REGIONAL
INVESTMENT PLAN 2024

CONTINENTAL SOUTH EAST

June 2025

entsoe
ELECTRIFYING EUROPE

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 **40 member TSOs**, representing 36 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

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering 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 with a combination of 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 using its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

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

As the 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 as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

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

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Questions?

Contact us as at **tyndp@entsoe.eu**

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1 Executive Summary: Key Messages for the RG CSE

The Regional Investment Plan (RegIP) CSE 2024 outlines key plans and strategies for the electricity transmission system across the Continental South East (CSE) region. This report shows the current context and future infrastructure needs, analysed with the aim of ensuring security of supply, facilitating renewable energy integration, and enhancing cross-border electricity exchanges. The CSE region, which includes 13 countries, from Central East Europe to the Balkans and the Mediterranean, has seen significant growth in renewable energy, notably in solar and wind power. This transition is crucial for the EU's energy goals as the region moves towards decarbonisation and aims to achieve carbon neutrality by 2050.

The CSE region is already experiencing significant shifts in its electricity landscape, with increasing levels of solar and wind energy generation. From 2019 to 2023, the installed capacity for renewables has grown substantially, especially in Italy, Greece, Hungary, and Bulgaria, leading to a reduction in fossil fuel dependency. However, this rapid shift and the ongoing energy transition, with high integration of onshore and offshore renewable energy sources (RES) and targets and the phase out of nuclear and fossil-fuel power units across the continent, have introduced several current and future challenges in the CSE region. These include grid stability, transmission efficiency, energy balance, voltage control, reactive power control, changes in flow directions, storage and power-to-gas (P2G) integration, and supply chain. All these elements are shaping the energy system and necessitate a regional approach.

Some key projects have already been completed, including the 400 kV Bulgaria–Greece interconnection, the Italy–France high-voltage direct current (HVDC) link, and new Hungary–Croatia–Slovenia cross-border connections, which have strengthened cross-border capacity within the region or in countries at the borders of the region. Looking towards 2040 and 2050, continued investment in both transmission infrastructure and storage solutions to ensure that Europe can meet its climate goals is essential for the region. With a focus on 2040, the System Needs Study identified opportunities on almost all the borders of the region. The TYNDP 2024 project portfolio includes 46 transmission projects and 12 storage projects, with a total investment of €60 billion to strengthen the regional grid and address system needs. However, further opportunities to develop new solutions for increasing capacity in 2040 have been identified, namely between Albania and Serbia, Albania and Montenegro, Bosnia and Herzegovina and Montenegro, and Croatia and Slovenia.

With the optimal 2040 grid, the CSE region achieves a 5 TWh reduction in RES energy surplus, avoids 10 Mt of CO_2 emissions, and sees an average electricity cost reduction of € 7/MWh, narrowing the margin difference among the countries. In 2050, 24.9 TWh of energy savings is achieved, with an average electricity cost reduction of € 10.3/MWh, while countries in the region achieve the zero-emissions target.

On a regional level, some enabling factors will be key to facing future challenges. These include the development of new technologies (e.g. storage systems, electrical vehicles), integration of various energy sectors (e.g. hydrogen technology, power-to-X (P2X)), reinforcement of internal networks, improved performance of existing system assets, implementation of non-infrastructure solutions (e.g. software), new design ideas for upgrading current assets, operational measures to enhance transmission capacity utilisation, and new technologies to address grid constraints and supply chain challenges.

Input Section

2 Introduction to the Regional Investment Plans 2024

The Regional Investment Plans (RegIPs) developed by ENTSO-E offer a comprehensive regional analysis of key findings from the TYNDP, highlighting regional specificities while ensuring coordination across Europe. RegIPs may also include studies performed by TSOs at the regional level.

The RegIPs are published in accordance with Regulation (EU) 2019/943 (Articles 34 and 48), which mandates regional cooperation among transmission system operators (TSOs) within ENTSO-E and requires their biennial publication. TSOs may also use these plans to inform investment decisions.

In developing the RegIPs, ENTSO-E incorporates crucial elements of the TYNDP, including the **ONDP**, **Scenario Report**, and **System Needs Study**. TYNDP scenarios outline potential European energy futures up to 2050, serving as a tool to evaluate prospective electricity and gas infrastructure needs and projects. These scenarios form the foundation for the RegIPs, illustrating the future challenges faced by each region. The System Needs Study examines opportunities to improve the system over the mid- and long-term time frames. The RegIPs then further analyse capacity enhancements identified in the System Needs Study at both the regional and national levels, providing detailed insights into infrastructure development needs. Finally, the ONDP assesses the need for offshore transmission infrastructure to integrate RES in alignment with Member States' targets.

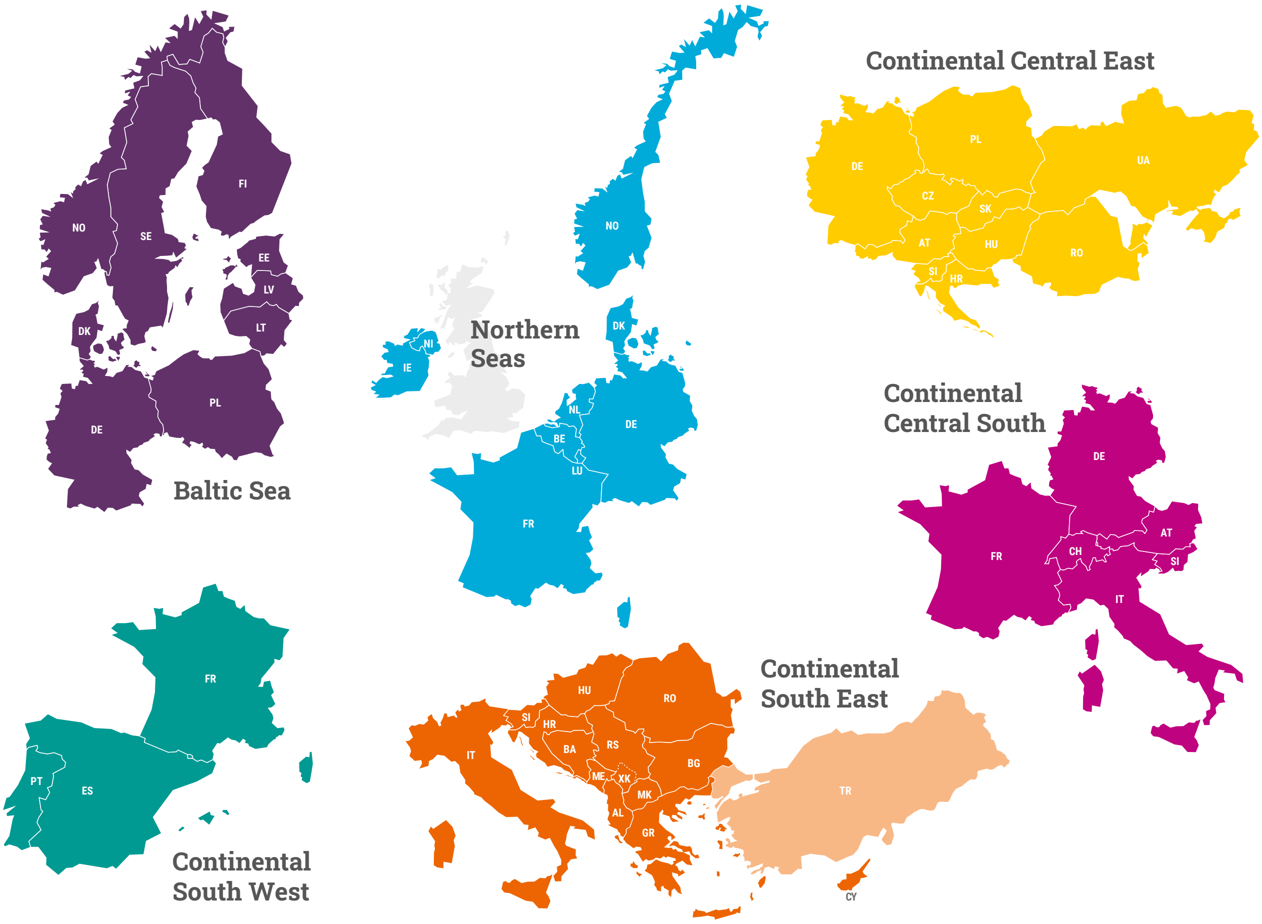

Figure 1: ENTSO-E's six system development regions, each region is covered by one Regional Investment Plan

3 Regional Context

3.1 Overview of the region and current situation

The CSE region

The CSE region is composed of 13 countries and covers the area from Central East Europe down to the Balkan Peninsula and the Mediterranean Sea, including Italy and Cyprus.

Countries	TSOs
Albania (AL)	OST – OST sh.a – Albanian Transmission System Operator
Bosnia and Herzegovina (BA)	NOSBiH – Nezavisni operator sustava u Bosni Hercegovini
Bulgaria (BG)	ESO – Electroenergien Sistemen Operator EAD (Електроенергиен системен оператор)
Croatia (HR)	HOPS – HOPS d.d.
Cyprus (CY)	Cyprus TSO – Cyprus Transmission System Operator
Greece (GR)	IPTO – Independent Power Transmission Operator S.A.
Hungary (HU)	MAVIR – MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság
Italy (IT)	Terna – Terna – Rete Elettrica Nazionale SpA
Montenegro (ME)	CGES – Crnogorski Elektroprenosni Sistem AD
North Macedonia (MK)	MEPSO – Transmission System Operator of the Republic of North Macedonia
Romania (RO)	Transelectrica – C.N. Transelectrica S.A.
Serbia (RS)	EMS – Akcionarsko društvo Elektromreža Srbije
Slovenia (SI)	ELES – ELES, d.o.o.

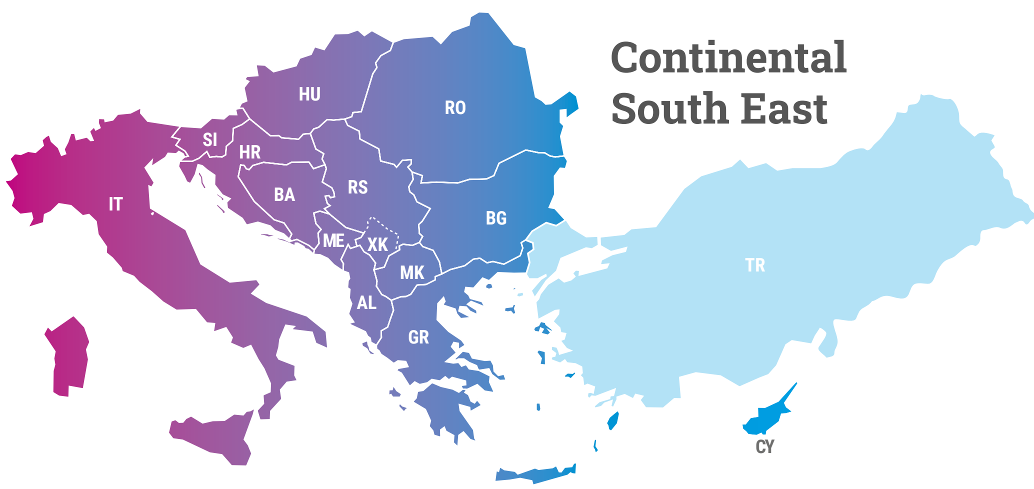

Figure 2: ENTSO-E's System Development Committee CSE Region

In addition, the Turkish TSO (TEIAS) participates in the work of Regional Group (RG) CSE with observer status. Transmission system and market operator KOSTT also participates in RG activities as an observer.

Current situation (capacities in the region)

The CSE region is connected by 100 tie-lines between the member countries and the countries at the borders of the region. Figure 3 shows the number of interconnections on each of the borders in the region by voltage level (double circuits are counted once). As shown in the figure, the region is interconnected synchronously (AC) and the voltage levels present in the CSE region are 400 kV, 220 kV and 110–150 kV. CSE is also interconnected with two DC links between Italy and the Balkan Peninsula, specifically to Greece and Montenegro.

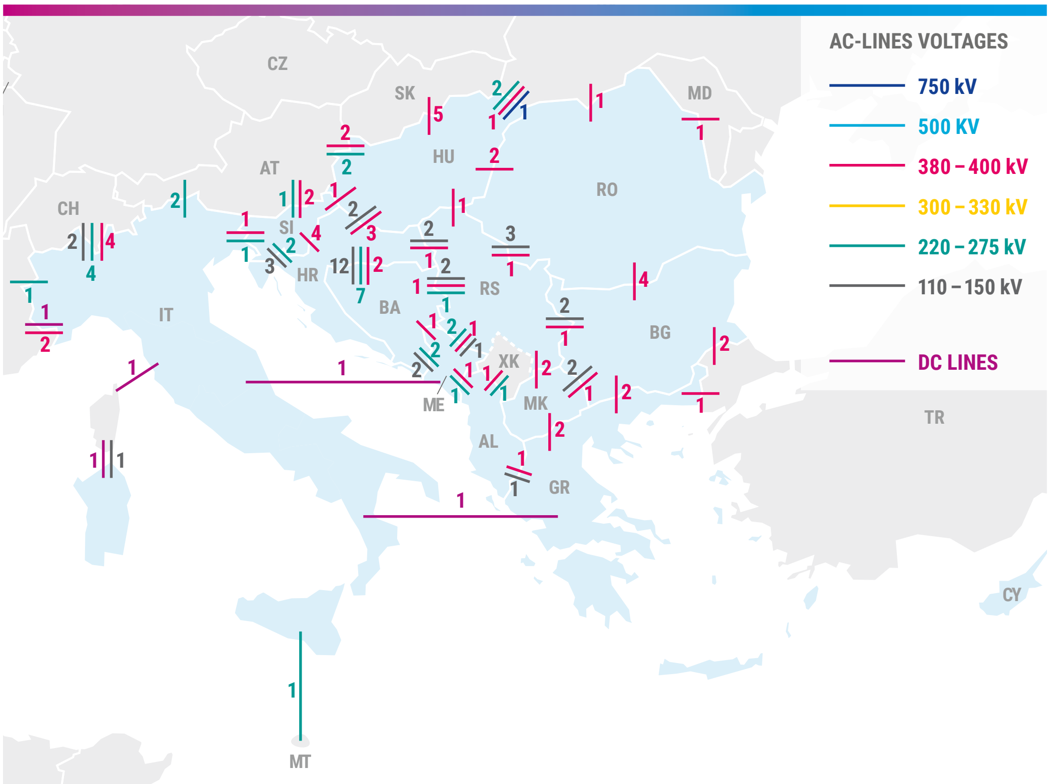

Figure 3: Number of interconnectors per voltage level

Figure 4 shows the average annual net transfer capacities (NTCs) on the borders in the CSE region registered during 2023. These values take into account available NTCs, forced outages, and the maintenance of tie-lines on each border. The majority of NTCs on each border in the region are around 300–500 MW bidirectionally, while at the Bulgaria–Romania border, values exceed 1,500 MW in both directions.

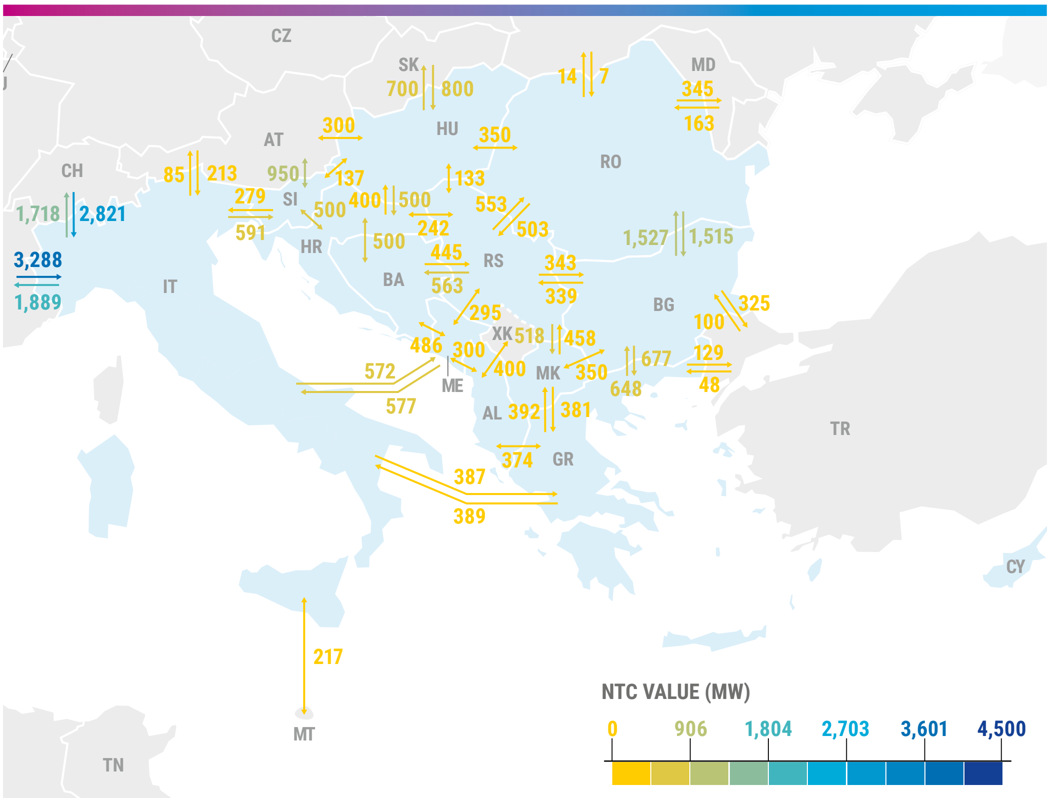

Figure 4: Map of NTCs in the region

Installed capacities

In recent years, there has been a significant increase in installed RES capacity throughout the region. Figure 5 shows the evolution of installed generation capacities, from 294.41 GW in 2019 to 329.77 GW in 2023, an increase of 10.8 %, including Turkey. Excluding Turkey, the increase in the region is 9 % (203.14 GW in 2019 to 223.03 GW in 2023). The increase in installed capacity is due to the high increase in RES power plants: 24.74 GW of new solar and 8.34 GW of new wind capacities in the region, including Turkey.

The increase in the period 2019–2023 mostly occurred in Italy (around 9.1 GW of new solar and 1.6 GW of new wind capacities), Greece (3.91 GW of new solar, 1.76 GW of new wind capacities), Hungary (2.34 GW of new solar), and Bulgaria (2.03 GW of new solar). In Turkey, the increase was 5.32 GW of new solar and 4.21 GW of new wind capacities.

There has been a noticeable decrease in fossil fuel share in favour of renewable sources, especially solar power plants, while other installed generation technologies are at approximately the same levels in 2023 and 2019.

This trend aligns with energy transition plans: the increase in capacity was primarily driven by the commissioning of more renewables power plants, while the decrease reflects the decommissioning of fossil fuel–based thermal units.

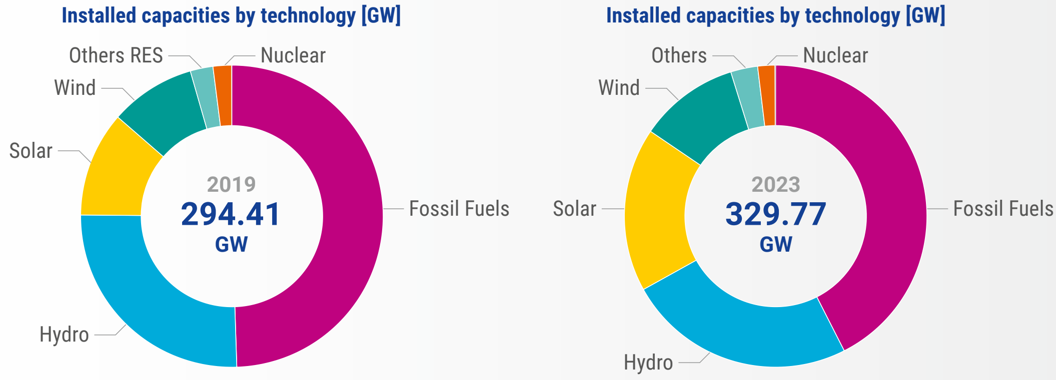

Figure 5: Installed capacities by technology in the region in 2019 and 2023

Generation and consumption

Figures 6 and 7 show annual electricity demand at the country level and annual generation by fuel type in the region in 2019 and 2023. Annual electricity demand is slightly less for all CSE countries in 2023 compared to 2019, with the exception of Turkey.

Total annual generation in 2023 slightly increased (0.33 %) over 2019, with the inclusion of Turkey. Excluding Turkey, the CSE region shows a decrease of 3.9 % in total electricity generation due to decreases in electricity demand in CSE countries.

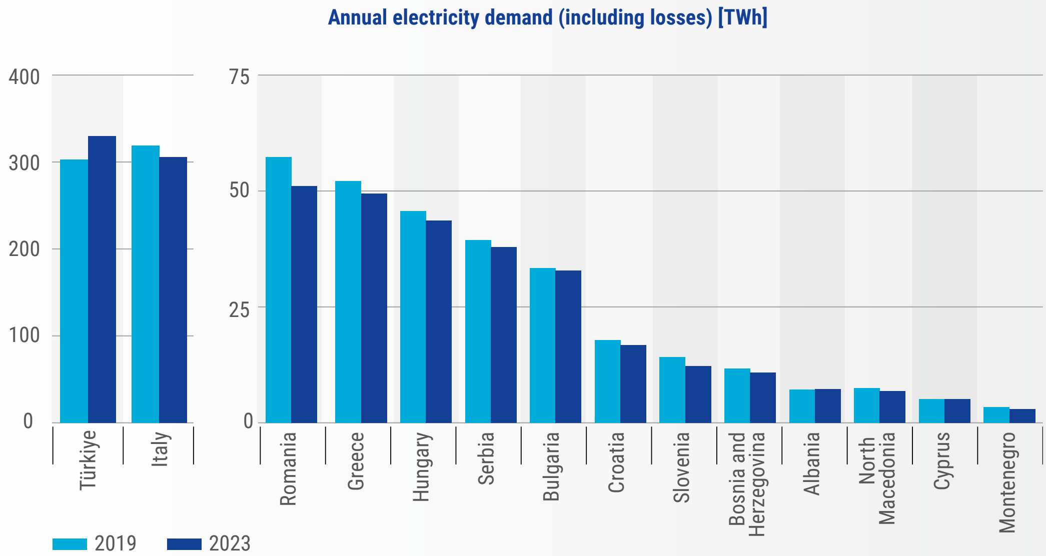

Figure 6: Annual electricity demand in 2019 and 2023 (in TWh)

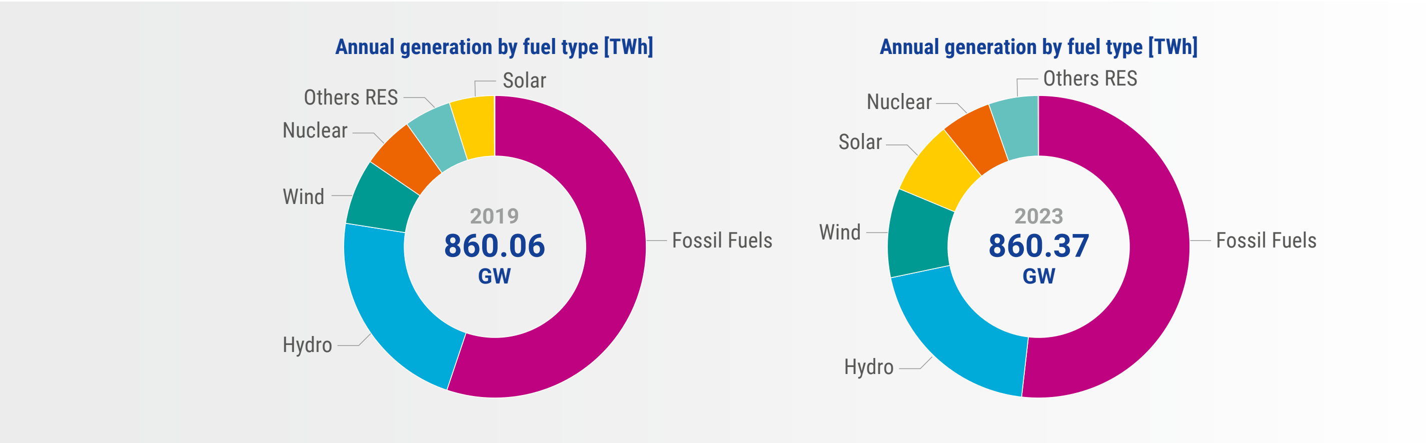

Figure 7: Annual electricity demand in 2019 and 2023 (in TWh)

Figure 8 shows a more detailed representation of the annual generation by fuel type, compared to country-level demand in 2019 and 2023. The largest percentage decrease in fossil fuel electricity generation from 2019 to 2023 occurred in Greece (−28 %), Bulgaria (−27.8 %), Hungary (−22.9 %), Romania (−22 %), and Italy (−15.6 %), with a corresponding increase in generation from solar and wind. This trend is also evident in Cyprus, which is not yet interconnected with the rest of the region, as it experiences increased solar generation. In Italy, Hungary, and Greece, annual demand outpaced generation in 2023, which was also the case in 2019.

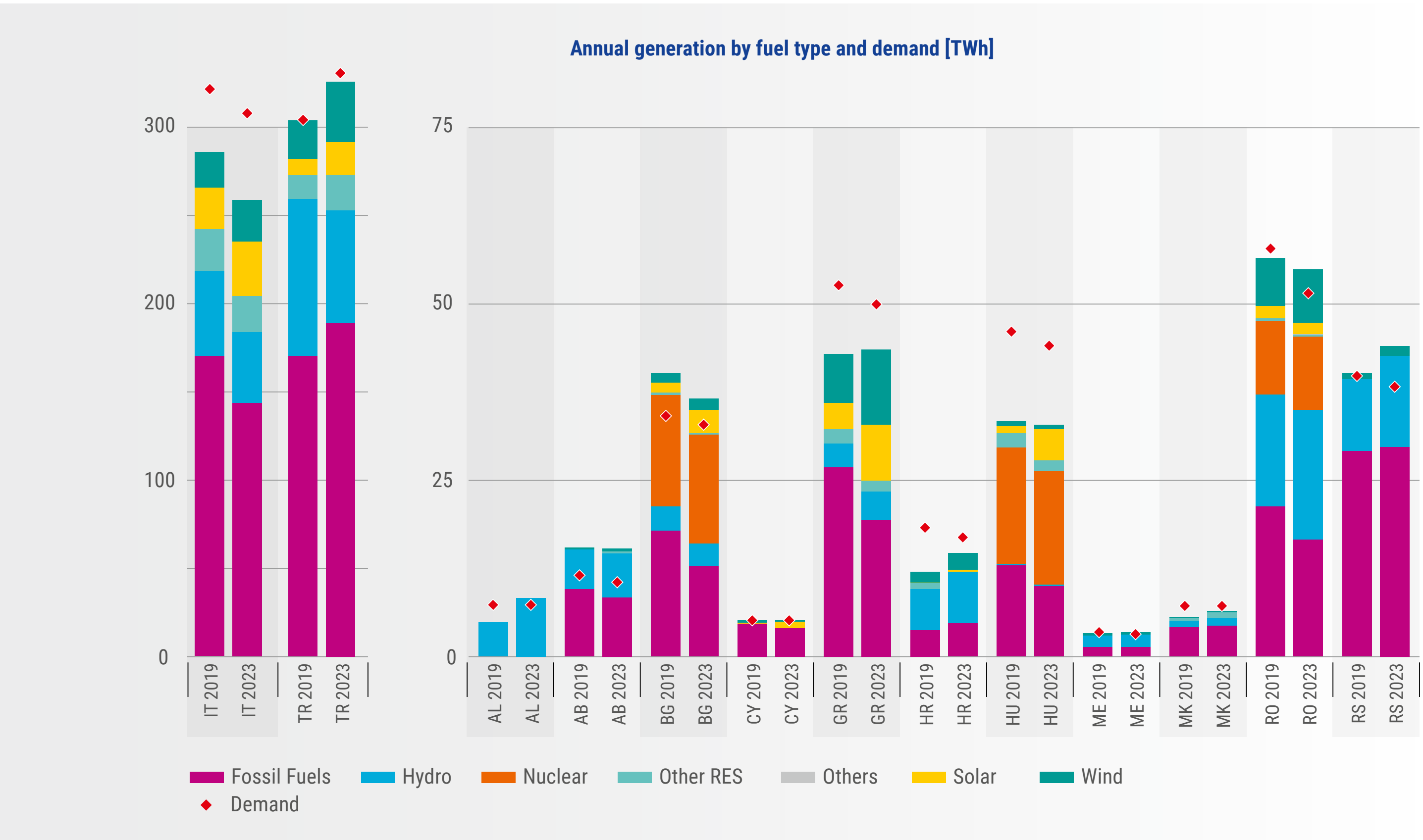

Figure 8: Comparison of the annual generation and consumption (in TWh) by country in 2019 and 2023

Exchanges

The analysis of annual electricity imports and exports per country in 2023 vs 2019 (Figure 9) shows that certain countries in the region, such as Croatia, Greece, Italy, and Hungary, consistently function as electricity importers. Notably, Italy and Hungary increased their import levels in 2023 compared to 2019. The main exporters of the region remain Bulgaria, Romania, and Bosnia and Herzegovina, all of which produced more energy than their domestic demand in 2023. Generally, the CSE region overall imported more electricity in 2023 than in 2019.

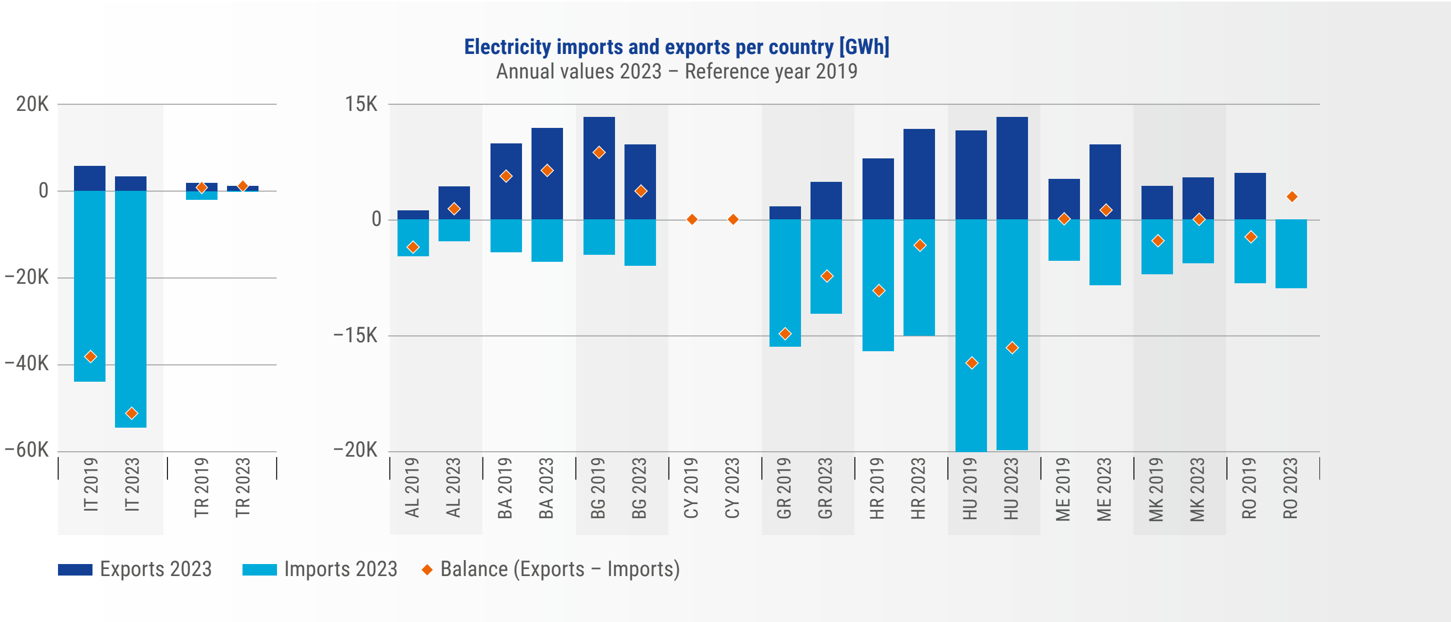

Figure 9: Annual electricity imports and exports per country in 2023 compared to 2019 (in GWh)

Figure 10 shows cross-border physical energy flows per border in 2023 compared to 2019. Energy exchange trends in the CSE region are slightly impacted by changes in the grid when comparing 2023 to 2019. The main borders affected are those at the northern borderline of the region.

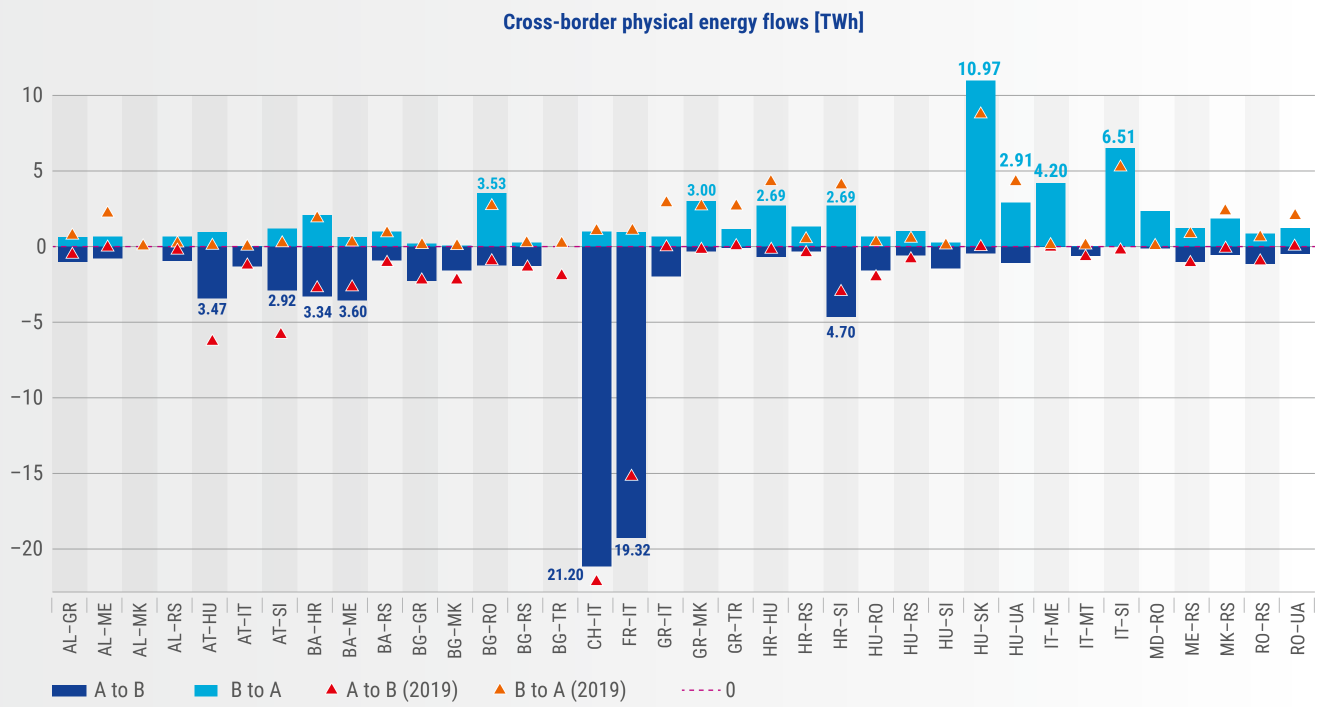

Figure 10: Cross-border physical energy flows per border in 2023 compared to 2019 (in TWh)

Evolution compared to RegIP 2022

Over the two years since the last RegIP in 2022, the following projects have become operational:

- **Project 142 – CSE4,** which involves significant 400 kV reinforcements in the southern part of the Bulgarian transmission network, has been completed. This includes the 400 kV transmission lines Maritsa East 1–Plovdiv, Maritsa East 1–Maritsa East 3, and Maritsa East 1–Burgas, as well as the second 400 kV interconnection between Nea Santa (Greece) and Maritsa East 1 (Bulgaria). The new interconnection was commissioned in July 2023. This project, with a length of 405 km in total, has been included in the ENTSO-E TYNDP since 2012 and labelled as a European Project of Common Interest (PCI) from the first EU PCI list. The completion of this large-scale project less than a decade from its inception is an example of regional cooperation. It also shows the importance of EU support in accelerating the permitting and implementation processes by enabling all available resources. The project's valuable contribution to EU-wide targets has been widely acknowledged, as it increases NTC at the BG–GR border, contributes to strengthening the north–south corridor in the Balkan Peninsula, and increases RES penetration in the area, thereby supporting the achievement of Clean Energy Package targets. The project also contributes to the convergence of market prices between neighbouring countries and reinforces the integration of the Turkish electricity system into the interconnected electricity system of continental Europe.

- **Project 320 – double 400 kV OHL Cirkovce–Heviz/Zerjavinec** was commissioned in June 2022, establishing the first cross-border connection with the transmission network of neighbouring Hungary. One system is connected to the Heviz substation in Hungary, while the other is connected to the Zerjavinec substation in Croatia. As part of the project, the 220/110 kV Cirkovce substation was reconstructed as a 400/110 kV substation. The project was included in the ENTSO-E TYNDP and the European Commission's PCI list in 2015, as it brings significant benefits to at least two Member States. The project facilitates greater market integration in the region, facilitates access to eastern electricity markets, contributes to RES integration, and improves security of supply in the region.
- **HVDC Italy France** consists of underground cables linking the Piossasco and Grande Ile electrical substations (poles 1 and 2), leading to an NTC increase of 1,200 MW on the IT–FR border. In August 2023, following the full commissioning of the entire system, the interconnection stretch owned by the national transmission grid became operational. Based on Regulation (EU) 347/2013, the work has been included in the European Commission's PCI list since 2013.
- **220 kV Nauders–Glorenza power line,** leading to an NTC increase of 300 MW on the Italy–Austria border. The line entered service in December 2023.
- **Various projects of regional relevance.** In Albania, a new shunt reactor at the 400 kV substation Tirana 2 became operational, while in Croatia, the upgrade of the existing 220 kV OHL SS Senj–SS Melina with High-Temperature Low-Sag (HTLS) conductors was completed. In Greece, the new 400 kV SS Korinthos, 400 kV OHL SS Megalopoli–SS Korinthos, and 400 kV OHL SS Megalopoli–SS Acheloos were commissioned and entered into commercial operation. In Italy, the Porto Ferraio (Elba Island)–Colmata (IT) project was completed, while in Romania, the in–out connections of the 400 kV OHL interconnections Rahman (RO)–Dobrudja (BG) and 400 kV OHL Stupina (RO)–Varna (BG) in substation Medgidia Sud were also completed.

Figures 11 and 12 present an overview of the CSE projects included in TYNDP 2022 and TYNDP 2024. In TYNDP 2024, 14 new transmission projects and nine new storage projects were submitted, adding more than 28 GW to the region's project portfolio and increasing investments by at least €35 billion. A shift in the estimated commissioning date can be observed compared to TYNDP 2022. Most projects included in TYNDP 2024 are estimated to become operational within the 2030–2039 time frame, while investments beyond 2040 represent only a small share of the overall portfolio. Based on their status, many projects included in TYNDP 2022 have progressed, with an increasing number reaching advanced stages: 46 % of the CSE projects included in TYNDP 2024 have entered the permitting or construction phase. Most of the region's projects included in TYNDP 2024 are either under consideration or planned, having not yet reached the permitting stage, as was also the case in the previous TYNDP.

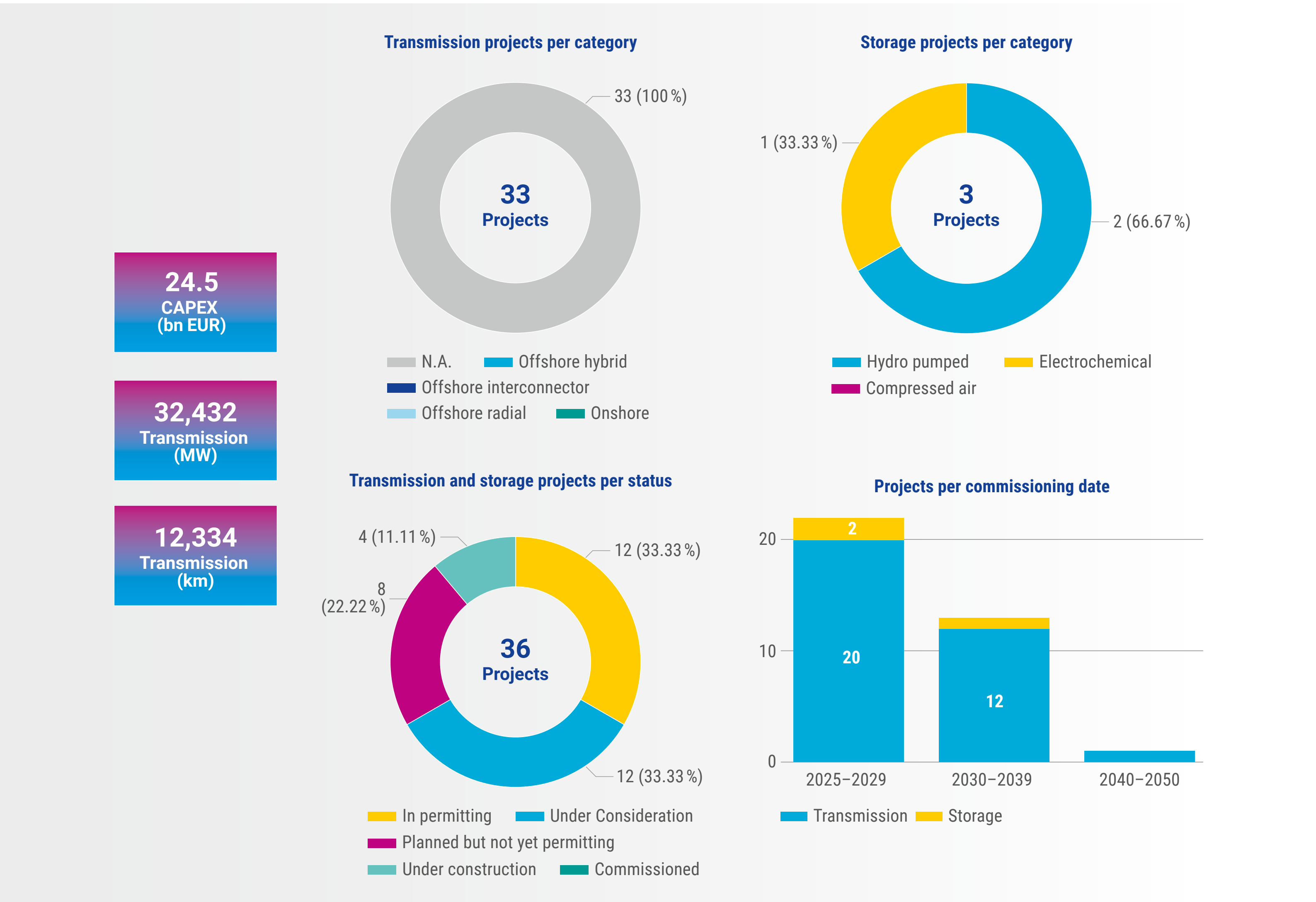

Figure 11: Overview of CSE projects included in TYNDP 2022

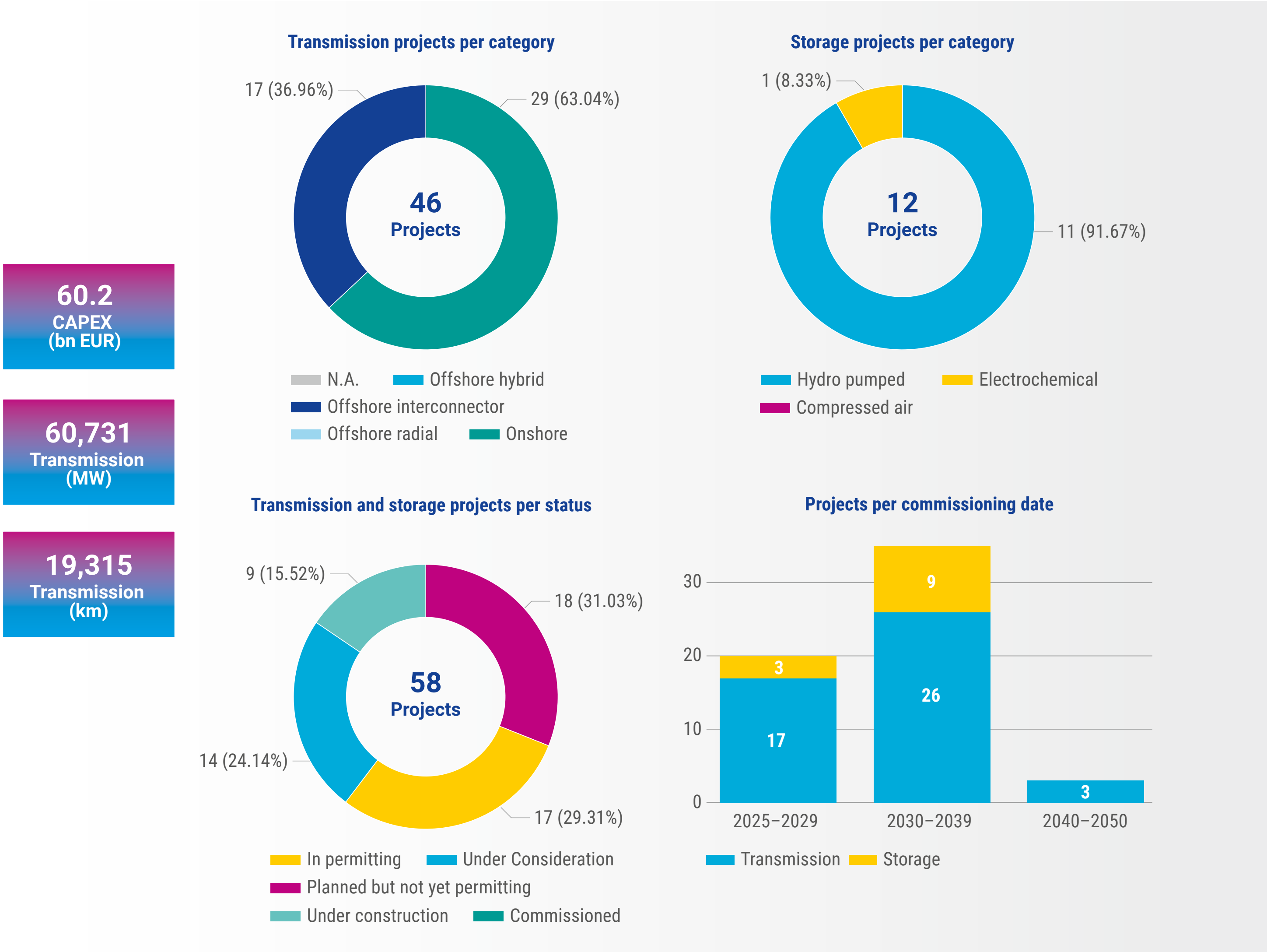

Figure 12: Overview of CSE projects included in TYNDP 2024

Figure 13 shows the TYNDP 2024 transmission and storage projects in the CSE region. A detailed list of these projects can be found in Appendix I.

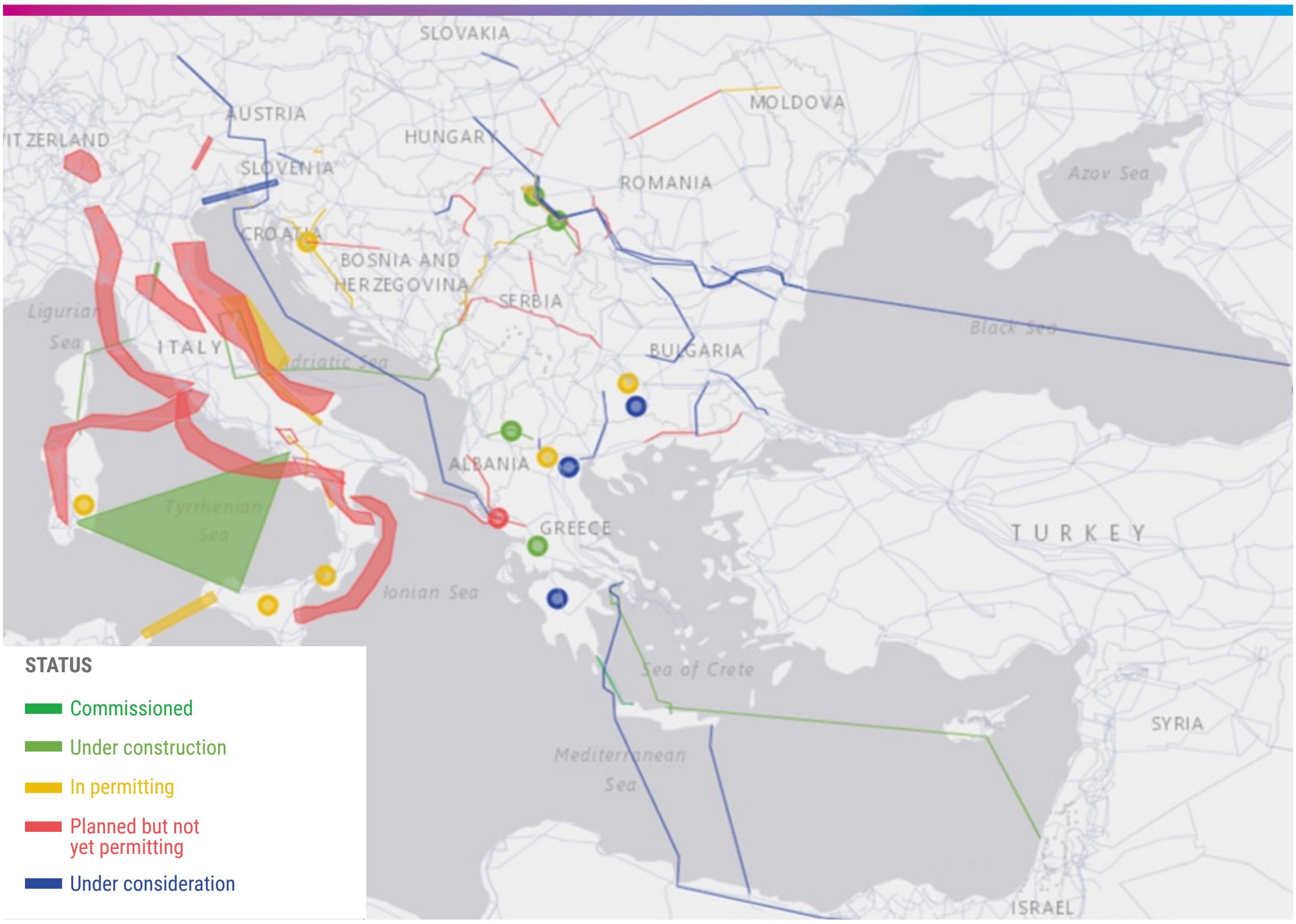

Figure 13: Map of TYNDP 2024 projects in the CSE region

3.2 Current and expected challenges in the region

EU targets: Europe has embarked on an unprecedented societal transformation with its Green Deal goal of reaching carbon neutrality by 2050. The European Climate Law sets an ambitious path towards decarbonisation, with an intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The Fit for 55 Package and REPowerEU plan will accelerate the energy transition to carbon neutrality at a much greater scale with the increase of renewable energy and energy efficiency targets for 2030.

EU Member States' National Energy and Climate Plans (NECPs): When developing these plans, EU Member States were required to meet the EU's objectives for 2030, including the energy efficiency target of reducing energy consumption by at least 32.5 % (compared to projections of expected energy use in 2030). The TYNDP 2024 National Trends (NT) 2040 scenario builds on the 2030 objectives. Although 2040 targets for EU energy efficiency have not yet been set, the capacity increase needs identified in the study exist in a world where significant energy efficiency gains have already been achieved.

Offshore targets: Ambitious non-binding offshore targets, as specified in the ONDPs, are an emerging challenge for TSOs across Europe.

Supply chain challenges: The EU's ambitious energy transition goals, including integrating vast amounts of green electricity and electrifying consumption sectors, will require significant infrastructure expansion and modernisation. However, implementing this infrastructure comes with a series of challenges: permitting delays often slow project timelines, financing complexities hinder investment flows, and gaining public acceptance for new infrastructure can be difficult. A critical focus in overcoming these barriers lies in addressing the resilience and efficiency of supply chains. As the demand for grid technologies rises sharply, the availability of critical components, skilled labour, and effective procurement processes will be central to meeting Europe's energy and climate objectives. Ensuring robust supply chains is essential to delivering the infrastructure required for a sustainable and secure energy future.

Maintaining inertia: During this transformation, the electricity transmission system must adapt not only to accommodate shifting patterns of demand and generation but also to address the varying operational characteristics associated with system dynamics and stability. As traditional rotating masses are increasingly replaced by inverter-based resources, the system will rely on advanced control strategies to maintain power system stability. The decrease in system inertia is one natural consequence of replacing rotating synchronous generators, leading to increased frequency sensitivity and reduced frequency stability in the electricity system. As a result, the Continental Europe Synchronous Area (CESA) electricity system will be exposed to larger frequency excursions in the event of power imbalances resulting from system splits (normal operation would not represent an immediate challenge). Therefore, maintaining frequency stability in all these situations and ensuring the effectiveness of emergency measures in extreme cases, e.g. out-of-range events such as system splits of the CESA, is of the utmost importance.

Fundamental changes in the energy system

Europe's ongoing energy transition has brought fundamental changes to the energy system, with high onshore and offshore RES integration and targets and the phase out of nuclear and fossil-fuel power units across the continent. These shifts introduce new challenges in the CSE region, including grid stability, transmission efficiency, energy balance, voltage control, reactive power control, changes in flow directions, storage and P2G integration, and supply chain dynamics. These complexities are reshaping the energy system and underscore the need for a coordinated regional approach. Although offshore development has not yet commenced in CSE, the non-binding agreements made by EU Member States in this region have shaped the first edition of the ONDP for South East Europe. These agreements present new challenges for the region and will be further evaluated in future editions of the ONDP.

4 Regional System Needs

4.1 Regional results of the identification of system needs

Overview of system needs in 2030

The 2030 System Needs Study considers a scenario where EU Member States implement the objectives set in their NECPs. Because the compilation of all national plans falls short of meeting EU targets for 2030, the TYNDP 2024 scenario bridges the gap to ensure all targets are reached.

With this scenario and the 2030 electricity grid, the EU will meet its CO_2 emission reduction targets and the share of RES in the primary energy supply mix will reach 40 % by 2030. System costs across the entire study area are expected to reach approximately € 95 billion by 2030, reflecting the significant evolution of the production mix, overall European demand, and the forecasted grid. However, with further investments in its electricity system, Europe could reduce its system costs while accelerating its energy transition.

In the CSE region for the 2030 horizon, this may be reflected by transmission opportunities mainly along the borders with Turkey, as well as the Albania–Montenegro, Bosnia and

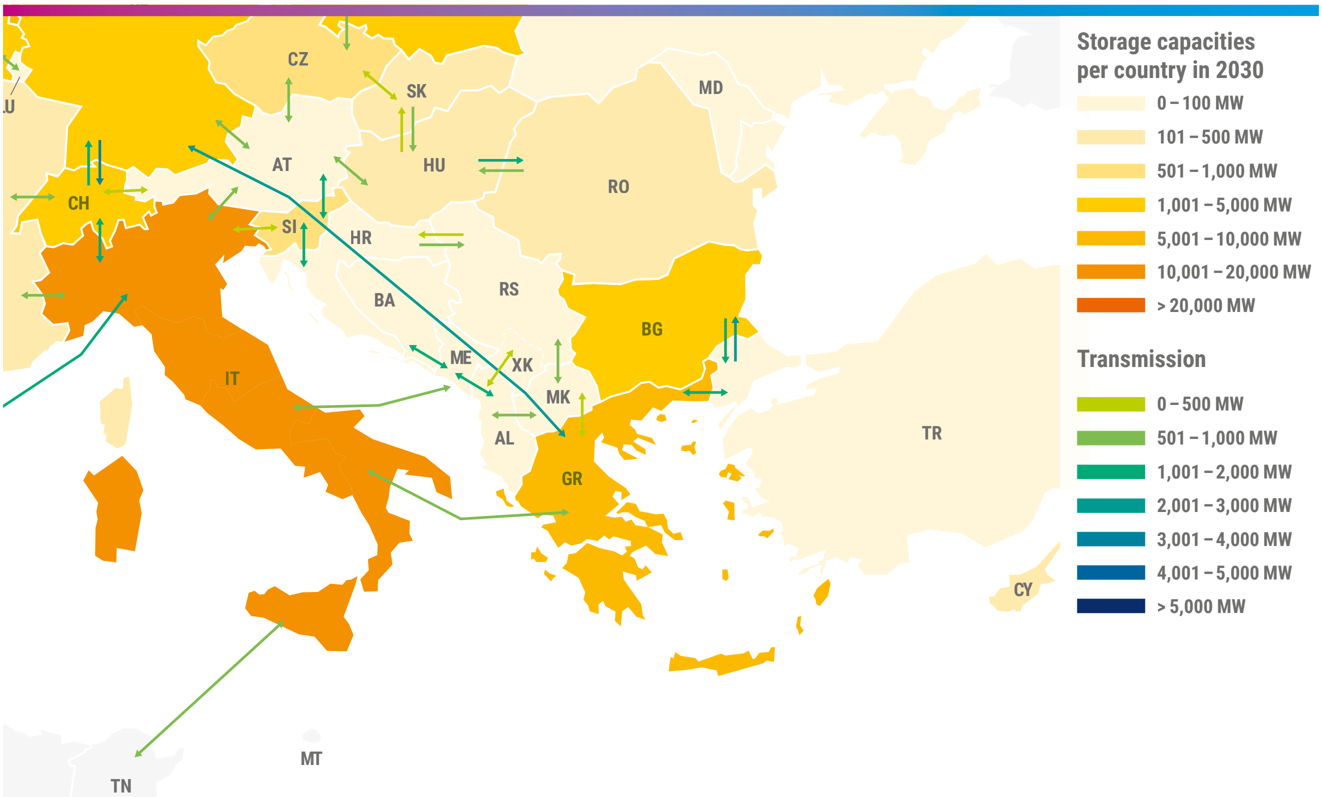

Figure 14: System needs in the 2030 NT scenario in the CSE region

Herzegovina–Montenegro, Croatia–Slovenia, Greece–Germany (Green Aegean Interconnector Project), Hungary–Romania, and Austria–Slovenia borders, each with capacity increases exceeding 1,000 MW. Smaller opportunities of less than 1,000 MW are also indicated at several borders in the region, including Albania–Serbia, Greece–North Macedonia, and Italy–Slovenia. No additional capacity increases are identified in the east corridor of the region, comprising Romania–Bulgaria–Greece, Romania–Serbia–Bulgaria, and Greece–Cyprus.

Storage opportunities could also emerge throughout the entire CSE region, mainly in Italy (10–20 GW) and Greece (5–10 GW). In Bulgaria, 1–5 GW flexibility opportunities have been identified, as well as up to 1 GW in Slovenia. Cyprus, Hungary, and Romania have significantly less flexibility needs, in the range of 100–500 MW. Flexibility needs are extremely low for the rest of the countries in the region and Turkey, ranging from 0 to 100 MW in 2030.

Overview of system needs in 2040

In 2040, as in 2030, needs appear on most European borders. The whole electricity grid is optimised in the System Needs Study, including the onshore cross-border network, offshore interconnections, and the offshore hybrid corridors identified by the ONDP. The System Needs Study did not identify additional storage needs for 2040; however, the identified needs are supplemental to the development of flexibility assets in the scenario considered.

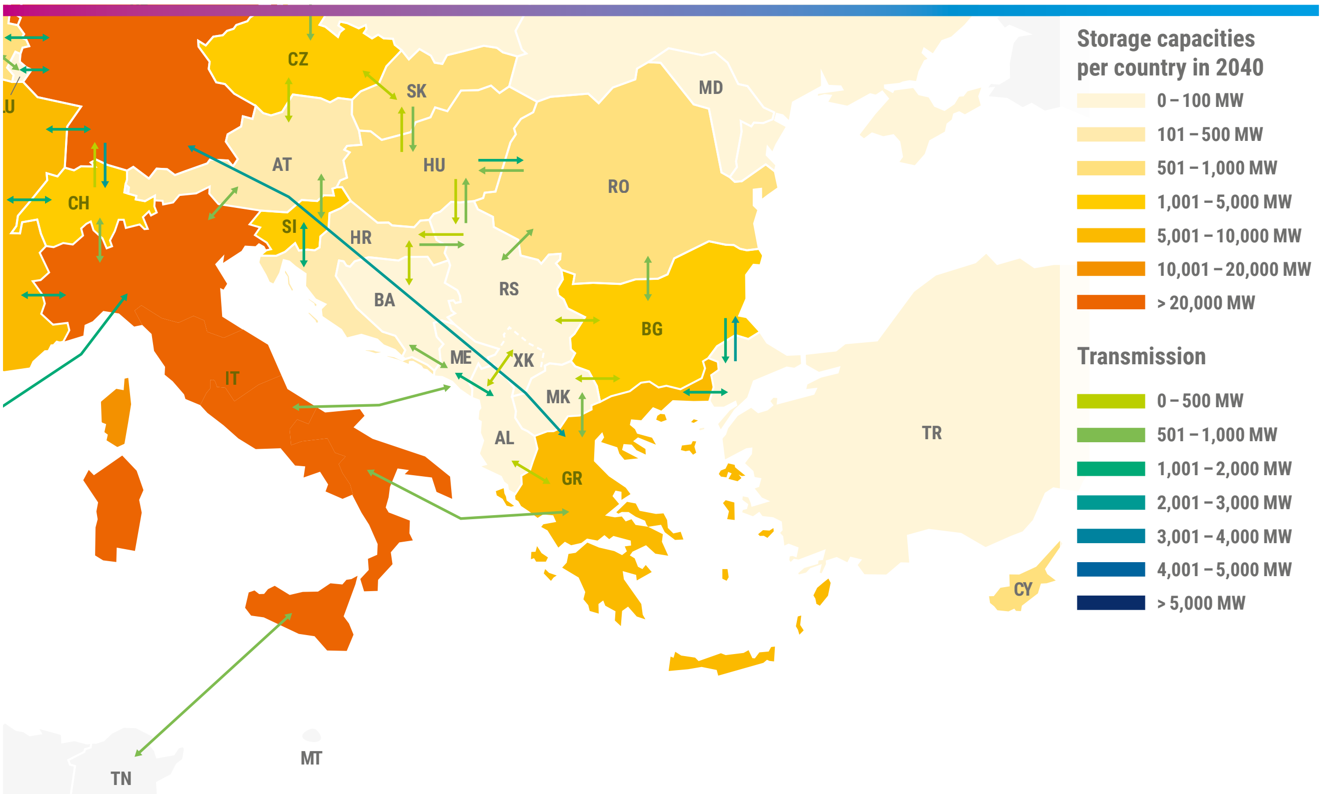

Figure 15: System needs in the 2040 NT scenario in the CSE region

In the CSE region, transmission opportunities are identified on almost all borders of the region. In addition to the borders where 2030 transmission opportunities are identified, opportunities up to 1,000 MW are indicated at the Bulgaria–Romania and Romania–Serbia borders, while opportunities at the Croatia–Serbia border are further increased in the 2040 study. Opportunities up to 500 MW are indicated at the Albania–Greece, Bosnia and Herzegovina–Croatia, Bulgaria–North Macedonia, and Bulgaria–Serbia borders. As in the 2030 study, no needs are identified at the Bulgaria–Greece, Bosnia and Herzegovina–Serbia, Croatia–Hungary, Cyprus–Greece, Montenegro–Serbia, and Hungary–Slovenia borders.

Storage opportunities derived from the NT 2040 scenario have increased compared to 2030. Predominant increases in flexibility opportunities are identified in Italy, exceeding 20 GW. A significant increase, in the range of 1–5 GW, is identified in Slovenia, and increases of up to 1 GW are also identified in Cyprus, Hungary, and Romania. To a lesser extent, increased opportunities are also identified in Croatia, in the range of 100–500 MW. Greece remains at the same high level as in 2030, between 5–10 GW. The remainder of the countries in the region, including Turkey, remain in the range of 0–100 MW, as identified in the 2030 horizon.

No hybrid corridors were identified in the ONDP for the 2040 horizon in CSE.

Overview of system needs in 2050

TYNDP 2024 includes, for the first time, an analysis of system needs in the 2050 time horizon. This study is based on the Distributed Energy (DE) 2050 scenario, which is aligned with the "Energy Efficiency First" objective and EU ambitions for carbon neutrality by 2050. The system needs analysis explores a distant and uncertain future in only one scenario, therefore providing a mere glimpse at one possible far-off potential future. The realisation of this future will largely depend on economic growth, electricity demand, technological progress, and political ambitions.

The System Needs Study finds that by 2050, investing in an additional 224 GW of cross-border grid – including 44 GW of hybrid offshore capacity and 540 GW of storage capacity (including 312 GW of battery storage capacity in scenario DE 2050 and a 228 GW increase in storage capacity) – would maximise the cost-efficiency of Europe's carbon-neutral electricity system.

In CSE, transmission opportunities in the 2050 horizon are identified on almost every border in the region, except Bosnia and Herzegovina–Serbia and Greece–Cyprus. In 2050, new opportunities up to 1,000 MW are identified at the Bulgaria–Greece, Croatia–Hungary, Italy–Slovenia, Montenegro–Serbia, and Hungary–Slovenia borders. Compared to the 2040 horizon, increased needs on most borders are also identified, in the range of 500–1,000 MW and 1,000–2,000 MW, except for the Albania–Montenegro, Bulgaria–North Macedonia, Bulgaria–Romania, Croatia–Slovenia, Greece–Germany, and Romania–Serbia borders, where no further increase is identified in the 2050 horizon. The highest opportunity in the region, exceeding 5,000 MW, is indicated on the Hungary–Romania border. Greater storage opportunities are identified for almost every country in the region, including Turkey, which ranges from 5–10 GW. The most prominent increased opportunities are identified in Greece, exceeding 20 GW, followed by Cyprus and Romania, with increased flexibility opportunities in the range of 1–5 GW. Significant lower increases in opportunities, in the range of 100–500 MW, are identified in Albania, Bosnia and Herzegovina, Montenegro, and North Macedonia. Unaffected in the 2050 horizon are Bulgaria, Croatia, Italy, Hungary, Serbia, and Slovenia, with Serbia demonstrating considerably less flexibility needs in the region, up to 100 MW.

As in 2040, no hybrid corridors were identified in the ONDP for the 2050 horizon in CSE.

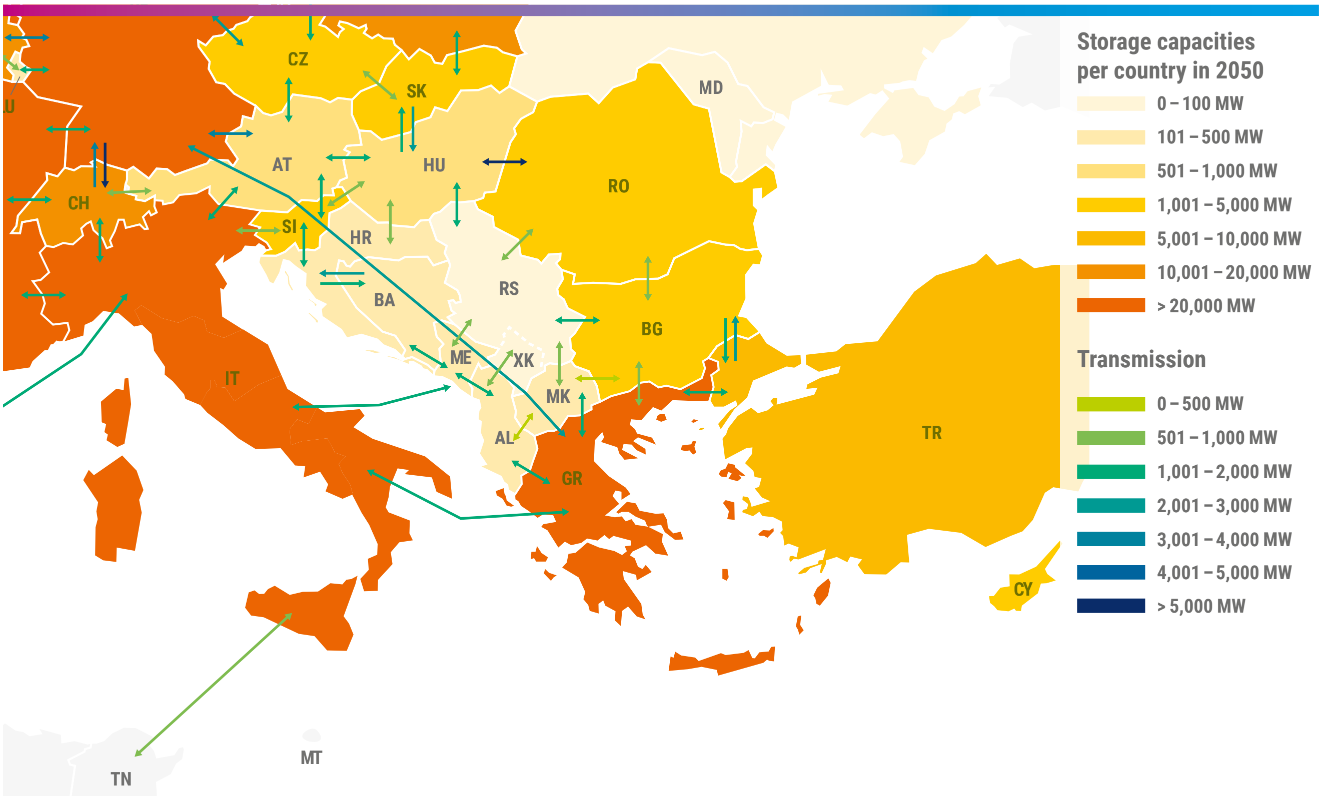

Figure 16: System needs in the 2050 DE scenario in the CSE region

4.2 Market results

Key findings

NT 2030

Although the NT 2030 scenario has been analysed, 2030 should be viewed as a short-term horizon. Conducting "what if" analyses to assess the impact of accelerating and completing projects scheduled for beyond 2030 before this date could reveal significant benefits at the European level. The market results of the 2030 study, particularly focusing on the CSE region, demonstrate that an optimised grid could yield substantial advantages: Italy alone could save 0.7 TWh of energy surplus, Greece, Italy, and Romania could collectively avoid 7 million tonnes of CO_2 emissions, and the average reduction in marginal costs would be €0.1/MWh.

NT 2040

The TYNDP 2024 primarily concentrates on the long-term horizon, with the NT 2040 scenario studied to pinpoint opportunities and gaps. This chapter presents an analysis of the key findings for the CSE region within this scenario.

In 2040, with RES targets set, the CSE region achieves 5 TWh less RES energy surplus in the optimal grid, avoids 10 Mt of CO_2 emissions, reduces electricity costs by an average of €7/MWh, and reduces margin differences among countries.

DE 2050

In the TYNDP study, focusing on the very long-term horizon of 2050 under the DE scenario, the optimised grid for the CSE region achieves total energy savings of 24.9 TWh, predominantly in Italy, Greece, and Romania. The average reduction in electricity costs is €10.3/MWh. Additionally, most countries reach the zero-emissions target, collectively avoiding 7 million tonnes of CO_2 emissions. Hungary also achieves the zero-emissions target, while Italy alone avoids 6 million tonnes of emissions.

Overview per indicator

2040 energy mix

Energy saved is mostly indicated in Italy, while also noted in Croatia, Greece, and Romania. Non-RES production is reduced in almost all countries, with the exception of Albania, which showed a slight increase. A high increase in P2G could be observed in Greece, with increases also observed in Croatia, Slovenia, and Hungary, and decreases seen in Italy and Romania. An increase in storage could be indicated in the region, with Italy and Greece showing the highest values. A reduction in nuclear energy is observed in Bulgaria and Hungary, whereas Romania experiences an increase.

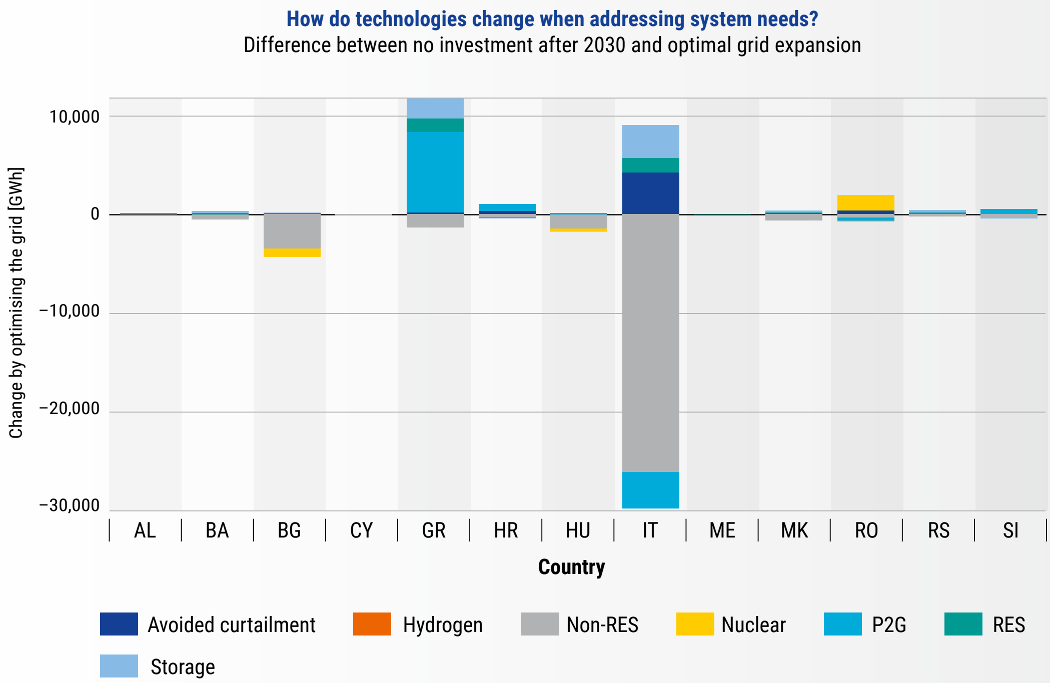

Figure 17: 2040 Optimal grid energy mix in the CSE region

2040 CO_2 emissions

In the CSE region, CO_2 emissions are mainly at very low levels, with the exception of Italy and Serbia. Albania and Montenegro have no emissions since they are RES-based power systems. In the optimal grid, CO_2 emissions in the region are further reduced from already low levels, with Bosnia and Herzegovina reaching the zero-emissions target and most of the other countries cutting CO_2 emissions in half. Italy also shows a reduction in its high levels of CO_2 emissions, while a slight decrease is observed in Serbia.

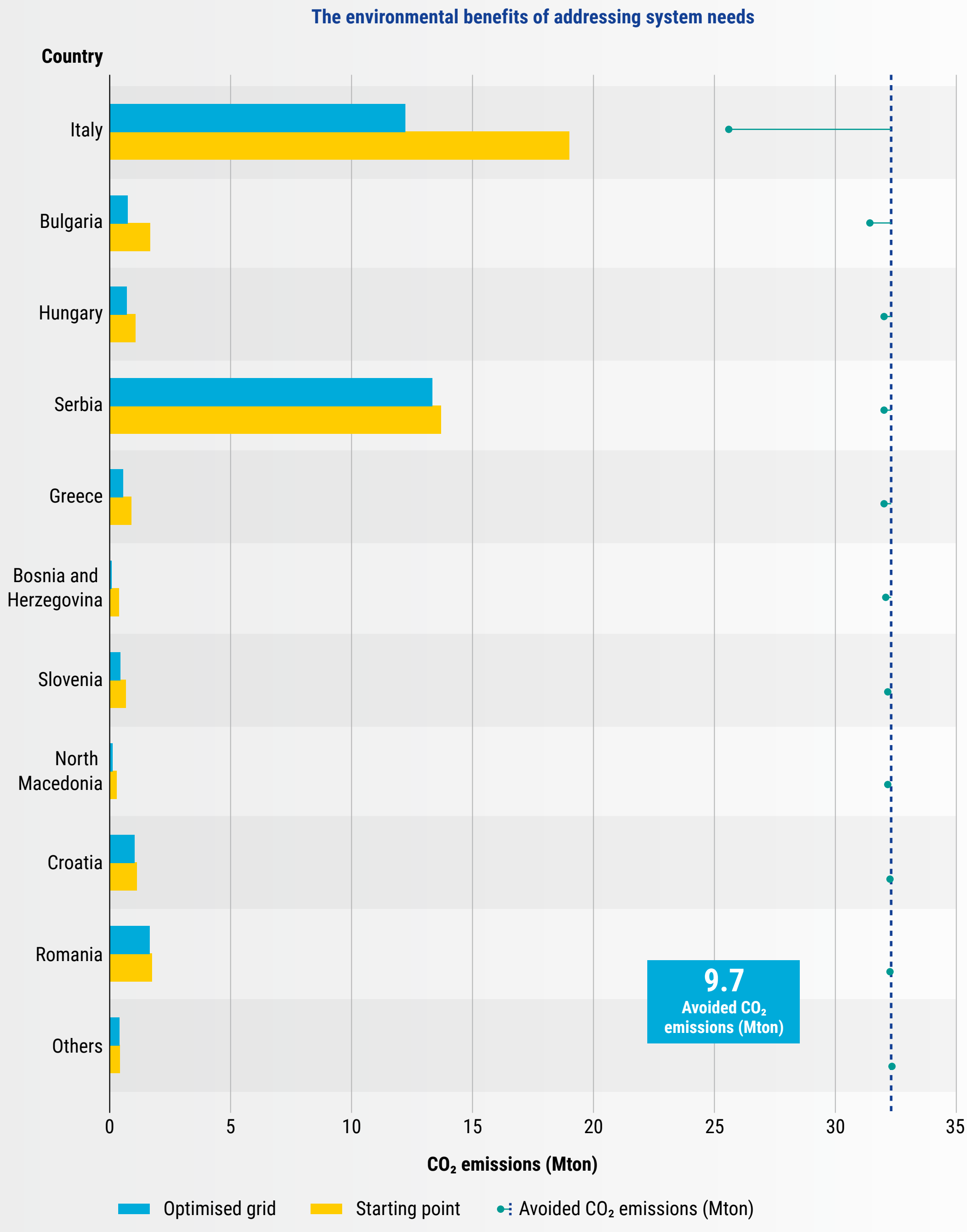

Figure 18: 2040 Optimal grid CO2 emissions (Mt) in the CSE region

2040 marginal costs

With the energy mix of the optimal grid and the achieved energy saved in the region, the largest decrease in the spread of electricity costs is achieved for the Greece–Italy and Bulgaria–Romania borders, exceeding €30/MWh. A significant decrease of €20–€30/MWh is achieved for the Romania–Serbia, Italy–Montenegro, and Hungary–Romania borders, as well as €19/MWh for Italy–Slovenia. Overall, marginal electricity costs have decreased noticeably on almost all borders within the CSE region, with an average value of €10/MWh. Significant decreases in marginal costs on the borders of Italy, Hungary, Romania, and Slovenia with neighbouring countries and external markets to the perimeter of the region are observed, in some cases far exceeding €30/MWh, as with Italy–France.

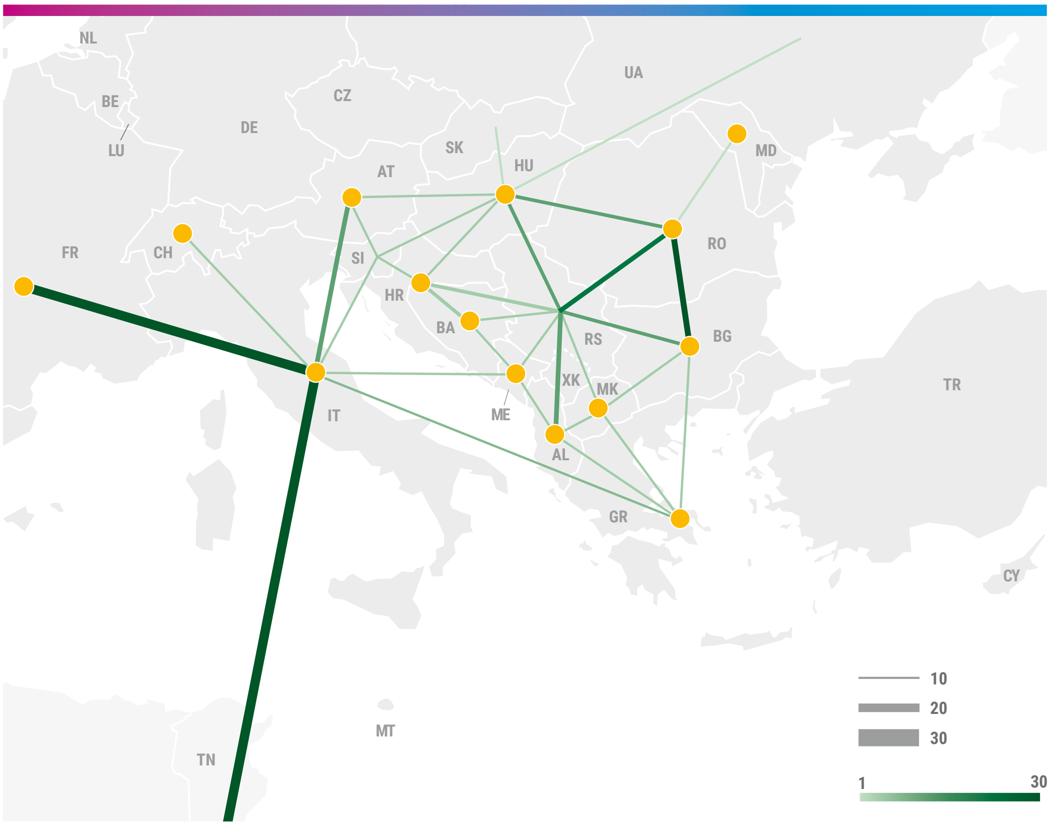

Figure 19: 2040 variation in marginal cost spread (€/MWh) per border in the CSE region

5 Roadmap to Address System Needs

Bridging the gap

Comparing the TYNDP project portfolio with the optimised grid identified in 2040 shows that existing projects only partially address the identified needs. In 2040, our study finds 108 GW of opportunities for cross-border capacity increases after 2030. By comparison, transmission projects with cross-border impact after 2030 and under development today amount to 80 GW in cross-border capacity increases. This leaves a gap of 28 GW in total cross-border transmission capacity.

Infrastructure gaps

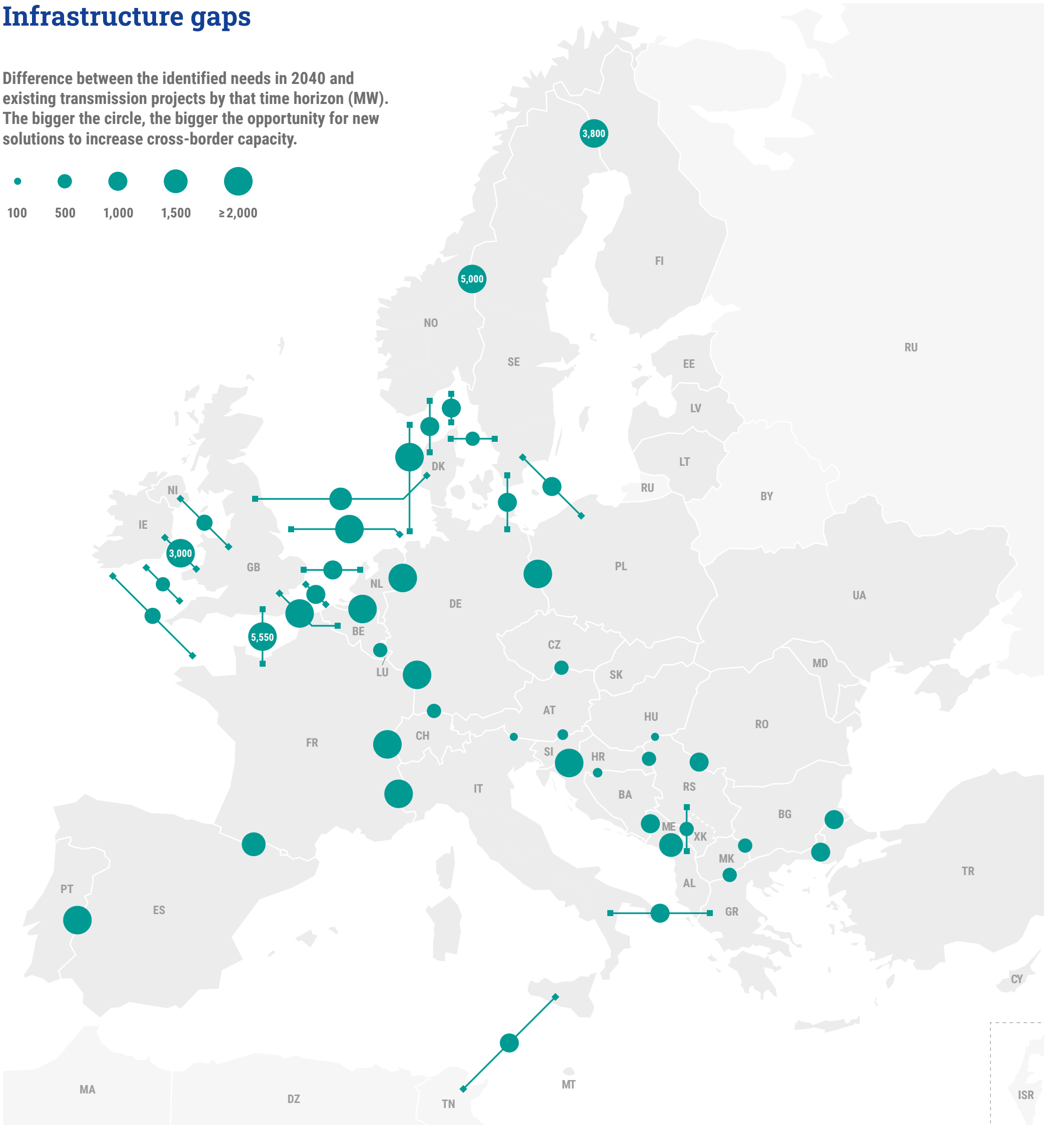

Figure 20: Difference between the cross-border needs identified in 2040 and the cross-border capacity increases expected from transmission projects due to commission by 2040: The bigger the circle, the bigger the opportunity for developing new solutions to increase capacity

Focusing on the CSE region and its borders, the System Needs Study identified opportunities for developing new solutions to enhance capacity. The following table provides a border-specific analysis of how these gaps are addressed through proposed transmission projects included in the TYNDP 2024.

Border	TYNDP 2024 Project
AT–IT	TR 375 – Lienz (AT)–Veneto region (IT) 220 kV meets the needs identified
AT–SI	TR 325 – Obersielach (AT)–Podlog (SI) meets the needs identified
BA–HR	TR 343 – CSE1 New meets the needs identified
BG–RS	TR 342 – Central Balkan Corridor meets the needs identified
BG–TR	TR 1066 – Bulgaria–Turkey partially addresses the needs identified
DE–GR	TR 1231 – Green Aegean Interconnector meets the needs identified
GR–IT	TR 1112 – GRITA 2 meets the needs identified
GR–MK	TR 376 – Refurbishment of the 400 kV Meliti(GR)–Bitola(MK) interconnector partially addresses the needs identified
GR–TR	TR 1067 – New AC 400 kV Greece–Turkey interconnection line partially addresses the needs identified
IT–ME	TR 28 – Italy–Montenegro meets the needs identified
HR–RS	TR 243 – New 400 kV interconnection line between Serbia and Croatia partially addresses the needs identified
HU–RO	TR 259 – HU–RO meets the needs identified
HU–RO	TR 1216 – Romania–Hungary HVDC Interconnector Project addresses the needs identified
HU–RS	TR 1074 – Pannonian Corridor meets the needs identified

Table 1: Transmission projects in the TYNDP 2024 project portfolio addressing infrastructure gaps

How to address future challenges

The outcomes of the System Needs Study indicate that in the CSE region, short-term transmission needs for 2030 are met by projects included in the TYNDP project portfolio. In the long-term horizon of 2040, increased transmission needs in the region are largely addressed by projects in the TYNDP project portfolio. However, there are opportunities to develop new solutions to enhance capacity between Albania and Serbia, Albania and Montenegro, Bosnia and Herzegovina and Montenegro, and Croatia and Slovenia. With insight into the very long term of 2050, substantial expansions in grid and storage infrastructure would be required and considered crucial to achieving energy transition and carbon neutrality in a timely, secure, and reliable way. Developing new technologies (e. g. storage systems, electrical vehicles) and interlinking various energy sectors (e. g. hydrogen, technology, P2X) will also be key.

Of course, internal networks must be reinforced to enable increases in cross-border flows.

Another way to partially meet system needs without building new infrastructure is by increasing grid capacity by improving the performance of existing system assets.

TSOs in the region already employ a range of strategies to optimise and expand existing grid capacity. These include both infrastructure solutions, such as the development of new projects, and non-infrastructure solutions, such as advanced software, innovative design concepts for upgrading current assets, operational measures to improve the utilisation of transmission capacities, and the implementation of new technologies to address grid constraints. Non-infrastructure-based solutions are already included in the region's national plans, such as the GreenSwitch project between Croatia and Slovenia. The GreenSwitch project will provide additional cross-border capacity and optimise grid operation, extending its impact to lower voltage levels. It will leverage a variety of new technologies and techniques, including power-flow prediction and control systems, optimal supply strategies for physical islands, and an advanced approach to strengthening distribution grid resilience through cross-border connections. The main advantage of these solutions is that they are relatively fast to implement.

TSOs of the CSE region are increasing annual investments in new transmission infrastructure and equipment at the national level. The projects in the investment pipeline are crucial to supporting Europe's energy transition. They aim to either enhance or expand existing infrastructure to accommodate the anticipated high volume of RES located in remote areas and facilitate the transfer of generated energy to load centres. These initiatives also focus on ensuring security of supply for isolated areas, maintaining voltage levels within acceptable limits, and replacing ageing equipment. Bulk investments are planned for 2030–2035, the vast majority of which are overhead synchronous connections to the grid, because enhancing the existing infrastructure to achieve the targets remains a high priority for all TSOs of the region. A significant portion of underground and subsea cable lines is planned to connect to the transmission grid. These connections aim to link remote areas, such as islands and offshore RES capacities, as well as strengthen the grid in urban areas. Moreover, to utilise these infrastructure investments effectively, large-scale investments in substation equipment are also included in the pipeline until 2030–2035. Addressing system needs in 2040 and 2050 will require additional equipment beyond what is currently planned.

Projects of regional relevance that address these challenges and further contribute to addressing the needs identified are listed in Appendix II. A significant portion of these projects are new investments that will be considered in the next edition of the TYNDP. The region's TSOs continue to cooperate to address current and future challenges. The main challenges and how they have been assessed in the CSE region are also included in the regional studies and initiatives section of this report.

Regional studies and initiatives

Sensitivity market study on NT 2030

This sensitivity market study, based on the NT 2030 scenario and the 2009 climate year, aims to underscore the challenges posed by increasing load demands in countries in the CSE region. Additionally, it examines the combined impact of these load increases with limitations in transfer capacity. The outcomes of two hourly winter and summer snapshots, in December and August, respectively, are presented in a two-step approach to capture the differences under seasonal conditions.

In winter conditions, when load increases and transfer capabilities are limited, in both cases, the region experiences electricity price spikes, particularly in Hungary and Slovenia, with prices exceeding €200/MWh. However, no price increase is indicated in Albania, Cyprus, Greece, and North Macedonia. In the rest of the countries, prices exceed €100/MWh. It should be noted that as a result of the study, Slovakia, a neighbouring country to the CSE region, is also highly affected.

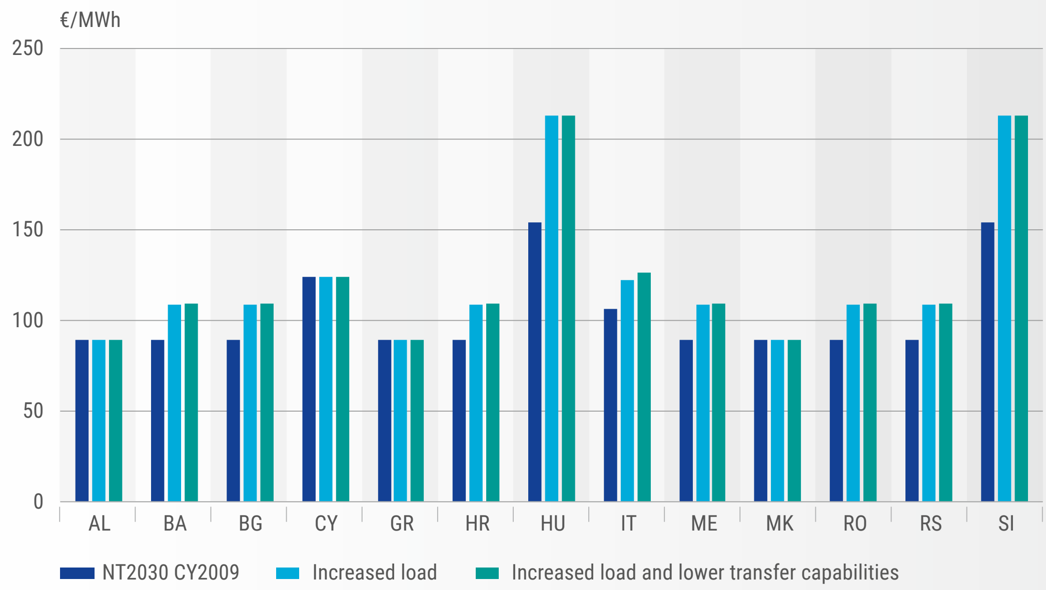

Figure 21: 2030 winter marginal costs in CSE in increased load and lower transfer capability conditions

Additionally, as the remaining generation margins decrease due to higher loads, the export capabilities of certain countries diminish, notably in Romania, as well as in Albania, Croatia, Italy, and Serbia. Conversely, export flows from Greece and Slovenia increase, and Bulgaria's net position shifts to that of an exporter. As a result, imports rise in other countries within the region, with Hungary experiencing a significant increase, and Cyprus and North Macedonia seeing smaller increases. It is important to note that external markets are also impacted, such as in Germany, where imports have increased.

When further examining restrictions in transfer capabilities in the region under high load conditions, Slovenia's exports further increase, while exports decrease in Greece and Italy. Hungary's net imports decrease compared to the increased load scenario, while Bosnia and Herzegovina's net imports rise. It is important to highlight that Germany's net import position is also affected, showing a decrease.

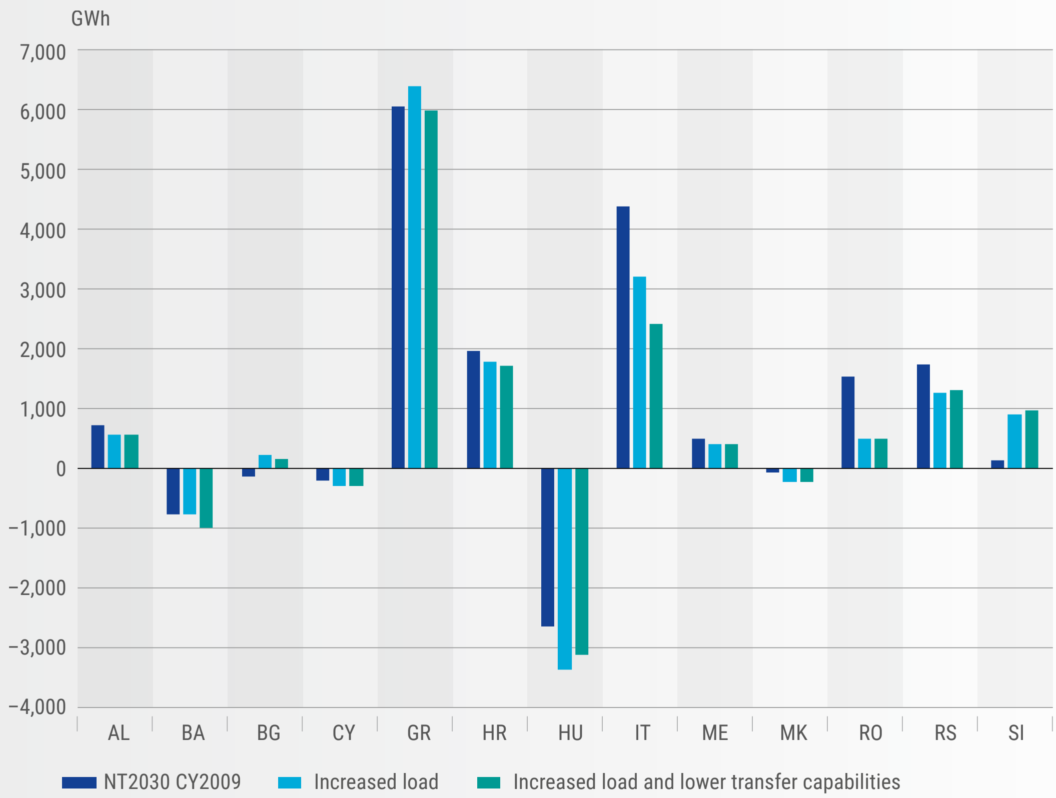

Figure 22: 2030 winter exchanges in CSE in increased load and lower transfer capability conditions

However, in summer conditions, electricity prices in the region exhibit a different pattern. While Cyprus's marginal costs remain unaffected, Albania, Bulgaria, Greece, Montenegro, and North Macedonia experience a slight increase in electricity prices when load increases. Interestingly, when transfer capabilities are further limited, prices in these countries decrease to levels seen prior to the load increase. On the other hand, for Croatia, Hungary, and Slovenia, prices decrease when the load increases, decreasing even further when transfer capabilities are limited. The highest price spikes are indicated in Bosnia and Herzegovina and Serbia, exceeding €130/MWh in both cases. Slight cost increases could be observed for Romania. Overall, the increase in electricity costs in the CSE region is noticeably lower than in winter conditions.

In both scenarios, Greece's exports increase significantly, while Romania's exports decrease noticeably, with Bulgaria also experiencing a smaller but still notable reduction. In summer conditions, slight decreases in exports are observed for Albania, Croatia, and Montenegro, which are also exporters. Among the region's importers, imports generally rise in both scenarios, with Italy being the most affected and Hungary the least. Cyprus is the only importer where a decrease is noted when the load increases, and this reduction is even more pronounced when transfer capabilities are limited. Despite these changes, the net position of the CSE countries remains unchanged.

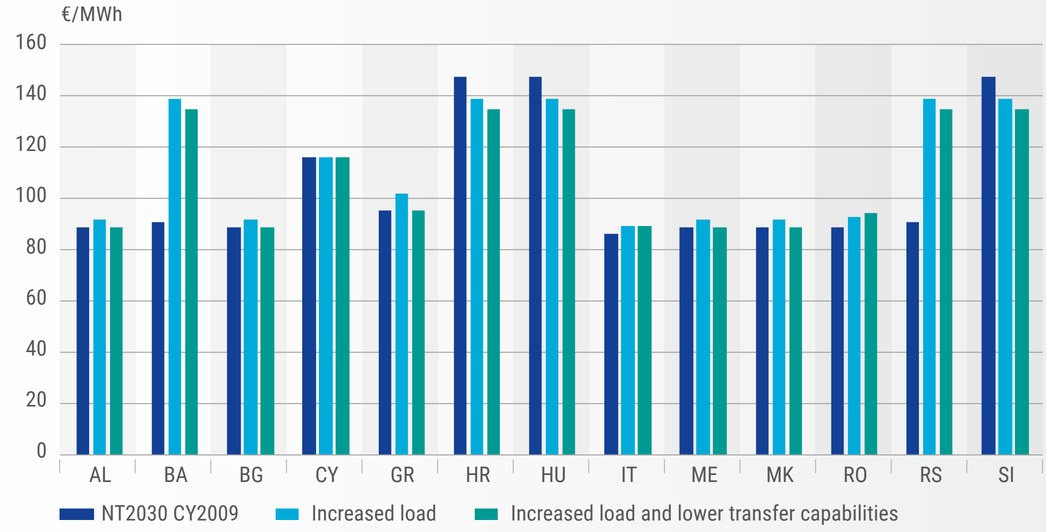

Figure 23: 2030 summer marginal costs in CSE in increased load and lower transfer capability conditions

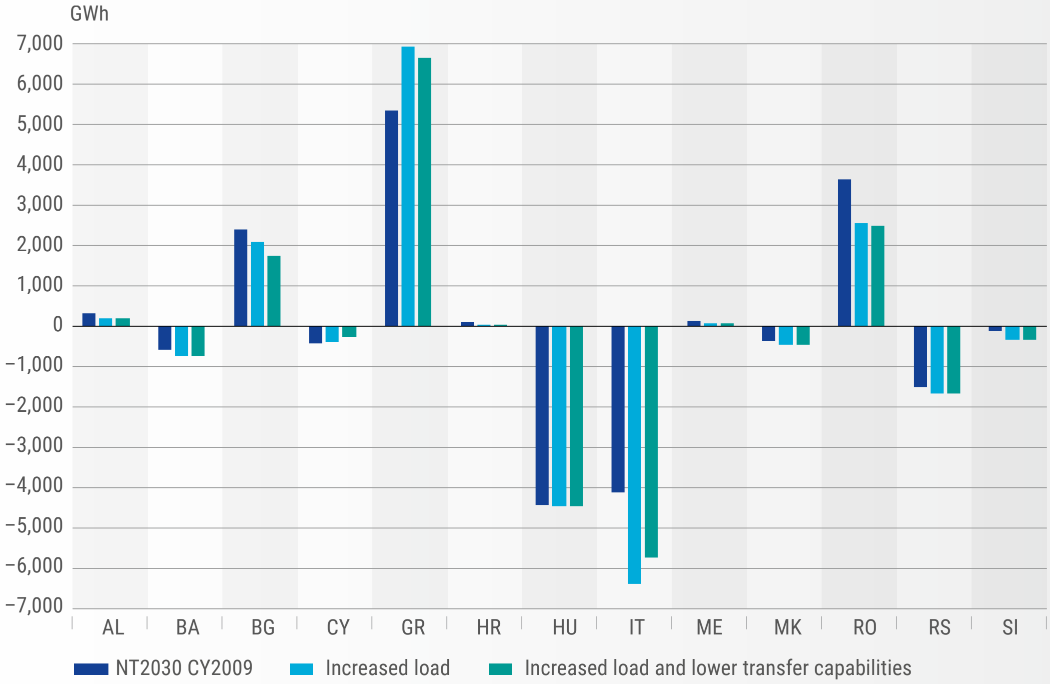

Figure 24: 2030 summer exchanges in CSE in increased load and lower transfer capability conditions

Addressing high voltages in the CSE region

In recent years, the CSE region has been facing persistent issues related to high voltages in transmission networks. TSOs across the region have reported that in several areas, voltage levels are frequently exceeding the operational limits defined by international standards and national regulations. This phenomenon has raised concerns about the stability and reliability of the power system, as well as potential risks to equipment and infrastructure.

The causes of these high voltage levels are multifaceted. Increased RES integration, reduced demand during specific time periods, and inadequate reactive power management have all contributed to this challenge.

These days, when assessing the future power system and planning new infrastructure projects, the region's TSOs pay close attention to implementing voltage control solutions.

Acknowledging the severity of this issue, many TSOs in the CSE region have conducted extensive studies to address high voltages in their power systems, deploying dedicated equipment and selecting the optimal solution for every case. In recent years, TSOs have taken proactive measures by installing compensation devices, mainly shunt reactors, and have extensive plans to continue such measures. This also includes the installation of advanced compensation equipment, which will help manage reactive power and retain voltage levels within limits, thereby avoiding the risk of overvoltage conditions. Most projects are either in the planning or construction stage. In total, up to 6,370 MVAr of new reactive power devices (shunt reactors) are expected to be installed in the next 10 years, predominantly in the Balkan Peninsula, with the majority of them in Greece. Apart from addressing current high voltage issues, the extensive long-length cable lines (underground and subsea) projects in the investment pipeline include compensation measures. In addition, flexible AC transmission systems (FACTS) have been installed in Greece, and more are in the investment pipeline of the Greek TSO.

Over the next decade, addressing high voltage challenges will remain a high priority for the CSE region. This will require continuous investments in voltage control technologies and coordinated efforts among TSOs, regulators, and policymakers. Tackling supply chain challenges to ensure the timely availability of these critical components is crucial. The resulting significant increase in investment costs, along with securing financing for these projects, are key barriers to overcome. Our long-term analysis shows that these investments are sufficient to address high voltages in the region.

Keeping voltage levels within limits is not only essential for maintaining the safe and reliable operation of the transmission system but also for supporting the ongoing energy transition. The timely deployment of advanced solutions across the region will play a pivotal role in the CSE electricity grid in the coming years.

Impact of large-scale RES integration on cross-regional power flows in CSE

This RG CSE study, initiated in 2021 with the collaboration of TSO members CGES, ELES, IPTO, MEPSO, NOS BiH, OST, TERNA, TRANSELECTRICA, JSC EMS, and observer TSO KOSTT, in the special project of SECI TSP under the coordination of RG CSE, investigates the impact of large-scale RES integration on cross-regional power flows in CSE in the 2040 horizon. The study was finalised in early 2024 and is based on available updates on the 2040 scenario at the time of the assessment. An overview of this extended investigation under different time points is presented in this report.

In 2040, for the market areas considered in this study, total imports are around 159.2 TWh, while exports amount to 112.5 TWh.

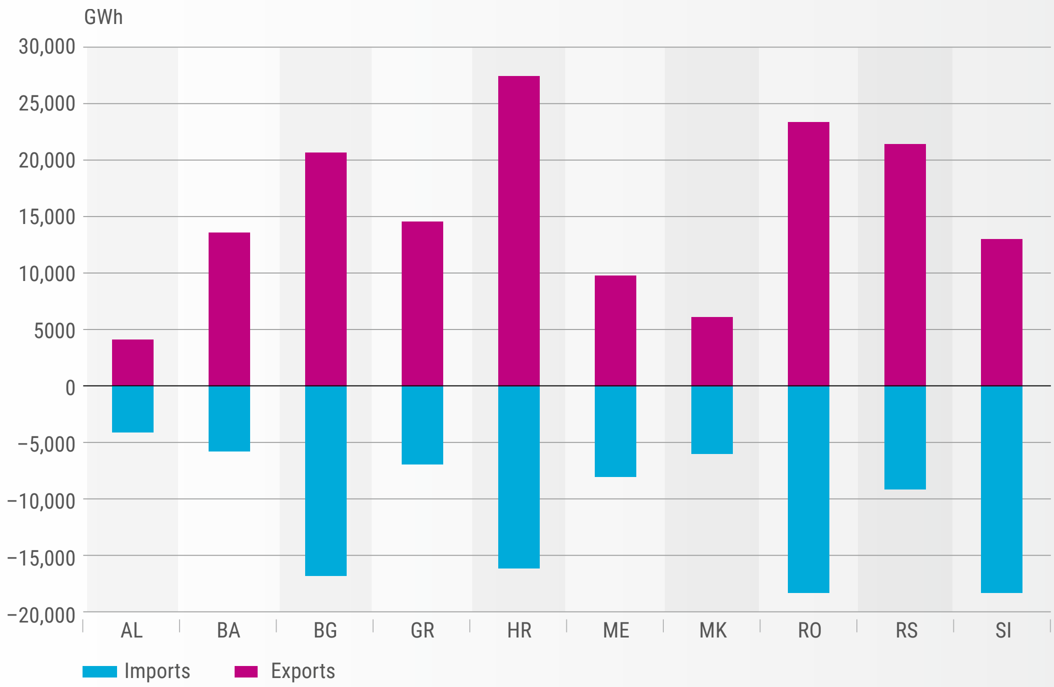

Figure 25: Imports and exports per market area of interest in 2040

When analysing flows across borders, it is apparent that the highest yearly flows will be on the BA–HR and HR–SI borders – around 7 and 11 TWh, respectively. Cross-border congestion represents the number of hours in a year in which the flow on an interconnection equals the modelled NTC. The highest number of congestion hours (5,055) is observed on the BA–HR border, followed by AL–ME, with 4,419 congested hours.

Market area	Flow (GWh)	Flow back (GWh)	Net interchange	Hours congested (h)	Hours congested back(h)
AL-GR	1,158.1	377.2	780.9	20	9
Al-RS	1,158.1	284.1	1,274.0	1,288	0
AL-ME	691.6	1,941.0	−1,249.4	745	3,674
Al-MK	513.6	789.0	−275.4	77	498
BA-HR	889.6	7,933.8	−7,043.9	205	4,850
BA-ME	1,506.9	1,576.6	−69.8	169	1,076
BA-RS	409.6	1,768.9	−1,359.3	0	1
BG-GR	3,082.9	1,571.6	1,511.3	0	80
BG-MK	1,743.5	207.0	1,536.5	275	51
BG-RO	3,478.1	6,817.6	−3,339.5	68	516
BG-RS	3,298.9	360.2	2,938.7	1,305	78
GR-MK	1,908.0	3,336.4	−1,428.5	449	2,451
HR-RS	2,584.7	887.9	1,696.8	0	48
HR-Si	830.0	12,056.9	−11,226.9	33	3,250
ME-RS	1,763.0	1,067.0	695.9	0	0
MK-RS	772.4	849.7	−77.3	2,024	434
RO-RS	3,740.1	1,338.8	2,401.3	11	9
Total	**33,476.6**	**45,086.8**	**−11,610.2**	**12,008**	**18,861**

Table 2: Cross-border flows and congestions at borders of interest

System needs are evaluated according to the dumped RES energy indicator. Simulations aimed to reduce dumped RES energy (the main driver) by achieving sufficient NTC between different market zones (national power systems and RES clusters) in CSE.

In the update of the models, the following planned interconnection reinforcement projects were modelled:

- 400 kV Ernestinovo (HR)–Sombor (RS)
- 400 kV Jozsa (HU)–Oradea Sud (RO)
- 400 kV Obersielach (AT)–Podlog (SI) (upgrade from 220 kV)
- Second 400 kV Portille de Fier (RO)–Djerdap (RS)
- Second 400 kV Sofia (BG)–Nis (RS)
- 400 kV Visegrad (BA)–Pozega (RS)
- 400 kV Pljevlja (ME)–Pozega (RS)
- 400 kV Maritsa East 2 (BG)–Vize Havza (TR)
- Second 400 kV Nea Santa (GR)–Babaeski (TR)
- Second 400 kV Sandorfalva (HU)–Subotica (RS)

These planned network reinforcements eliminate most detected bottlenecks in the region under various scenarios. Simulation results indicate that dumped energy, and consequently opportunity cost, in the CSE region is significantly reduced with grid reinforcement. The total system cost comparison between scenarios shows a reduction of around € 50 million with grid reinforcement.

To fully integrate RES, it is not sufficient to merely strengthen and increase the transmission capacities of interconnections; the capacity of internal networks must also be enhanced accordingly.

Network analyses were conducted for 11 scenarios, evaluating the impact of planned network reinforcements and addressing identified issues in national models. Certain challenges were observed, particularly under scenarios with a high ratio of RES. In terms of voltage control issues, scenarios with minimal conventional units in operation showed inadequate voltage control and difficulty maintaining the desired voltage profiles. The current reactive power capabilities of RES units in some areas were insufficient, highlighting the need for measures such as expanding reactive power availability, installing compensation devices, or requiring more conventional base units.

Planned reinforcements addressed many bottlenecks, but some persisted, particularly in the following areas:

Romania: Overloading of the 400 kV Isaccea–Vulkanesti tie-line in five scenarios. Bottlenecks in the northwest (400 kV Rosiori–Mukacevo tie-line and the 400/220 kV transformer at Rosiori).

Bulgaria: Bottlenecks in the 220 kV grid near Dobruja and Varna, and 400 kV interconnections with Romania.

Italy–Slovenia Border: Overloading of the 220 kV Padriciano–Divaca tie-line in four scenarios during outages of the 400 kV Redipuglia–Divaca tie-line. However, operational measures and protection schemes mitigate this issue, so it is not considered a critical bottleneck.

Scenario-Specific Bottlenecks: Other bottlenecks, such as those on tie-lines IT–SI, HR–SI–HU, eastern HR–HU, and the internal Romanian grid near the Serbian border, occurred only in one or two scenarios, indicating scenario-dependent constraints.

In conclusion, TSOs should enhance voltage control capabilities by expanding the reactive power availability of RES units, installing compensation devices, or requiring additional baseload conventional units. Persistent bottlenecks in Romania, Bulgaria, and other areas require targeted reinforcements and operational strategies. Scenario-specific issues highlight the need for tailored solutions in response to specific grid conditions.

CSE TSO studies of regional relevance

Cooperation among CSE TSOs towards achieving EU targets includes several studies for maturing the projects of the TYNDP portfolio, studies for new projects for inclusion in future TYNDP editions, and studies beyond the perimeter of CSE. All such studies included in RegIP 2022 have been finalised, while ongoing studies of regional relevance by the TSOs are listed below.

- Central-Balkan Corridor: Pre-feasibility study and strategic environmental assessment. TSO: Joint study JSC EMS–ESO EAD.
- New Interconnection line 400 kV Greece–Albania: Feasibility and environmental study, partly in Albania. TSO: OST
- Green Aegean Interconnector: Feasibility study for the interconnection between Greece and Germany. TSO: IPTO
- Saudi Greek Interconnection: Feasibility study for the electrical interconnection between Greece and Saudi Arabia. TSO: Joint study between IPTO and National Grid S.A – Saudi Electricity Company.

6 Conclusions

Focusing on 2040, the System Needs Study shows opportunities for additional solutions in the east in the corridor running from Turkey to central Europe through the Balkans. Further investments in grid infrastructure and electricity storage allow connecting more consumers with more producers, therefore making better use of the cheapest generation. Increasing interconnection capacities between regional countries is essential to further optimise the electricity system from a socioeconomic perspective. A total of 26 transmission projects in the region have already reached maturity and 18 projects are planned, while 14 projects proposed in the TYNDP 2024 portfolio address the majority of the needs identified. New planned projects of regional relevance listed in the pipeline of TSO investments are also key to addressing identified needs in the CSE region.

Accelerating projects, overcoming barriers, addressing challenges, maintaining continuous regional cooperation, and investing in new technologies and non-infrastructure solutions that are relatively fast to implement are crucial for TSOs in the region to ensure long-term energy security and support the EU's goal of achieving a fully decarbonised power system by 2050.

7 Appendix

Appendix I: TYNDP Projects

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?	PCI or PMI?
28	Italy–Montenegro	2027	Under construction	Yes	PCI
29	Italy–Tunisia	2028	Under construction	Yes	
33	Central Northern Italy	2026	Under construction	Yes	
127	Central Southern Italy	2029	In permitting	Yes	
138	Black Sea Corridor	2026	Under construction	Yes	PCI
144	Mid Continental East corridor	2029	In permitting	Yes	
150	Italy–Slovenia	2042	Under consideration	Yes	
219	Great Sea interconnector	2029	Under construction	Yes	PCI
227	Trans-Balkan corridor	2027	In permitting	Yes	
243	New 400 kV interconnection line between Serbia and Croatia	2038	Under consideration	Yes	
259	HU–RO	2030	Planned but not yet in permitting	Yes	PCI
299	SACOI3	2029	Under construction	Yes	
323	Dekani (SI)–Zaule (IT) interconnection	2026	In permitting	Yes	
324	Redipuglia (IT)–Vrtojba (SI) interconnection	2026	In permitting	Yes	
325	Obersielach (AT)–Podlog (SI)	2035	Under consideration	Yes	
338	Adriatic HVDC link	2029	In permitting	Yes	
339	Italian HVDC Tyrrhenian link	2028	Under construction	Yes	
341	North CSE corridor	2029	Planned but not yet in permitting	Yes	
342	Central Balkan corridor	2034	Planned but not yet in permitting	Yes	
343	CSE1– New	2035	Planned but not yet in permitting	Yes	

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?	PCI or PMI?
350	South Balkan corridor	2026	Under construction	Yes	
375	Lienz (AT)–Veneto region (IT) 220 kV	2035	Planned but not yet in permitting	Yes	
376	Refurbishment of the 400 kV Meliti (GR)–Bitola (MK) interconnector	2035	Under consideration	Yes	
1041	Gregy Green Energy interconnector	2030	Under consideration	Yes	PMI
1048	GAP interconnector	2030	Under consideration	Yes	
1055	Interconnection of Crete to the Mainland system of Greece	2025	Under construction	Yes	
1059	Southern Italy	2030	In permitting	Yes	
1066	Bulgaria – Turkey	2035	Under consideration	Yes	
1067	New AC 400 kV interconnection line Greece–Turkey	2031	Planned but not yet in permitting	Yes	
1074	Pannonian corridor	2030	Planned but not yet in permitting	Yes	PMI
1085	Malta–Italy cable link No. 2	2026	Under construction	Yes	
1105	Georgia–Romania Black Sea (submarine) inter-connection cable project	2031	Under consideration	Yes	
1109	Basilicata–Campania reinforcements	2035	Planned but not yet in permitting	Yes	
1110	Sicily–Calabria	2027	In permitting	Yes	
1112	GRITA 2	2031	Planned but not yet in permitting	Yes	
1138	400 kV OHL Suceava (RO)–Balti (MD)	2030	Planned but not yet in permitting	No	
1157	HG North Tyrrhenian corridor	2032	Planned but not yet in permitting	No	
1166	HG Adriatic corridor	2036	Planned but not yet in permitting	No	
1167	HG central link	2031	Planned but not yet in permitting	No	
1168	HG Ionian–Tyrrhenian corridor	2035	Planned but not yet in permitting	No	
1169	SAPEI 2	2040	Planned but not yet in permitting	No	

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?	PCI or PMI?
1171	Interconnection IT–CH	2038	Under consideration	No	
1182	EHV S/S Thesprotias and its connection to the 400 kV system	2031	Planned but not yet in permitting	No	
1183	New interconnection line 400 kV Greece–Albania	2031	Planned but not yet in permitting	No	
1216	High-voltage direct current interconnector project Romania–Hungary	2030	Under consideration	No	
1226	North–South electricity corridor in Eastern Europe	2036	Under consideration	No	
1231	Green Aegean interconnector	2036	Under consideration	No	
1235	Second circuit of the 400 kV OHL Sajóivanka (HU)–Rimavska Sobota (SK)	2027	Under consideration	No	
1240	Interconnection Ukraine–Romania	2028	Planned but not yet in permitting	No	
1003	Hydro-pumped storage in Bulgaria – Yadenitsa	2030	In permitting	Yes	
1006	HPS AMFILOCHIA	2026	Under construction	Yes	PCI
1029	PSPP Kozjak	2030	In permitting	No	
1035	Ptolemaida battery energy storage system	2027	In permitting	Yes	PCI
1071	Villarosa	2029	In permitting	No	
1072	HPS VROCHONERA	2031	In permitting	No	
1073	Taccu Sa Pruna	2031	In permitting	No	
1074	Construction of pumped-storage hydropower plant “Batak”, which utilises the pre-existing dams of the “Batashki hydroelectric cascade” – (PSHPP “Batak”)	2030	Under consideration	No	
1075	Construction of pumped-storage hydropower plant “Dospat” – (PSHPP "Dospat")	2032	Under consideration	No	
1076	Favazzina	2032	In permitting	No	
1077	Serra Del Corvo	2030	In permitting	No	
1078	HPS LADONAS	2031	In permitting	No	

Appendix II: Regional projects

Country	Project name	Investment		Expected commissioning year
		From	To	
AL	Construction of 220 kV double circuit line Tirana2–Rrashbull	Tirana-2	Rrashbull	2025
AL	Construction of new 400 kV line Elbasan–Fier and extension of 220/110 kV Fier substation	Elbasan-2	Fier	2025
AL	New 400 kV line Rrashbull–Fier	Rrashbull	Fier	2030
AL	Upgrade to 400 kV of 220/110 kV Vau Dejes substation	Vau Dejes		2030
AL	Upgrade to 400 kV of Fierza substation and new 400 kV interconnection Albania–Kosovo	Fierza	Prizren 4	2030
AL	Shunt reactors of 240 MVAr in total			2026–2030
BA, ME	Increasing the capacity of existing 220 kV interconnection between Bosnia and Herzegovina and Montenegro, 220 kV OHL Trebinje–Perucica (E01)	TS Trebinje (BA)	TS Perucica (ME)	2030
BA	New 400 kV interconnection between Montenegro and Bosnia and Herzegovina, 400 kV overhead line Brezna–Sarajevo with construction of 400/220 kV substation Piva's mountain (E03)	TS Sarajevo 20 (BA)	TS Brezna (ME)	2033
BA	New 400 kV interconnection between Bosnia and Herzegovina and Montenegro, 400 kV OHL Gacko–Brezna (E02)	TS Gacko (BA)	TS Brezna (ME)	2035
BA	Shunt reactors of 800 MVAr in total			2028–2030
BG	Upgrade of the existing substation 220/110 kV Bobov Dol to 400/220/100 kV	ss Bobov Dol		2030
BG	Upgrade of the existing substation 220/110 kV Obraztsov Chiflik to 400/100 kV	ss Obraztsov Chiflik		2032
BG	Upgrade of the existing 220 kV single-circuit line to 400 kV OHL	ss Obraztsov Chiflik	ss Tsarevets	2032
BG	Upgrade of the existing 220 kV single-circuit line to 400 kV OHL	ss Tsarevets	ss Zlatitsa	2032

	Description	Main drivers	In RegIP 2022?
		Accommodation of physical flows	Yes
		Strengthening the 400 kV grid	Yes
	Projects of Energy Community Interest (PECI) 2024 project	Strengthening the 400 kV grid	
		Strengthening the 400 kV grid	
	PECI 2024 project	Strengthening the 400 kV grid	
		High voltage issues	
	Project is included in final PECI list (E01). Promoters of the project are CGES and NOSBiH/Elektroprenos BiH.	Resolving exiting congestions between BA and ME, increasing NTC between BA and ME, enabling and supporting RES integration in the region, and further market integration	
	Project was proposed but is not included in the final PECI list for 2024. Promoters of the project were CGES and NOSBiH/Elektroprenos BiH.	Reduction of losses in the transmission system, security of supply, connection of RES to the transmission system. The new connection between Montenegro and Bosnia and Herzegovina will eliminate the possibility of congestion with increased NTC at this border and electricity market integration.	
	Project was proposed but is not included in the final PECI list for 2024. Promoters of the project were CGES and NOSBiH/Elektroprenos BiH.	Enabling and supporting integration of a large number of RES in BA (region of East Herzegovina) and Montenegro (west region), enabling the transfer of energy from BA to ME and avoiding existing congestion between BA and ME, further development and integration of the market and security of supply.	
		High voltage issues	
		Increasing the security of electricity supply to big consumers in the western part of Bulgaria	
		Increasing the security of electricity supply to big consumers in the northern part of Bulgaria	
		Increasing the security of electricity supply to big consumers in the northern part of Bulgaria	
		One of the main directions for electricity transmission in Southeastern Europe is north–south, as well as the opposite direction, south–north. To guarantee the security of the electricity system and the possibility of transmitting large amounts of energy, ESO intends to increase the transmission capacity in these directions.	

Country	Project name	Investment		Expected commissioning year
		From	To	
BG	Upgrade of the existing 220 kV single-circuit line to 400 kV OHL	ss Tsarevets	ss Maritsa Iztok 2	2032
BG	Shunt reactors of 300 MVAr in total			2034
GR	Installation of two new 400/150/30 kV autotransformers in SS Nea Santa	SS Nea Santa		2025
GR	Installation of two new 400/150/30 kV autotransformers in SS Meliti	SS Meliti		2025
GR	400 kV OHL SS Korinthos–SS Koumoundouros	SS Korinthos	SS Koumoundouros	2026
GR	New 400 kV SS Lamia and 400 kV OHLs SS Lamia – 400 kV grid	SS Lamia	400 kV grid	2034
GR	New 400 kV SS Mesogion and 400 kV OHLs SS Mesogion – 400 kV grid	SS Mesogion	400 kV grid	2034
GR	New 400 kV SS Thessalia and 400 kV OHLs SS Thessalia – 400 kV grid	SS Thessalia	400 kV grid	2035
GR	Shunt reactors of 3,230 MVAr in total			2025–2034
HR	New transformer 400/220 kV in SS Konjsko (HR)			2025
HR	Upgrade of existing 220 kV OHL SS Konjsko–SS Krs Padene with HTLS conductors			2026
HR	Upgrade of existing 220 kV OHL SS Krs Padene–SS Brinje with HTLS conductors			2026
HR	Upgrade of existing 220 kV OHL SS Senj–SS Brinje with HTLS conductors			2027
HR	Shunt reactors of 450 MVAr in total			2030
IT, AU	Brennero			2023 (Rationalisation of 132 kV grid from Italy side is not yet complete)
IT	Paterno–Priolo			2028
IT	Chiaramonte Gulfi–Ciminna			2026/2032
ME	Existing 220 kV B&H–MNE–ALB transmission line rehabilitation	SS Trebinje (BA)	SS Koplik (AL)	2030

Description	Main drivers	In RegIP 2022?
	One of the main directions for electricity transmission in Southeastern Europe is north–south, as well as the opposite direction, south–north. To guarantee the security of the electricity system and the possibility of transmitting large amounts of energy, ESO intends to increase the transmission capacity in these directions.	
	High voltage issues	
	RES integration, increasing transfer capacity	
	RES integration, increasing transfer capacity	
	Strengthening the 400 kV grid, RES integration, security of supply	Yes
	Strengthening the 400 kV grid, RES integration, security of supply	
	Strengthening the 400 kV grid, RES integration, security of supply	
	Strengthening the 400 kV grid, RES integration, security of supply	
	High voltage issues, reactive power control, security of supply to isolated areas	
Internal project	Increasing transfer capacity due to high integration of RES	Yes
Internal project	Increasing transfer capacity due to high integration of RES	Yes
Internal project	Increasing transfer capacity due to high integration of RES	Yes
Internal project	Increasing transfer capacity due to high integration of RES	
	High voltage issues	
Main 132 kV cross border line is completed. Rationalisation of 132 kV grid from Italy side is not yet complete.	Strengthening the grid (Italy–Austria border)	Yes
Main 380 kV OHL line and substation/rationalisation of 150 kV of the grid near the area	Strengthening the grid	Yes
Main 380 kV OHL line and rationalisation of 150 kV of the grid near the area	Market efficiency/strengthening the grid	Yes
Project is included just partially in the PECI list for 2024, this is the 220 kV OHL Trebinje–Perućica (E01)	Eliminating congestion between BA, ME, and AL, including internal 220 kV in ME, increase NTC on BA–ME and ME–AL borders; reducing losses in the transmission system; further developing and integrating the market and security of supply	

Country	Project name	Investment		Expected commissioning year
		From	To	
ME	Montenegro–Albania new 110 kV transmission line	SS Ulcinj (ME)	SS Velipolje (AL)	2030
ME	Shunt reactors of 250 MVAr in total			2026
MK	Shunt reactors of 150 MVAr in total			2027
MD,RO	400 kV OHL Gutinas–Straseni	Straseni (MD)	Gutinas (RO)	2033
RO	Replacing the wires on the 220 kV OHL Stejaru (RO)–Gheorghieni (RO)	Stejaru	Gheorghieni	2025
RO	Replacing the wires on the 220 kV OHL Fantanele (RO)–Gheorghieni (RO)	Fantanele	Gheorghieni	2025
RO	Upgrade of the existing 220 kV single-circuit line to 400 kV OHL Stalpu (RO)–Teleajen (RO)–Brazi (RO)	Stalpu	Brazi	2026
RO	Upgrade of the 220/110 kV substation Teleajen to 400/110 kV	SS Teleajen		2028
RO	Installation of flexible AC transmission systems to control power flows			2028
RO	Installation of a new transformer 400/220 kV 400 MVA and extension of the substation Brazi Vest	SS Brazi Vest		2027
RS, BA	110 kV interconnection line SS Srebrenica (BA)–SS Ljubovija (RS)	SS Srebrenica (BA)	SS Ljubovija (RS)	2027
RS	Leading of OHL 400 kV SWY Djerdap 1–SWY Drmno into SS Bor 2 and new SS Bor 6			2026/2027
RS	Four new VSRs in Serbian system, with total capacity of 950 MVAr			2026–2030
RS	SS 400/110 kV Nikolinci			After 2034
RS	SS 400/110 kV Nis North			After 2034
RS	Upgrading the grid in Middle Banat region to 400 kV voltage level			After 2034
SI	SS 220/110 kV Ravne			2027
SI, HR	GreenSwitch			2028

	Description	Main drivers	In RegIP 2022?
	Not included in PECI list for 2024	Enabling the integration of RES in the Ulcinj area, reducing losses in the transmission system, security of supply	
		High voltage issues	
		High voltage issues	
		Reducing RES curtailment	
		Increasing transmission capacity	Yes
		Increasing transmission capacity	Yes
		Strengthening the 400 kV grid	Yes
		Strengthening the 400 kV grid	Yes
		Accommodating physical flows	Yes
		Strengthening the 400 kV grid	Yes
	The project has been slightly delayed compared to the previous RegIP. It is included in JSC EMS Investment Plan.	Security of supply, better interconnectivity in the region	Yes
	New 400 kV OHL alignment (and new line sections) in the near proximity of the Serbian–Romanian border	Security of supply, potential new RES in the affected area	
	The project has been expanded compared to the previous edition of RegIP (there, it only included VSR in SS Vranje 4, now it includes three more VSRs in Serbian 400 kV grid).	High voltage issues, security of supply, RES integration	Partially (only the first out of four was mentioned)
	New 400/110 kV substation in the near proximity of the Serbian–Romanian border (it will be connected to the tie-line)	RES integration, security of supply, loss reduction	Yes
	New 400/110 kV substation close to the Serbian–Bulgarian border	Security of supply, potential new RES in the affected area	Yes
	New 400 kV infrastructure close to the Serbian–Romanian border.	RES integration, security of supply, loss reduction	
	Connection of new SS 220/110 kV Ravne to existing OHL Podlog–Obersielach	Security of supply	Yes
		RES integration, security of supply	

Appendix III:
Links to national development plans

Country	TSO	Link
Albania	OST	https://ost.al/2022/02/03/dokumentacion-udhezues/
Bosnia and Herzegovina	NOSBIH	Dugoročni plan razvoja prenosne mreže 2021–2030 – Knjiga I
Bulgaria	ESO EAD	https://www.eso.bg/fileObj.php?oid=5272
Croatia	HOPS	Ten-Year Development Plan 2022–2031
Cyprus	TSOC	https://tsoc.org.cy/electrical-system/cyprus-transmission-system/tydplan/
Greece	IPTO	https://www.admie.gr/systima/anaptyxi/dekaetes-program-ma-anaptyxis
Hungary	MAVIR	Network Development Plans since 2021
Italy	TERNA	Piano di Sviluppo Terna
Montenegro	CGES	https://www.cges.me/en/regulation/system-development
North Macedonia	MEPSO	
Romania	TRANSELECTRICA	https://www.transelectrica.ro/ro/web/tel/planul-de-dez-voltare-ret-2024-2033;jsessionid=213F699F-84CD704DB7B6870E93917D1E
Serbia	JSC EMS	https://ems.rs/planovi-razvoja/
Slovenia	ELES	Slovenian Network Development Plan 2023–2034

Appendix IV: Glossary

Acronym	Term	Definition
AC	Alternating Current	An electric current that periodically reverses direction and changes its magnitude continuously with time, in contrast to direct current (DC), which flows only in one direction. Alternating current is the form in which electric power is delivered to businesses and residences.
ACER	Agency for the Cooperation of Energy Regulators	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 for both electricity and natural gas.
BEMIP Electricity	Baltic Energy Market Interconnection Plan in electricity	One of the four priority corridors for electricity identified by the TEN-E Regulation. Supports interconnections between Member States in the Baltic region and strengthening the internal grid infrastructure to end the energy isolation of the Baltic states and foster market integration; this includes working towards the integration of renewable energy in the region.
BOGI	Baltic Offshore Grid Initiative	A working group established by Baltic Sea region TSOs focused on TSO cooperation in planning hybrid connections, with an emphasis on short-term (2–3 year) actions and timelines.
	Bottom-up	This approach of the scenario-building process collects supply and demand data from gas and electricity TSOs.
	Carbon budget	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.
CAPEX	Capital Expenditure	The funds used by a company to acquire, upgrade, or maintain physical assets like buildings, equipment, or infrastructure.
CBA	Cost–Benefit Analysis	A method used to evaluate the economic pros and cons of a project or decision by comparing its costs with its expected benefits.
CBAM	Carbon Border Adjustment Mechanism	An EU policy that imposes a carbon price on certain imported goods to match the costs EU producers face under the Emissions Trading System (ETS). It aims to prevent carbon leakage and promote cleaner industrial production globally.
CCE	Continental Central East	Region of Europe comprising Austria, Croatia, Czechia, Germany, Hungary, Poland, Romania, Slovakia, Slovenia, and Ukraine.
CCS	Carbon Capture and Storage	Process of sequestrating CO_2 and storing it in a way that prevents it from entering the atmosphere.
CCS	Continental Central South	Region of Europe comprising Austria (AT), France (FR), Germany (DE), Italy (IT), Slovenia (SI), and Switzerland (CH).

Acronym	Term	Definition
CCU	Carbon Capture and Usage	Captured CO_2 that instead of being stored in geological formations is used to create other products, such as plastic.
CE	Continental Europe	The continent of Europe is situated in the Northern Hemisphere and bordered to the south by the Mediterranean Sea, the north by the Arctic Ocean, and the west by the Atlantic Ocean. It is separated from the continent of Asia by the Caucasus Mountains and the watershed divide of the Ural Mountains.
CEF	Connecting Europe Facility	A key EU funding instrument to promote growth, jobs, and competitiveness through targeted infrastructure investment at the European level.
CEN/CESA	Continental Europe Network/ Continental Europe Synchronous Area	Formerly known as the UCTE grid, it is one of the largest synchronous electrical grids in the world, primarily operating in Europe. It is interconnected as a single phase-locked 50 Hz main frequency electricity grid that supplies over 400 million customers in 32 countries, including most of the European Union.
CFI	Agreement on the conditions of the future interconnection of the power system of the Baltic states and the power system of Continental Europe	The specific rules and requirements issued by the TSOs of the CE Network to Baltic state TSOs for successful Baltic state synchronisation and connection to the CE power system.
CHP	Combined Heat and Power	A technology that produces electricity and thermal energy at high efficiencies using a range of technologies and fuels. With onsite power production, losses are minimised and heat that would otherwise be wasted is applied to facility loads in the form of process heating, steam, hot water, or even chilled water.
CNEC	Critical Network Element with Contingency	A transmission grid component, such as a line or transformer, that becomes critically loaded under specific system conditions, including the failure of another element (the contingency). It is used in grid planning and capacity calculations to identify and manage potential congestion risks in the electricity network.
CO_2	Carbon Dioxide	An important heat-trapping gas, also known as a greenhouse gas, that comes from the extraction and burning of fossil fuels (such as coal, oil, and natural gas), wildfires, and natural processes like volcanic eruptions.
	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 international trade requested by market participants due to insufficient capacity in the interconnectors and/or the relevant national transmission systems.
COP21		21st Conference of the Parties to the United Nations Framework Convention on Climate Change, organised in 2015, where participating states reached the Paris Agreement.

Acronym	Term	Definition
CSE	Continental South East	Region of Europe comprising 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).
CSW	Continental South West	Region of Europe comprising France, Portugal, and Spain.
	Curtailed electricity	Curtailment is a reduction in the output of a generator from otherwise available resources (e.g. wind or sunlight), typically on an unintentional basis. Curtailments can result when operators or utilities control wind and solar generators to reduce output to minimise transmission congestion or otherwise manage the system or achieve the optimal mix of resources.
DC	Direct Current	An electric current that flows steadily in one direction, maintaining a constant magnitude over time, unlike alternating current (AC), which periodically reverses direction. DC is commonly used in batteries, electronics, and some power transmission systems.
DE	Distributed Energy	One of the TYNDP 2024 assessment scenarios.
DLR	Dynamic Line Rating	A technology and technique that uses the environmental conditions or a set of conditions to calculate the ampacity of the conductor. The calculation of DLR relies on some degree of physical technology to implement the solution.
DSR	Demand Side Response	Consumers play an active role in softening peaks in energy demand by changing their energy consumption based on energy price and availability.
EC	European Commission	The executive branch of the European Union, responsible for proposing legislation, implementing decisions, managing EU policies, and upholding EU treaties. It acts in the interest of the EU as a whole, independently of national governments.
ENS	Energy Not Supplied	The volume of energy to customers that is lost as a result of faults or failures on the network, measured in megawatt hours (MWh).
ENTSO-E	The European Network of Transmission System Operators for Electricity	An association representing 40 electricity transmission system operators (TSOs) from 36 countries across Europe, thus extending beyond EU borders. It manages the CE Synchronous Area (CESA). ENTSO-E was established and given legal mandates by the EU's Third Package for the Internal Energy Market in 2009, which aims at further liberalising the gas and electricity markets in the EU. Ukrainian Ukrenergo became the 40th member of the association on 1 January 2024.
ERAA	European Resource Adequacy Assessment	A pan-European monitoring assessment of power system resource adequacy up to 10 years ahead. Building on the work done with the Mid-term Adequacy Forecast (MAF), the ERAA is a leap forward in system modelling. It is based on state-of-the-art methodologies and probabilistic assessments, aiming to model and analyse possible events that can adversely impact the balance between the supply and demand of electric power. It will be an important element for supporting qualified decisions by policymakers on strategic matters, such as the introduction of capacity mechanisms (CMs).

Acronym	Term	Definition
EU	European Union	A supranational political and economic union of 27 Member States located primarily in Europe. The EU has a total area of 4,233,255 km² (1,634,469 sq mi) and an estimated total population of over 449 million. The EU has often been described as a sui generis political entity combining the characteristics of both a federation and a confederation.
EVA	Economic Viability Assessment	A crucial but complex analysis that enables the assessment of the economic viability (under certain conditions) of existing or new generation, storage, and demand response capacity in the electricity market. The ERAA methodology indicates that the EVA shall either assess the viability for each capacity iteratively or by minimising the overall system costs, where all capacities are optimised at once.
FACTS	Flexible Alternating Current Transmission System	A family of power electronic–based devices designed for use on an AC transmission system to improve and control power flow and support voltage. FACT devices are alternatives to traditional electric grid solutions and improvements, where building additional transmission lines or substations is not economically or logistically viable.
FFR	Fast Frequency Reserve	Procured to handle low-inertia situations. Inertia means the ability of the kinetic energy stored in the rotating masses in the electricity system to resist changes in frequency.
GTC	Grid Transfer Capacity	Represents 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 that are represented by this branch; it is represented by a typical value across the year.
GW	Gigawatt	A unit of power. Power measures the rate at which energy is generated, used, or transferred. Watts are the standard unit of power. A gigawatt is a much larger unit, equivalent to 1 billion watts.
HVAC	High Voltage Alternating Current	HVAC transmission refers to the transmission of electrical power using supply voltages ranging from 33 kV AC to 230 kV AC. In HVAC transmission, the power generated is stepped up to high voltages and transmitted through transmission lines. It requires at least three line conductors to transmit three-phase electrical power.
HTLS	High-Temperature-Low-Sag	A type of conductor capable of maintaining transmission capacity without physically deteriorating at higher temperatures than conventional conductors.
HVDC	High Voltage Direct Current	A type of high voltage transmission system where power is transmitted in the form of DC at voltages between 100 kV and 800 kV. In this system, electrical power produced in the form of AC is first converted into DC using rectifiers and then transmitted through HVDC lines. At the receiving end, the DC is converted back to AC. The major advantage of HVDC is that it requires only two conductors for transmission and has comparatively low power losses over long distances.

Acronym	Term	Definition
IEM	Internal Energy Market	The main objectives of the EU IEM are to strengthen and expand the rights of individual consumers and energy communities; address energy poverty; clarify the roles and responsibilities of market participants and regulators; address security of supply for electricity, gas, and oil; and develop trans-European networks for gas and electricity.
IGBT	Insulated Gate Bipolar Transistors	Semiconductor devices that efficiently switch and control high voltages and currents. They are commonly used in power electronics such as inverters, electric vehicles, and renewable energy systems.
	Investment (in the TYNDP)	Individual equipment or facility, such as a transmission line, a cable, or a substation.
ITEG	Interconnection Targets Expert Group	A European Commission expert group that advises on achieving electricity interconnection targets to enhance energy market integration and security of supply in the EU.
IPS/UPS	Integrated Power System/ Unified Power System	The IPS/UPS (Russian: ЕЭС/ОЭС), also widely known as the Russian grid or the post-Soviet grid, is a wide area synchronous transmission grid, the Unified Power System (UPS; Единая энергетическая система России [ЕЭС]) being the Russian grid, and the Integrated Power System (IPS; Объединенная энергетическая система [ОЭС]) portion of the network being the national networks of Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, and Uzbekistan.
LCC	Line Commutated Converters	The conventional, mature, and well-established technology used to convert electric power from AC to DC or vice versa. The term “line-commutated” indicates that the conversion process relies on a stable line voltage, with clear zero-crossings of the AC system to which the converter is connected to enable a flow commutation from one switching element to another.
LFC	Load Frequency Control	The mechanism that regulates the power flow between the different regions of an interconnected system to keep frequency constant.
LNG	Liquefied Natural Gas	Natural gas that has been cooled to liquid form for ease and safety of non-pressurised storage or transport.
LOLE	Loss of Load Expectation	The expected number of hours per year that a country’s electricity production park fails to meet its demand.
MIBEL	Mercado Ibérico de Electricidad	The integrated electricity market of Spain and Portugal, enabling cross-border electricity trading to promote competition and price convergence. It is a key step towards aligning the Iberian market with the broader European energy market.
MoU	Memorandum of Understanding	An agreement between two (bilateral) or more (multilateral) parties that expresses a convergence of will between the parties, indicating an intended common line of action. It is often used either in cases where parties do not imply a legal commitment or in situations where the parties cannot create a legally enforceable agreement. It is a more formal alternative to a gentlemen’s agreement.

Acronym	Term	Definition
MS	Member State	
MSP	Maritime Spatial Plan	A tool to coordinate the use of seas and oceans to ensure human activities occur efficiently, safely, and sustainably.
Mton	Million ton	Measurement unit.
MW	Megawatt	The standard term of measurement for bulk electricity. One megawatt is 1 million watts.
	N-1 criterion	The rule according to which elements remaining in operation within a TSO's responsibility area after a contingency from the contingency list must be capable of accommodating the new operational situation without violating operational security limits.
NDP	National Development Plan	In the context of EU electricity development, a strategic plan created by individual EU Member States to outline investments, infrastructure upgrades, and policies aimed at achieving national energy and electricity goals. It supports EU-wide initiatives, such as decarbonisation and grid integration, ensuring alignment with broader energy objectives.
NECP	National Energy and Climate Plans	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 must develop NECPs on a 10-year rolling basis, with an update halfway through the implementation period. The NECPs covering the first period from 2021 to 2030 must ensure that the EU's 2030 targets for greenhouse gas emission reductions, renewable energy, energy efficiency, and electricity interconnection are met.
NGDP	Nordic Grid Development Perspective	The purpose of this report is to present a unified perspective on the development of the Nordic electricity grid. Released biennially, it is prepared collaboratively by the four Nordic transmission system operators (TSOs): Energinet, Fingrid, Statnett, and Svenska kraftnät. It is intended for everyone who has an interest in the development of the Nordic grid and the challenges related to managing this increasingly complex and evolving system.
NSEC	North Seas Energy Cooperations	A regional collaboration among nine European countries to develop offshore renewable energy, particularly wind power, and improve cross-border energy infrastructure. Its goal is to enhance energy security, reduce emissions, and support the transition to a greener energy system in the North Seas region.
NSOG	North Seas Offshore Grid	One of the four priority corridors for electricity identified by the TEN-E Regulation. Integrated offshore electricity grid development and related interconnectors in the North Sea, Irish Sea, English Channel, Baltic Sea, and neighbouring waters to transport electricity from renewable offshore energy sources to centres of consumption and storage and increase cross-border electricity exchange.
NSI East Electricity	North–south electricity interconnections in central eastern and southeastern Europe	One of the four priority corridors for electricity identified by the TEN-E Regulation. Interconnections and internal lines in the north–south and east–west directions to complete the EU internal energy market and integrate renewable energy sources.

Acronym	Term	Definition
NSI West Electricity	North–south electricity interconnections in western Europe	One of the four priority corridors for electricity identified by the TEN-E Regulation. Interconnections between EU countries in this region and with the Mediterranean area including the Iberian Peninsula, to integrate electricity from RES and reinforce internal grid infrastructures to promote market integration in the region.
NT	National Trend	One of the TYNDP 2024 assessment scenarios.
NTC	Net Transfer Capacity	The expected maximum volume of generation that can be transferred between two power systems without causing network constraints in either system, while accounting for technical uncertainties in future network conditions.
ONDP	Offshore Network Development Plan	A new component of the TYNDP focused on offshore transmission infrastructure needs. It translates the EU Member States' non-binding agreements on offshore goals from January 2023 into offshore transmission corridors, transmission equipment needs, and related costs. ONDP is mandated by the TEN-E Regulation (2022/869 EU Reg Art. 14.2).
OTC	Offshore TSO Collaboration	The OTC was established in 2022 and consists of TSOs from the Northern Seas working together to develop a sustainable offshore network infrastructure.
P2G	Power-to-Gas	The process of converting surplus renewable energy into hydrogen gas through PEM electrolysis technology. The hydrogen can then be injected into the natural gas grid to displace natural gas, reduce greenhouse gas emissions, and lower reliance on high-carbon fuels.
P2X	Power-to-X	Conversion technologies that allow the decoupling of power from the electricity sector for use in other sectors (such as transport or chemicals), possibly using power provided by additional investments in generation.
PCI	Projects of Common Interests	A category of projects launched in 2013, which the European Commission has identified as essential for interconnecting the energy infrastructure in the European Union. These projects are eligible to receive public funds.
PINT	Put IN one at the Time	Methodology that considers each new network investment/project (line, substation, PST, or other transmission network device) on the given network structure one by one and evaluates the load flows over the lines with and without the examined network reinforcement.
PMI	Project of Mutual Interest	Analogous to Projects of Common Interest, Projects of Mutual Interest are between the EU and non-EU countries, which contribute to the energy and climate policy objectives of the Union.
PEID	Power Electronic Interface Devices	Essential components of contemporary power systems that permit the efficient conversion and control of electrical energy. They are the vital link between electrical power sources and the loads that use them, allowing for the necessary power conversions (DC/AC, AC/DC, AC/AC, and DC/DC).

Acronym	Term	Definition
PPM	Power Park Module	A unit or group of units that generate electricity and are connected to the network either non-synchronously or via power electronics. They share a single connection point to a transmission system, distribution system (including closed distribution systems), or HVDC system (defined in Article 2(17) of the Network Code on Requirements for Grid Connection of Generators (NC RfG)).
	Project (in the TYNDP)	Either a single investment or a set of investments, clustered together to form a project to achieve a common goal.
PST	Phase Shifting Transformer	A specialised type of transformer typically used to control the flow of active power on three-phase electric transmission networks. It does this by regulating the voltage phase angle difference between two system nodes. The principle relies on a phase-shifted voltage source injection into the line by a series-connected transformer, which is fed by a shunt transformer. The configuration of the shunt and series transformer unit induces the phase shift.
PV	Photovoltaics	Refers to the technology that converts sunlight directly into electricity using semiconductor materials, typically in solar panels. It is a key renewable energy source widely used in residential, commercial, and utility-scale power generation.
	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.
RegIP	Regional Investment Plan	The investment plan for specific regions, which outlines 10 years of infrastructure development projects from a regional perspective. Based on joint planning studies among Member States – a core added value of the TYNDP – they provide details on the regional constraints and needs of the high-voltage grid. Infrastructure projects resulting from these studies are part of the final list of projects.
REPowerEU	REPowerEU plan	An ambitious plan launched by the EU to reduce its dependence on fossil-fuel imports and accelerate the green transition. In October 2022, the EIB announced it is substantially increasing its commitment to supporting the goals of the REPowerEU plan by providing €30 billion in additional financing over the next 5 years to businesses and public authorities for clean energy.
RES	Renewable Energy Sources	Also called renewables, energy sources that replenish (or renew) themselves naturally. Typical examples are solar energy, wind, and biomass.
RfG	Requirement for Generators	The Network Code on Requirements for Generators is harmonising standards that generators must respect to connect to the grid. These harmonised standards across Europe will boost the market of generation technology and increase competitiveness.
RG	Regional Group	A collaboration of TSOs from a specific area to coordinate cross-border grid investments.

Acronym	Term	Definition
RGBS	Regional Group Baltic Sea	Region comprising Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, and Sweden.
RGNS	Regional Group Northern Seas	Region of Europe comprising Belgium, Denmark, France, Germany, Great Britain, Ireland, Luxembourg, Netherlands, Northern Ireland, and Norway.
RoCoF	Rate of Change of Frequency	The time derivative of the power system frequency (df/dt). This quantity was traditionally of minor relevance for systems dominated by synchronous generators because the inertia of these generators naturally counteracts load imbalances and limits RoCoF.
	Scenario	A set of assumptions for modelling purposes related to a specific future situation in which certain conditions regarding electricity and gas demand and supply, infrastructures, fuel prices, and global context occur.
SEW	Socioeconomic Welfare	Refers to the overall economic and social benefits to society, including consumer and producer surplus, typically used as a key metric to assess the value of energy market decisions or infrastructure projects.
SMR	Steam Methane Reforming	A process used to produce hydrogen by reacting methane with steam over a catalyst, typically producing hydrogen and carbon monoxide as the primary products.
SoS	Security of Supply	Signifies that a supply of energy is guaranteed at all times, now and in the future. A secure supply of energy, not only electricity but also other final and primary energy sources, is vital both economically and socially.
SSI	Smart Sector Integration	An energy system approach that addresses all value chains of the energy sectors while supporting energy transition and decarbonisation goals. It links various energy resources and networks to consumption sectors in an optimal way. This leads to a "system of systems" vision, where electricity becomes the leading energy carrier and power grids form the backbone for decarbonising all energy sectors. In this context, smart sector integration is expected to deliver a scalable solution that improves overall system efficiency and resilience, allows greater integration of renewables, enables flexible consumption, and supports deeper consumer empowerment.
SSSC	Static Synchronous Series Compensator	A type of FACTS device used in power systems to control power flow and improve stability by injecting a controllable voltage in series with a transmission line.
SVC	Static Var Compensator	A device used in power systems to regulate voltage and improve stability by providing reactive power compensation.
t	ton	Measurement unit.
TEN-E	Trans-European Networks for Energy	A long-standing EU instrument for connecting the energy networks of EU countries, strengthening cohesion, and developing solidarity and cooperation across the EU.

Acronym	Term	Definition
TSO	Transmission System Operator	An organisation responsible for efficient and reliable transmission of electricity from generation plants via the power grid to regional or local electricity distribution operators. In Europe, transmission grids usually have voltage levels of 220 kilovolts (kV) to 380 kV.
TOOT	Take Out One at the Time	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 evaluate the load flows over the lines with and without the examined network reinforcement.
	Top-down	The “top-down carbon budget” scenario-building process is an approach that uses “bottom-up” model information gathered from gas and electricity TSOs. The methodologies are developed in line with the carbon budget approach.
TWh	Terawatt hour	A unit of energy representing 1 trillion watt hours. A kilowatt hour is equivalent to a steady power of 1 kilowatt running for 1 hour and is equivalent to 3.6 million joules or 3.6 megajoules.
TYNDP	10-Year Network Development Plan	Prepared by ENTSO-E and published every 2 years, it plays a central role in the development of electricity transmission infrastructure in Europe, which is needed to achieve European policy goals. It builds on national investment plans prepared by TSOs and takes into account regional investment plans.

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