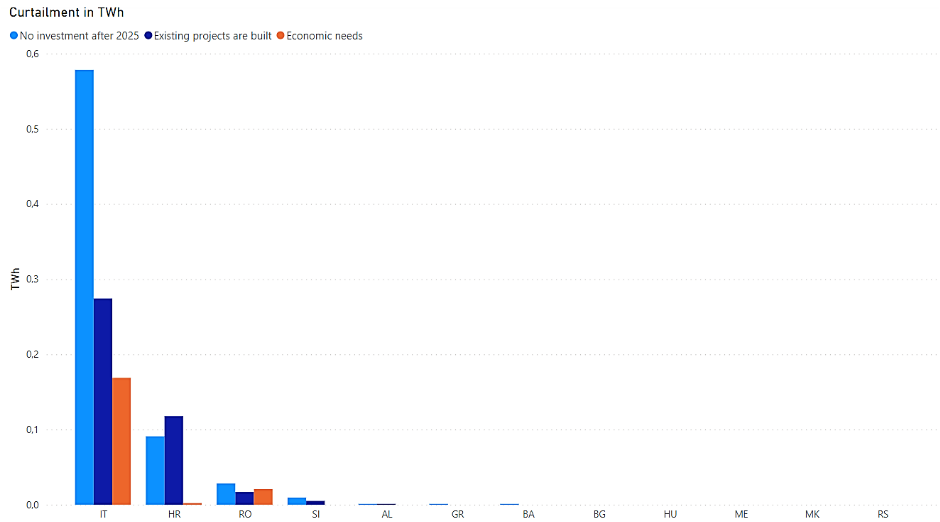

Figure 4-4: RES Curtailment [TWh] in the CSE region for 2030.

It is clear that not all of the countries in the region have issues regarding the curtailment of renewable sources. Nevertheless, it is also obvious that the situation in Italy, the country with the highest curtailment values, progressively improves as the grid advances towards the one recommended in the IoSN process.

The next indicator is CO_2 emission levels, shown in Fig. 4-5.

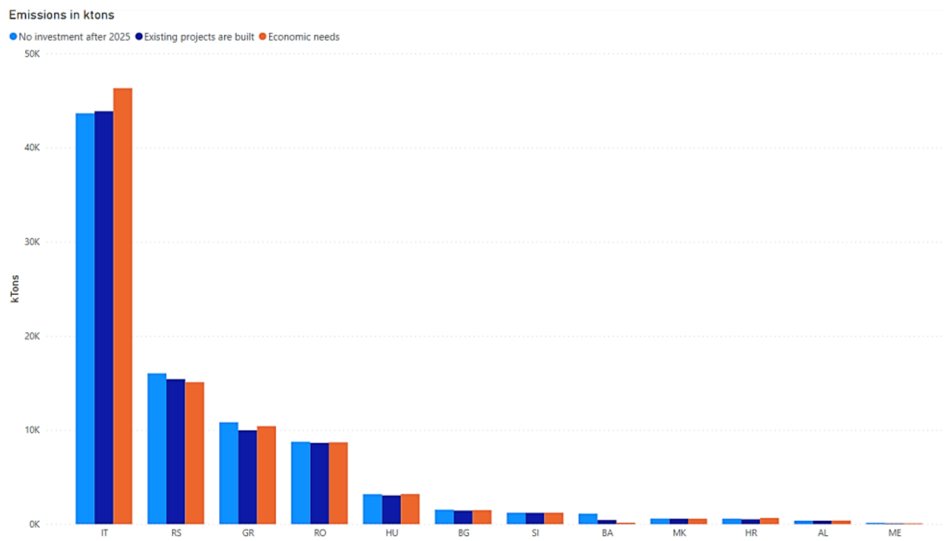

Figure 4-5: CO_2 emission levels [ktons] in the CSE region for 2030.

Regarding CO_2 emissions, one of the most important causes of the greenhouse effect, it appears that emissions fall in most countries with the development of the network. The notable exceptions to this rule are Greece and Italy, where the levels are lowest for the case in which only the projects from the actual TYNDP portfolio are commissioned. Similar situations, albeit at a much smaller scale, can also be observed for Romania, Hungary and Croatia.

Finally, the last two indicators included in the section on the 2030 horizon are those related to the economic parameters of system operation. The first will illustrate the impact that grid development may have on the evolution of the marginal costs in the CSE region (Fig. 4-6).

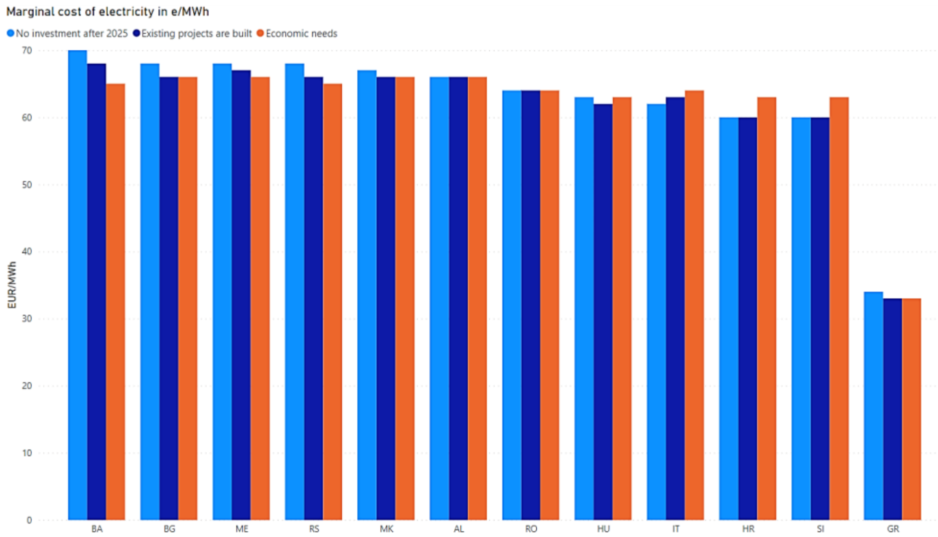

Figure 4-6: Marginal costs [€/MWh] in the CSE region for 2030.

In accordance with expectations, the increases in NTC values caused by grid development help to balance the marginal costs throughout the region: prices rise in countries where the costs were initially lower than the average and fall where costs were initially higher than average.

Annual system costs are the final indicator that will be shown in this section (Fig. 4-7).

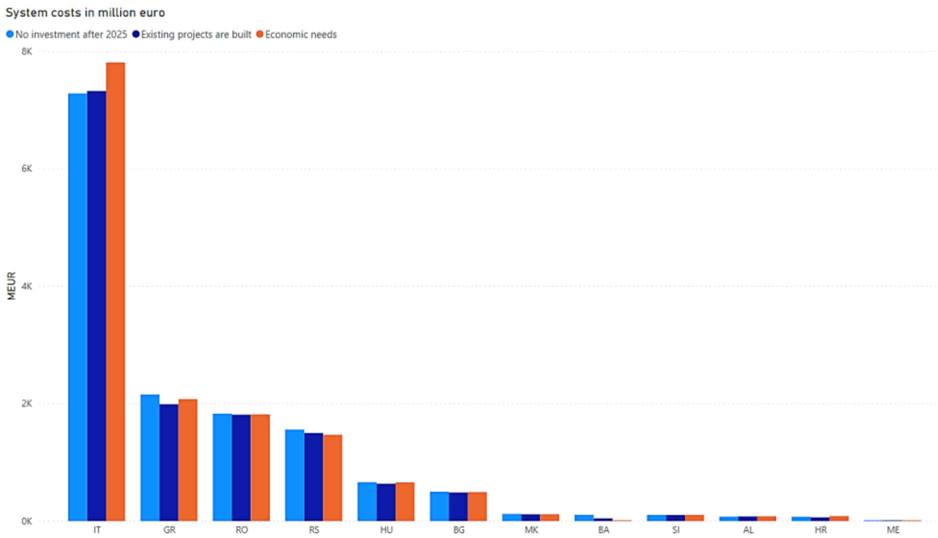

Figure 4-7: System costs [M€] in the CSE region for 2030.

This diagram shows that the system costs may be significantly affected by the evolution of the grid in the CSE region. However, there is no clear universal rule governing how they will change once the new lines are built, and the case in which they reach their lowest values varies from one country to another.

4.2. Overview of system needs in 2040

As was shown for the 2030 time horizon, Fig. 4-8 contains a map showing cost-effective NTC increases obtained from the analyses conducted for 2040. Once again, the different colours of the arrows correspond to the ranges of values of those NTC increases. Also, the recommended storage capacity increases are indicated by the different colours in which the countries are marked on this map (from light shades to darker shades of orange). The installation of the new CO_2-free peaking units that are needed per country is suggested by the small power plant icons.

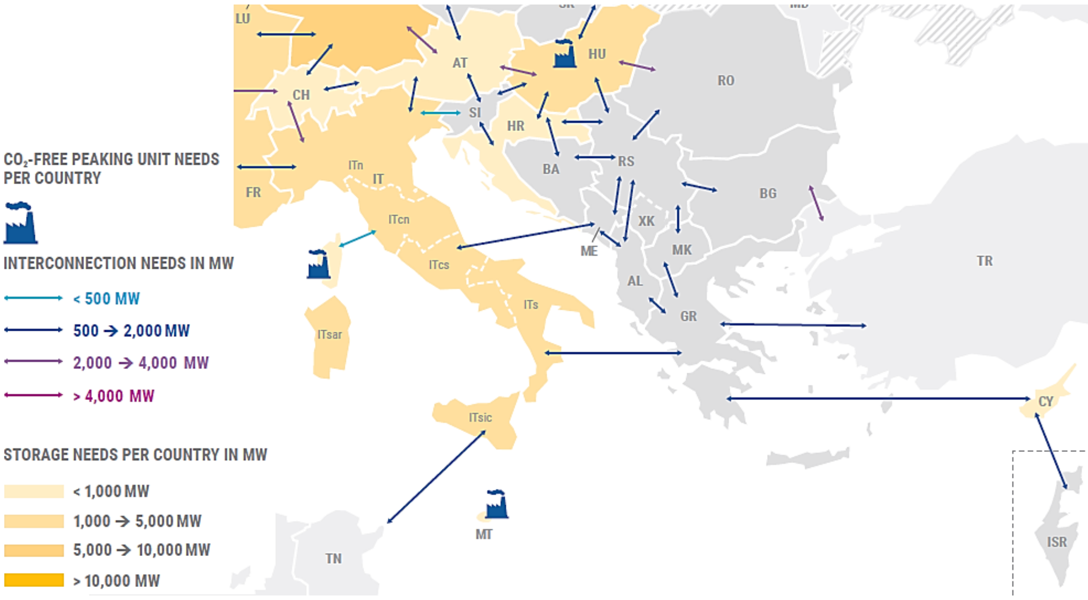

Figure 4-8: Map of the recommended system improvements in the CSE region for 2040.

It is important to note that numerous factors may affect the comparability of the results for 2030 and those for 2040. Among these, the most prominent are the variations in the generation mixes of some relevant countries and the different types of modelling that were used for these time horizons; in particular, a zonal model was used for 2030, whereas an NTC model was selected for 2040. Hence, if the need on a particular border falls from 2030 to 2040, this should not be seen as an obstacle to commissioning the projects on that border, as the existence of the need is a sufficient indicator to plan the projects. For 2040, the optimisation algorithm showed that the NTC increases would be perfectly justified on almost any border in the CSE region.

Regarding additional energy storage capacities in the region, the need to implement this type of project was not identified in most of the countries. Indeed, only four of the members of the RG CSE are highlighted in the map below: Italy, Hungary, Croatia and Cyprus. Among these, particular attention should be paid to Cyprus, whose system now operates in complete isolation from the remainder of the region. As can be seen, an NTC increase between Cyprus and Greece on one side and Israel on the other is identified in both observed years, and the 2040 analysis includes the storage capacities in this country, which are bound to improve the security of supply and the system flexibility in this region. It is also important to note that the most prominent CO_2-free peaking unit capacities in the CSE region were recommended for installation in Hungary.

Following the pattern established for 2030, the discussion below will focus on the six indicators chosen to illustrate how developing the system in the desired direction would affect its operational state. The first indicator that will be used for this purpose is the net annual balance, shown in the bar diagram in Fig. 4-9.

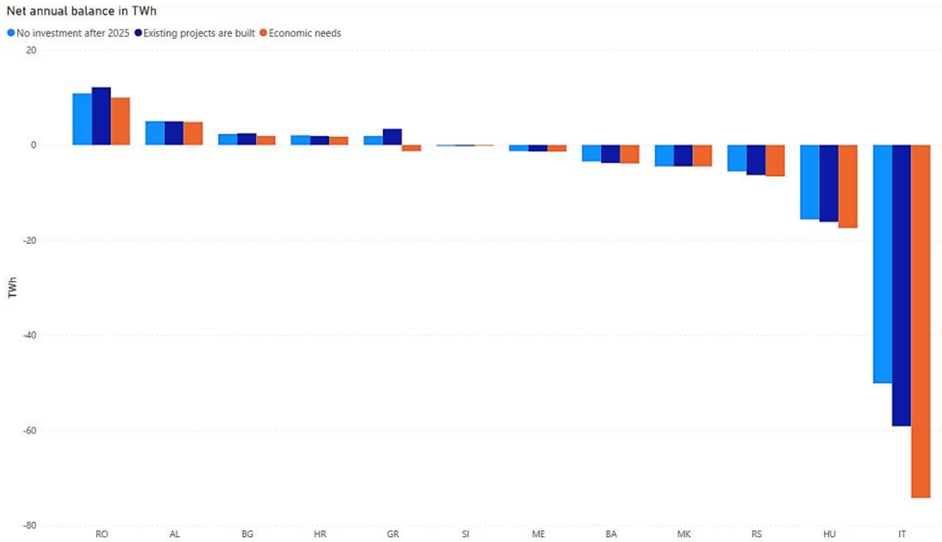

Figure 4-9: Net annual balances [TWh] in the CSE region for 2040.

Fig. 4-9 shows that, for this time horizon, Greece is the one country that behaves as an importer in one of the analysed cases (the situation where all of the cost-effective solutions are built) and as an exporter in the other two. The remainder of the countries that belong to the region behave consistently in all three cases shown in the diagram above, regardless of whether they are energy exporters or importers. Next, the generation mix in the region is given in Fig. 4-10.

Figure 4-10: Annual generation mix [TWh] in the CSE region for 2040.

Again, the development of the grid undoubtedly causes some turbulence in the absolute values of the energy production in the countries. However, it does little to make any substantial difference in the share of various fuel types in the energy generation on an annual level. This is not unexpected, as the results for 2030 supported the same conclusion.

The next step is to analyse and compare the values of curtailment of the energy generated in renewable sources for each of the three cases to draw conclusions regarding the impact of grid development on this parameter. The values themselves are shown in the diagram provided below (Fig. 4-11).

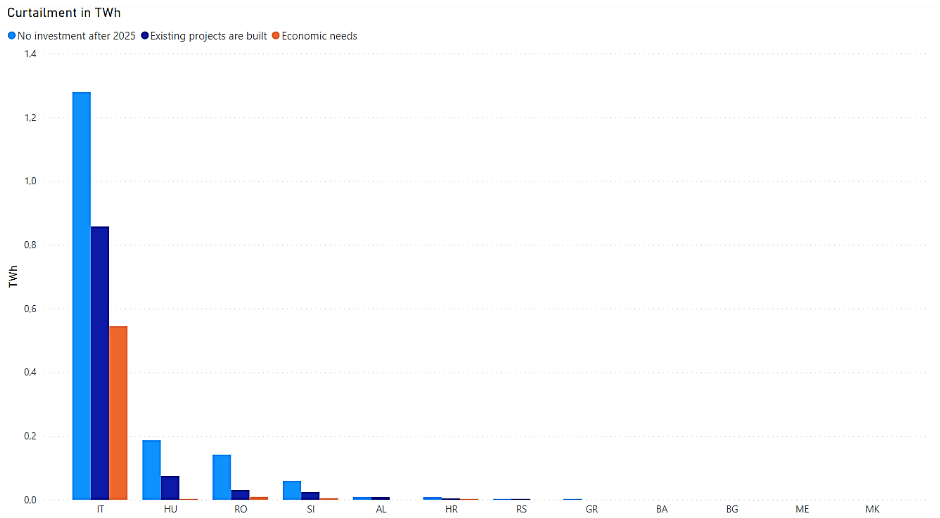

Figure 4-11: RES Curtailment [TWh] in the CSE region for 2040.

Here, along with the fact that grid development once again causes notable decreases in the amounts of curtailed energy in countries such as Italy, it should also be noted that curtailment is present in more countries than in 2030, at least for the case with no reinforcements. For example, this is evident in Croatia, where further RES development is foreseen for the period from 2030 to 2040. Levels of CO_2 emissions for 2040 are given in Fig. 4-12.

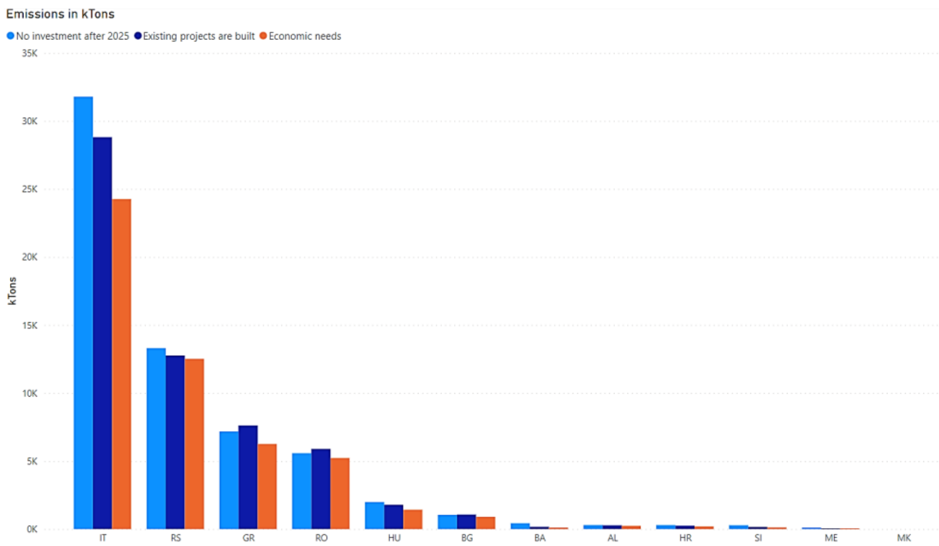

Figure 4-12: CO_2 emission levels [ktons] in the CSE region for 2040.

The emission levels of CO_2 show tendencies similar to the ones spotted for 2030, falling (at least in most countries in the region) once the grid is built. Nevertheless, exceptions to this rule, in which the emission levels reach the minimal point even if no new infrastructure is commissioned, also exist and should not be overlooked.

To complete this chapter, two economic parameters will be applied in order to align the scope of this section with the section on the 2030 horizon. Accordingly, Fig. 4-13 gives an overview of the impact of grid development on marginal prices in the countries in the CSE region for the three analysed cases.

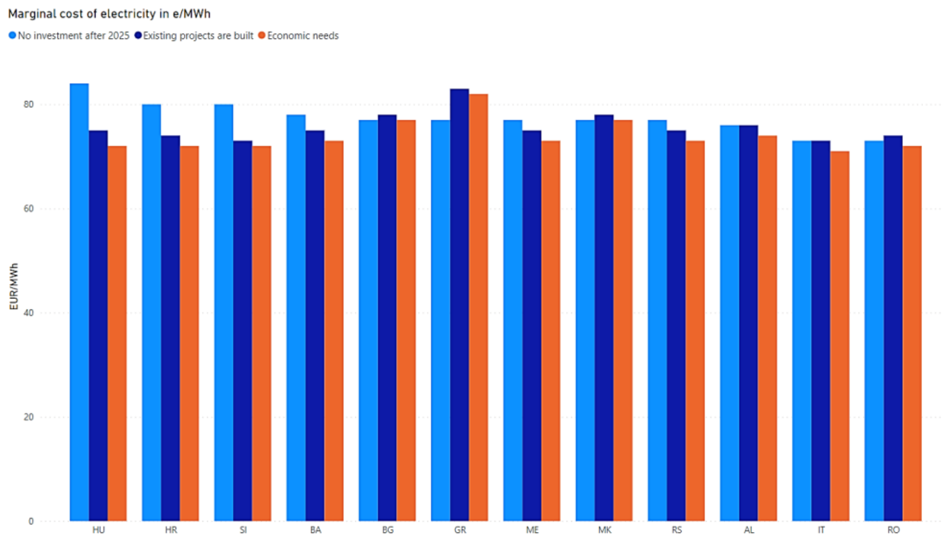

Figure 4-13: Marginal costs [€/MWh] in the CSE region for 2040.

Consistently with the observations made for the 2030 analysis of this kind, the development of the network in the region affects the marginal costs in the countries differently. In particular, costs increase in Greece and Bulgaria while falling in Hungary, Slovenia and Croatia.

Fig. 4-14 shows the values for the last parameter: system costs in the CSE region.

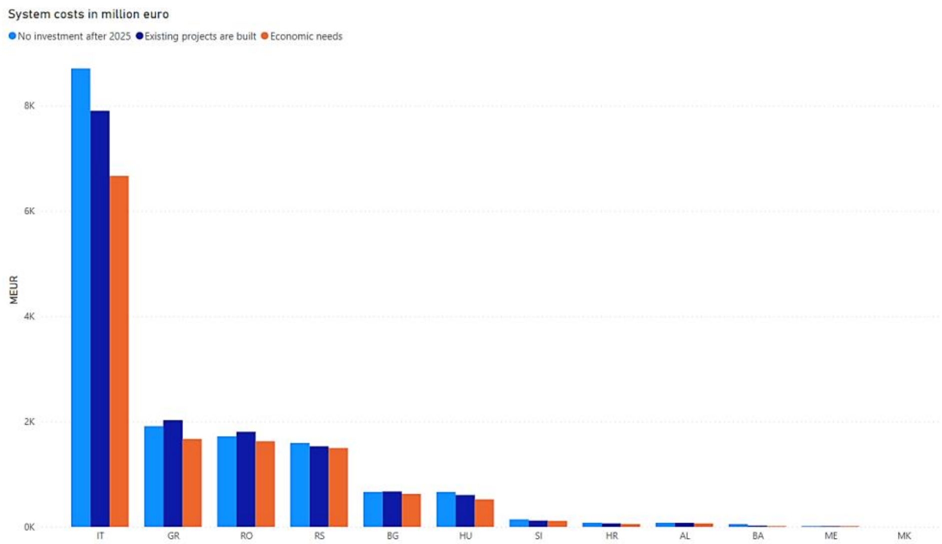

Figure 4-14: System costs [M€] in the CSE region for 2040.

Even though this diagram clearly proves that advancing the grid towards the recommended level has major effects on system costs in the CSE region, there is no clear trend that can summarise the tendencies of these variations. The only rule is that the costs are not lowest for the case without grid development.

5. Future challenges in the CSE region

Following the results of the IoSN process presented in the previous chapter, this chapter will focus primarily on the actions that the TSOs of the CSE region must take to achieve the capacity increases and other improvements that were proven to be cost-effective. First of all, it must be underlined that the region's TSOs will have to prepare for significant investments in approximately the next 20 years to be able to respond to the NTC increases shown in the maps in Chapter 4. For instance, the borders between Bulgaria and Greece on one side and Türkiye on the other require massive reinforcements to allow the desired energy flow across them, dramatically increasing the Turkish power system's expected impact on the operation of the systems in the CSE region.

For borders where increasing the NTC was proven to be desirable and where some projects already exist, the justification for investing in the projects was provided by the results of the IoSN process. Occasionally, however, an NTC increase may be suggested for a border on which no projects were planned by the TSOs in charge. In such cases, the relevant TSOs should agree to analyse the possibility of establishing a new project to be submitted for assessment in the next edition of TYNDP. The results of the presented IoSN process can serve both as a source of ideas for such projects and an indicator of their potential benefits.

The Regional Investment Plan 2020 also showed another way in which the introduction of new projects can be ensured: by providing the project promoters with the possibility to submit additional projects for inclusion in the TYNDP after the IoSN results are completed and published. Of course, the time plan of the TYNDP process must accommodate this possibility with an additional time slot. This slot was known as the second submission window in the 2020 edition of the TYNDP, and it was seen as a connection between the IoSN results and the reactions of the promoters. Projects that were submitted could not have the commissioning year before 2035 and were, therefore, designated 'future projects'. In the CSE region, there were four projects of this kind:

- New interconnection between Bulgaria and Türkiye;
- New interconnection between Greece and Türkiye;
- Refurbishment of the 400 kV OHL between SS Meliti (GR) and SS Bitola (MK); and
- Pannonian Corridor (an increase of transmission capacity between RS and HU).

All these projects reappeared in TYNDP 2022 under the following respective numbers and names:

- Project No. 1066: Bulgaria – Türkiye;
- Project No. 1067: New AC interconnection line Greece – Türkiye;
- Project No. 376: Refurbishment of the 400 kV Meliti (GR) – Bitola (MK) interconnector; and
- Project No. 1074: Pannonian Corridor.

5.1. Massive integration of renewable sources in the CSE region

It is well known that Europe's generation portfolio is moving toward renewable energy sources, which are expected to take over the dominant role in the energy production mix. This trend is in line with environmental tendencies that have bloomed in the public in the previous two decades, as well as the relevant decisions and acts that determine the actions that will need to be undertaken for the set climate and emission goals to be reached. However, it is no secret that this shift does not affect all European countries in the same way; instead, its effects depend on the energy source that each country previously relied upon. In the case of countries whose production portfolios were initially dominated by hydro generation units, which generally meet the standards set by the green energy transition, the necessary changes will be relatively minor; their original reliable production will stay operational even after the connection of the new renewable sources. However, the challenges are far more serious for countries that were primarily supplied by thermal power plants before the energy transition began. Indeed, these countries will not only have to deal with the connection of new power plants based on renewable principles but will also have to figure out a way to keep the system stable and functioning without thermal power plants. The latter are expected to be put out of the operational state either by political decisions or by market forces, as the production of energy from thermal (coal) units will no longer be economically viable.

To illustrate the magnitude of the changes that must occur in the CSE region in the next ten years, data were collected from each of the region's TSOs concerning the amount of renewable energy sources expected to be connected to the grid in the upcoming period. These data were compared to the current levels of renewable sources connected to the transmission systems controlled by each of the operators in the region. Hence, Fig. 5-1 shows the current installed capacities of renewables connected to the transmission grid (blue) and the expected additional capacities of the renewables that will be connected to the transmission grid in the next ten years (red). For JSC EMS, the data shown in this diagram and the next only include projects that have advanced in the connection process; the total number of connection requests is several times higher.

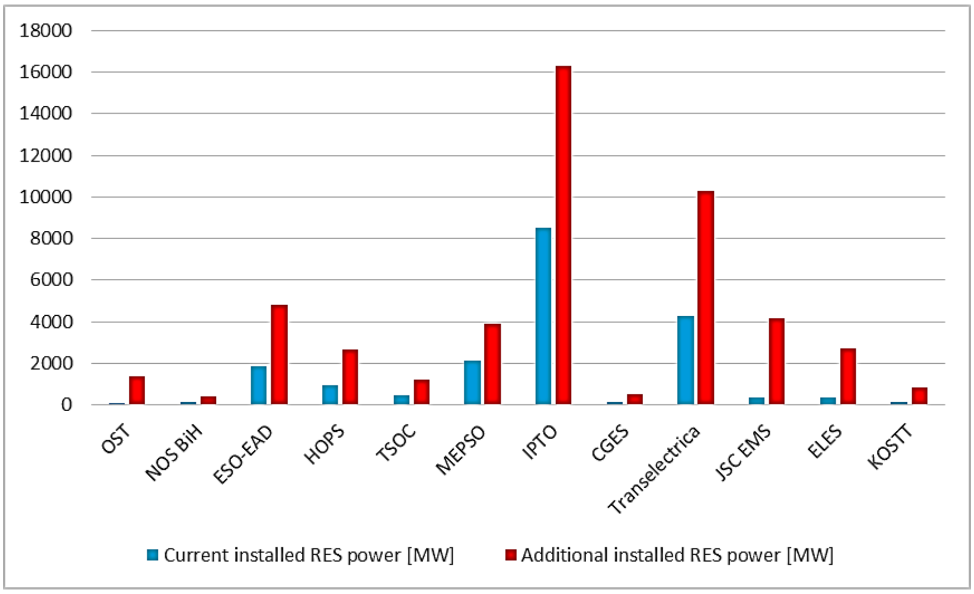

Figure 5-1: Current and additional installed RES powers in the region [MW].

5.2. TSO studies in the CSE region

In line with the decision of ENTSO-E's System Development Committee, the new editions of the Regional Investment Plans should also include an overview of some of the major studies that are currently ongoing (or planned for the near future) in each of the regions. The list of the studies stated by the TSOs of the CSE region can be found below (the scope of the studies is limited to the DC links and to the AC projects of the voltage level equal to or higher than 220 kV):

- Feasibility Study for the North CSE Corridor project – initiated by EMS, with Transelectrica specialists' cooperation – expected completion date: 2023;
- Feasibility Study of Georgia – Romania Black Sea Submarine Cable Project – initiated by GSE JSC, with Transelectrica specialists' cooperation – expected completion date: December 2023;
- A feasibility study of a new electricity interconnection project between Greece and Italy is ongoing. Completion is expected within 2022;
- A joint WG to further investigate the potential increase of bidirectional NTC at the GR–MK border has been established;
- A joint WG for a potential new interconnection between AL–GR is ongoing. Completion is expected by the end of 2022;
- The ToR for the Bilateral Study for the RS–HU interconnection (in the scope of the Pannonian Corridor – project 1074) is currently being harmonised between JSC EMS and MAVIR. Completion is expected before the end of 2022.

Aside from the WG established to further investigate the potential increase of the NTC at the border between Greece and North Macedonia, the remaining five studies have defined completion dates. To illustrate this, Fig. 5-2 gives an overview of the completion times for the studies listed above. The bars in the figure show the number of studies that are set for completion in each year; based on the input data, the timeframe is limited only to 2022 and 2023. This diagram can be used to easily track the number of studies done in the CSE region.

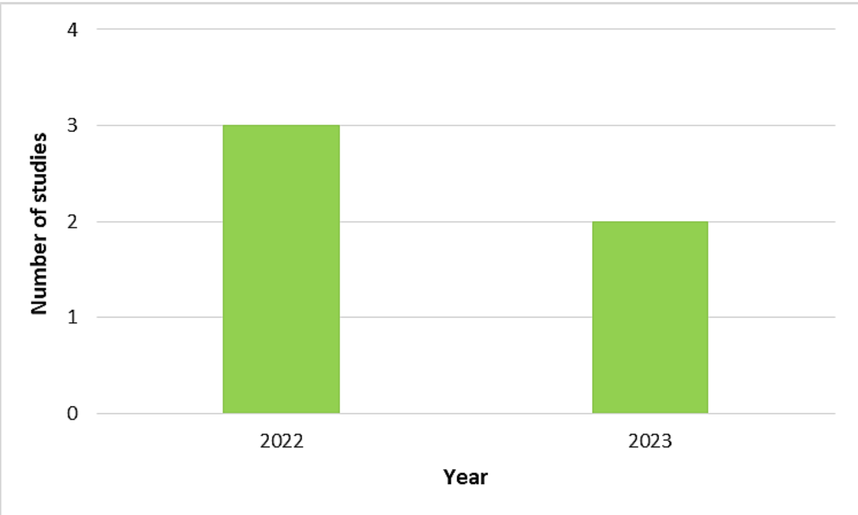

Figure 5-2: Overview of the studies' completion dates.

6. Regional studies in the CSE region

To complement the work done in the scope of the TYNDP package and to provide additional information for interested readers, this chapter will focus on some of the more relevant studies and analyses in the CSE region. Each of these will be given a dedicated section in which their main points, conclusions and status (for ongoing studies) will be briefly described.

6.1. The Ukraine/Moldova network connection

In 2006, the UA and MD transmission system operators requested synchronous interconnection to the system of the Union for the Coordination of Transmission of Electricity (UCTE). Later, in 2014, a Consortium was formed of ENTSO-E member TSOs in order to perform a 'Feasibility Study on the Synchronous Interconnection of the Ukrainian and Moldovan Power Systems to ENTSO-E Continental Europe Power System'. The main objectives of this feasibility study, finalised in 2016, were as follows:

- To investigate the possibility of the synchronous operation of Ukrainian and Moldovan power systems with the Continental European synchronous area, respecting both its technical operational standards and the limitations of the systems;
- To investigate the degree of implementation of ENTSO-E's technical operational standards in the Ukrainian and Moldovan power systems;
- To analyse differences in the relevant legislation in the field of energy between Ukraine and Moldova, on the one side, and the countries of Continental Europe on the other.

The main conclusions of the study were as follows:

- According to the 2014 forecast, from a steady-state perspective, the synchronous connection of Ukraine and Moldova to the Continental Europe power system is feasible with infrastructure (both existing and planned) expected in 2020.
- From a dynamic perspective, the interconnection is not feasible without applying proper countermeasures due to inter-area instability risks identified in the interconnected model. The source of the instability was insufficient damping for low-frequency oscillations at large generators in Ukraine.
- Inter-area stability can be improved by applying one of the proposed countermeasures. The adopted solution must be verified by the manufacturers of existing control systems in power plants in Ukraine and Moldova, especially in the case of nuclear power plants.
- Only after completing a revision of the proposed measures and the on-site testing of selected exciters and governors can the evaluation of the efficiency of countermeasures, and their influence on the small-signal inter-area stability of the interconnected systems, be made.

In June 2017, agreements on the conditions of the future interconnection of the Ukrainian and Moldovan power systems with the power system of Continental Europe were signed. These agreements contain Catalogues of Measures to be implemented by Ukraine and Moldova. One of the envisaged actions was to perform additional studies to investigate, in detail, the technical measures needed to ensure the system stability required for proper connection.

The additional studies were made by a Consortium of ENTSO-E member TSOs. The studies began in April 2020 and were finalised in December 2021. They analysed the possibility of the synchronous interconnection of the power systems of Ukraine, Moldova and Continental Europe in the present situation (without development projects). The technical measures to ensure system stability were determined based on dynamic models that considered the results of recent unit tests performed in Ukraine and Moldova.

The main conclusions of the study were as follows:

- From the perspective of steady-state analyses, the synchronous connection of Ukraine and Moldova to the continental part of ENTSO-E is feasible even without any additional requests for reinforcements or the construction of new infrastructure.
- Out of conducted dynamic analyses, the only dynamic threat to the safe operation of the connected systems was the insufficient damping of low-frequency oscillations with a large participation of generators in Ukraine. It was found that these threats occur in off-peak scenarios for power exports from Ukraine / Moldova. Under certain conditions, the 5% inter-area oscillation damping limit is not met. Countermeasures necessary to improve the inter-area stability of Ukraine and Moldova in the interconnected power systems were analysed. This analysis included assessing the effectiveness of existing solutions in the Ukrainian system for damping low-frequency oscillations and investigating new potential countermeasures.

Considering the obtained results, the proposed solution to improve the damping of the inter-area oscillations was the retuning of selected dual input power system stabilisers (M1). The selection should be based on the damping improvement achieved by retuning. Therefore, retuning should apply to units with generators that contribute significantly to inter-area oscillations and for which PSS is not properly tuned. It was also found that limiting retuning to generators with rated power over 50 MVA (M1**) only slightly decreases effectiveness.

This measure must be supplemented with additional measures selected from the following:

- adding standalone stabilisers to the 1,111 MVA nuclear units equipped with REM700 brushless excitation systems (M2);
- retuning AVR on all generators of the nuclear units (M3);
- installing STATCOMs with POD using frequency signals or other power electronics devices that could provide equivalent damping (M4);
- retuning frequency feedback on generators at Zaporizka NPP (M5);
- retuning frequency feedback and AVR gain reduction on generators at Zaporizka NPP (M6).

Each of these additional measures ensures a significant and sufficient improvement in damping the inter-area oscillations that involve Ukraine and Moldova (except the M1** + M5 combination, for which the calculated damping may be slightly below 5% for high power exports in CESA). The solution adopted may even be a mix of the suggested measures.

The study's load flow calculations also show that after applying the proposed countermeasures, there will be no inter-area stability constraints for the maximum power exports from Ukraine and Moldova.

On 27 February and 28 February 2022, Continental Europe TSOs received a request from Ukrenergo (a Ukrainian TSO) and Moldelectrica (a Moldovan TSO) for an emergency synchronisation with the Continental Europe power system, which was supported by EU Energy Ministers. The Continental Europe TSOs committed to responding positively to Ukrenergo's request and began to analyse the conditions for an emergency synchronisation while maintaining the safety of the Continental Europe power system. A Task Force was created under the ENTSO-E System Operation Committee – Regional Group Continental Europe to cover the following topics: Protection and Dynamic Stability, Operations and Markets, Legal and Regulatory and Information Technology including Cybersecurity.

The Task Force (TF) determined the minimum requirements of synchronisation, assessed its risks and defined the actions necessary to mitigate those risks. Exceptional actions have been implemented with the support of concerned stakeholders and authorities.

On 11 March, the Continental Europe TSOs concluded that the conditions for an emergency synchronisation had been met, and the synchronisation was completed on 16 March. Throughout this process, the Continental Europe TSOs received support from the European Commission, the Member States and the Regulatory Authorities. However, to ensure the stability and proper operation of all the affected systems, the situation is comprehensively monitored 24/7 and appropriate measures are also planned for the upcoming period.

Currently (at the moment of the drafting of this document – end of June 2022), there are no commercial exchanges between UA/MD systems and the system of Continental Europe. However, transfer capacity will be increased gradually after the implementation of certain necessary measures.

The Catalogues of Measures that were established in 2017 were updated in 2020 in order to ensure harmonisation with SAFA (Synchronous Area Framework Agreement) and European Network Codes.

6.2. SECI TSP Project – First cycle

The early stages of the South Eastern Cooperation Initiative Transmission System Planning (SECI TSP) project as we know it today can be traced back to 2017, when the SDC recommended that the RG CSE and Secretariat implement the organisation through which the project was established. The Terms of Reference (ToR) for SECI TSP were consequently approved by SDC, encompassing two cycles of the project (or two working years, as mentioned in some of the documents dealing with this topic). The first cycle, which also represents the focal point of this section on RegIP, focuses on the following five tasks:

- Organising and conducting the Quarterly Meetings of the SECI Working Group;
- Supporting ENTSO-E in the development of the Ten-Year Network Development Plan;
- Conducting a Ukraine/Moldova network sensitivity study on the pan-European level with a focus on the impact on the RG CSE region using the Scenarios defined in the TYNDP;
- Updating the RG CSE network models in PSS/E format and the market models with full details respecting the rules defined in the Guidelines for the construction and use of regional models;
- Providing training and capacity-building workshops relevant to the daily operations of the member TSOs and in support of the SECI TSP studies in this work plan.

In continuation of the previously described Ukraine/Moldova Network Connection Sensitivity Study, the effect that the connection and synchronisation of the systems of Ukraine and Moldova to that of Continental Europe could have on the situation in the CSE region was estimated, both in relation to the electricity market operation and the transmission grid itself. The most up-to-date scenarios from the ENTSO-E TYNDP 2018 preparation process were used, with the first being the Best Estimate scenario for 2025 and the second the Sustainable Transition scenario for 2030. In order to enable proper comparisons and to correctly assess the influence of the synchronisation, both the scenarios were individually modelled for two separate cases: the Base Case (case without UA/MD connected to the ENTSO-E area) and the New Case (case with UA/MD connected to the ENTSO-E area).

The Antares software package was used for the market analyses. To complete the tasks that were foreseen in the making of this study, it was necessary to develop a regional market model first. This was done in strong cooperation between the consultants and the affected TSOs. Here, each of the market areas was modelled as a single node except for the TERNA market area, which was done in line with the limitations and characteristics of the applied software tool. For efficiency purposes, all the generators in the market areas were simply connected to their respective market node. The nodes were connected among themselves by fictitious lines with capacities equal to the NTC values between the two respective areas. TERNA had to be modelled as six different zones due to its size, its connections to different market areas and the zonal pricing model that was applied.

Thermal generator units in each of the market areas were modelled with all the relevant technical and economic parameters, and the Monte-Carlo approach allowed simulations of various availability combinations of the thermal units. Hydro plants were modelled taking into account their corresponding maximum capacity and average monthly generation, with different models used for run-of-river HPPs, storage HPPs and pumped-storage HPPs. Finally, wind and solar power plants and load were modelled with hourly time series for one characteristic climatic year (2007).

The study's conclusions were based on comparing the market results for the Base Case and the New Case in each of the modelled years and estimating the impact of the UA/MD connection on the foundation of the results of that comparison. The first parameter assessed was the total regional energy production, for which the following was concluded:

- In 2025, the connection of the Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in the total energy generation in the CSE region of up to 7 TWh due to increased energy imports from Ukraine and Moldova when possible;
- In 2030, the connection of Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in the total energy generation in the CSE region of up to 11 TWh due to the increased energy imports from Ukraine and Moldova when possible.

The study also examined the impact of UA/MD synchronisation on the total import of the CSE region for both of the years covered, with the following results:

- In 2025, the connection of the Ukrainian and Moldovan systems to that of Continental Europe could lead to an increase in the total energy import of the CSE region of up to 7.8 TWh;
- In 2030, the connection of the Ukrainian and Moldovan systems to that of Continental Europe could lead to an increase in the total energy import of the CSE region of up to 11.8 TWh.

These results regarding the imports and exports of the region can also be seen in Fig. 6-1. The upper half of the figure is dedicated to the flows in 2025, while the lower half is dedicated to the flows in 2030. The left part of both years is for the Base Case, and the right part is for the New Case.

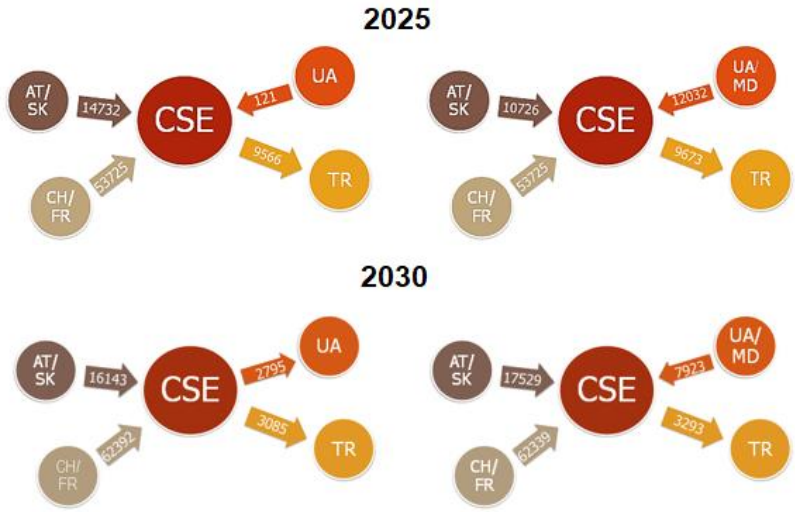

Figure 6-1: Imports and exports of the region [GWh] for the analysed years.

Concerning the cross-border energy flows in the region, the same conclusions were drawn for both of the discussed years:

- In 2025, the connection of the Ukrainian and Moldovan systems to that of Continental Europe could lead to an increase in the total cross-border energy flows in the region;
- In 2030, the connection of Ukrainian and Moldovan systems to the system of Continental Europe could lead to an increase in the total cross-border energy flows in the region.

The economic impact of the UA/MD connection was assessed by comparing several parameters, of which the total yearly operating costs in the CSE region is among the most prominent:

- In 2025, the connection of the Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in the yearly operating costs of the CSE region of up to 342.8 M€;
- In 2030, the connection of the Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in the yearly operating costs of the CSE region of up to 1,080 M€.

In addition to this decrease in operating costs, it was also shown that the UA/MD interconnection may affect wholesale electricity prices in the market areas of the CSE region:

- In 2025, the connection of the Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in wholesale electricity prices in almost all areas of the region;
- In 2030, the connection of the Ukrainian and Moldovan systems to the system of Continental Europe could lead to a decrease in wholesale electricity prices in almost all areas of the region.

It should also be emphasised that the new UA/MD interconnection could noticeably increase the benefits of the new interconnection projects in the CSE region. More specifically, the projects' economic evaluations, such as the determination of NPV at the regional level, would have significantly different results if the new UA/MD synchronisation were taken into account, which is currently not the case in the relevant processes.

For the network models, the first step was the creation of the starting models. This was done for a total of eight critical working regimes, four for each of the two target years: the winter peak, summer peak, summer off-peak and absolute minimum. While the models of the countries in the SECI region were collected from the TSOs themselves, the simplified ENTSO-E models were used for the remainder of the relevant countries in the proximity of the region. Next, the obtained models were merged to form the working model for this study. These merged models were then modified to include four operational regimes, obtained as the results of the market analyses: bulk exchange, high RES production, maximal demand and minimal demand. The data for each TSO was updated based on market outputs for generation per fuel type, total load, exchange pattern and balance.

It should be emphasised that, for the sake of the readability of the report, the chapter that was intended to show the specifications of the created network models also contained a brief introduction to the method of presenting all the results. This turned out to be rather useful for regional stakeholders who were not familiar with PSS/E (the software tool selected for the network component of the described study), thus significantly aiding the comprehensiveness of the document.

Similar to the method for the market analyses, the main conclusions here have been obtained by directly comparing the results for the case without the UA/MD connection with the case in which the connection is simulated. First of all, the analyses of the loop flows were performed through analyses on starting models (four initially collected regimes). As the loop flows through the SECI region were not significant in either of the cases, it was concluded that the simulated connection of UA/MD did not affect this parameter of the SECI region significantly. Nevertheless, it was observed that the BtB station in Vulkanesti (MD), which is on the tie-line Isaccea (RO) – Vulkanesti (MD), had a considerable influence on the reduction of the loop flows. The set point for the exchange on this BtB was determined by using the defined power exchanges on the border between Romania and Moldova from the market output, respecting the direction of the exchange and the capacity of the BtB station.

For the next part, the influence of the connection of UA/MD to the SECI region was analysed by calculating TTCs within the SECI region (i.e. among SECI countries). The four starting models did not show any difference after the connection, as the exchanges between the considered part of the UA and MD systems and the ENTSO-E region were set to zero. However, the impact was observed in the four additionally created models that took market outputs as the data source, as several TTCs in the region changed after the connection was simulated.

It is also important to note that due to the changes in the energy flows after the connection, many overloads in Romania – primarily those on certain important north-to-south corridors – decrease or entirely disappear after synchronisation. Here, the exchanges were improved and the TTCs increased after UA/MD connection in some scenarios. It can therefore be concluded that the interconnection projects that would increase capacity on Romanian borders have more benefits when UA/MD is connected to the system of Continental Europe.

6.3. SECI TSP Project – Second cycle

Due to the crisis caused by the COVID-19 pandemic and the slight reduction of the number of TSOs participating in the project, the beginning of the second cycle of SECI TSP project was slightly delayed; it was officially initiated on 02.08.2021. The ToR for the second cycle (or the second working year, as it is listed in some documents) was approved by the SDC after the completion of internal harmonisation within the SDC member group. According to this document, the second cycle of the SECI TSP project will focus on four major tasks:

- Organising and conducting the Quarterly Meetings of the SECI TSP Working Group;
- Supporting ENTSO-E in the Development of the Ten-Year Network Development Plan;
- Conducting a study of the impact of large-scale RES integration on cross-regional power flows in CSE on mid- and long-term planning horizons (years 2030 and 2040) – RES Study;
- Updating the CSE network models in PSS/E format (RTSM) and market models in Antares format (REMD) with full details respecting the rules defined in the Guidelines for the construction and use of regional models.

The motivation for the RES study, which is the main deliverable of this cycle, was the rapidly increasing number of connection requests for the commissioning of new renewable energy sources in the CSE region and the consequences of those connections. This made it necessary to envisage a growing number of projects just to deal with the aftermath of the energy transition. In order to identify these issues' solutions as efficiently as possible, it was proposed that the SECI TSP, as the leading regional cooperation initiative related to system planning problems, take this topic as the subject of the entire cycle. Hence, the Study will be based on the implementation of the long-term market scenario (National Trends 2040) created with data taken from NECPs, the planning documents of the individual TSOs and, where necessary, the TSOs' best estimation of the upcoming RES development in their systems. It will address the Identification of System Needs for the regional network, similarly to the TYNDP team's approach when making the main TNDP package reports; however, its scenario will be adjusted according to the aforementioned information.

Once completed, the Study will provide TSOs with accurate focal points for further investments by designating the critical infrastructure and suggesting optimal new projects from the regional perspective. The main idea is to define a methodology that can merge both market and network simulations in a single overarching planning procedure. This procedure is expected not only to obtain market and network results but also to combine them using logic loops and optimisation methods. The zonal market analyses are expected to accomplish several tasks:

- Identify zones/clusters in the grid with high RES penetration;
- Identify the need for reinforcements of inter-zone links;
- Propose new candidate inter-zonal lines (projects).

For this cycle, the market simulations will be performed with the PLEXOS software package, whereas the grid analyses will be completed with the PSS/E software package. For this purpose, it was decided that consultants will develop specific Python scripts for automated mapping between market outputs and the network model. The expected outcome is the identification of regional projects to support RES integration. The expansion of cross-border capacity will undoubtedly help to ensure that renewable resources are efficiently dispatched throughout the CSE region.

6.4. SINCRO.GRID project

The increasing integration of decentralised renewable sources has led to a lack of the flexibility resources needed to regulate the electricity systems of Croatia and Slovenia. The transmission and distribution system operators of these countries decided to seek a joint solution to this common problem in 2014. As the most promising solution was the establishment of international cooperation dedicated to fulfilling smart grid requests in these two countries, the idea of the SINCRO.GRID project was born in 2015. This project, included in the list of European Projects of Common Interest (PCIs), offered an innovative integration of mature technologies working in synergy. It aimed to improve the efficiency and security of not only the Slovenian and Croatian electricity systems but of the other countries in the region as well. The main goals of this project were as follows:

- Solving the issues of voltage profiles;
- Improving system balancing performance;
- Improving grid utilisation;
- Achieving higher potential penetration of RES;
- Increasing grid transfer capacity;
- Improving observability of MV & HV grids.

At the moment of the project's initiation, its official timeline was established. The official completion year for the project was set for 2021, and it was divided into six separate phases:

- Completing studies and technical documentation;
- Preparing Connecting Europe Facility (CEF) application;
- Tendering procedures;
- Upgrading the existing infrastructure;
- Implementing advanced tools in systems operation;
- Completing system testing and optimisation of all systems.

For a clear overview of the project, Fig. 6-2 illustrates the impact that the chosen improvements should have on the affected countries in the CSE region:

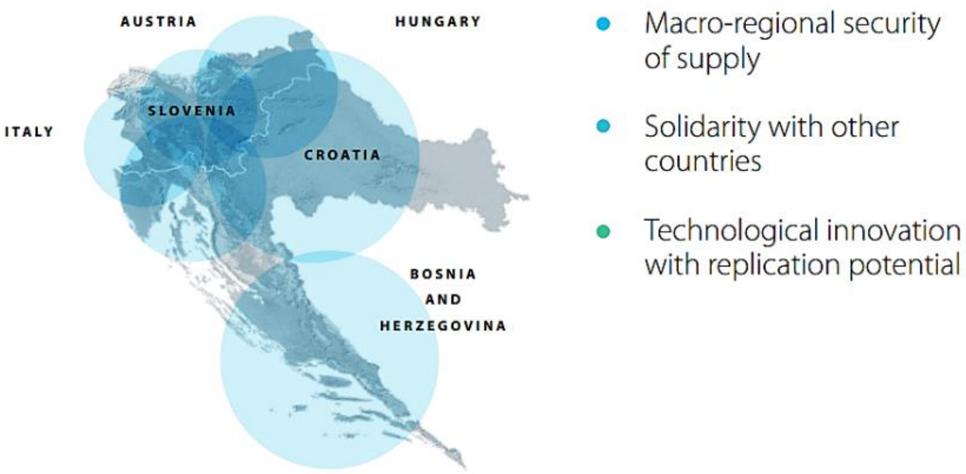

Figure 6-2: Impact of the improvements on countries in the CSE region.

In accordance with the objectives stated above, Fig. 6-3 provides an illustration of the outcomes and benefits of the SINCRO.GRID project:

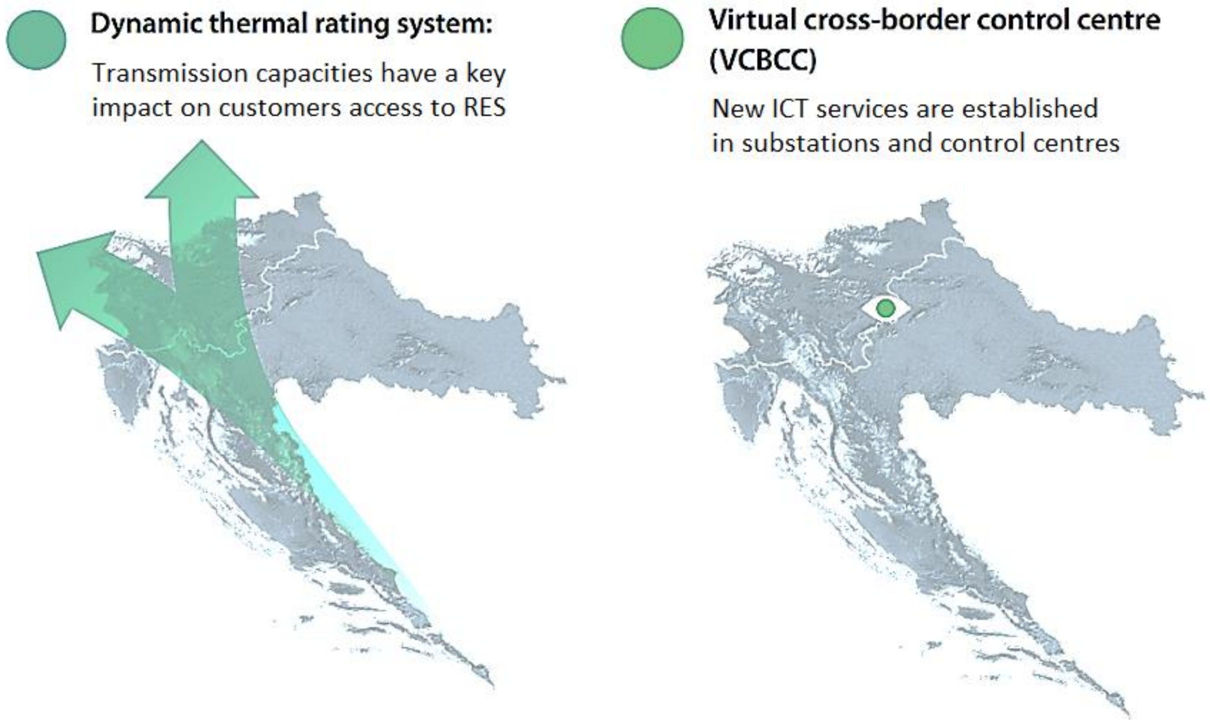

Figure 6-3: Outcomes and benefits of the SINCRO.GRID project.

It is important to mention that within the scope of the SINCRO.GRID project, a virtual cross-border control centre (VCBCC) was set up with several purposes: voltage control and loss optimisation, the efficient and coordinated management of RES and the secure operation of the whole control area. The variable shunt reactors have been implemented in the Croatian SS Mraclin (in 2020), Croatian SS Melina (in 2021), Slovenian SS Cirkovce (in 2021) and Slovenian SS Divaca (in 2021). Moreover, a mechanically switched capacitor was installed for operation in SS Divaca (in 2020). The SVC device in the Croatian SS Konjsko and STATCOM device in the Slovenian SS Bericevo were installed in 2021 and 2022, respectively.

The project also encompasses the integration of battery energy storage systems in Slovenian substations Pekre and Okroglo, both of which have been operational since 2020.

7. Projects relevant for the CSE region

This chapter is divided into three sections, with the first containing a list of projects in the region that were submitted for analysis within the scope of TYNDP 2022, the next focusing on the PECI/PMI projects in the CSE region and the last listing additional projects considered by the TSOs to be sufficiently relevant to include in the Regional Investment Plan.

7.1. TYNDP 2022 projects in the CSE region

As noted in the chapter introduction, this section will be based on the projects that were nominated for inclusion in TYNDP 2022 and that affect at least one country in the CSE region. The list of these projects can be seen in Table 7-1.

Table 7-1: List of TYNDP 2022 projects in the CSE region.

Project number	Project name	Affected countries in the region
26	Reschenpass Interconnector Project	Italy
28	Italy – Montenegro	Italy
29	Italy – Tunisia	Italy
33	Central Northern Italy	Italy
48	New SK–HU interconnection – phase 1	Hungary
127	Central Southern Italy	Italy
138	Black Sea Corridor	Bulgaria, Romania
142	CSE4	Bulgaria, Greece
144	Mid Continental East Corridor	Serbia, Romania
150	Italy – Slovenia	Italy, Slovenia
174	Greenconnector	Italy
219	EuroAsia Interconnector	Cyprus, Greece
227	Transbalkan Corridor	Serbia, Bosnia and Herzegovina, Montenegro
243	New 400 kV interconnection between Serbia and Croatia	Serbia, Croatia
250	Merchant line – Castasegna (CH) – Mese (IT)"	Italy
259	HU–RO	Hungary, Romania
283	TuNur	Italy
299	SACOI3	Italy
320	Slovenia-Hungary/Croatia interconnection	Slovenia, Hungary, Croatia

Project number	Project name	Affected countries in the region
323	Dekani (SI) – Zaule (IT) interconnection	Italy, Slovenia
324	Redipuglia (IT) – Vrtojba (SI) interconnection	Italy, Slovenia
325	AT, SI, IT – South-East Alps Project	Italy, Slovenia
336	Prati (IT) – Steinach (AT)	Italy
338	Adriatic HVDC link	Italy
339	Italian HVDC Tyrrhenian link	Italy
341	North CSE Corridor	Serbia, Romania
342	Central Balkan Corridor	Serbia, Bosnia and Herzegovina, Bulgaria, Montenegro
343	CSE1 New	Bosnia and Herzegovina, Croatia
375	Lienz (AT) – Veneto region (IT) 220 kV	Italy
376	Refurbishment of the 400 kV Meliti (GR) – Bitola (MK) interconnector	North Macedonia, Greece
1003^	Hydro-pumped storage in Bulgaria – Yadenitsa	Bulgaria
1006^	HPS AMFILOCHIA	Greece
1035^	Ptolemaida Battery Energy Storage System	Greece
1041	GREGY Interconnector	Greece
1048	Greece – Africa Power Interconnector (GAP Interconnector)	Greece
1055	Interconnection of Crete to the Mainland System of Greece	Greece
1059	Southern Italy	Italy
1066	Bulgaria – Türkiye	Bulgaria, Türkiye
1067	New AC 400 kV interconnection line Greece – Türkiye	Greece, Türkiye
1074	Pannonian Corridor	Serbia, Hungary
1085*	Malta – Italy Cable Link No.2	Italy
1105*	Georgia – Romania Black Sea (submarine) interconnection cable project	Romania
1107*	EuroAfrica Interconnector	Cyprus
1109*	Basilicata – Campania reinforcements	Italy
1110*	Sicily – Calabria	Italy
1112*	GRITA 2	Italy, Greece

Projects that are marked with the (*) symbol are new to the TYNDP process, whereas the (^) symbol denotes storage projects. The TYNDP 2022 project portfolio in the region is graphically represented on a map of the region in Fig. 7-1 below. Before proceeding with the analysis of the map, it should be stated that the different colours used for the project sections in this figure mark different statuses of the projects, as follows:

- Green – Under construction;
- Orange – In permitting;
- Red – Planned but not yet in permitting;
- Blue – Under consideration.

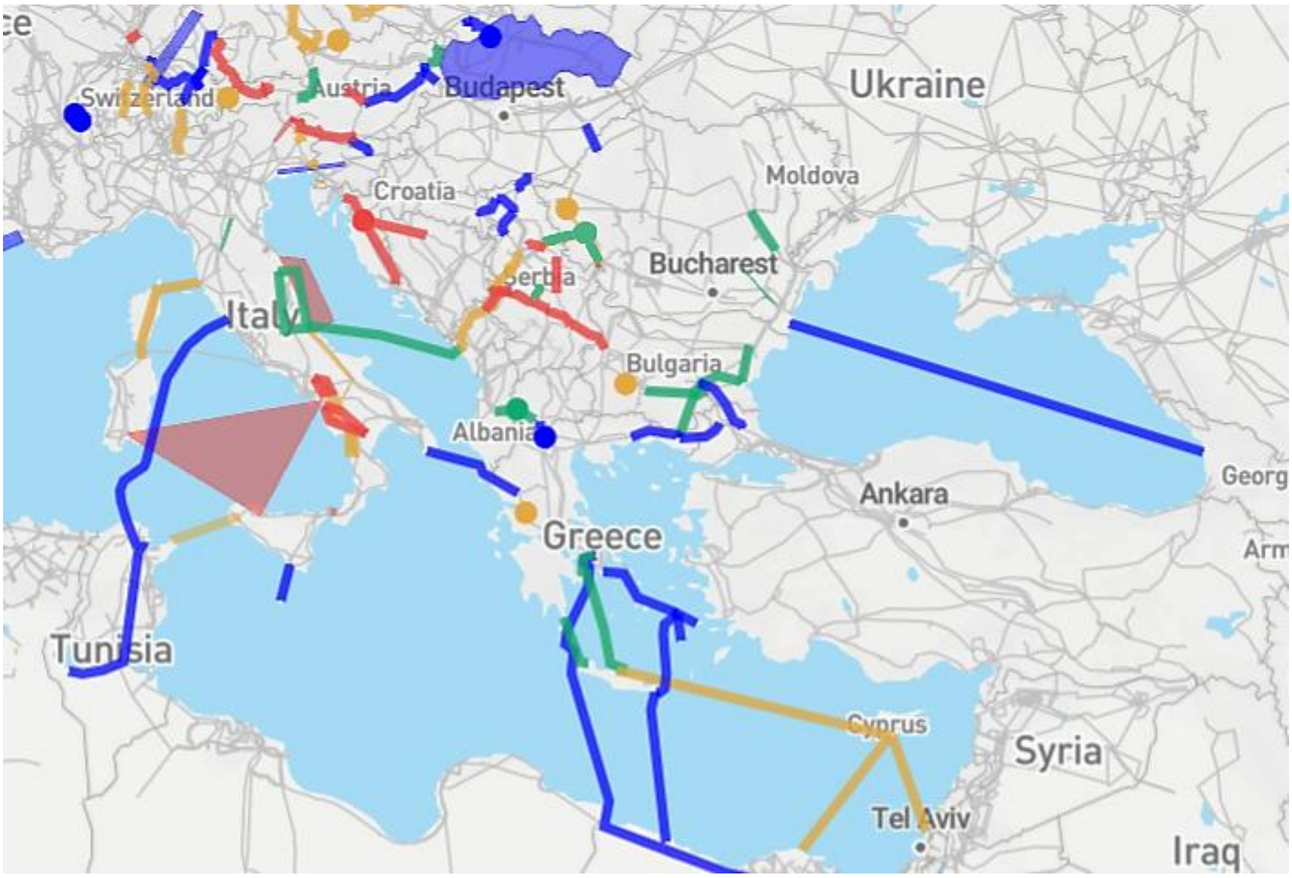

Figure 7-1: TYNDP 2022 projects in the CSE region.

A careful observation of Fig. 7-1 reveals that there are several major areas of interest for the construction of the new projects. The more prominent of these include the Mediterranean Sea (with a large number of projects connecting Italy, Greece and Cyprus with, for example, Egypt, Tunisia or Israel), the northern borders of Italy (with a large number of projects dedicated to increasing the transmission capacity of Italy towards its neighbouring countries, such as Austria and Slovenia), the western borders of Serbia (with several lines envisaged to increase the NTC of Serbia towards Croatia, Montenegro and Bosnia and Herzegovina) and even the Black Sea, with one of the new TYNDP projects (number 1105) connecting Romania to Georgia.

7.2. PECI/PMI projects in the CSE region

In order to provide the most up-to-date list of the projects that have obtained the PECI or PMI label, it is first necessary to give a brief introduction explaining the background of these lists. The beginning of the establishment of PECI and PMI dates back to October 16, 2015, when the Ministerial Council of the Energy Community adopted the Decision on the implementation of the EU regulation no. 347/2013 of the European Parliament and of the Council on guidelines for trans-European energy infrastructure. The main purpose of this measure was to create a legal framework for prioritising key energy infrastructure projects among Energy Community Contracting Parties as well as projects that affect both the Energy Community Contracting Parties and EU Member States. As adopted by the Energy Community, the regulation sets an all-inclusive environment for streamlining the permitting, legal and cost-allocation procedures in the Energy Community Contracting Parties.

As part of the measures adopted to fulfil the regulation's requirements, the Ministerial Council of the Energy Community has decided to set up a list of Priority infrastructure projects located in the Contracting Parties, named Projects of Energy Community Interest (PECI list). The regulation also offers the possibility of applying its provisions to the projects that are included in the PECI list but are announced as Projects of Mutual Interest (PMI projects) that are recognised as important by at least two neighbouring countries. One of these countries must be a Contracting Party, whereas the other must be a EU member state.

The contemporary lists of PECI and PMI projects were formed in the year 2020, when the projects were submitted by the promoters during the appropriate window. After this step, the projects that fulfilled certain criteria regarding eligibility for PECI and PMI status were reviewed by means of a public consultation launched by the Energy Community Secretariat. The following project was selected to be a part of the PECI list:

1) Transbalkan Corridor – new 400 kV OHL SS Kragujevac 2 (RS)–SS Kraljevo 3 (RS), with voltage level upgrade in SS Kraljevo 3 (RS) to 400 kV; new double-circuit 400 kV OHL SS Obrenovac (RS)–SS Bajina Basta (RS), with voltage level upgrade of SS Bajina Basta (RS) to 400 kV; new 400 kV interconnection between SS Bajina Basta (RS)–SS Visegrad (BA)–SS Pljevlja (ME).

The list of PMI projects was agreed upon at the same time. The following projects that have an effect on at least one country of the CSE region obtained the PMI label, confirming their importance for both the EU Member States and the Contracting Parties:

1) Rehabilitation and modernisation of OHL 750 kV NPP Pivdennoukrainska (UA)–SS Isaccea (RO).
2) Rehabilitation of OHL 400 kV SS Mukacheve (UA)–SS V. Kapusany (SK). Even though this project is not directly related to the CSE region, as none of the involved countries belong to it, its commissioning will still have a major influence on the situation in the CSE area; as such, it was deemed appropriate for inclusion in this subchapter.

Importantly, the new TEN-E regulation acknowledges the specific category of the PMI projects in the PCI process. This allows the PMI projects (as long as they meet certain criteria) the opportunity to obtain additional recognition in front of the appropriate bodies, which could later simplify the financing of these projects and make their construction faster and less complicated.

7.3. Additional projects relevant for the CSE region

Finally, this section was added to give the TSOs a unique opportunity to underline projects that were not nominated to be assessed within the TYNDP 2022 but which the TSOs still consider impactful enough to be a part of the Regional Investment Plan. The responses that were received by the TSOs once this question was raised can be seen in Table 7-2.

Table 7-2: List of additional relevant projects in the CSE region.

Project name	Commissioning year	Affected TSO in the region
New 400 kV SS Korinthos and 400 kV OHL SS Megalopoli – SS Korinthos	2022	IPTO
Brennero	2023	TERNA
Paternò-Piolo	2023	TERNA
400 kV OHL SS Megalopoli – SS Acheloos	2023	IPTO
110 kV interconnection line SS Srebrenica (BA) – SS Ljubovija (RS)	2024	JSC EMS, NOS BiH / Elektroprenos BiH
Upgrade of existing 220 kV OHL SS Senj – SS Melina with HTLS conductors	2024	HOPS
Upgrade of existing 220 kV OHL SS Konjsko – SS Krš Pađene with HTLS conductors	2024	HOPS
Upgrade of existing 220 kV OHL SS Krš Pađene – SS Brinje with HTLS conductors	2024	HOPS
New transformer 400/220 kV in SS Konjsko (HR)	2024	HOPS
Increase the capacity of the OHL 400kV București Sud – Pelicanu	2024	Transelectrica, ESO-EAD
In–out connection of the interconnection 400 kV OHL Rahman (RO) – Dobrudja (BG) in substation Medgidia Sud	2024	Transelectrica, ESO-EAD
In–out connection of the interconnection 400 kV OHL Stupina (RO) – Varna (BG) in substation Medgidia Sud	2024	Transelectrica, ESO-EAD
Increasing the transmission capacity by replacing the wires on the 220 kV OHL Stejaru (RO) – Gheorghieni (RO)	2025	Transelectrica

Project name	Commissioning year	Affected TSO in the region
Increasing the transmission capacity by replacing the wires on the 220kV OHL Fântânele (RO) – Gheorghieni (RO)	2025	Transelectrica
Upgrade of the existing 220 kV single-circuit line to 400kV OHL Stalpu (RO) – Teleajen (RO) – Brazi (RO)	2025	Transelectrica
Upgrade of the 220/110 kV substation Teleajen to 400/110 kV	2025	Transelectrica
Installation of flexible AC transmission systems to control power flows	2025	Transelectrica, ESO-EAD
Installation of a new transformer 400/220kV 400 MVA and extension of the substation Brazi Vest	2025	Transelectrica, ESO-EAD
Porto Ferraio (Elba Island) – Colmata (IT)	2025	TERNA
Dolo – Camin	2025	TERNA
Ciminna area	2025	TERNA
400 kV OHL SS Korinthos – SS Koumoundouros	2025	IPTO
SS 400/110 kV Konatice	2025	JSC EMS
S. Teresa – Budduso	2026	TERNA
Chiaramonte Gulfi – Ciminna	2026	TERNA
Reactive power compensator in SS 400/110 kV Vranje 4	2026	JSC EMS
SS 220/110 kV Ravne	2027	ELES
SS 400/110 kV Miletkovo	2027	MEPSO
Increase the capacity of the following power lines: 1. OHL 220 kV Gutinaș – Dumbrava; 2. OHL 220 kV Dumbrava – Stejaru; 3. OHL 220 kV Fântânele – Ungheni; 4. OHL 400 kV Gura Ialomiței – București Sud.	2028	Transelectrica, ESO-EAD

Project name	Commissioning year	Affected TSO in the region
New 400 kV double-circuit (one circuit wired) OHL Constanta Nord (RO) – Medgidia Sud (RO)	2028	Transelectrica
Media Valle Piave Rationalisation	2028	TERNA
Milan	2028	TERNA
Naples	2028	TERNA
Install Static VAR compensators (SVC) to allow power transmission to distant consumption nodes	2028	Transelectrica, ESO-EAD
Increase the capacity of the OHL 400kV Pelicanu – Cernavodă	2029	Transelectrica, ESO-EAD
Upgrade of existing OHL 400 kV Isaccea (RO) – Tulcea (RO) to double circuit	2030	Transelectrica
New 400 kV simple circuit OHL Suceava (RO) – Gadalin (RO)	2030	Transelectrica
New 400 kV OHL Suceava (RO) – Balti (MD)	2030	Transelectrica
New 2x400 kV OHL SS Tumbri – SS Velesevec	2030	HOPS
Treviso	2030	TERNA
Turin	2030	TERNA
Assoro	2030	TERNA
Sorgente 2	2030	TERNA
Assoro – Villafranca	2030	TERNA
SS 400/110 kV Vršac 4 (Nikolinci)	2030	JSC EMS
Restructuring of the Sorrento Peninsula network (IT)	2030	TERNA
New 220/110 kV substation Vodnjan	2032	HOPS
New 400 kV OHL Stalpu (RO) – Brasov (RO)	2036	Transelectrica
SS 400/110 kV Niš North	after 2030	JSC EMS

Appendices

As stated in both the Executive Summary and the Scope of the Regional Investment Plan, the main text is accompanied by three appendices that can be found below.

Appendix 1 – Glossary

TERM	ACRONYM	DEFINITION
Agency for the Cooperation of Energy Regulators	ACER	EU Agency established in 2011 by the Third Energy Package legislation as an independent body to foster the integration and completion of the European Internal Energy Market, both for electricity and natural gas.
Bottom-Up		This approach to the scenario-building process collects supply and demand data from Gas and Electricity TSOs.
Carbon budget		This is the amount of carbon dioxide the world can emit while still having a likely chance of limiting average global temperature rise to 1.5 °C above pre-industrial levels, an internationally agreed-upon target.
Combined heat and power	CHP	Combined heat and power generation.
Congestion revenue / rent		The revenue derived by interconnector owners from the sale of interconnector capacity through auctions. In general, the value of the congestion rent is equal to the price differential between the two connected markets multiplied by the capacity of the interconnector.
Congestion		A situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from the international trade requested by market participants due to a lack of capacity of the interconnectors and/or the national transmission systems concerned.
Cost-benefit analysis	CBA	Analysis carried out to determine the degree to which a project is worthwhile from a social perspective.
Curtailed electricity		A reduction in the output of a generator from otherwise available resources (e.g. wind or sunlight), typically on an unintentional basis. Curtailments can occur when operators or utilities control wind and solar generators to reduce output to minimise the congestion of transmission, achieve the optimum mix of resources or otherwise manage the system.

Demand-side response	DSR	Consumers have an active role in softening peaks in energy demand by changing their energy consumption according to the energy price and availability.
e-Highway2050	EH2050	Study funded by the European Commission aimed at building a modular development plan for the European transmission network from 2020 to 2050, led by a consortium including ENTSO-E and 15 TSOs from 2012 to 2015 (to e-Highway2050 website).
Energy not served	ENS	Expected amount of energy not being served to consumers by the system during the period considered, either due to system capacity shortages or unexpected severe power outages.
Grid transfer capacity	GTC	The aggregated capacity of the physical infrastructure connecting nodes in reality; it is not only set by the transmission capacities of cross-border lines but also by the ratings of so-called 'critical' domestic components. The GTC value is thus generally not equal to the sum of the capacities of the physical lines represented by this branch. It is represented as a typical value across the year.
Investment (in the TYNDP)		Individual equipment or facility, such as a transmission line, cable or substation.
Mid-term adequacy forecast	MAF	ENTSO-E's pan-European monitoring assessment of power-system resource adequacy, spanning a timeframe from one to ten years ahead.
Net transfer capacity	NTC	The maximum total exchange programme between two adjacent control areas that is compatible with the security standards applicable in all control areas of the synchronous area and taking into account the technical uncertainties about future network conditions.
N-1 criterion		Rule requiring elements that remain in operation within a TSO's responsibility area after a contingency from the contingency list to be capable of accommodating the new operational situation without violating operational security limits.
National Energy and Climate Plan	NECP	National Energy and Climate Plans are the new framework within which EU Member States must plan, in an integrated manner, their climate and energy objectives, targets, policies and measures for the European Commission. Countries will have to develop NECPs on a ten-year rolling basis and provide an update halfway through the implementation period. The NECPs covering the first period from 2021 to 2030 will have to ensure that the Union's 2030 targets for greenhouse gas emissions, renewable energy, energy efficiency and electricity interconnection are met.

North–south electricity interconnections in Central Eastern and South Eastern Europe	NSI East Electricity	One of the four priority corridors for electricity identified by the TEN-E Regulation, including interconnections and internal lines in the north–south and east–west directions to complete the EU internal energy market and integrate renewable energy sources.
Project (in the TYNDP)		Either a single investment or a set of investments clustered together to form a project in order to achieve a common goal.
Put in one at a time	PINT	Methodology that considers each new network investment/project (line, substation, PST or other transmission network device) on the given network structure one by one, evaluating the load flows over the lines with and without the examined network reinforcement.
Reference grid		The existing network plus all mature TYNDP developments, allowing the application of the TOOT approach.
Reference capacity		Cross-border capacity of the reference grid, used for applying the TOOT/PINT methodology in the assessment according to the CBA.
Scenario		A set of assumptions for modelling purposes describing a specific future situation in which certain conditions regarding infrastructure, the supply and demand of electricity and gas, fuel prices and the global context occur.
Take out one at a time	TOOT	Methodology that consists of excluding investment items (line, substation, PST or other transmission network device) or complete projects from the forecasted network structure on a one-by-one basis and evaluating the load flows over the lines with and without the examined network reinforcement.
Ten-Year Network Development Plan	TYNDP	The Union-wide report carried out by ENTSO-E every other year as (TYNDP) part of its regulatory obligation as defined under Article 8, para 10 of Regulation (EC) 714 / 2009.
Top-Down		The ‘Top-Down Carbon Budget’ scenario-building process is an approach that uses the ‘bottom-up’ model information gathered from the gas and electricity TSOs. The methodologies are developed in line with the Carbon Budget approach.
Trans-European Networks for Energy	TEN-E	Policy focused on linking the energy infrastructure of EU countries. It identifies nine priority corridors (including four for electricity) and three priority thematic areas.

Appendix 2 – Hyperlinks to the Network Development Plans

TSO	LINK
OST	***can be found at:** https://www.ost.al/
NOS BiH	https://www.nosbih.ba/files/2021/03/20210311-lat-Dugorocni-plan-razvoja-prenosne-mreze-2021-2030-Knjiga-1.pdf
ESO-EAD	https://www.eso.bg/doc?93
HOPS	https://www.hops.hr/page-file/bsAQ9AhqCaU33Auv0GyGe5/92136ad3-dfa8-4674-b6aa-3c7a0d41654c/HOPS%2010G%20plan%20razvoja%202022%20-%202031%20web.pdf
TSOC	https://tsoc.org.cy/files/electrical-system/tydplan/%CE%94%CE%A0%CE%91%CE%A3%CE%9C%202022-2031.pdf
IPTO	https://www.admie.gr/sites/default/files/users/dssas/DPA%202023-2032/%CE%94%CE%A0%CE%91%202023-2032%20%CE%9A%CF%8D%CF%81%CE%B9%CE%BF%20%CE%A4%CE%B5%CF%8D%CF%87%CE%BF%CF%82.pdf
MAVIR	https://www.mavir.hu/documents/10258/239341965/HFT2021_A+magyar+VER+h%C3%A1l%C3%B3zatfejleszt%C3%A9si+terve_kivonatolt.pdf/7255772f-c929-cedd-f32c-df74d64372f2?t=1640105340687
TERNA	https://www.terna.it/en/electric-system/grid/national-electricity-transmission-grid-development-plan
KOSTT	https://www.ero-ks.org/2019/Tregu/KOSTT_Plani%20Zhvillimor%20i%20Transmetimit%202020-2029_ver.0.1_eng.pdf
CGES	https://www.cges.me/regulativa/razvoj-sistema
MEPSO	https://www.mepso.com.mk/docs/puben/Development%20plan%202021-2030.pdf
Transelectrica	https://www.transelectrica.ro/ro/web/tel/planului-de-dezvoltare-ret-2020-2029?p_p_id=82&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_count=1&_82_struts_action=%2Flanguage%2Fview&_82_redirect=%2Fro%2Fweb%2Ftel%2Fplanului-de-dezvoltare-ret-2020-2029%3Fp_p_id%3D82%26p_p_lifecycle%3D1%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_count%3D1%26_82_struts_action%3D%252Flanguage%252Fview%26_82_redirect%3D%252Fro%252Fweb%252Ftel%252Fplanului-de-dezvoltare-ret-2020-2029%26languageId%3Den_US%26random_token%3D611a547f-48af-4204-ce9f-3ba168df77a4&languageId=en_US&random_token=a4834ae1-058e-4f7f-8cd2-cf4dc4b99228
JSC EMS	http://ems.rs/media/uploads/Plan_razvoja_prenosnog_sistema_2.pdf
ELES	https://www.eles.si/Portals/EN/Document/ELES_Development_plan_2021-2030-r.pdf

Appendix 3 – Hyperlinks to the Simulation Results

IoSN results that were used as the basis for Chapter 3 can be found on the online system needs data visualisation platform https://needs.entsoe.eu/

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