REGIONAL
INVESTMENT PLAN 2024

CONTINENTAL CENTRAL 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 CCE

Europe is on an unprecedented societal transformation journey, driven by the Green Deal's objective of achieving climate neutrality by 2050. The European Climate Law establishes an ambitious trajectory towards decarbonisation, with an intermediate goal of reducing net greenhouse gas emissions by at least 55 % by 2030 compared to 1990 levels – a target also embraced by the Continental Central East (CCE) countries. Compared to the previous CCE Regional Group (RG) Investment Plan 2022 (CCE RegIP 2022), the main agenda and messages presented in this revised CCE RegIP 2024 have remained consistent.

For the CCE region, this transformation entails a unique and significant overhaul of its energy system, compounded by a challenging geopolitical landscape, particularly influenced by the ongoing war in Ukraine. This crisis has underscored the urgency for Europe to achieve independence from fossil fuels as quickly as possible. To support the 2050 carbon neutrality goal, the evolution of EU climate legislation has introduced and adopted ambitious targets for 2030 and 2040.

A key change in the electricity sector within the CCE region is the shift in the power generation mix. Traditional coal-based generation is being replaced by the extensive integration of renewable energy sources (RES), marking a fundamental transformation in the region's generating capacity. **Solar capacities increased by nearly 50 GW, an 80 % increase from 2019 to 2023, while fossil capacities fell by 26 GW in the CCE region**. This trend, driven by the European Fit-for-55 and RePowerEU packages, is evident across all countries. Nuclear power declined by 6 GW, mainly due to Germany's plant closures, though Czechia, Poland, Hungary, and Slovakia are preparing to expand their nuclear fleet. **The share of low-carbon technologies in the regional energy mix grew from 56 % in 2019 to 63 % in 2023. Total installed capacity rose by over 30 GW, reaching nearly 452 GW.**

From 2019 to 2023, all CCE region countries saw a decline in electricity demand due to the COVID-19 pandemic and the war in Ukraine, with reductions ranging from −3 % in Poland to −30 % in Ukraine. Total electricity generation also fell, mainly due to a decline of around 100 TWh/a in fossil fuel and nuclear power, while solar, wind, and hydropower saw moderate increases. As a result, the region's electricity supply and demand remained nearly balanced over the period. **In CCE, there was a slight surplus in 2019, while 2023 saw an even more balanced situation between generation and demand**.

The 10-Year Network Development Plan (TYNDP) 2024 cycle introduced methodological changes, new tools, and a significant expansion of projects – an evolution in TYNDP projects is evident. For the CCE region, a total of 72 transmission projects (18 more than in TYNDP 2022) and seven storage projects were analysed, resulting in 81 GW of transmission capacity and 110 GWh of storage, with a slight decline in storage capacity since TYNDP 2022. The total capital expenditure (CAPEX) in the CCE region surged by 123 % to € 158.1 billion, with Germany's CAPEX alone doubling to € 124.4 billion. Germany also added six new projects, contributing to the overall cost increase. Also contributing to the increase is the inflation and implementation of costly technologies like high-voltage direct current (HVDC).

The System Needs Study in TYNDP 2024 analysed system needs for 2030, 2040, and 2050 using different scenarios. By 2030, Germany will have the highest energy demand and is the largest producer of RES in the CCE region, requiring 15.2 GW of new interconnectors and 2.6 GW of storage, contributing to total CCE region storage of 6.5 GW, reducing RES spillage and CO_2 emissions. By 2040, Germany needs 13.4 GW of new interconnectors, with total CCE storage reaching 106.2 GW, significantly lowering CO_2 emissions and marginal costs. For 2050, Germany requires 28 GW of new interconnectors, with total CCE storage reaching 102.2 GW, further reducing non-RES generation and CO_2 emissions. **The implementation of cross-border grids and storage systems will result in declining fossil fuel dependence and improved energy efficiency across the region**, with an average marginal cost reduction of € 4.1/MWh in 2030, € 6.1/MWh in 2040, and € 22.8/MWh in 2050, highlighting the economic benefits of grid expansion. **These findings support continued investment in transmission infrastructure to enhance energy security and sustainability in the CCE region**.

The CCE RG conducted two additional market studies to assess the impact of policy changes and hydrogen system integration in the CCE region. The 2030 policy sensitivity study focused on Germany, where delays in RES expansion and extended coal plant operations led to a 59 TWh drop in wind generation, increased reliance on lignite and coal, and higher CO_2 emissions (+12 million tonnes). Reduced wind capacity resulted in higher electricity imports and rising socioeconomic costs, as conventional generation was not cost-effective enough to fully compensate. The 2040 hydrogen sensitivity study tested the impact of introducing import costs to a subset of previously assumed zero-cost hydrogen imports, reducing hydrogen imports from non-modelled nodes from 680 TWh to 619 TWh. This led to higher marginal electricity costs, especially in Germany (+€5/MWh to €69/MWh) and Austria (+€5/MWh to €77/MWh), while system-wide energy market costs remained stable. However, the regional total hydrogen system cost nearly doubled from €34 billion to €62 billion, with Germany seeing the highest increase (+€6.6 billion) due to its significant hydrogen demand. **These findings highlight the economic and energy security implications of policy and market changes, emphasising the need for strategic, robust, and stable infrastructure and regulatory planning**.

On 16 March 2025, Ukraine and Moldova celebrated the third anniversary of their electricity grids' synchronisation with the Continental European Network. This achievement has been crucial for securing energy supplies and maintaining grid stability under challenging conditions. **It also strengthens political ties with ENTSO-E and enhances electricity trade opportunities with the EU. Several infrastructure projects are considered, including upgrading interconnectors between Ukraine and Poland, Slovakia, Hungary, and Romania. These developments aim to improve regional energy integration and long-term system reliability**.


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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.

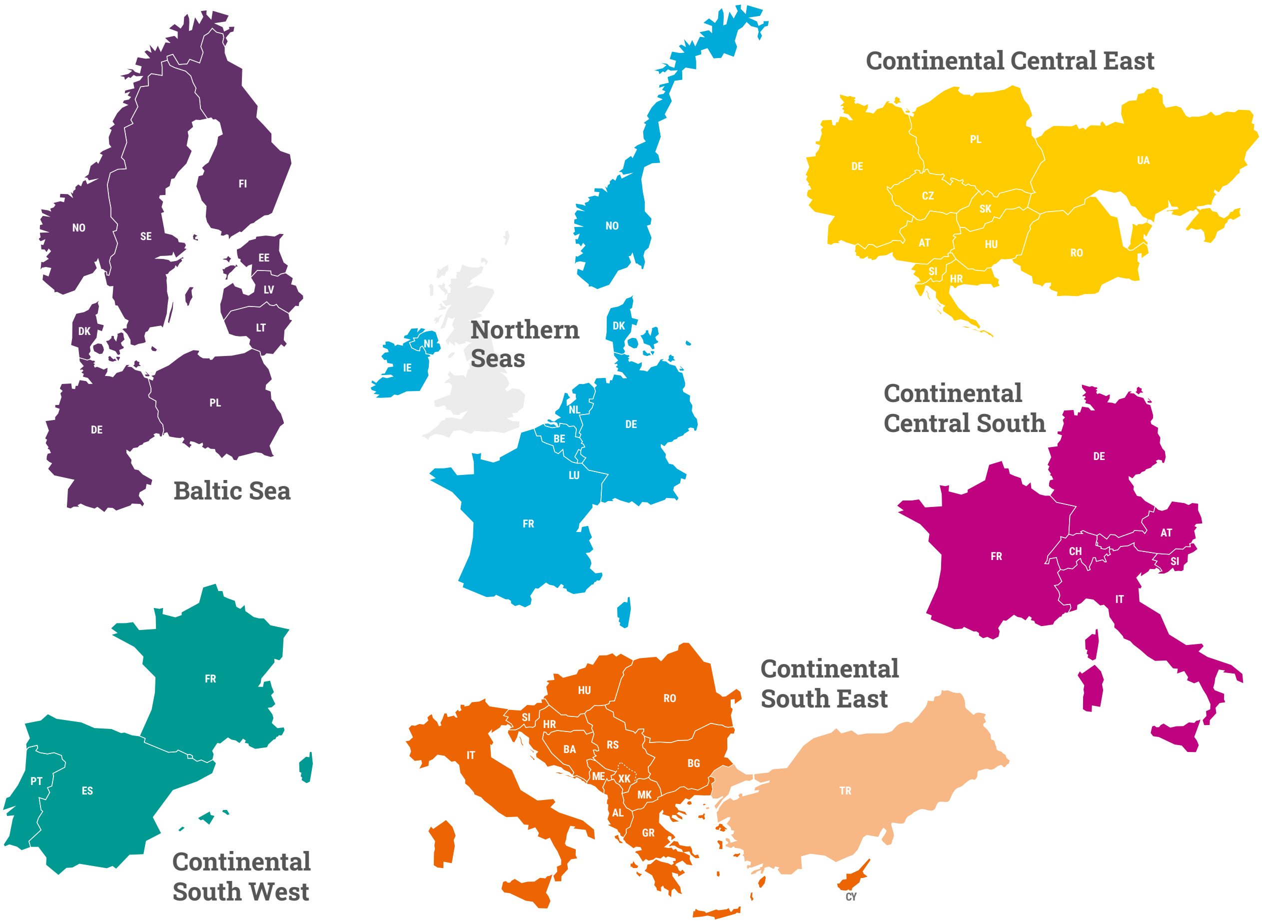

Figure 1: ENTSO-E's six system development regions, each region is covered by one Regional Investment Plan

3 Regional Context

3.1 Overview of the region and current situation

This section outlines the geographical coverage of the CCE RG and compares key electric system indicators and statistics between 2019 and 2023. It highlights the evolution of installed capacities, generation, consumption, energy balance, interconnection capacities, and exchange for each country over this period. Additionally, it examines the differences between CCE RegIP 2022 and CCE RegIP 2024, particularly changes in the long-term project portfolio of **TYNDP 2022 and 2024**.

3.1.1 The Continental Central East Region

The CCE region covers the most central part of Europe, as well as Eastern European countries – including Ukraine for the first time, as it became a full ENTSO-E member in 2024. The RG CCE incorporates TSOs of 10 European countries, forming connections between the Baltic Sea, the Adriatic Sea, and the Black Sea. Figure 2 shows an overview of the CCE region, listing corresponding Member States and their respective TSOs in the CCE region. As for Germany, only 50Hertz Transmission GmbH and TennetT TSO GmbH are part of the CCE region.

Countries	TSOs	
Austria (AT)	APG – Austrian Power Grid AG,	VUEN – Vorarlberger Übertragungsnetz GmbH
Croatia (HR)	HOPS – HOPS d.d.	
Czechia (CZ)	ČEPS – ČEPS a.s.	
Germany (DE)	Amprion – Amprion GmbH 50Hertz – 50Hertz Transmission GmbH	TenneT DE – TenneT TSO GmbH TransnetBW – TransnetBW GmbH
Hungary (HU)	MAVIR – MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság	
Poland (PO)	PSE – Polskie Sieci Elektroenergetyczne S.A.	
Romania (RO)	Transelectrica – C.N. Transelectrica S.A.	
Slovakia (SK)	SEPS – Slovenská elektrizačná prenosová sústava, a.s.	
Slovenia (SI)	ELES – ELES, d.o.o.	
Ukraine (UA)	Ukrenergo – National Power Company Ukrenergo	

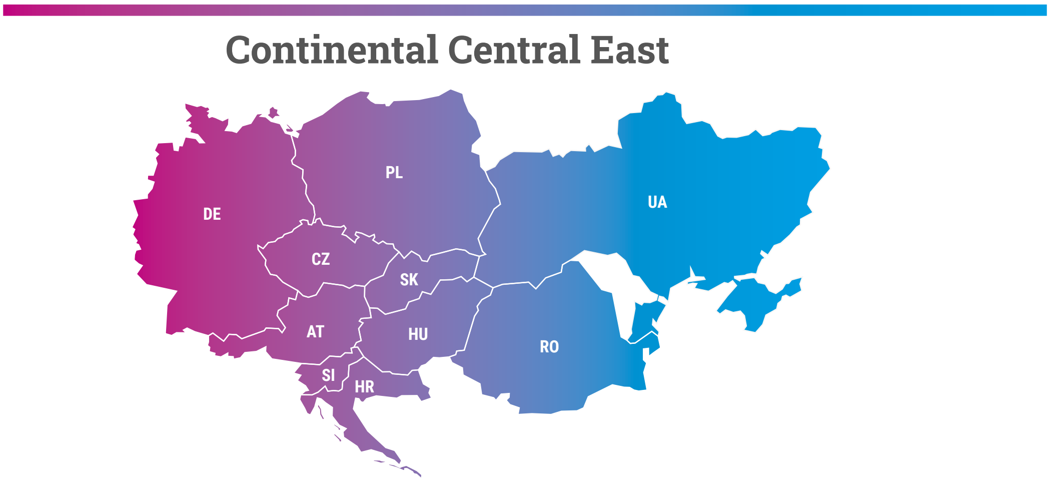

Figure 2: ENTSO-E's System Development Committee CCE region members and their respective TSOs

3.1.2 Current situation (interconnection capacities in the region)

The CCE region can be considered a strongly interconnected region compared to other European regions. In particular, the electricity grids of Germany, Czechia, and Austria serve as a pivot point for today's European electricity transmission, facilitating power exchanges in the northern–southern and western–eastern directions. This central interconnection can be analysed through the number of cross-border lines in Figure 3, as well as the corresponding forecasted net transfer capacities (NTC) in Figure 4. Increased transfer capacities are inevitable to couple energy markets of Member States, which show a gradient structure in terms of net position and electricity prices.

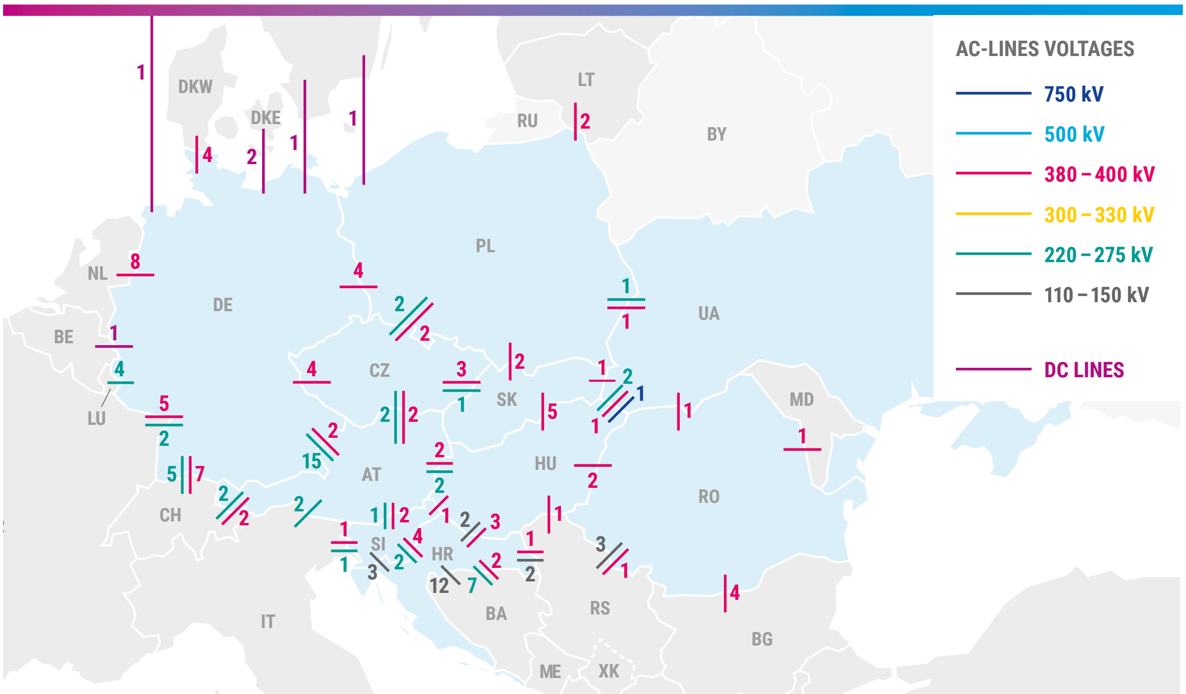

Figure 3: Map showing the number of interconnectors per voltage level

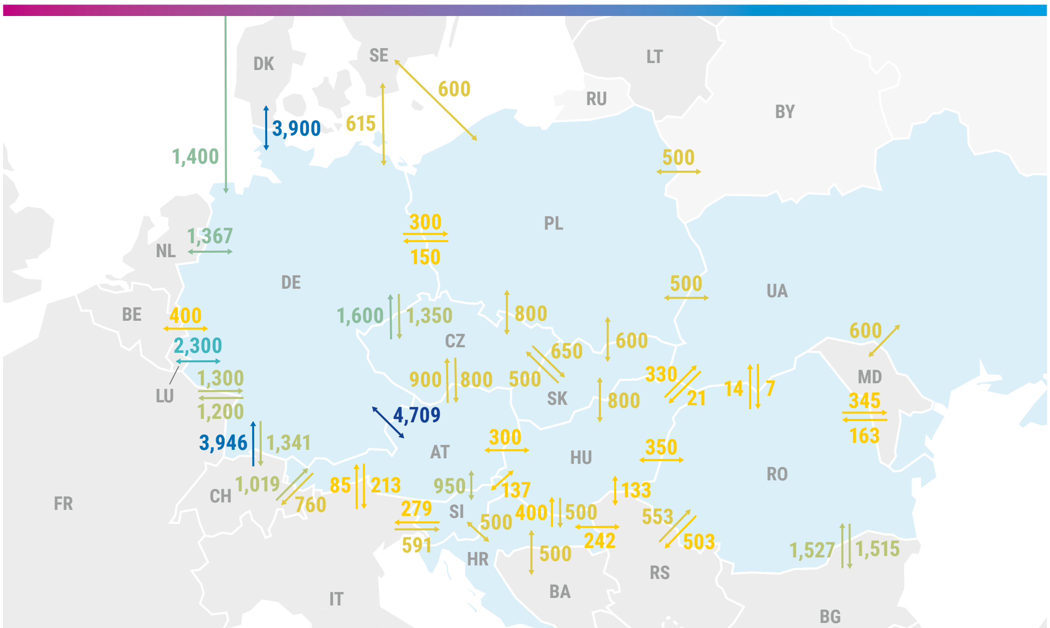

Figure 4: Map showing NTCs (2023 – Forecasted NTCs of ENTSO-E Transparency Platform; Remark: HU–UA 01.01.2024–21.02.2024: 0/0 MW, 21.02.2024–30.11.2024: 680/160 MW, 01.12.2024–31.12.2024: 840/220 MW)

3.1.3 Installed capacities

Overview of key statistics

The upswing of the European energy transition has started, reflected in the increasing capacities of renewables power plants and the decrease of fossil fuel plants – see Figure 7 (right). Solar capacities rose by almost 44 GW, leading to an increase of around 77 % from 2019 to 2023, while fossil capacities decreased by around 21 GW in the CCE region. This trend can be observed in all countries in the region and is an apparent effect of the European Fit-For-55 and RePowerEU packages. Furthermore, installed nuclear power capacities fell by 4.7 GW, mostly caused by the decommissioning of German power plants.

In Figure 5, this structural change is reflected in the share of low-carbon technologies compared to the total installed power, which has increased from 55 % in 2019 to 62 % in 2023. The total capacities rose by over 36 GW, from about 416 GW to approximately 452 GW.

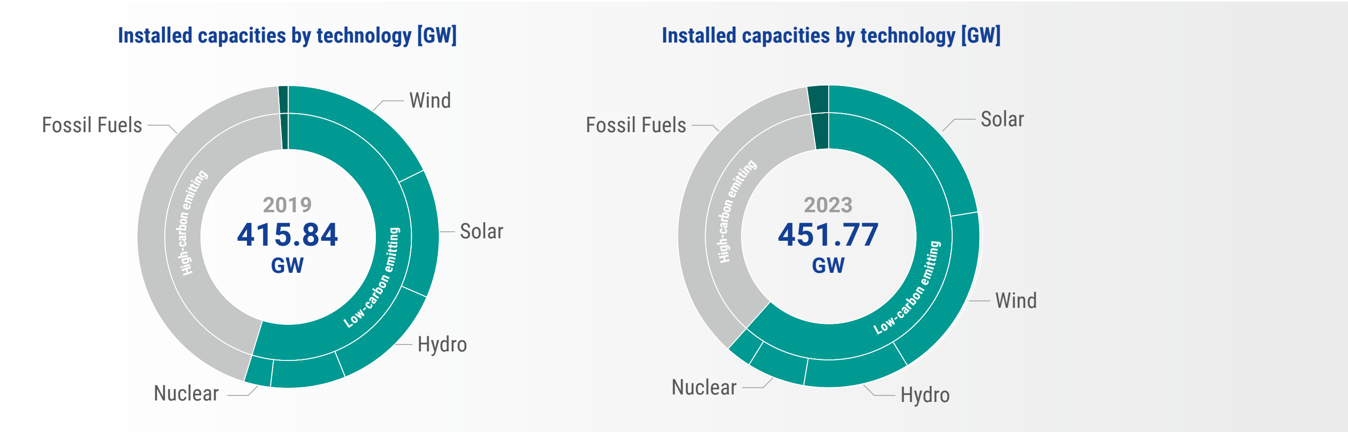

Figure 5: Installed capacity of high- and low-carbon emitting technology within the RG CCE in 2019 and 2023; "Others" marked dark green

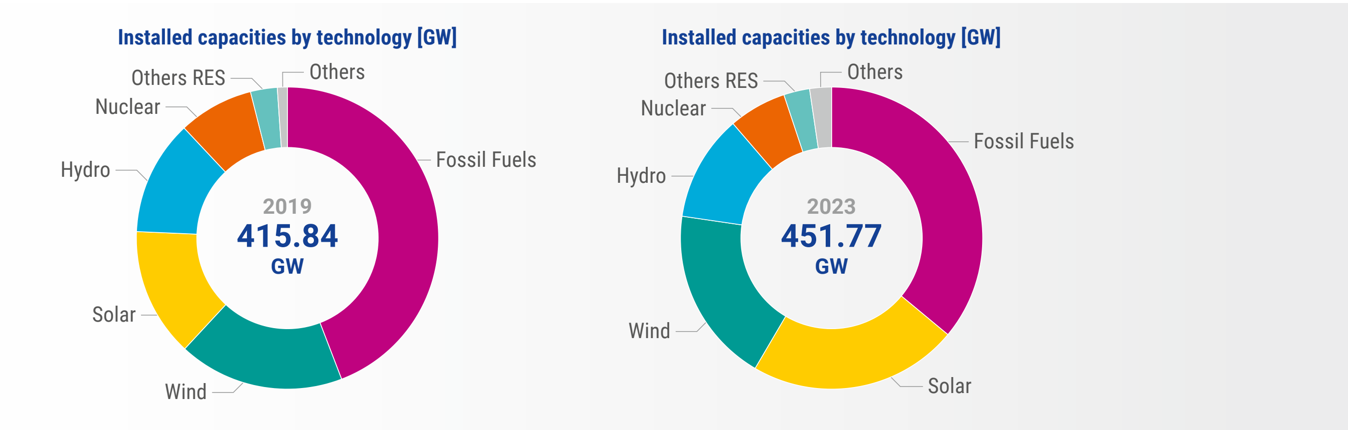

Figure 6: Installed capacity fuel mix within the RG CCE in 2019 and 2023

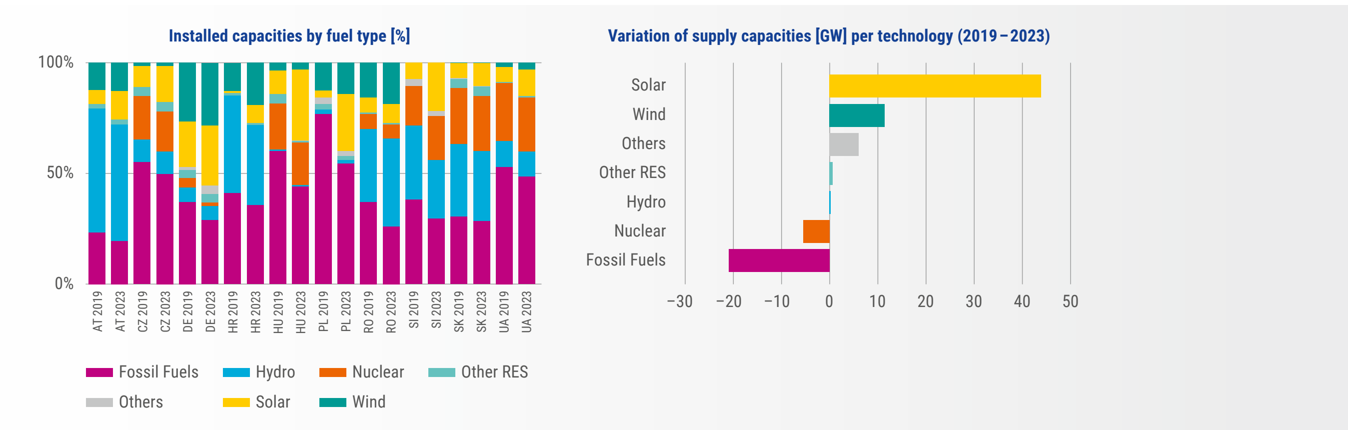

Figure 7: Left: Country-specific relative installed capacity fuel mix in 2019 and 2023;
Right: Variation of installed capacity per technology within RG CCE from 2019 to 2023

3.1.4 Generation and consumption

Overview of key statistics

All countries in the CCE region experienced a decrease in annual electricity demand from 2019 to 2023 (see Figure 8). This was caused by the combined effects of the global COVID pandemic, which impacted all countries in the CCE region, and the war in Ukraine, resulting in volatile markets, high fuel prices, and reduced demand in energy-intensive sectors. The relative decrease during this time period ranges from −3% in Poland to −30% in Ukraine. Germany, with its relatively high population, stands out in the region in terms of demand figures (497 TWh/a in 2019), while Slovenia's electricity demand was the lowest (14.15 TWh/a in 2019).

Over the entire region, a decrease of −10% was identified, reducing the demand of 1,125 TWh/a in 2019 to 1,010 TWh/a in 2023 (see Figure 8).

Total generation across the given perimeter was lower in 2023 as a result. The annual regional generation dropped from 1,134 TWh/a in 2019 to 1,006 TWh/a in 2023 (Figure 9), resulting in nearly balanced annual net positions for both years. As seen in Figure 10, this decrease in generated energy is characterised by lower generation of fossil fuel and nuclear plants, both technologies dropping by roughly 100 TWh/a. Simultaneously, solar energy rose by 35 TWh/a, wind energy by 27 TWh, and hydropower energy by 10 TWh. These changes are in line with the corresponding changes in installed generating capacities mentioned in **Section 3.1.3**.

Energy balance

In the entire CCE region, there was a slight positive balance in 2019, with generation of 1,134 TWh/a compared to 1,125 TWh/a of demand. In 2023, this was even more balanced, with 1,006 TWh/a of generation and 1,010 TWh/a of demand (see Figure 11 and Figure 12).

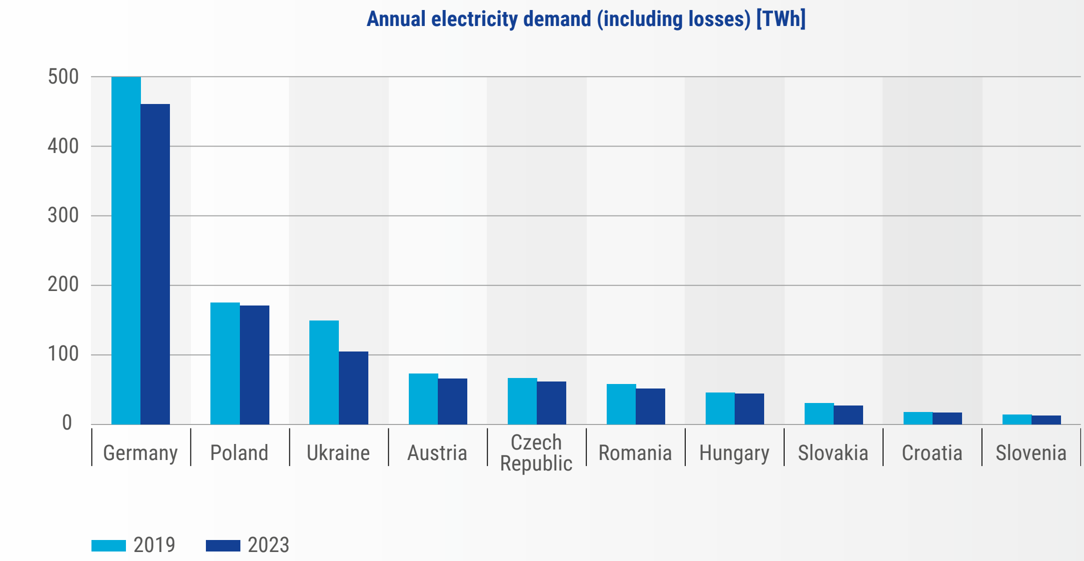

Figure 8: Annual electricity demand within the RG CCE in 2019 and 2023

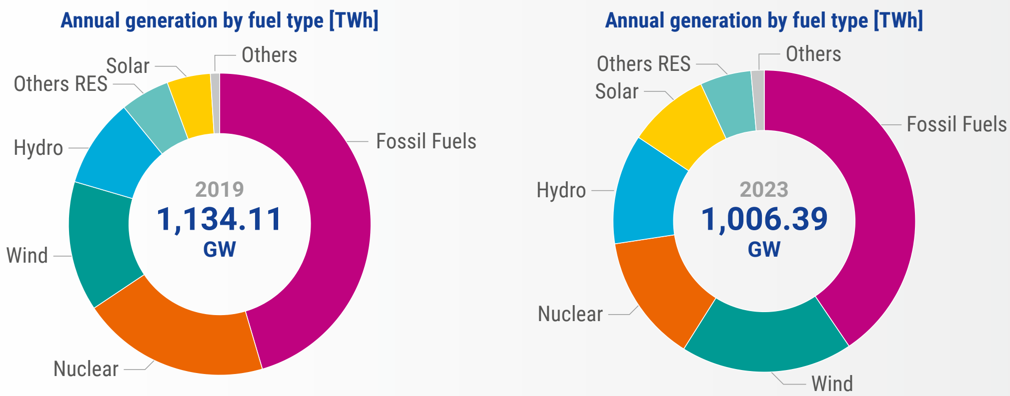

Figure 9: Annual generation fuel mix within the RG CCE in 2019 and 2023

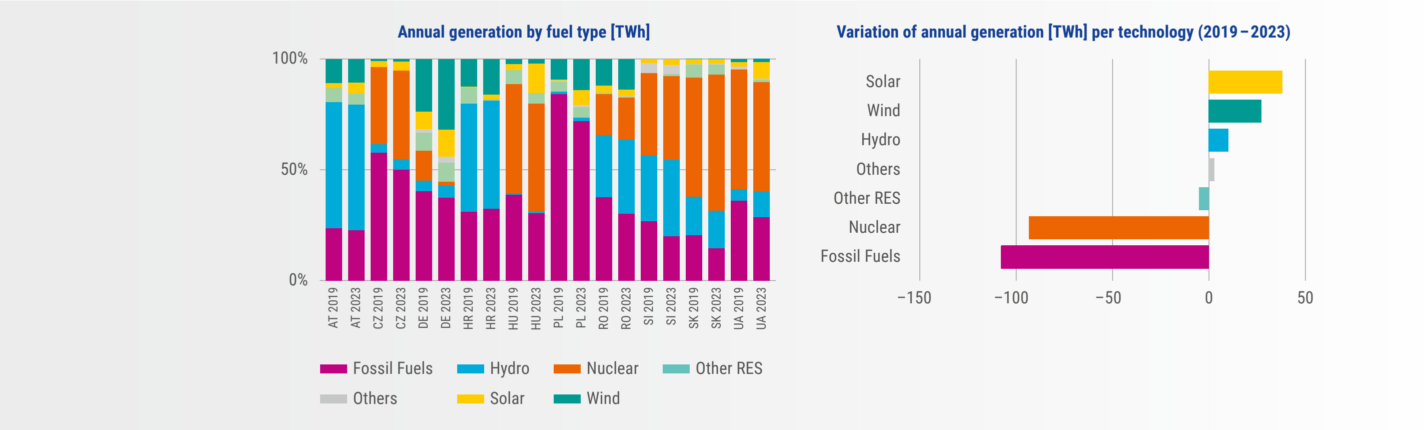

Figure 10: Left: Country-specific relative annual generation fuel mix in 2019 and 2023;
Right: Variation of annual generation per technology within RG CCE from 2019 to 2023

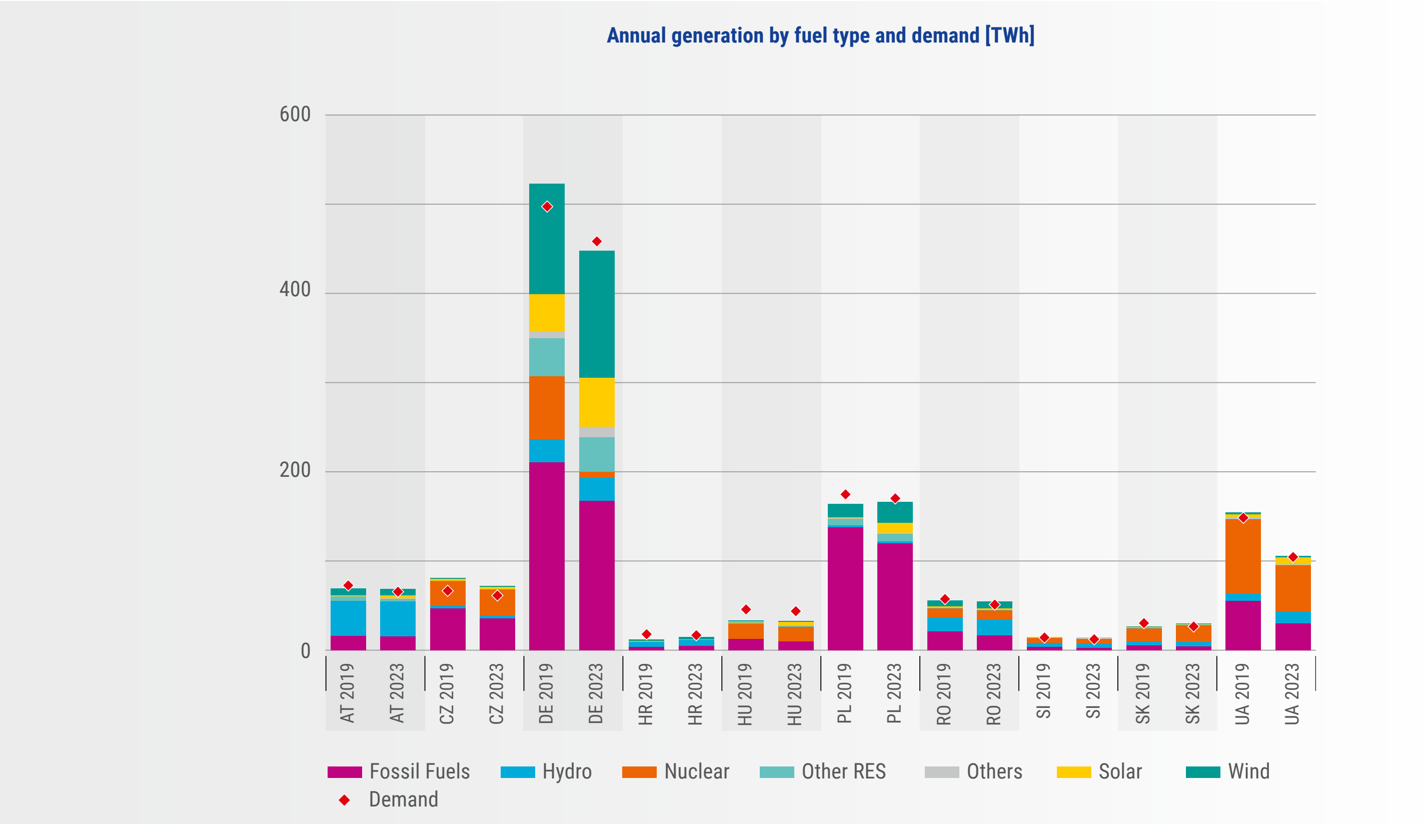

Figure 11: Country-specific annual generation fuel mix compared to demand in 2019 and 2023

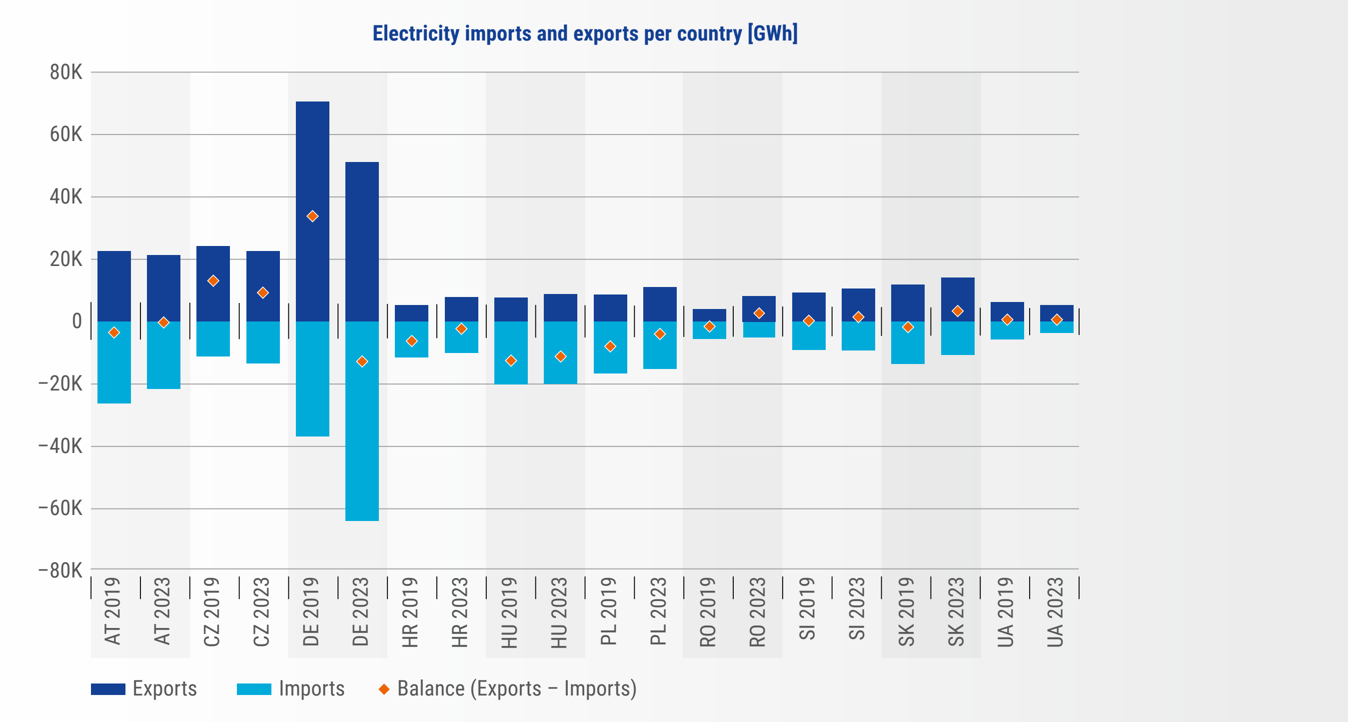

Figure 12: Country-specific balances, imports, and exports in 2019 and 2023

3.1.5 Exchanges

Due to the aforementioned shift in individual energy systems in the CCE region, transitioning towards carbon-free generation as well as electrification on the demand side, many countries experience a switch of past exchange and balance situations. From 2019 to 2023, the exchange balance changed significantly in Germany. Electricity imports from France and Sweden and electricity exports to the other neighbouring countries were common in the past. In recent years, imports from Czechia, Denmark, the Netherlands, and Belgium have become more significant. While Germany was a net exporter of electricity in the past, 2023 showed more imports. These effects are profound, as they impact nearby countries in the region, like Austria. As a result, exchanges have shifted to 8.3 TWh export and 9.8 TWh import on AT–DE interconnectors, and decreased flows from Austria towards the south and east.

Poland's cross-border exchange is primarily focused on the synchronous profile PL–DE/CZ/SK, where energy imported from Germany is transited through Poland to Czechia and Slovakia. In the 2019–2023 horizon, energy imports from Germany decreased by 1.9 TWh, while exports increased by 1.8 TWh to Czechia and 0.4 TWh to Slovakia. The war in Ukraine led to the commissioning of the PL–UA connection at 400 kV, which had been disconnected since 1993. This new connection provides additional synchronous support for Ukraine's power system through Poland, complementing the existing connections with Slovakia, Hungary, and Romania. The impact of the permanent synchronisation of Ukraine and the Republic of Moldova on Romania's energy system led to an increase in cross-border capacity and the easier evacuation of energy from the Dobrogea area, where many wind and nuclear power plants are installed, by closing the 400 kV ring in the eastern and northern areas of Romania on the Romania–Republic of Moldova–Ukraine route.

3.1.6 Evolution compared to RegIP 2022

Over the two-year TYNDP cycle, several aspects of its scope changed, including methodology, new co-products, updated tools, and a revolution in TYNDP projects.

Projects in the CCE RG included in the TYNDP 2024 are listed in **Chapter 7 (Appendix)**.

A total of 72 transmission projects involving RG CCE were submitted and analysed during TYNDP 2024, 18 more than in TYNDP 2022. There are seven storage projects in the region, two less than TYNDP 2022. This results in 81 GW of project-induced transmission capacities and 110 GWh of storage capacities, compared to 72 GW and 152 GWh in the previous TYNDP. The growing quantity of TYNDP projects can also be seen in the overview tables in Figure 13[1)] and Figure 14.[2)]

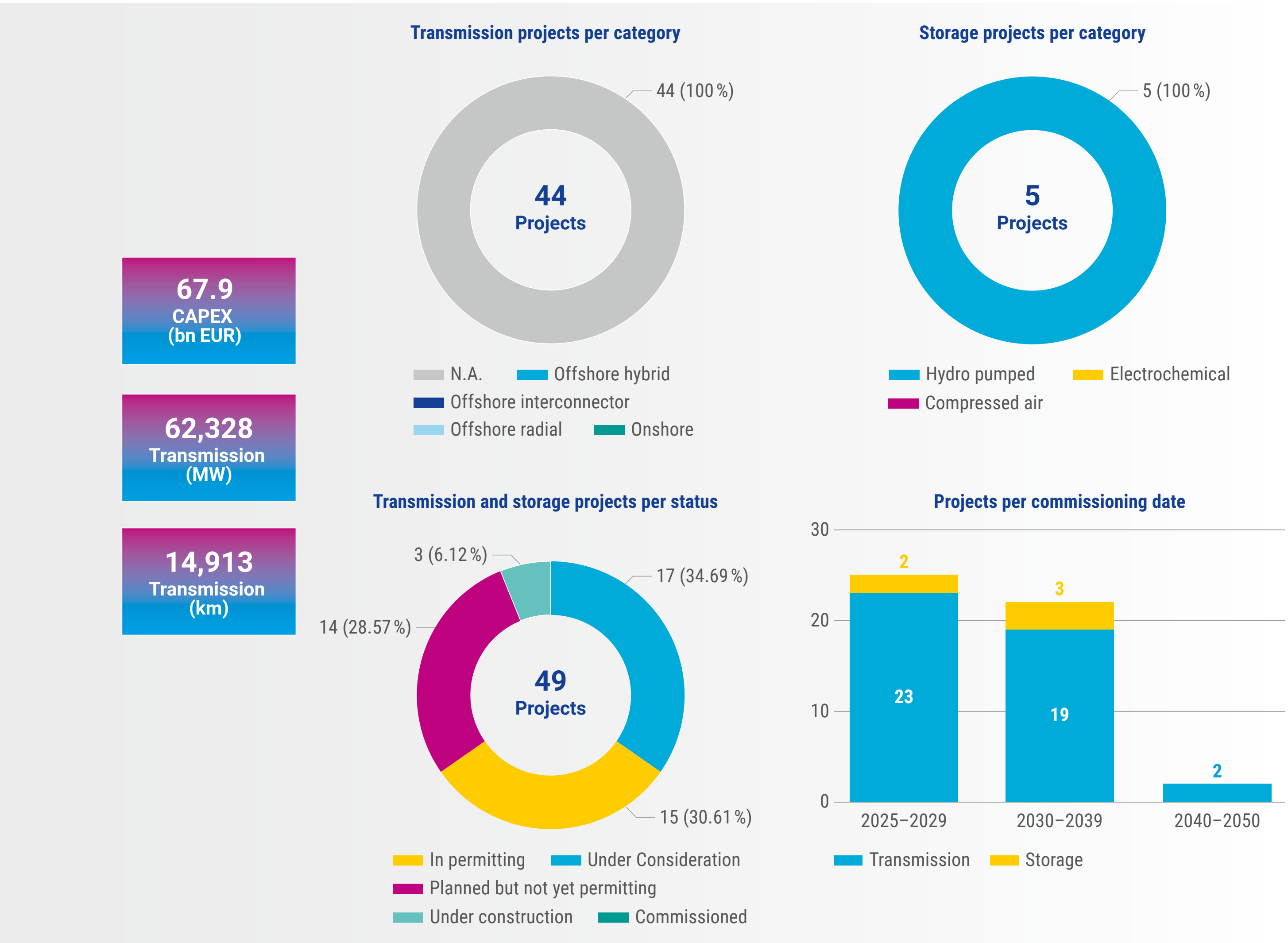

Figure 13: TYNDP 2022 CCE projects

1) TYNDP 2022 Project Sheets.
2) TYNDP 2024 Project Sheets.

The total CAPEX of these projects in the CCE region soared 123 %, reaching € 158.1 billion in TYNDP 2024. In Germany alone, CAPEX rose from € 60.6 billion to € 124.4 billion, while an additional six projects were submitted between the two studies. Besides the addition of 18 more projects, individual investment costs have risen due to inflation and high demand for specific equipment, such as transformers, or the further implementation of costly technologies like HVDC.

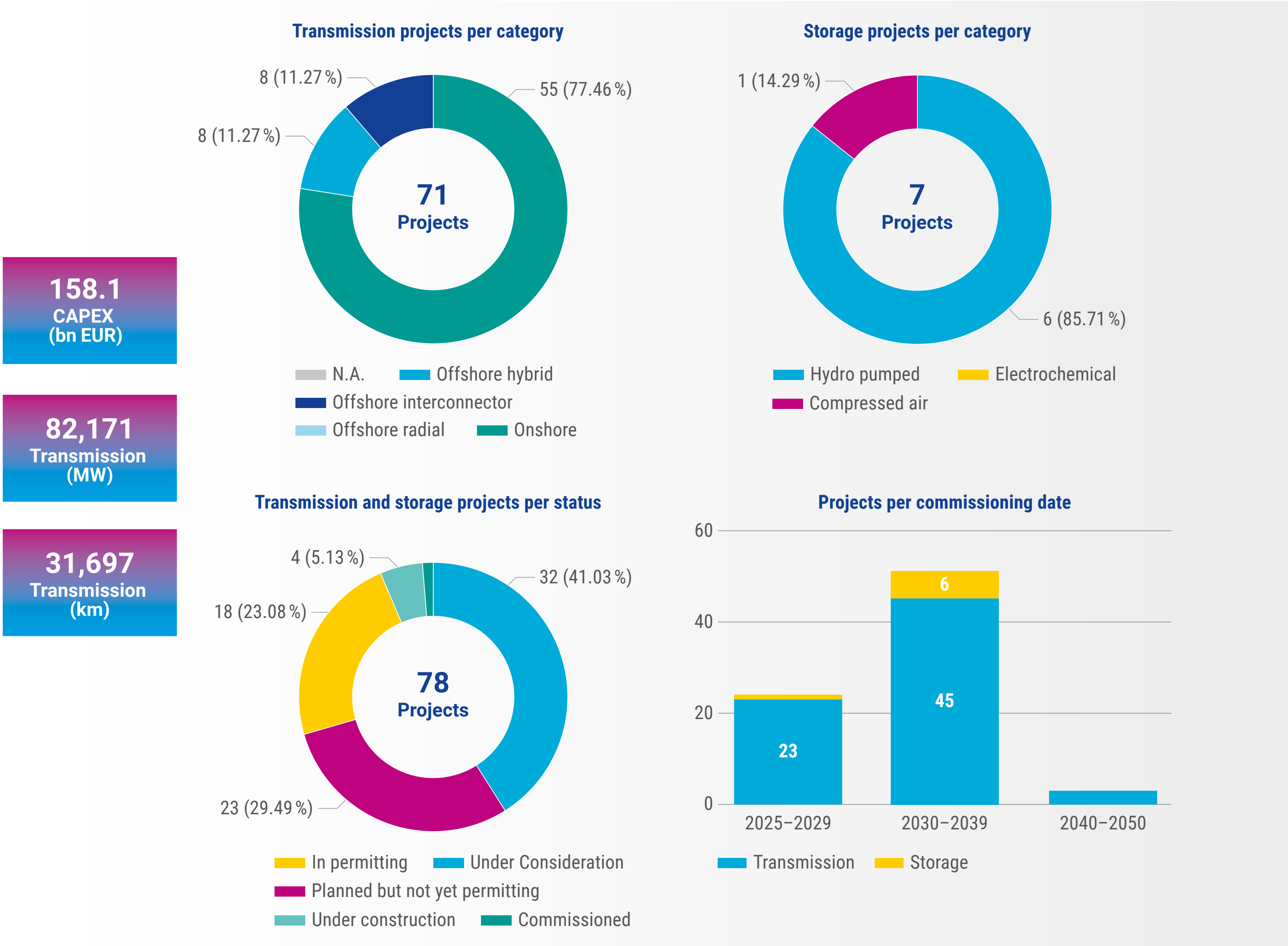

Figure 14: TYNDP 2024 CCE projects

3.2 Current and expected challenges in the region

3.2.1 Fundamental changes of the energy system

Climate goals

The EU has agreed to a comprehensive update of its energy policy framework to facilitate the transition from fossil fuels to carbon-neutral energy. Since RegIP 2022, the EU has increased the binding target for RES in the EU's energy mix from 32 % to 42.5 % by 2030. The development of RES also leads to greater energy independence. Over the course of implementing the REPowerEU plan by the European Commission, energy independence has risen significantly. Further details can be found in a later section.

Rapid increase in storage connection requests

In recent years, the cost of storage components (particularly battery cells) has decreased significantly. This has led to growing interest among project promoters in building and operating storage facilities in medium- to high-voltage grids. Batteries have already saturated parts of the balancing markets in Germany and are expected to play an increasing role in the day-ahead and intra-day markets. While storage capacities are vital to the energy transition, TSOs are experiencing a rapid rise in network connection requests for large-scale facilities. Battery market participation is expected to influence market-clearing prices in the European bidding zones in the coming years, further increasing the complexity of energy markets. To prevent additional strain on the electricity network from market-driven capacities, it is essential to define network connection rules that define the technical capabilities and obligations of new large-scale power facilities to support the energy system.

Many grid connection requests for battery storage are present in most of the regional countries.

Power to gas

The hydrogen strategy presented by the European Commission in July 2020 outlines how to upscale the supply and demand of renewable hydrogen. It set a strategic objective of installing at least 40 GW of renewable hydrogen electrolyser capacity within the EU (producing about 5 million tonnes of renewable hydrogen) based on an estimated demand of up to 10 million tonnes per year for renewable hydrogen in the EU by 2030. RG CCE Member States will play a crucial role in transitioning this European target, as hydrogen will decarbonise steel-making, haulage, rail, and maritime transport applications. International trade in hydrogen is expected, especially with eastern and southern neighbouring partner countries. The EU industry has issued a strategic and ambitious vision of incorporating an additional 40 GW of renewable hydrogen electrolyser capacity in Europe's neighbourhood, with plans for export to the EU. In particular, the EU promotes cooperation with Ukraine on renewables electricity and hydrogen.

In the National Trends 2030 scenario used in the analyses of RG CCE performed under RegIP 2024, there is a 236 % increase in energy used for hydrogen production by electrolysers compared to the previous edition, RegIP 2022. It should be noted that an innovation task concerning modelling the H_2 sector in cost–benefit analysis (CBA) market simulations was implemented for the first time during TYNDP 2024 and subsequently adopted in the analyses of RegIP 2024.

Offshore

The increase in offshore wind energy penetration increases the transit through the CCE region. More information can be found in the ONDP document or regional investment plan of the Baltic Sea and North Sea regional groups.

As a reference, the EU's strategy on offshore renewable energy (COM/2020/741[3)]) in 2020 defined the following ambitions:

- 60 GW wind by 2030
  (Member States ambition COM(2023) 668[4)]: 111 GW by 2030)
- 300 GW wind by 2050
- 1 GW ocean energy by 2030
- 40 GW ocean energy by 2050

Leading to non-binding goals of offshore RES generation agreed on by Member States in January 2023.

3) EUR-Lex – 52020DC0741 – EN – EUR-Lex.
4) EUR-Lex – 52023DC0668 – EN – EUR-Lex.

ONDPs are built on the joint non-binding agreements of Member States (MSs) on joint offshore RES goals for each sea basin. These agreements represent goals for offshore renewable generation to be deployed within each sea basin by 2050, but they also include intermediate steps in 2030 and 2040. In the CCE region, the following countries were part of the published ONDP report: Croatia, Slovenia, Germany, Poland, and Romania, with the following goals:

MS Target [GW]	2030	2040	2050
HR	0.51	1.20	3.0
RO	1.0	1.0	1.0
SI	0	0	0
DE	4.1	4.1	4.1
PL	10.1	10.9	10.9

Germany and Poland are included in the Sea-Basin ONDP Report BEMIP (Baltic Energy Market Interconnection Plan) Offshore Grids, while Croatia, Slovenia, and Romania are part of the Sea-Basin ONDP Report TEN-E Offshore Priority Corridor South and East Offshore grids. However, Croatia, Romania, and Slovenia currently have no installed offshore RES. This can be partly attributed to the fact that most countries in this sea basin have not adopted maritime spatial plans (MSPs) yet. Also, most connections are assumed as radial. Such connections will require significant reinforcements of internal onshore transmission networks.

Russia's war on Ukraine

On 16 March 2025, Ukraine and Moldova will mark the third anniversary of synchronising their electricity grids with the Continental European Network. This is a crucial milestone in securing energy supplies for both countries and a strong political symbol of ENTSO-E's continued support. Synchronisation has been vital in maintaining grid stability under extremely challenging circumstances while also opening opportunities for electricity trade with the EU in both import and export directions.

The volatility in energy exchange is likely to be driven by the scale of interconnected global systems (synchronisation of UA and MD to the Continental East system), where disruptions in one region can have widespread effects. The ongoing war against Ukraine has intensified energy instability and disrupted energy supplies. As a result, for instance, Slovakia provided emergency assistance to Ukrenergo, Ukraine's national power company (NPC), leading to a significant increase in power flows from Slovakia to Ukraine. In this context, the reinforcement or development of new interconnector infrastructure is crucial, as it enhances energy security and reduces reliance on geopolitically vulnerable sources. Strengthening these connections helps mitigate market fluctuations and ensure resilience in the face of global crises.

4 Regional System Needs

4.1 Regional results of the identification of system needs

In TYNDP 2024, the System Needs Study considered three time horizons (2030, 2040, and 2050). The National Trends+ (NT+) scenario, a bottom-up approach, was used for 2030 and 2040. The Distribution Energy (DE) scenario, top-down scenario, was applied for the 2050 time horizon. Input data was provided by the TSOs. The following subchapters are divided into three sections covering each of the above-mentioned time horizons. The subchapters will provide insight into identified system needs in the CCE region with information about more prominent parameters of system operation.

4.1.1 TYNDP System Needs Study 2030 results

The results of the final pan-European market studies of the NT 2030 scenario were evaluated with different grid expansion states:

- 2030 grid development considering existing projects in the TYNDP that are expected by their promoters to commission by 2030 (existing projects are built)
- 2030 optimal grid (economic needs)

The economic needs assessment was carried out to determine how the identified cross-border capacity increases will improve the situation in the power systems in terms of market indicators. Only Germany required 15,200 MW of new interconnector capacity in the optimal grid results. Additionally, the installation of 2,627 MW of storage capacity is expected. In the CCE region, the total implementation of storage capacity should be 6,501 MW in the optimal grid, with Poland also needing 2,441 MW in storage capacity. RES energy spillage also decreased by 8,344 GWh, with Germany having the main share (7,889 GWh). Figure 15 shows the results of the TYNDP System Needs Study 2030 study, with NTC increases and storage capacity expectations in the CCE region.

Cross-border grid and energy storages installation will also reduce RES energy spillage by 8,344 GWh, with Germany having the main share of 7,889 GWh. Non-RES generation in the CCE region will also decrease by 33,511 GWh, of which two-thirds are in Germany and Poland. A similar situation applies to the expected reduction of CO_2 emissions, with the CCE region seeing a decrease of 12 million tonnes and Poland making the largest contribution to this reduction. The spread of marginal costs in the CCE region in the case of Germany and Poland is concentrated northwards, while Austria is concentrated towards the southeast. The average reduction of marginal costs in the CCE region through the implementation of cross-border grid and energy storage can be €4.1/MWh.

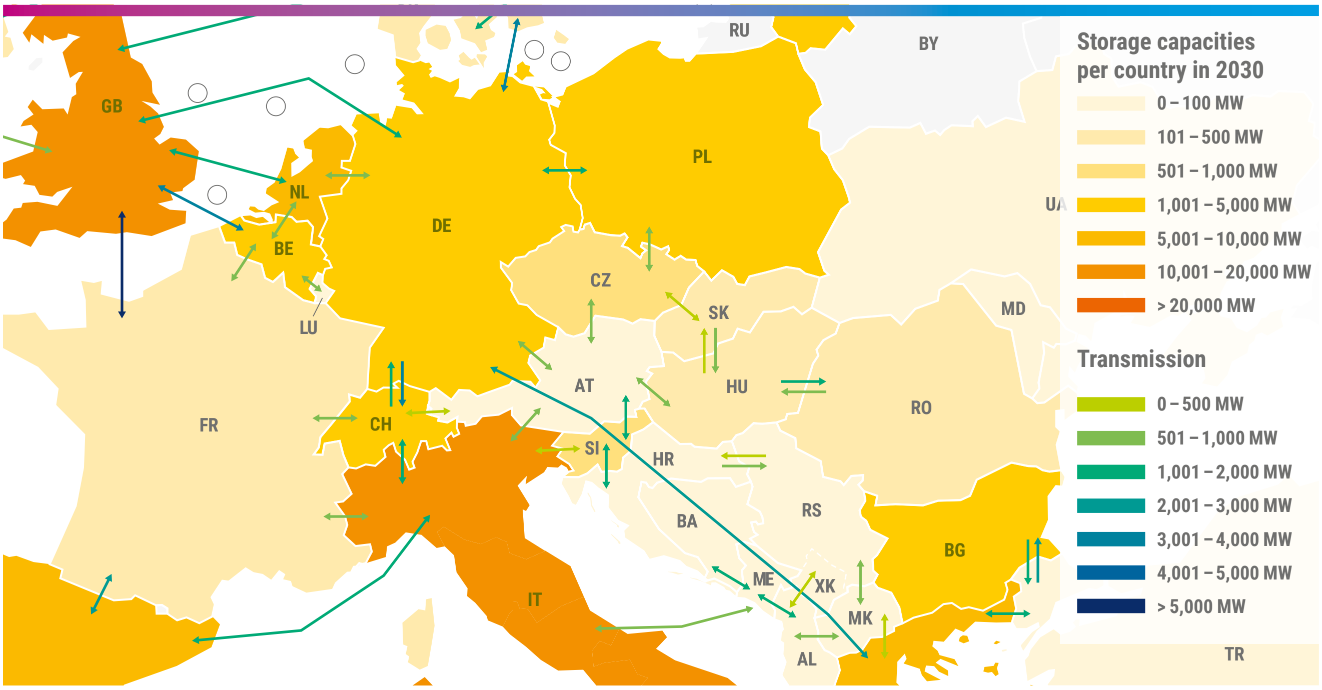

Figure 15: Map of identified capacity and storage increases of the CCE region in the 2030 horizon

4.1.2 TYNDP System Needs Study 2040 results

The results of the final pan-European market studies of the NT 2040 scenario were evaluated with different grid expansion states:

- 2030 grid development considering existing projects in TYNDP (existing projects are built)
- 2040 optimal grid (economic needs)

The economic needs assessment was carried out to see how the identified cross-border capacity increases will improve the power system situation in terms of market indicators. Only Germany required 13,400 MW of additional new interconnector capacity in the optimal grid results. Additionally, the installation of 104,996 MW of storage capacity is expected. In the CCE region, total implementation of storage capacity should be 106,212 MW in the optimal grid, with Czechia also needing 1,893 MW in storage capacity. Figure 16 shows the results of the TYNDP System Needs Study 2040, with NTC increases and storage capacity expectations in the CCE region.

Cross-border grid and energy storages installation will also reduce RES energy spillage by 35,349 GWh, with Germany having the main share by 33,588 GWh. Non-RES generation in the CCE region will also decrease by 42,111 GWh, of which four-fifths are located in Poland. The CCE is expected to see a 16.5 million tonne reduction in CO_2 emissions, with Poland contributing the most to this decrease (13.6 million tonnes). The spread of marginal costs in the CCE region in the case of Poland and Germany is concentrated northwards, while Romania is concentrated westwards. The average reduction of marginal costs in the CCE region through the implementation of cross-border grid and energy storages can be €10.2/MWh.

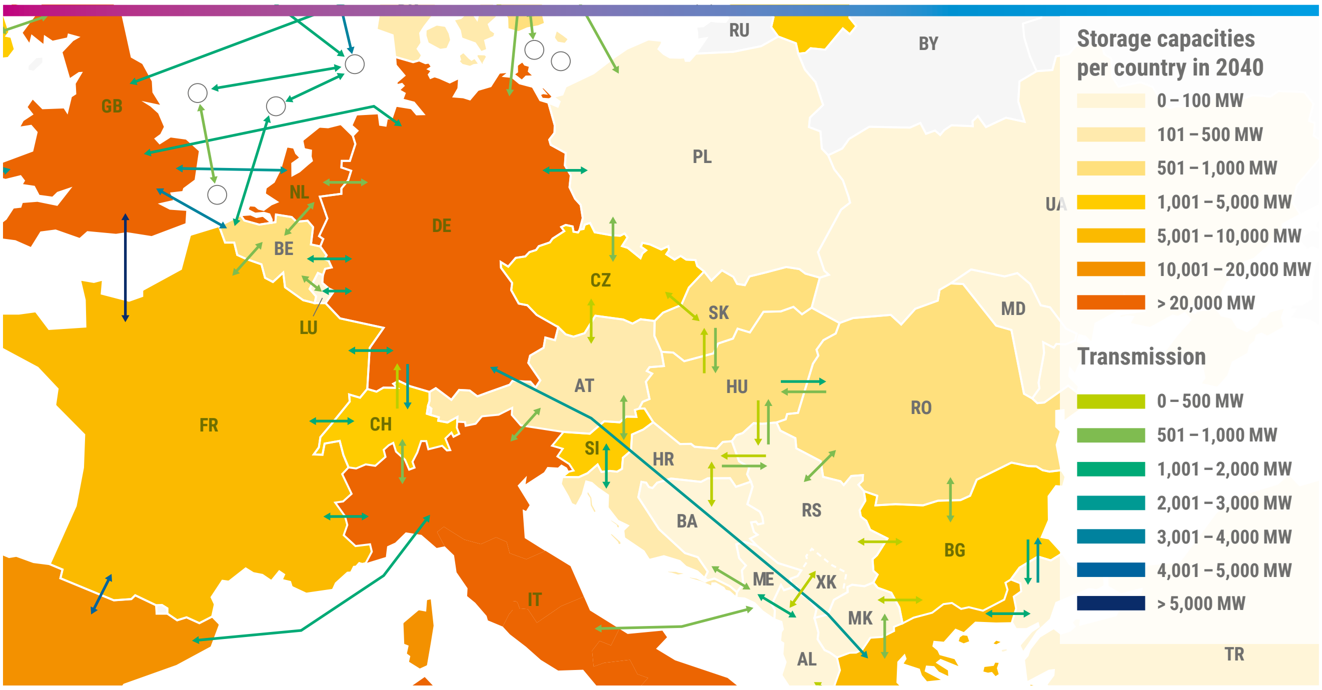

Figure 16: Map of identified capacity and storage increases of the CCE region in the 2040 horizon

4.1.3 TYNDP System Needs Study 2050 results

The results of the final pan-European market studies of the DE 2050 scenario were evaluated with different grid expansion states:

- 2035 grid development considering existing projects in TYNDP (existing projects are built)
- 2050 optimal grid (economic needs)

The economic needs assessment was carried out to see how the identified cross-border capacity increases will improve the power system situation in terms of market indicators. Only Germany required 28,000 MW of additional new interconnector capacity of in the optimal grid results. Additionally, the installation of 81,227 MW of storage capacity is expected. The total implementation of storage capacity in the CCE region should be 102,196 MW in the optimal grid, with Poland also needing 16,186 MW of storage capacity. Figure 17 shows the results of the TYNDP System Needs Study 2050 study, with NTC increases and storage capacity expectations in the CCE region.

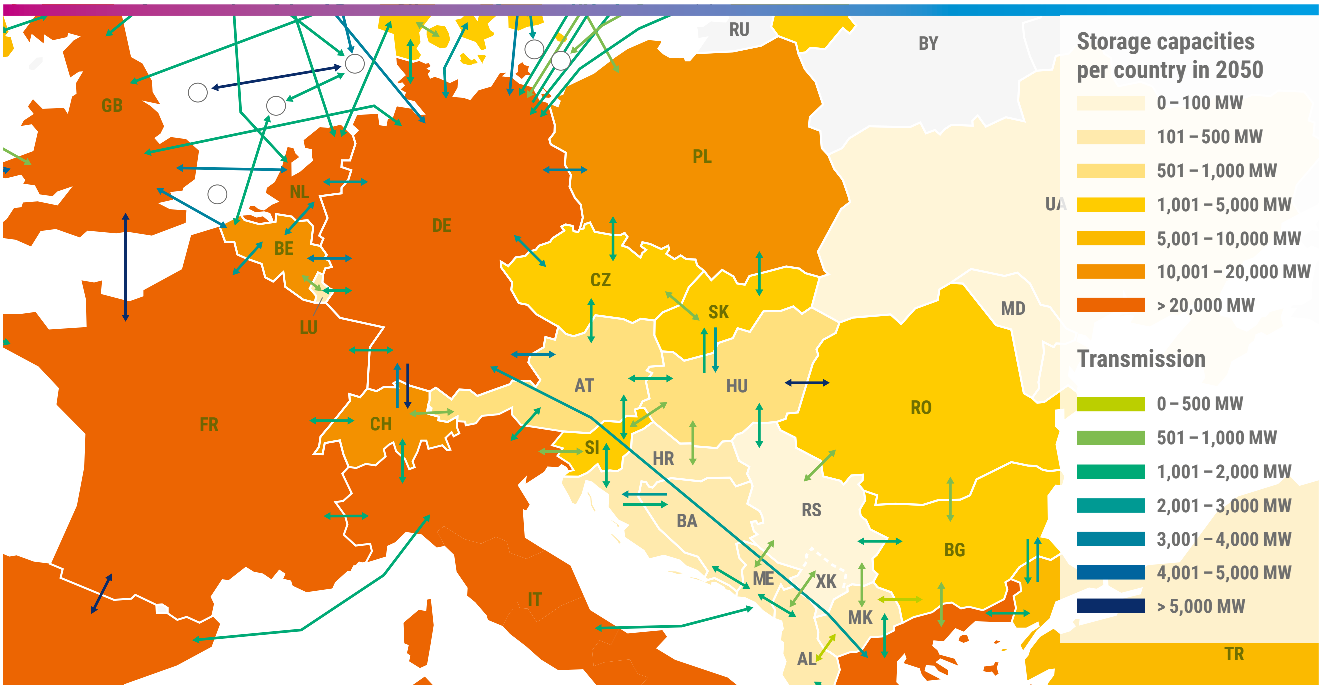

Figure 17: Map of identified capacity and storage increases of the CCE region in the 2050 horizon

Cross-border grid and energy storage installation will increase RES energy spillage in the CCE region by 5,063 GWh, especially in Poland and Germany by 5,118 GWh, with Romania decreasing by 1,463 GWh. Non-RES generation in the CCE region will also decrease by 13,654 GWh, of which two-thirds are in Poland and Czechia. The CCE region is expected to see a 6 million tonne reduction in CO_2 emissions, with Poland making the largest contribution to the reduction (4 million tonnes). In Czechia, a large spread of marginal costs is observed across all cross-border connections with neighbours. Germany also has a significant spread of marginal costs with Belgium and Czechia. The average reduction of marginal costs in the CCE region through the implementation of cross-border grid and energy storage can be €22.8/MWh. This provides economic potential for investments in the electricity transmission sector.

More information is available at the following links.

- TYNDP 2024
- TYNDP 2024: Europe's electricity infrastructure plan. Paving the way towards a more efficient European power system
- TYNDP 2024 / Infrastructure Gaps Report / Opportunities for a more efficient European power system by 2050

4.2 Market results

4.2.1 Key findings

The TYNDP System Needs Study 2024 assessed system needs for 2030, 2040, and 2050, focusing on CO_2 emissions, RES energy spillage, non-RES generation, and marginal costs. By 2030, increased interconnection capacity in Germany significantly reduces CO_2 emissions and non-RES generation in the CCE region, with Poland playing a key role in emission reductions. In 2040, further grid expansion continues to lower RES spillage and emissions, with Poland contributing the most to CO_2 reduction. By 2050, while interconnection capacity further increases, RES spillage rises in some areas, particularly in Poland and Germany, highlighting challenges in balancing supply and demand. The spread of marginal costs becomes more pronounced, particularly in Czechia, Germany, and Belgium. Overall, investments in cross-border grid infrastructure and energy storage are crucial for improving market efficiency, reducing emissions, and integrating renewable energy in the CCE region. Further market results of the TYNDP System Needs analysis can be found in **Chapter 4.1**.

4.2.2 Overview per ITEG indicators

The European Commission Expert Group on Interconnection Targets (ITEG) evaluates the need for cross-border transmission infrastructure to support electricity market integration and RES development goals using three indicators. The assessment was carried out for the NT 2030 scenario. In the CCE region, Germany, Austria, Czechia, Poland, and Ukraine show a marginal price difference of more than €2/MWh in almost all directions, which provides economic potential for the development of cross-border connections. In the case of Poland, the nominal transmission capacity of interconnectors is above 30% but less than 60% of installed RES. Germany also demonstrates nominal interconnector transmission capacity of less than 30% compared to its installed RES capacity. Figure 18 shows the graphical results of the ITEG assessment.

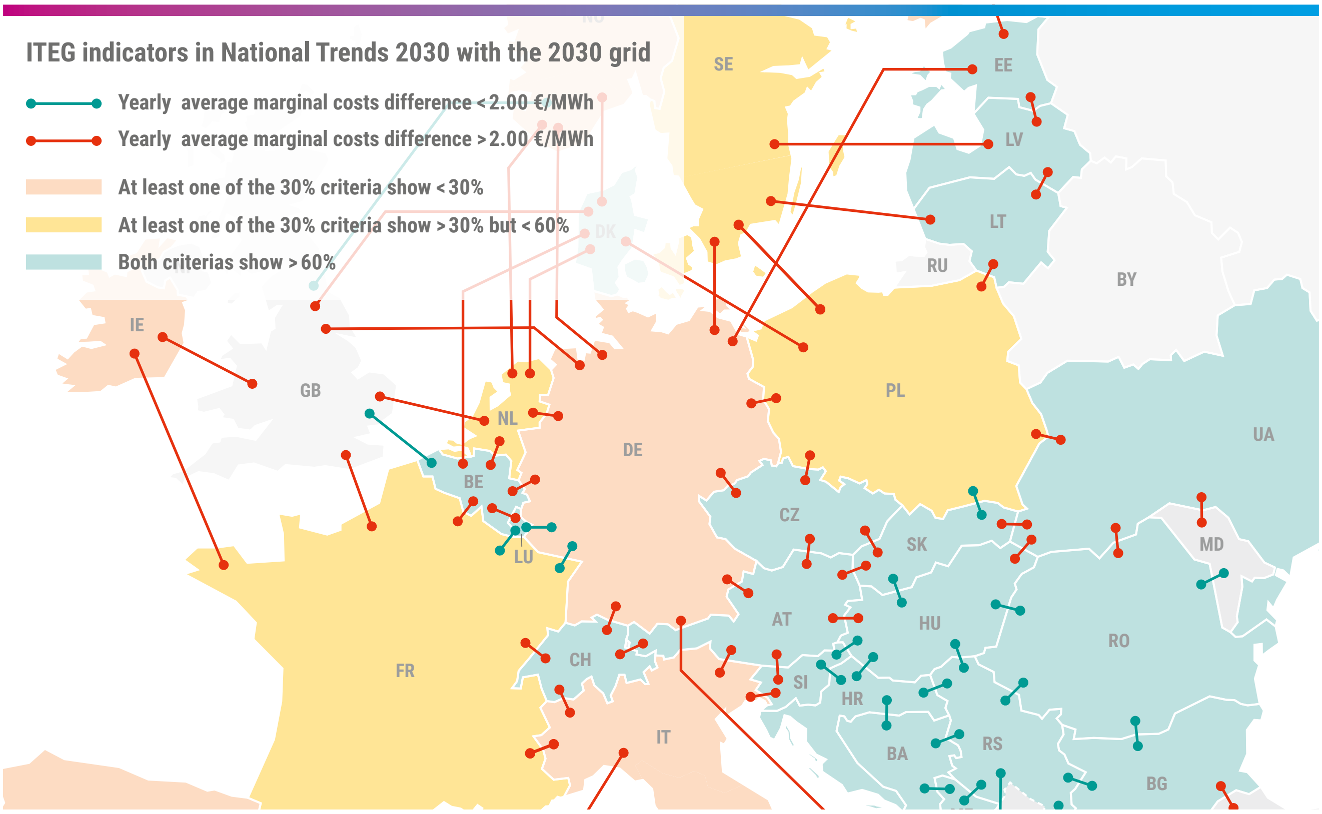

Figure 18: ITEG indicators in National Trends 2030, considering the 2030 grid (starting point of the System Needs Study)

5 Roadmap to Address System Needs

5.1 Bridging the gap

The needs described in the previous section can be partially or fully covered by TYNDP projects listed in Appendix I. This section outlines which borders need greater transmission capacity and how this capacity can be fulfilled. It assesses whether existing TYNDP projects can meet the required capacity, evaluates the feasibility of these projects, and outlines additional measures that could be implemented to address any gaps. For the purposes of this document, only RG CCE internal borders are considered. Borders with neighbouring countries should be mostly covered by the regional investment plans of other RGs.

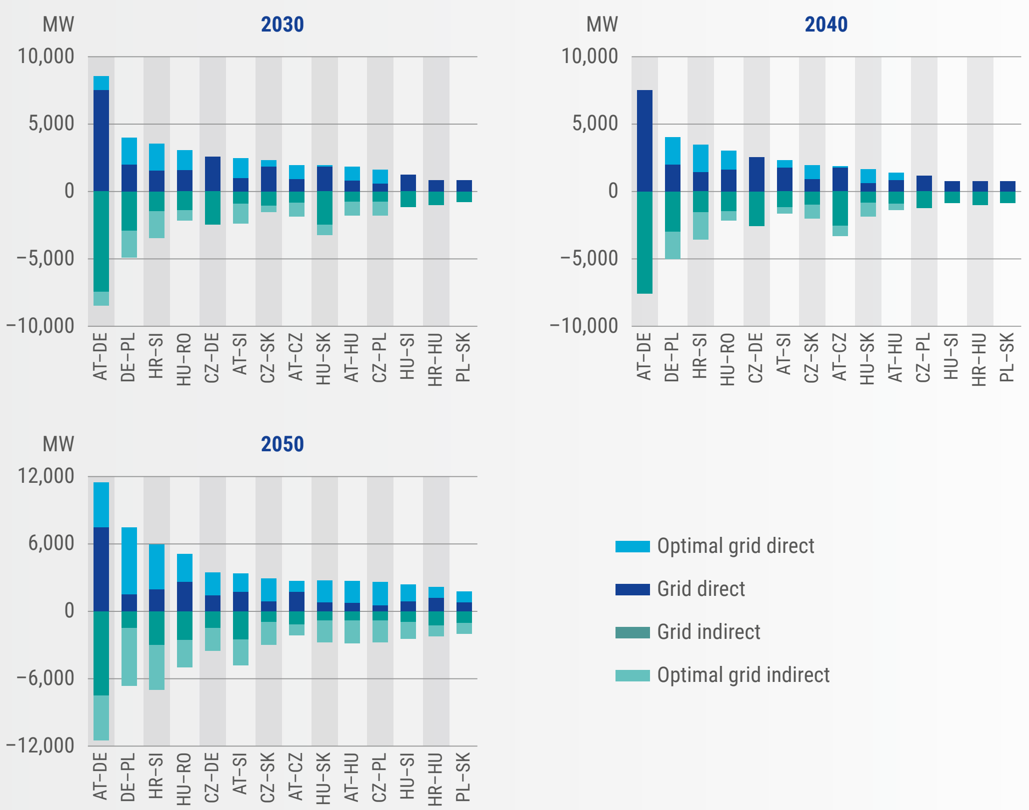

Figure 19: Cross-border capacity increase in RG CCE region in horizons 2030, 2040, and 2050

Austria–Czechia border

The TYNDP System Needs exercise has identified a need for a capacity increase from 500 to 1,500 MW during the years 2030 to 2050 on the common profile, which is not covered by any TYNDP 2024 project. Due to the geographical location of Austria and Czechia in the centre of Europe, this need is identified on all borders of both countries. These needs between Austria and Czechia must therefore always be considered in a regional context, reflecting future evolutions in the grid structures of both countries, with particular attention to the 220 kV phasing-out programme in Czechia, projected for the 2035–2040 time horizon. Further analyses are needed to support a coordinated overall approach that considers both national strategies and European needs.

Austria–Germany border

Three projects on the Austria–Germany border are part of TYNDP 2024. Upgrades to existing overhead lines are planned between Westtirol (AT) and Vöhringen (DE). The project is not yet in permitting but is expected to be underway in 2030. Upgrades to an existing line from St. Peter (AT) to Isar (DE) are expected to be completed in 2027, and a new 380 kV line from St. Peter (AT) to Pleinting (DE) is being constructed by 2030. These projects have been previously identified, and the additional capacity needs will be discussed between the two countries. The 2024 TYNDP System Needs Study identified transmission needs ranging from 1,000 MW in 2030 to 4,000 MW in 2050.

Austria–Hungary border

There is no feasible new cross-border line planned between Austria and Hungary that could increase capacity; however, the 2024 TYNDP System Needs Study identified transmission needs of 1,000 MW for 2030 and 2,000 MW for 2050. Based on flow-based core day-ahead market coupling results, bottlenecks are not expected to occur on the border for most of the time. Due to extensive RES integration and internal network reinforcement around the border region in the upcoming years, there is a potential need for joint investigation on the common profile.

Austria–Slovenia border

For the Austrian-Slovenian profile, the TYNDP System Needs Study identified additional transmission needs of around 1,000–2,000 MW in 2030 and 2050. There are two existing TYNDP projects contributing to further interconnection on the common profile: 325 Obersielach-Podlog, an under-consideration project with an expected commissioning year of 2035, and an internal system reinforcement ranging east to west across Carinthia that is expected to support wholesale market capacities towards Slovenia and Italy. The latter project, 1052 Lienz-Malta-Obersielach, is planned but not yet permitted and is expected to be commissioned in 2033.

Czechia–Germany border

There are three TYNDP 2024 projects affecting the CZ–DE border – P35, P200, and P1100 – and all are planned to be commissioned before 2030. There is no need identified for the 2030 and 2040 horizons for this border beyond the commissioned projects. The System Needs Study for 2050 identified a need for more than 2 GW to increase the capacity on this border. Currently, there are no projects planned after 2030 to address this need. The additional capacity need will be discussed between the two countries.

Czechia–Poland border

Taking into account specific drivers, such as the phase out of the 220 kV grid in certain CCE countries like Slovakia and Czechia, there is potential for future TYNDPs to consider new projects at certain borders. For example, the Czech–Polish border might require attention due to the phasing out of the 220 kV grid in Czechia. This transition will impact the existing two interconnectors on the CZ–PL cross-border file, with potential completion by 2035. This prospective cross-border project, which has yet to be finalised, could serve as a replacement for the 220 kV interconnectors. Its primary goal would be to uphold the security and reliability of power exchange on the shared CZ–PL cross-border profile. An ongoing bilateral study is investigating the impact on the two TSOs.

Czechia–Slovakia border

There is currently one existing TYNDP project (Project No. 330) increasing the capacity in both directions by 500 MW, which would be enough for optimal grid requirements in the 2030 and 2040 time horizons. However, the planned commissioning date for the project is 2035. For the 2050 optimal grid, an additional unaccounted capacity increase of 500 MW is expected in both directions. ČEPS and SEPS are discussing the possibilities of increasing the existing capacity.

Germany–Poland border

The identified capacity increase on the border between Germany and Poland is subject to further discussion and analysis, as there is no existing agreement or planned project at this stage. In addition, new cross-border capacity would require a significant amount of internal network reinforcement.

Hungary–Slovenia border

There is currently one existing connection between Hungary and Slovenia. A bilateral study is being conducted in parallel with TYNDP processes regarding Y-shaped Hévíz (HU)–Žerjavinec (HR)–Cirkovce (SI) connections. None of the theoretical projects were selected in the TYNDP System Needs Study process.

Croatia–Hungary border

There is currently no existing TYNDP project on the border. All the substations on either side of the border are connected. The border could be affected by the potential Slovenia–Hungary project due to the Y-shaped topology of Hévíz (HU)–Žerjavinec (HR)–Cirkovce (SI) interconnectors.

Croatia–Slovenia border

The identified capacity increase on the border between Croatia and Slovenia for the 2030 and 2040 time horizons is subject to further discussion and analysis, as there is no existing agreement or planned project (in terms of construction of new interconnection) at this stage. However, conductor replacement with increased transmission capacity (HTLS) is ongoing on the following interconnections: OHL 110 kV Buje–Koper, OHL 110 kV Matulji–Ilirska Bistrica, and OHL 220 kV Pehlin–Divača.

Hungary–Romania border

The border was identified as having additional needs in line with the planned strengthening of the border through Project No. 259. The new 400 kV lines are planned between Debrecen Dél (formerly Józsa) (HU) and Oradea (RO), with the installation of the second circuit between Békéscsaba (HU) and Nadab (RO). For further expansion, a conceptual HVDC link was defined in the TYNDP System Needs Study and in the TYNDP for CBA assessment.

Hungary–Slovakia border

There is currently one TYNDP project on this border (Project No. 1235), increasing the capacity by 100 MW and 760 MW in the opposite direction. This would be sufficient for the 2030 and 2040 grid requirements. For 2050, there is an additional unaccounted capacity increase of 1,500 MW in both directions. MAVIR and SEPS are discussing the possibility of increasing existing capacity. One possibility is installing two Phase Shifting Trabsformers (PSTs) – one in Rimavská Sobota (SK) and the other in Göd (HU) – which would increase the utilisation of existing infrastructure.

Poland–Slovakia border

This border does not need capacity increases in 2030 or 2040. In 2050, however, a 2,000 MW capacity increase is necessary in both directions. PSE and SEPS currently have no plans to increase capacity on the common border.

Ukraine capacity needs

Currently, the balance stability of Ukraine's power system largely depends on the import component from Continental Europe, and it is difficult to predict system needs before the war ends. However, strengthening cross-border capacities will be crucial in increasing the stability of the electricity supply to consumers.

5.2 How to address future challenges

Many challenges are directly related to and can at least be partially solved by increasing crossborder capacities, as outlined in the previous chapter.

Climate goals

All European countries are increasing the share of RES in their energy production. This increases the need for flexibility, which should not rely on CO_2-producing technologies. Instead, it should be supported by CO_2-neutral technologies such as biofuel/biogas, power-to-gas (P2G), gas-to-power (P2G), and general energy storage.

Improved RES generation prediction models would also be invaluable in enhancing system safety and lowering system costs.

Increased the penetration of RES will also lead to loss of inertia in the system. This missing inertia could be provided by synchronous compensators, flywheels and converters capable of providing virtual inertia, etc.

Rapid increase in storage connection requests

Although the introduction of storage can solve many of the problems TSOs are currently facing, growing investor interest is placing huge demands on existing grids. Projects are often not sufficiently mature, and there are risks associated with these investments. In addition to reinforcing the power grid, flexible connection agreements can offer a viable solution.

In many countries, there is also a need to further define technical, market, and legal rules for connecting and operating energy storage systems.

Power to gas

Like energy storage solutions, P2G technology can impose significant demands on existing networks. This includes not only electricity grids but also gas infrastructure. To support the efficient transmission of hydrogen gas, it is essential to modernise the current infrastructure, ensuring it is equipped to handle the unique requirements of P2G systems.

Offshore

The significant development of offshore production is leading to increased demands on the electricity infrastructure. Challenges include connecting a large volume of wind parks and addressing the geographical misalignment of electricity demand and production in Europe, which necessitates increased cross-border capacities. Offshore development will present significant challenges, even for landlocked countries like Austria, Czechia, Hungary, and Slovakia.

Smart grids

TSOs are increasingly exploring smart solutions, including congestion management and higher utilisation of existing infrastructure through PSTs, Static Synchronous Series Compensator (SSSCs), static VAR compensators (SVCs), dynamic line rating, grid boosters, High-Temperature Low-Sag (HTLS), etc.

There may also be voltage or system stability issues where devices like STATCOMs or variable shunts can be used.

Smart grids often require extensive IT solutions, including the use of AI, which demands significant computing capacities and presents increased cybersecurity risks.

Russia's war on Ukraine

Following the war, Ukraine intensified the discussion with neighbouring countries, resulting in further capacity reinforcements. Some of these were already constructed, like the renewed interconnection between Poland and Ukraine, while others, including projects towards Romania and Slovakia, are currently planned but not yet under construction.

Beyond ensuring grid stability, the synchronous TSOs of the CCE region have initiated several key system development projects:

- Poland–Ukraine Interconnection: PSE and NPC Ukrenergo launched an inactive line between Poland and Ukraine at 400 kV in 2023.
- Slovakia–Ukraine Reinforcement: SEPS and NPC Ukrenergo conducted a joint study in 2018 to assess future system needs to strengthen the Slovakia–Ukraine interconnection as the existing infrastructure nears the end of its lifespan. Studies have determined that the line should be reconstructed as a double-circuit line. The corresponding agreement was signed between SEPS and NPC Ukrenergo, and the project has already been submitted to the Projects of Mutual Interest (PMI) list for EC assessment.
- Hungary–Ukraine Upgrade: MAVIR has announced plans to upgrade the existing 220 kV line, which is currently not part of the synchronisation.
- Romania–Ukraine Expansion: Transelectrica and NPC Ukrenergo have agreed to include the 400 kV (formerly 750 kV) OHL Artsyz (Ukraine)–Isaccea (Romania) interconnection in the TYNDP 2024 and National Development Plans. This project has already been submitted to the PMI list for EC assessment.

These initiatives reflect the ongoing commitment to strengthening regional grid integration, enhancing cross-border electricity exchanges, and reinforcing energy security in the region.

Beyond the electricity sector, Europe overall needs to further diversify the sources of fuels and materials – through new trade routes, pipelines, Liquefied Natural Gas (LNG) terminals, etc. – to mitigate the impact of similar situations in the future.

5.3 Regional studies and initiatives

The RG CCE decided to include two market studies to analyse the impact on the region.

The first study concerns the policy changes affecting the projected generation mix for the 2030 horizon. The second challenges scenario results extracted from the TYNDP 2024 scenario-building process, particularly focusing on the inclusion of a hydrogen system in the project's CBA phase for the first time. Originally, these scenarios assumed zero-cost imports to continental Europe; however, the current analysis aims to assess the impact of import costs.

The studies were calculated on two market modelling tools, APG Tool and PLEXOS, for comparison and redundancy reasons. The results were compared and aligned. For simplicity reasons, only one result will be shown for each sensitivity. For 2030 (PLEXOS) and for 2040 (APG Tool). One climate year (2009) was chosen for these analyses, as this year is the most representative and highest-weighted in the TYNDP CBA results.

Policy sensitivity for the 2030 horizon

The policy sensitivity for 2030 mainly focuses on the German market (and slightly on the Slovakian). Since the data collection for the TYNDP 2022, changes have occurred in the trajectory for renewables as well as discussions about the lifespan of conventional power plants. The early exit from coal power generation in 2030 as a political goal was bypassed, with Germany planning to phase out coal-fired power generation by 2038 at the latest, preferably by 2035. The power plant strategy and funding instruments for hydrogen power plants are on hold for political reasons and implementation will be delayed. Furthermore, the trajectory for wind on land and offshore was slightly altered. Under the TEN-E Regulation (EU) 2022/869, which establishes non-binding goals for offshore renewable generation, the projected offshore capacities for 2030 have been slightly reduced. This adjustment is due to extended project lead times and grid delays, resulting in an approximate 1-year postponement for two specific projects. The capacity of onshore wind in 2030 is also decreased because of slight delays in the permitting and installation process for some generation capacities. This results in less capacity for wind and hydrogen-based power generation. On the other hand, coal-fired power plants will be present for a few more years in Germany and are therefore included in the sensitivity analysis. Figure 20 illustrates the change in installed capacity between the reference case and the policy sensitivity.

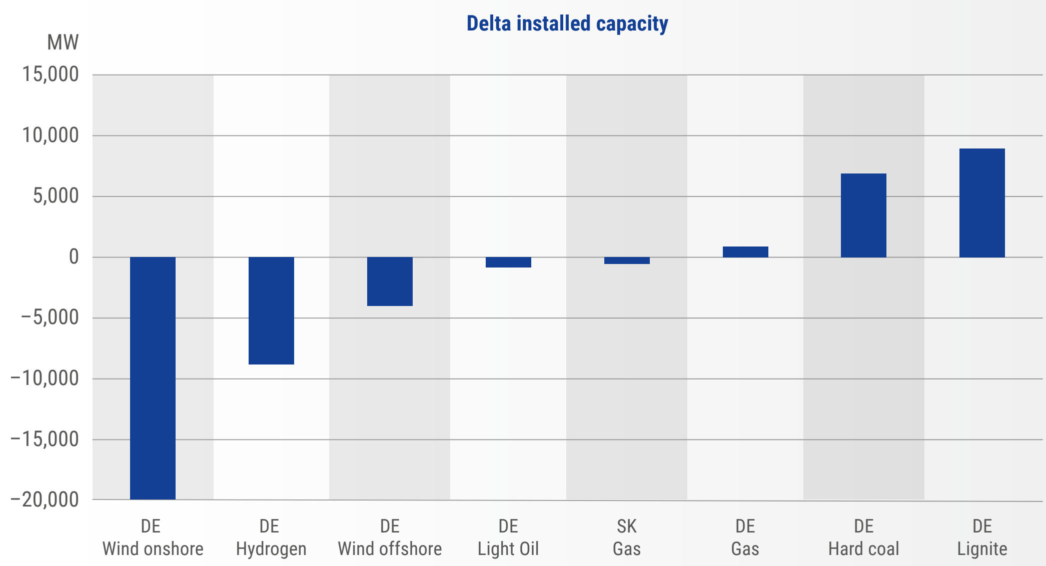

Figure 20: Delta installed capacity between the reference case and the policy sensitivity

With the changes in the scenario data, a few key aspects can be identified in the German market:

- Lignite and hard coal power plants show a significant number of full load hours
- Gas-fired power plants are used more extensively (more than 500 additional full load hours)
- Pump storage and electrolysers have fewer operating hours
- Demand-side response is used in some additional hours

The market results show the impact of fewer renewables in the system, leading to higher imports to Germany and rising socioeconomic costs. Reduced wind capacities are not fully offset by conventional power plants in the German market due to the high cost of operation relative to import options. This is not caused by a lack of availability of generation capacity but by the associated cost of conventional generation in the European context. Consequently, the loss of load expectation and the amount of unserved energy are both reduced in the sensitivity scenario while the societal cost rises. With additional conventional power plants in the system, CO_2 emissions also increase. Over 12 million tonnes of carbon emissions are emitted additionally.

While the effects in the European context are significant, the impact on the CCE region is much less pronounced. Most sensitivity differences are directly related to Germany, with partial effects in neighbouring countries to the west and north.

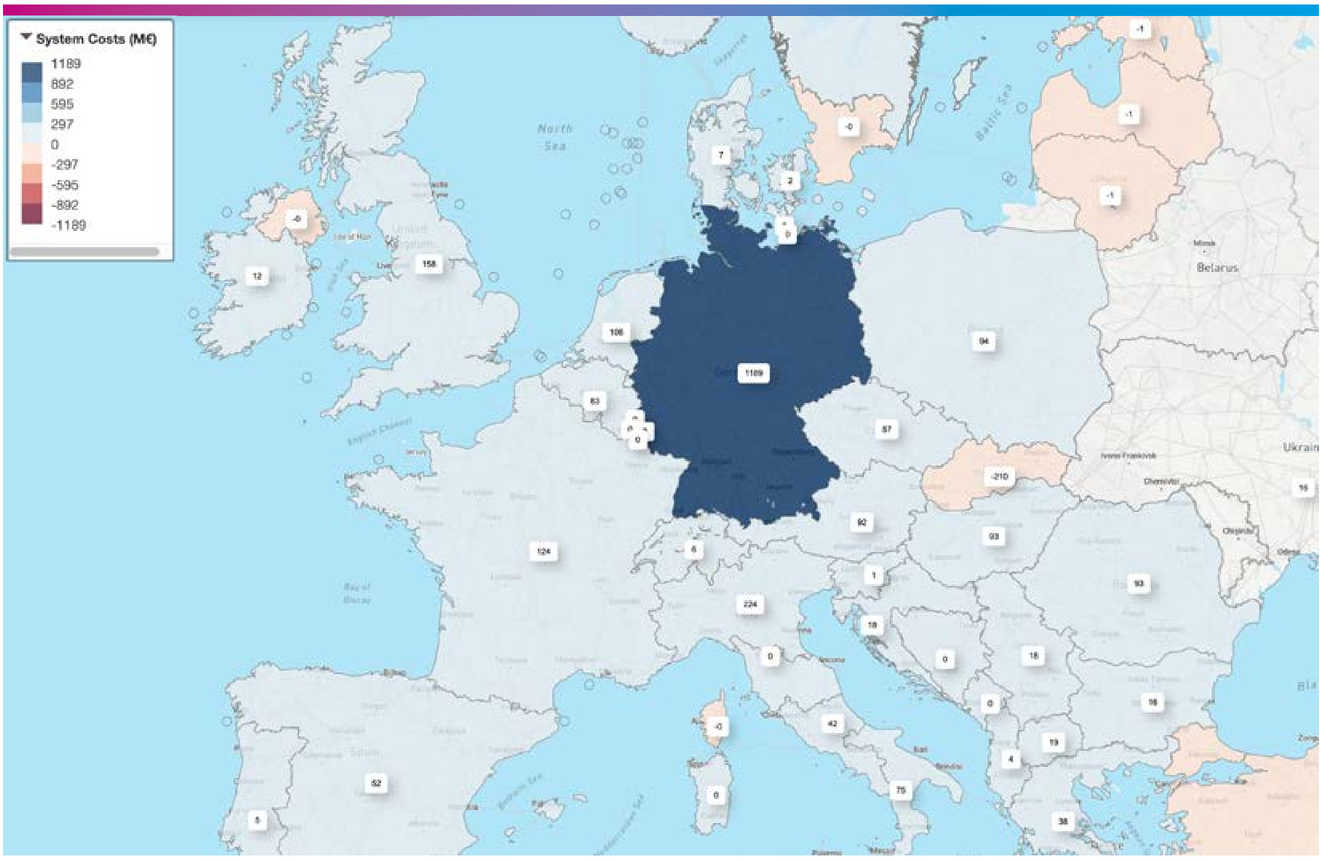

Figure 21: System cost change with policy sensitivity

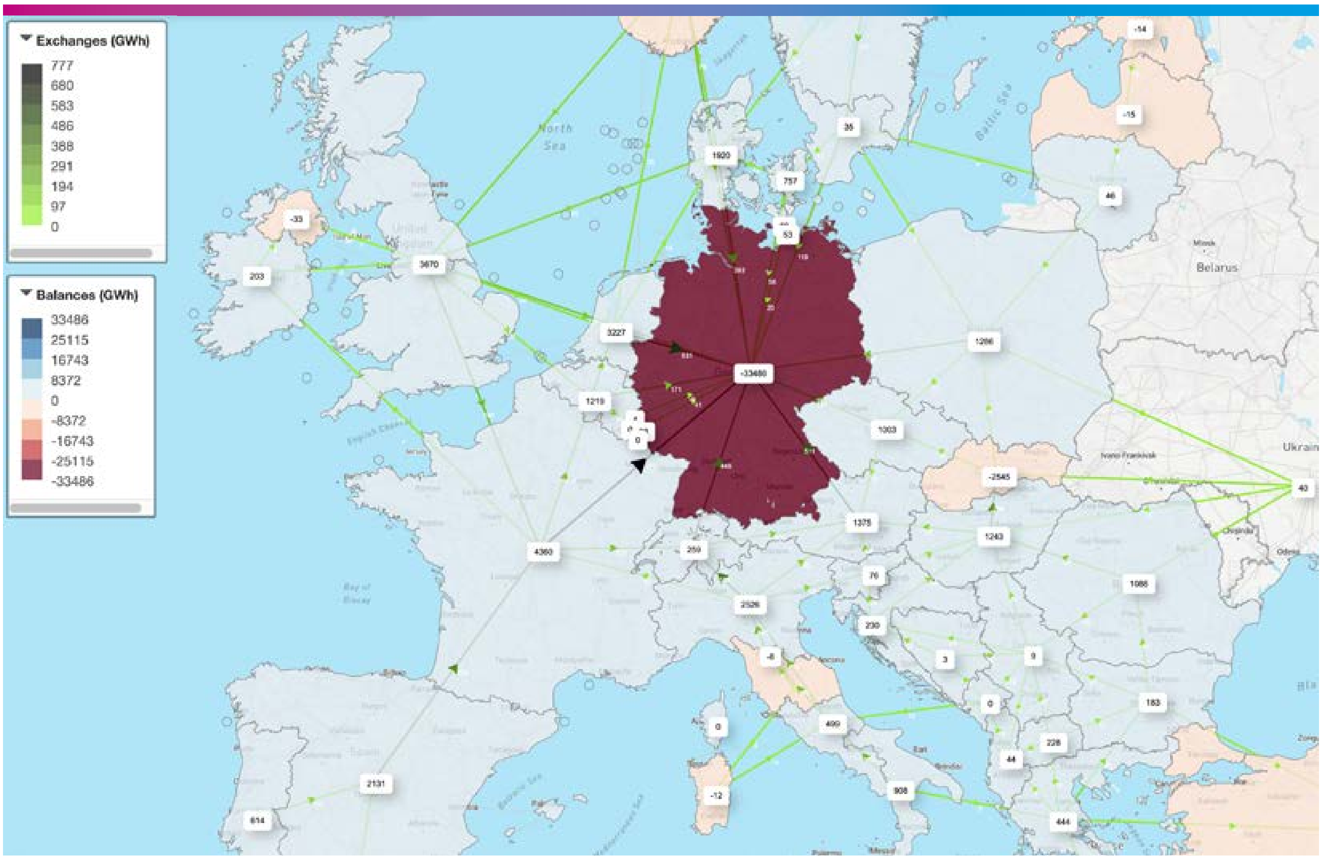

Figure 22: Balance change with policy sensitivity

H_2 sensitivity for the 2040 horizon

Developing modelling approaches to better support an energy-sector coupled system model, in line with Article 11 (8) of Regulation 347/2013,[5] has led to extensions, such as H_2 elements like steam-methane-reformers (SMR), storage, H_2 grid, external H_2 imports, explicit H_2 demands, and electrolysers between the power and H_2 sectors.

The scenario methodology report[6] states that fixed imports have been implemented into the models to ensure alignment with National Energy and Climate Plans (NECPs): *"These imports have no associated prices and are restricted to 30 % of the import potential"*.

This sensitivity was set up to challenge the zero-cost imports to the H_2 sector which was assumed in the reference NT 2040 scenario. Import costs were updated to the cost of the higher price band of the individual H_2 imports. The following H_2 import corridors were changed: DZ–ES, MA–ES, DZ–IT, NO–DE, NO–BE, UA–RO, UA–HU, UA–SK, Ammonia-BE, Ammonia-DE, Ammonia-FR, and Ammonia-NL. Of the approximately 490 TWh of potential imported H_2 in NT 2040 at a price of € 0, around 460 TWh were utilised in the reference scenario. Only 218 TWh of H_2 were utilised through priced imports in the scenario; 135 TWh from the potential zero-cost imports are in the form of ammonia.

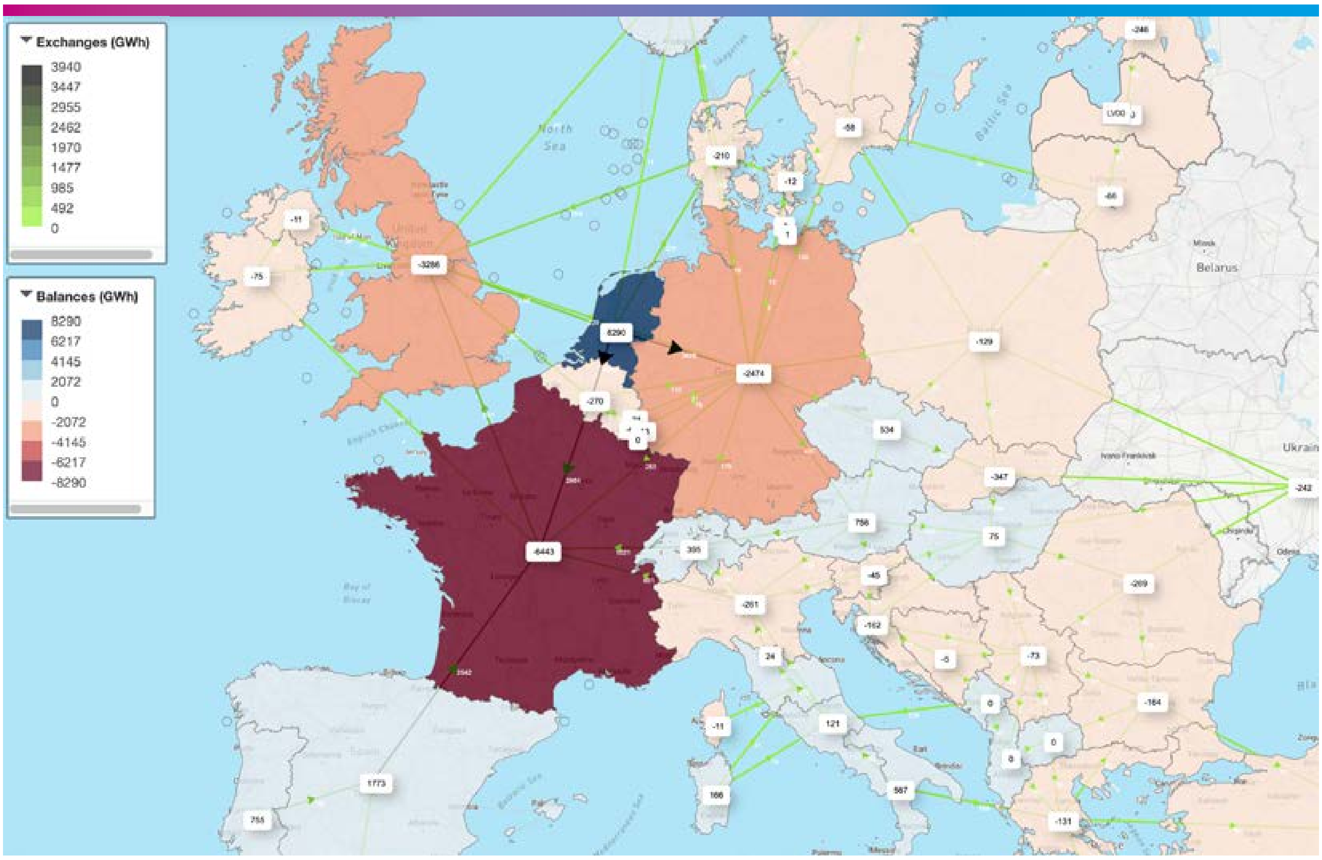

Figure 23: Difference of balances and market exchanges between the H_2 sensitivity and the regular TYNDP simulation (TYNDP 2024, Scenario NT 2040, CY 2009)

5) Regulation (EU) No 347/2013 of the European Parliament and of the Council.
6) TYNDP 2024 // Scenarios Methodology Report.

Applying the price band for H_2 imports in the H_2 sensitivity simulation results in approximately 14 TWh less curtailed energy from RES. This causes some countries to shift their balance to generate more hydrogen using P2G. The highest shifts in balance (electricity system) are in the Netherlands (−8.3 TWh), France (+6.4 TWh), the United Kingdom (+3.3 TWh), and Germany (+2.5 TWh). Germany is the only CCE country with a balance deviation greater than ±1 TWh, as shown in Figure 23.

The marginal costs of electricity in the region increase significantly, by at least €1.20/MWh for most of the CCE countries, with Austria (+€5.23/MWh), Germany (+€4.81/MWh), and Czechia (+€2.40/MWh) facing even higher price increases. This can be attributed to the already substantial volumes of costly demand-side response in Germany, which increased by another 1.8 TWh, as well as the utilisation of P2G plants at the higher H_2 prices applied in the sensitivity scenario. Changes in marginal costs in the CCE region are shown in Figure 24.

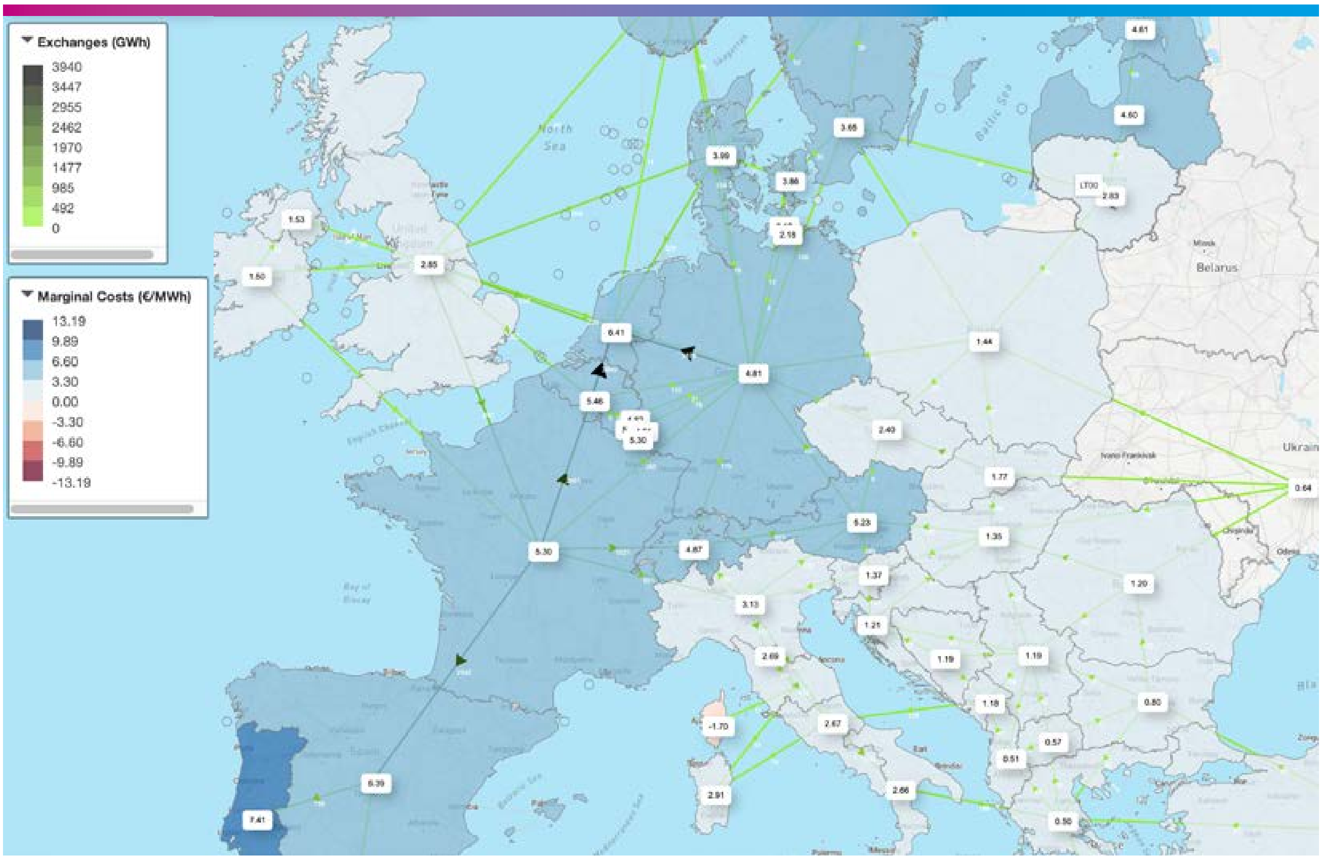

Figure 24: Difference in marginal cost and market exchanges between the H_2 sensitivity and the regular TYNDP simulation (TYNDP 2024, Scenario NT 2040, CY 2009)

Regarding the additional curtailed energy reduced due to P2G utilisation in the sensitivity case, Portugal alone reduced its curtailed energy by over 20 % (39 TWh to 31 TWh), supplying the Spanish H_2 node with lower-cost hydrogen compared to imports from Northern Africa. This leads to a combined balance shift of over − 2.5 TWh for the Iberian Peninsula.

Total system costs in the EU market have not changed as significantly across the overall TYNDP perimeter, as no structural changes were made in the electricity sector. Considering the total system cost of the H_2 market, the sensitivity scenario has naturally led to significant increases due to priced imports, nearly doubling the cost, from € 34 billion to € 62 billion. As shown in Figure 25, Germany experiences the highest increase in H_2 system costs (+ € 6.6 billion) in the CCE region, while also experiencing significantly higher H_2 demand (430 TWh) compared to the other member TSOs.

By introducing priced H_2 imports to the model, most of the import corridors are utilised less, leading to increased H_2 generation through other technologies, such as SMRs (+24.3 TWh H_2) and electrolysers (+16.9 TWh H_2), and by using other import corridors, mainly through DE and IT, as shown in Figure 26. Overall, hydrogen imports from non-modelled nodes see a reduction from 680 TWh to 619 TWh, induced by the sensitivity.

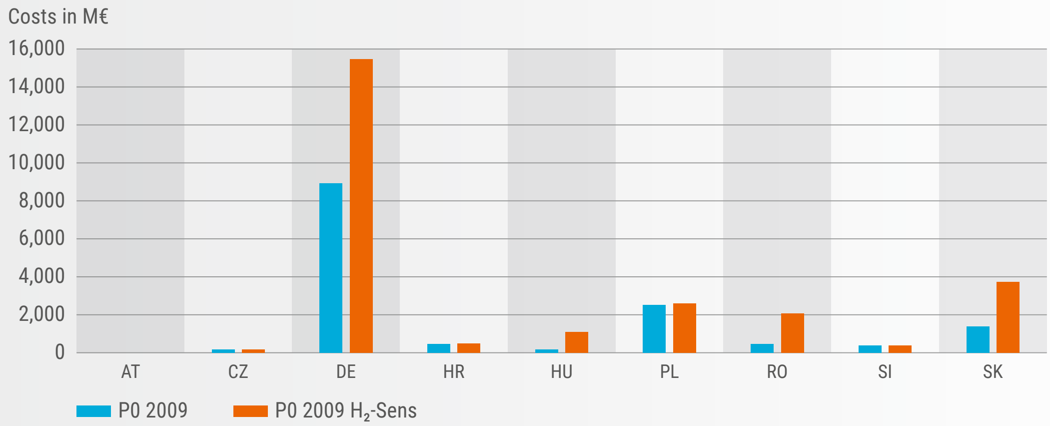

Figure 25: System cost of H_2 market nodes; regular TYNDP vs H_2 sensitivity

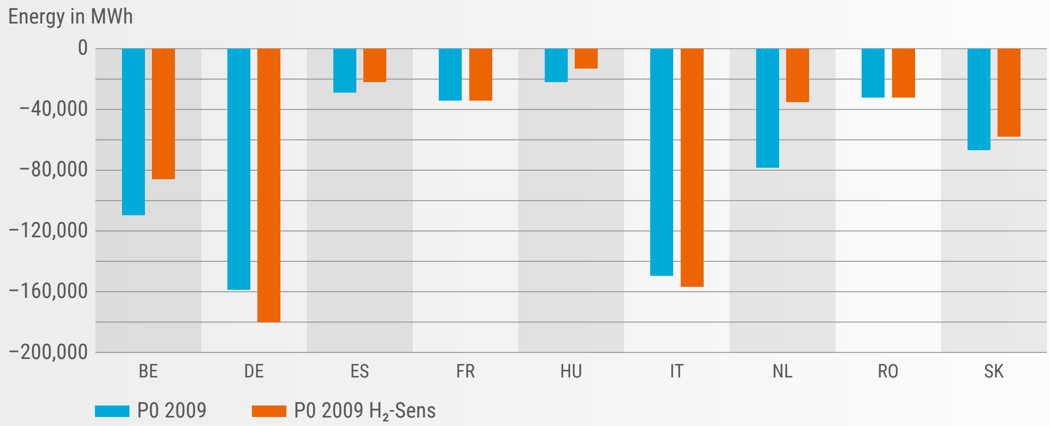

Figure 26: H_2 imports from external nodes; regular TYNDP vs H_2 sensitivity

6 Conclusions

The CCE region is undergoing significant energy transformation, with a shifting generation mix mainly from fossil-fuel generation to RES. The Fit for 55 Package and REPowerEU Plan will fast-forward the energy transition to carbon neutrality at a much greater scale with the increase of RES and energy efficiency targets for 2030 and 2040. The rapid replacement of fossil-fuel generation by RES including the replacement of the Russian gas supply after February 2022, the greater electrification of other sectors, increasing energy efficiency, the development of new technologies (storage systems, electrical vehicles, etc.), and interlinking the various energy sectors (hydrogen technology, P2X, etc.) will be key. **This underscores the urgent need for expanded electricity infrastructure and interconnectors to enhance energy security and integration.**

This CCE RegIP 2024 notably demonstrates that the challenges cited above apply not only to interconnections but also to **national electricity grids**. The development of the energy mix by 2030, 2040, and 2050 alone **creates significant needs for building and primarily renewing internal infrastructure**. The system needs originating from the integration of the pan-European internal electricity market and those from the national RES integration target mutually impact each other. On the one hand, optimising the socioeconomic welfare of the European energy system via the development of cross-border exchange capacity puts an additional strain on national networks. On the other hand, national transmission system reinforcements to accommodate RES integration impacts cross-border flows and capacities.

7 Appendix

Appendix I: TYNDP Projects

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?
35	CZ Southwest–East corridor	2029	In permitting	Yes
40	Belgium–Luxembourg–Germany: long-term perspective	2040	Under consideration	Yes
47	Westtirol (AT)–Vöhringen (DE)	2030	In planning but not permitting	Yes
94	GerPol improvements	2025	Under construction	Yes
130	HVDC SuedOstLink Wolmirstedt to area Isar	2027	In permitting	Yes
132	HVDC Line A-North	2027	In permitting	Yes
138	Black Sea Corridor	2026	Under construction	Yes
144	Mid-Continental East Corridor	2029	In permitting	Yes
150	Italy–Slovenia	2042	Under consideration	Yes
170	Baltic states synchronisation with Continental Europe	2030	In planning but not permitting	Yes
176	Hansa PowerBridge I	2029	In permitting	Yes
187	St. Peter (AT)–Pleinting (DE)	2030	In permitting	Yes
200	CZ Northwest–South corridor	2024	Under construction	Yes
210	Würmlach (AT)–Somplago (IT) interconnection	2029	In permitting	Yes
225	Second interconnector Belgium–Germany	2037	Under consideration	Yes
228	Muhlbach–Eichstetten	12-2027	In permitting	Yes
231	Beznau–Tiengen	2035	In planning but not permitting	Yes
235	HVDC SuedLink Brunsbüttel/Wilster to Großgartach/ Bergrheinfeld West	2028	In permitting	Yes

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?
243	New 400 kV interconnection line between Serbia and Croatia	2038	Under consideration	Yes
244	Vigy–Uchtelfangen area	12-2029	In permitting	Yes
254	HVDC Ultranet Osterath to Philippsburg	2026	In permitting	Yes
259	HU–RO	2030	In planning but not permitting	Yes
267	Hansa PowerBridge II	2040	Under consideration	Yes
309	NeuConnect	2027	Under construction	Yes
312	St. Peter (AT)–Tauern (AT)	2025	Under construction	Yes
313	Isar/Altheim/Ottenhofen (DE)–St. Peter (AT)	2027	In permitting	Yes
325	Obersielach (AT)–Podlog (SI)	2035	Under consideration	Yes
328	Interconnector DE–LUX	2028	In planning but not permitting	Yes
330	4th 400 kV CZ–SK interconnector	2035	Under consideration	Yes
335	North Sea wind power hub	2035	Under consideration	Yes
341	North CSE corridor	2029	In planning but not permitting	Yes
343	CSE1 new	2035	In planning but not permitting	Yes
375	Lienz (AT)–Veneto region (IT) 220 kV	2035	In planning but not permitting	Yes
1034	HVDC corridor from Northern Germany to Western Germany	2032	In planning but not permitting	Yes

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?
1050	Tarchon Energy Ltd	2030	Under consideration	Yes
1052	Lienz (AT)–Malta (AT)–Obersielach (AT)	2033	In planning but not permitting	Yes
1054	220 kV Westtirol (AT)–Zell/Ziller (AT)	2030	In planning but not permitting	Yes
1058	HVDC interconnector DE–CH	2037	Under consideration	Yes
1074	Pannonian corridor	2030	In planning but not permitting	Yes
1100	Reinforcement of the existing CZ–DE interconnector (Hradec–Röhrsdorf) on the CZ side	2028	In permitting	Yes
1104	Bauler–Roost	2025	In planning but not permitting	Yes
1105	Georgia–Romania Black Sea (submarine) interconnection cable project	2030	Under consideration	Yes
1106	Bornholm Energy Island (BEI)	2030	Under consideration	Yes
1121	220 kV Hessenberg (AT)–Weißenbach (AT)	2030	In planning but not permitting	Yes
1138	400 kV OHL Suceava (RO)–Balti (MD)	2030	In planning but not permitting	No
1139	380 kV Westtirol (AT)–Zell/Ziller (AT)	2037	Under consideration	No
1140	380 kV St. Peter (AT)–Dürnrohr (AT)	2037	Under consideration	No
1145	380 kV Obersielach (AT)–Hessenberg (AT)	2035	Under consideration	No
1155	380 kV Burgenland North (AT)–Sarasdorf (AT)–Greater Vienna (AT)	2032	In planning but not permitting	No
1156	380 kV Greater Vienna (AT)–Hessenberg (AT)	2033	Under consideration	No
1158	380 kV Bisamberg (AT)–Gaweinstal (AT)–Zaya (AT)	2037	Under consideration	No
1159	220 kV Bisamberg (AT)–Wien Südost (AT)	2033	In planning but not permitting	No

ID	Project name	Commissioning year	Status	Included in TYNDP 2022?
1192	Germany–UK hybrid interconnector – Phase 1	2033	Under consideration	No
1193	Germany–UK hybrid interconnector – Phase 2	2035	Under consideration	No
1200	Hybrid interconnector Norway-Sørvest F Windfarm–Continent (DK, DE, or BE)	2035	Under consideration	No
1207	380 kV Niederstedem–Bertrange/Bofferdange	2037	In planning but not permitting	No
1211	Baltic WindConnector (BWC)	2037	Under consideration	No
1213	Offshore hybrid interconnector (DE–NL)	2035	Under consideration	No
1214	Hybrid interconnector Denmark–Germany	2036	Under consideration	No
1215	Xlinks Morocco–Germany	2032	Under consideration	No
1216	High-voltage direct current interconnector project Romania–Hungary	2030	Under consideration	No
1219	Bofferdange–Bertrange	2035	In planning but not permitting	No
1226	North–South Electricity corridor in Eastern Europe	2036	Under consideration	No
1229	Rhine main link	2033 and 2035	In planning but not permitting	No
1231	Green Aegean interconnector	2035	Under consideration	No
1233	Laufenburg–Beznau–Breite	2035	Under consideration	No
1234	220 kV Reitdorf (AT)–Weißenbach (AT)	12-2028	In permitting	No
1235	Second circuit of the 400 kV OHL Sajóivánka (HU)–Rimavská Sobota (SK)	2027	Under consideration	No
1239	Interconnection Ukraine–Slovakia	08-2032	In planning but not permitting	No
1240	Interconnection Ukraine–Romania	2028	In planning but not permitting	No

Appendix II: Regional projects

This section lists CCE projects of regional and national significance, as they need the substantial and inherent support of pan-European projects for inclusion into the future transmission systems. All projects are listed with appropriate descriptions, their main drivers, and why they are included in future scenarios, along with the expected commissioning dates and evolution drivers if they have been introduced in past RegIPs.

Country	Project name	Investment		Expected commissioning year
		From	To	
Czechia	New 420 KV substation Praha Sever	Praha Sever (CZ)		2027
Czechia	New loop 400 kV OHL from Vyskov–Cechy Stred to Praha Sever	A line Vyskov–Cechy Stred (CZ)	Praha Sever (CZ)	2027
Czechia	New 400 kV OHL Chodov–Cechy Stred	Chodov (CZ)	Cechy Stred (CZ)	2027
Czechia	New 400 kV OHL Hradec–Vyskov	Hradec (CZ)	Vyskov (CZ)	2027
Czechia	New loop 400 kV OHL from Prosenice–Nosovice to Kletne	A line Prosenice–Nosovice (CZ)	Kletne (CZ)	2031
Czechia	New 400 kV OHL Hradec–Chrast	Hradec (CZ)	Chrast (CZ)	2029
Czechia	New 400 kV OHL Chrast–Prestice	Chrast (CZ)	Prestice (CZ)	2025
Czechia	New 400 kV OHL Slavetice–Cebin	Slavetice (CZ)	Cebin (CZ)	2038
Czechia	New 400 kV OHL Babylon–Bezdecin	Babylon (CZ)	Bezdecin (CZ)	2026
Czechia	New 420 kV substation Milin	Milin (CZ)		2025
Czechia	New loop 400 kV OHL from Reporyje–Kocin to Milin	A line Reporyje–Kocin (CZ)	Milin (CZ)	2025

	Description	Main drivers	In RegIP 2022?	Status
	New 400/110 kV substation equipped with transformers 2x350 MVA	Security of supply, facilitation of power evacuation, line connection, RES integration	Yes	Under construction
	New loop from the OHL Vyskov–Cechy Stred to Praha Sever of 13 km in length. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line 35.1 km long. Target capacity 2x1,700 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line, 45.3 km long. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	A new loop from the OHL Prosenice–Nosovice to Kletne of 29 km in length. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 82.4 km in length. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 33.4 km in length. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 52 km in length. Target capacity 2x1,700 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 54 km in length. Target capacity 2x1,700 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New 400/110 kV substation equipped with 2x350 MVA transformers	Security of supply, facilitation of generation connection, line connection, RES integration	Yes	Under construction
	New loop from the OHL Reporyje–Kocin Stred to Milin of 1 km in length. Target capacity 2x1,730 MVA	Security of supply, facilitation of generation connection, RES integration	Yes	Under construction

Country	Project name	Investment		Expected commissioning year
		From	To	
Czechia	Upgrading of OHL Reporyje–Mirovka	Reporyje (CZ)	Mirovka (CZ)	2026
Czechia	Upgrading of 420 kV substation Hradec	Hradec (CZ)		2034
Czechia	Upgrading of 420 kV substation Chrast	Chrast (CZ)		2027
Czechia	Upgrading of 420 kV substation Slavetice	Slavetice (CZ)		2032
Czechia	Changing existing 220 kV double OHL line Cechy-Stred–Malesice to loop 400 kV OHL from Cechy-Stred–Chodov to Malesice	Malesice (CZ)	Cechy-Stred (CZ)	2035
Czechia	Upgrading substation Malesice 245 kV to 420 kV	Malesice (CZ)		2035
Czechia	New 400 kV OHL Sokolnice–Otrokovice	Sokolnice (CZ)	Otrokovice (CZ)	2031
Czechia	New 400 kV OHL Otrokovice–Prosenice	Otrokovice (CZ)	Prosenice (CZ)	2033
Czechia	New 400 kV double OHL Slavetice–Sokolnice	Slavetice (CZ)	Sokolnice (CZ)	2033
Czechia	Upgrading of 220 kV OHL to double 400 kV Milin–Orlik	Milin (CZ)	Hydro power plant Orlik (CZ)	2031
Czechia	New 400 kV OHL Kocin/Dasny–Slavetice	Kocin, Dasny (CZ)	Slavetice (CZ)	2032
Czechia	New loop 400 kV OHL from Sokolnice–Krizovany to Rohatec	A line Sokolnice (CZ)–Krizovany (SK)	Rohatec (CZ)	2034
Czechia	New 420 kV substation Rohatec	Rohatec (CZ)		2034
Czechia	New 400 kV OHL Hradec–Reporyje	Hradec (CZ)	Reporyje (CZ)	2035

	Description	Main drivers	In RegIP 2022?	Status
	Upgrading of the existing OHL of 146 km in length. Target capacity 1,385 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	Upgrading the existing 420 kV substation Hradec to short-circuit power 63 kA	Security of supply, facilitation of generation connection, line connection, RES integration	Yes	Under construction
	Upgrading of the existing 420 kV substation Chrast to short-circuit power 50 kA	Security of supply, facilitation of generation connection, line connection, RES integration	Yes	Under construction
	Upgrading of the existing 420 kV substation Slavetice to short-circuit power 63 kA	Security of supply, facilitation of generation connection, line connection, RES integration	Yes	Under construction
	Changing the existing double 220 kV line to a double-circuit 400 kV line of 20.2 km in length. Target capacity 2 x 1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	Planned but not yet permitting
	Increasing transformation capacity by upgrading current 245 kV Malesice substation to 420 kV, new 400/110 kV substation equipped with transformers 2 x 350 MVA	Security of supply, facilitation of generation connection, line connection, RES integration	Yes	Planned but not yet permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 74 km in length. Target capacity 2x1730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 37.7 km in length. Target capacity 2 x 1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	New OHL double-circuit line 56 km (x 2) long. Target capacity 2 x 1,700 MVA	Security of supply, facilitation of power evacuation, RES integration	Yes	In permitting
	Upgrading existing OHL single-circuit 220 kV to double-circuit 400 kV line of 9 km to secure power transmission from hydro power plant Orlik	Security of supply, facilitation of power evacuation	Yes	Planned but not yet permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line from the OHL Kocin and second line from Dasny to Slavetice of 163 km in length. Target capacity 2 x 1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	No	In permitting
	A new loop from the OHL Sokolnice–Krizovany to Rohatec, 2.7 km long. Target capacity 2 x 1,730 MVA.	Security of supply, facilitation of power evacuation, RES integration	No	Planned but not yet permitting
	New 400/110 kV substation equipped with transformers 2 x 350 MVA	Security of supply, facilitation of generation connection, line connection, RES integration	No	In permitting
	New OHL involving changing the existing single-circuit line to a double-circuit line of 99.5 km in length. Target capacity 2 x 1,730 MVA.	Security of supply, facilitation of power evacuation, RES integration	No	In permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Czechia	New loop 400 kV OHL from Kocin–Mirovka to Leskovice	A line Kocin (CZ)–Mirovka (CZ)	Leskovice (CZ)	2030
Czechia	New 420 kV substation Leskovice	Leskovice (CZ)		2030
Czechia	New loop 400 kV OHL from Tynec–Krasikov to Opocinek	A line Tynec (CZ)–Krasikov (CZ)	Opocinek (CZ)	2035
Czechia	New 420 KV substation Opocinek	Opocinek (CZ)		2035
Czechia	New 400 kV double OHL Nosovice–Liskovec	Nosovice (CZ)	Liskovec (CZ)	2034
Czechia	New 420 kV substation Liskovec	Liskovec (CZ)		2034
Germany	DC20	Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin	Isar	2030
Germany	AMP-P21/TTG-P21	Conneforde	Merzen/Neuen-kirchen	2026
Germany	TTG-P24	Stade	Landesbergen	2026
Germany	P33	Wolmirstedt	Wahle	2032
Germany	TTG-P37/50HzT-P37	Vieselbach	Mecklar	2027
Germany	50HzT-P38	Pulgar	Vieselbach	2025
Germany	50HzT-P39	Röhrsdorf	Remptendorf	2025
Germany	AMP-P41	Punkt Metternich	Niederstedem	2026
Germany	P43	Mecklar	Bergrheinfeld West	2031
Germany	TTG-P46	Redwitz	Schwandorf	2026
Germany	AMP-P47/TNG-P47	Urberach	Daxlanden	2031

	Description	Main drivers	In RegIP 2022?	Status
	A new loop from the OHL Kocin–Mirovka to Leskovice, 0.4 km long. Target capacity 2x1,730 MVA.	Security of supply, facilitation of power evacuation, RES integration	No	In permitting
	New 400/110 kV substation equipped with transformers 2x350 MVA	Security of supply, facilitation of generation connection, line connection, RES integration	No	In permitting
	A new loop from the OHL Tynec–Krasikov to Opocinek, 4.7 km long. Target capacity 2x1,730 MVA.	Security of supply, facilitation of power evacuation, RES integration	No	Planned but not yet permitting
	New 400/110 kV substation equipped with transformers 2x350 MVA	Security of supply, facilitation of generation connection, line connection, RES integration	No	Planned but not yet permitting
	New OHL double-circuit line 10.9 km (x2) long. Target capacity 2x1,730 MVA	Security of supply, facilitation of power evacuation, RES integration	No	Planned but not yet permitting
	New 400/110 kV substation equipped with transformers 2x350 MVA	Security of supply, facilitation of generation connection, line connection, RES integration	No	Planned but not yet permitting
	New HVDC Line. Detailed information provided in Germany's grid development plan	RES integration	Yes	In permitting
	New 380 kV OHL, Replacement of existing 220 kV OHL	RES integration	Yes	Under construction
	New 380 kV OHL in existing corridor	RES integration	Yes	Under construction
	Reinforcement and new construction of 380 kV OHL	RES integration	Yes	In permitting
	Reinforcement of existing 380 kV OHL	RES integration	Yes	Under construction
	Replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	Yes	Under construction
	Replacement of existing OHL with new 380 kV OHL	Security of supply	Yes	Under construction
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	Under construction
	New 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	Under construction
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Germany	TTG-P48/TNG-P48	Grafenrheinfeld	Großgartach	2026
Germany	TNG-P49	Daxlanden	Eichstetten	2029
Germany	P51	Großgartach	Endersbach	2030
Germany	P206	Herbertingen	Waldshut/Tiengen	2032
Germany	TNG-P70	Birkenfeld	Ötisheim (Mast 115A)	2025
Germany	P23	Dollern	Elsfleth West	2028
Germany	50HzT-P34	Güstrow	Wolmirstedt	2027
Germany	P53	Raitersaich	Altheim	2031
Germany	TTG-P72	Kreis Segeberg	Siems	2027
Germany	50HzT-P150	Schraplau/ Obhausen	Vieselbach	2028
Germany	P222	Oberbachern	Ottenhofen	2029
Germany	P26	Brunsbüttel	Amt Geest/Marsch Südholstein	2030
Germany	P84	Hamburg Nord	Ämter Büchen/ Breitenfelde/ Schwarzenbek-Land	2031
Germany	P215	Güstrow	Sanitz/Gnewitz/ Dettmannsdorf/ Marlow	2029
Germany	P216	Güstrow	Pasewalk	2031
Germany	P22	Conneforde	Unterweser	2028
Germany	P22	Elsfleth West	Ganderkesee	2029
Germany	P119	Conneforde	Samtgemeinde Sottrum	2031
Germany	P116/P135	Dollern	Bechterdissen	2033

	Description	Main drivers	In RegIP 2022?	Status
	Reinforcement of existing 380 kV OHL	RES integration	Yes	Under construction
	New 380 kV OHL, partially in existing corridor	RES integration	Yes	In permitting
	New 380 kV OHL	Security of supply	Yes	In planning but not yet permitting
	New 380 kV OHL, partially in existing corridor	Security of supply	Yes	In planning but not yet permitting
	New 380 kV OHL	RES integration	Yes	Under construction
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	New 380 kV OHL, replacement of existing 220 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In planning but not yet permitting
	Reinforcement of existing OHL, new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Upgrade from 220 kV to 380 kV	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	New 380 kV OHL, reinforcement of existing OHL	RES integration	Yes	In planning but not yet permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Germany	P113	Ämter Büchen/ Breitenfelde/ Schwarzenbek-Land	Wahle	2029
Germany	P228	Landesbergen	Salzgitter	2032
Germany	P124/P359/450	Siedenbrünzow	Lauchstädt	2034
Germany	P315	Hanekenfähr	Gronau	2033
Germany	P403	Hattingen	Bezirk Ronsdorf	2033
Germany	P133/P211	Borken	Karben	2029
Germany	P161	Großkrotzenburg	Urberach	2028
Germany	AMP-P159	Bürstadt	BASF (Ludwigshafen am Rhein)	2029
Germany	P302	Höpfingen	Hüffenhardt	2030
Germany	P175	Wilhelmshaven/ Landkreis Friesland	Conneforde	2029
Germany	P200	Punkt Blatzheim	Oberzier	2027
Germany	P462	Siersdorf	Verlautenheide	2034
Germany	P225	Isar	Altheim	2029
Germany	DC31	Hemmingstedt/ Lieth/Lohe-Rick-elshof/Wöhrden	Klein Rogahn/ Stralendorf/ Warsow/Holthusen/ Schossin	2032
Germany	DC32	Pöschendorf/ Hadenfeld/ Kaisborstel/ Agethorst/Mehlbek	Klein Rogahn/ Stralendorf/ Warsow/Holthusen/ Schossin	2034
Germany	P227	Lübeck	Ämter Büchen/ Breitenfelde/ Schwarzenbek-Land	2029
Germany	P223	Güstrow	Ämter Büchen/ Breitenfelde/ Schwarzenbek-Land	2034

Description	Main drivers	In RegIP 2022?	Status
New 380 kV OHL in existing corridor	RES integration	Yes	In permitting
Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In planning but not yet permitting
New 380 kV OHL in existing corridor	RES integration	Yes	In permitting
Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In permitting
New 380 kV OHL in existing corridor, upgrade from 220 kV to 380 kV	RES integration, security of supply	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In planning but not yet permitting
New 380 kV OHL in existing corridor	RES integration	Yes	In permitting
Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In permitting
New 380 kV OHL	RES integration, security of supply	No	In permitting
New HVDC line. Detailed information provided in Germany's grid development plan	RES integration	Yes	In permitting
New HVDC Line. Detailed information provided in Germany's grid development plan	RES integration	No	In permitting
New 380 kV OHL	RES integration	Yes	In permitting
Reinforcement of existing 380 kV OHL	RES integration	Yes	In permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Germany	P367	Emden-Ost	Emden-West	2034
Germany	50HzT-P180/P252/P531	Wulheide/Thyrow/ Teufelsbruch	Marzahn/Berlin Mitte/Malchow/ Schönefeld	2038
Germany	P212	Landesbergen	Borken	2030
Germany	P402	Westerkappeln	Gersteinwerk	2033
Germany	P501	Gersteinwerk	Mengede	2038
Germany	P408	Emscherbruch	Hattingen	2037
Germany	P502	Walsum	Beek	2030
Germany	P528	Lauchstädt	Pulgar	2033
Germany	P504	Sechtem	Weißenthurm	2030
Germany	P500	Aschaffenburg	Urberach	2035
Germany	P464	Punkt Fraulautern	Diefflen	2032
Germany	AMP-009/TTG-007	Dörpen West	Niederrhein	2025
Germany	AMP-014/AMP-032	Niederrhein	Osterath	2030
Germany	AMP-014/AMP-015	Osterath	Weißenthurm	2025
Germany	AMP-010	Wehrendorf	Gütersloh	2028
Germany	AMP-022	Keuckel	Dauersberg	2026
Hungary	Uprating of 220 kV lines	–	–	2025

	Description	Main drivers	In RegIP 2022?	Status
	New 380 kV OHL	RES integration, security of supply	No	In planning but not yet permitting
	New 380 kV lines, reinforcement of existing lines and substations	Security of supply	Yes	In planning but not yet permitting/In permitting
	Reinforcement of existing 380 kV OHL	RES integration	Yes	Under construction
	New 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In planning but not yet permitting
	New 380 kV OHL, reinforcement of existing OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration	Yes	In permitting
	Replacement of existing OHL with new 380 kV OHL	Security of supply	Yes	In permitting
	Reinforcement of existing 380 kV OHL	RES integration	Yes	Under construction
	New 380 kV OHL	RES integration	Yes	In permitting
	New 380 kV OHL in existing corridor, upgrade from 220 kV to 380 kV	Security of supply	Yes	In planning but not yet permitting
	New 380 kV OHL, partially in existing corridor	RES integration	Yes	Under construction
	New 380 kV OHL, reinforcement of existing OHL	RES integration, security of supply	No	In permitting
	Replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	No	Under construction
	Replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	No	Under construction
	New 380 kV OHL, replacement of existing OHL with new 380 kV OHL	RES integration, security of supply	No	Under construction
	Uprating of 220 kV lines: Detk (HU)–Zugló (HU) double-circuit, Detk (HU)–Sajószöged(HU) double-circuit, Kisvárda (HU)–Sajószöged (HU), Tiszalök (HU)–Sajószöged(HU), Mezőcsát (HU)–Szolnok (HU), Mezőcsát (HU)–Sajószöged (HU)	RES integration	Yes	Under construction

Country	Project name	Investment		Expected commissioning year
		From	To	
Hungary	Replacement of primary devices at 400 kV voltage level	–	–	2025
Hungary	Switching Station Ludas (HU)	Ludas (HU)	–	2028
Hungary	Switching Station Szihalom (HU)	Szihalom (HU)	–	2027
Hungary	Extension of 220 kV voltage level at Sajószöged (HU)	Sajószöged (HU)	–	2027
Hungary	New MSCDN at substation Göd (HU)	Göd (HU)	–	2027
Hungary	New MSCDN at substation Debrecen Dél (HU)	Debrecen Dél (HU)	–	2027
Hungary	Extension of 400 kV voltage level at Szabolcsbáka (HU)	Szabolcsbáka (HU)	–	2028
Hungary	Switching Station Nyirád (HU)	Nyirád (HU)	–	2029
Hungary	Switching Station Balotaszállás (HU)	Balotaszállás (HU)	–	2029
Hungary	Switching Station Vadosfa (HU)	Vadosfa (HU)	–	2029
Hungary	Substation Göd Kelet (HU)	Göd Kelet (HU)	–	2024
Hungary	New transformer in Debrecen Józsa (HU)	Debrecen Józsa (HU)	–	2024
Hungary	New transformer in Békéscsaba (HU)	Békéscsaba (HU)	–	2025
Hungary	New transformer in Buj (HU)	Buj (HU)	–	2025

	Description	Main drivers	In RegIP 2022?	Status
	Uprating of 400 kV voltage level primary devices in order to not limit the thermal capacity of the 400 kV lines	RES integration	No	Under construction
	New switching station Ludas (HU) connected by splitting existing 400 kV line Göd Kelet (HU)–Sajószöged (HU), for the connection of new app. 650 MW CCGT generation	Connection of generation	No	Planned
	New switching station Szihalom (HU) connected by splitting existing 220 kV line Detk (HU)–Sajószöged (HU), for the connection of 5 x 49.9 MW PV generation	RES integration, connection of generation	Yes	Planned
	Extension of 220 kV voltage level at Sajószöged (HU) to connect 187.2 MW PV generation	RES integration, connection of generation	No	Planned
	New MSCDN in substation Göd (HU) to avoid low voltages in the northeastern Hungarian region	Security of supply	Yes	Planned
	New MSCDN in substation Debrecen Dél (HU) to avoid low voltages in the northeastern Hungarian region	Security of supply	No	Planned
	Extension of 400 kV voltage level at Szabolcsbáka (HU) to connect 49.95 MW PV generation	RES integration, connection of generation	No	Planned
	New switching station Nyirád (HU) connected by splitting existing 400 kV line Hévíz (HU)–Litér (HU), for the connection of 399.2 MW PV generation and 69.8 MW battery	RES integration, connection of generation	No	Planned
	New switching station Balotaszállás (HU) connected by splitting existing 400 kV line Paks (HU)–Sándorfalva (HU), to connect new 249.5 MW PV generation and 24 MW battery	RES integration, connection of generation	No	Planned
	New switching station Vadosfa (HU) connected by splitting existing 400 kV line Győr (HU)–Szombathely (HU), to connect 695 MW Wind generation and 196 MW battery	RES integration, connection of generation	No	Planned
	New substation Göd Kelet (HU) with 3 x 250 MVA 400/120 kV transformation, connected by splitting existing 400 kV line Sajószöged (HU)–Göd (HU)	Security of supply, RES integration	Yes	Commissioned
	Installation of third 400/132 kV transformer in Debrecen Józsa (HU)	RES integration, security of supply	Yes	Commissioned
	Installation of third 400/132 kV transformer in Békéscsaba (HU)	RES integration, security of supply	No	Under construction
	Installation of third 400/132 kV transformer in Buj (HU)	RES integration, security of supply	No	Commissioned

Country	Project name	Investment		Expected commissioning year
		From	To	
Hungary	Substation Debrecen Dél (HU)	Debrecen Dél (HU)	–	2026
Hungary	400 kV line Felsőzsolca (HU)–Sajóivánka (HU)	Felsőzsolca (HU)	Sajóivánka (HU)	2026
Hungary	New transformer in Pécs OVIT (HU)	Pécs OVIT (HU)	–	2027
Hungary	New transformer in Hévíz (HU)	Hévíz (HU)	–	2027
Hungary	New voltage level (132 kV) and transformer in substation Szabolcsbáka (HU)	Szabolcsbáka (HU)	–	2026
Hungary	Reconstruction of Szolnok (HU)–Szeged (HU) 220 kV line to 400 kV line Szolnok (HU)–Sándorfalva (HU)	Szolnok (HU)	Szeged/Sándorfalva (HU)	2028
Hungary	Substation Törökfái (HU)	Törökfái (HU)	–	2028
Hungary	New transformer in Szolnok (HU)	Szolnok (HU)	–	2028
Hungary	Substation Biritó (formerly Paks II) (HU)	Biritó (HU)	–	2029
Hungary	400 kV line Biritó (HU)–Törökfái (HU)	Biritó (HU)	Törökfái (HU)	2029
Poland	Construction of the 400/220/110 kV Baczyna substation	Baczyna (PL)		2025
Poland	Construction of the 400 kV Baczyna–Plewiska line	Baczyna (PL)	Plewiska (PL)	2023

	Description	Main drivers	In RegIP 2022?	Status
	New 400 kV substation Debrecen Dél (HU) for connecting new consumers in the region of Debrecen, connecting it with double-circuit 400 kV line to Debrecen Józsa (HU)	Security of supply, RES integration	No	Under construction
	New 400 kV double-circuit transmission line between new substation Felsőzsolca (HU) and existing substation Sajóivánka (HU)	RES integration, security of supply	No	Planned
	Installation of third 400/132 kV transformer in Pécs OVIT (HU)	RES integration	No	In permitting
	Installation of third 400/132 kV transformer in Hévíz (HU)	RES integration, security of supply	No	In permitting
	Construction of a 132 kV voltage level and installation of 400/132 kV transformer in Szabolcsbáka (HU)	RES integration, security of supply	No	Planned
	Reconstruction of the Szolnok–Szeged 220 kV single line to a double-circuit 400 kV line with topology reconfiguration. Splitting Albertirsa (HU)–Józsa (HU) into Szolnok (HU) and connect-ing the uprated line end into Sándorfalva (HU) instead of Szeged (HU), and connecting the other to the split Albertirsa (HU)–Szolnok (HU) 400 kV line	Security of supply, RES integration	No	Planned
	New 400 kV substation Törökfái (HU), connected by splitting Albertirsa (HU)–Sándorfalva (HU) 400 kV line	RES integration, security of supply	No	Planned
	Installation of 400/220 kV transformer in Szolnok (HU)	RES integration, security of supply	No	Planned
	New 400 kV substation Biritó (HU) to connect new units of Paks Nuclear Power Plant through reconnect lines from Paks (HU) to Biritó (HU): Perkáta (HU)–Paks (HU), Litér (HU)–Paks (HU), Toponár (HU)–Paks (HU) and establish two line between Paks (HU)–Biritó (HU)	Connection of generation	Yes	Planned
	New 400 kV double-circuit transmission line between new substation Biritó (HU) and Törökfái (HU)	Connection of generation	No	Planned
	Construction of the 400/220/110 kV Baczyna substation and connecting the 400 kV Krajnik-Plewiska line and the 220 kV Krajnik-Gorzów line	Cross-border exchange with Germany, RES integration	No	Under construction
	Construction of the 400 kV Baczyna–Plewiska line	Cross-border exchange with Germany, RES integration	No	Commissioned

Country	Project name	Investment		Expected commissioning year
		From	To	
Poland	Construction of the 400 kV Mikułowa–Świebodzice line	Mikułowa (PL)	Świebodzice (PL)	2025–2026
Poland	Expansion of the 400/220/110 kV Pątnów substation	Pątnów (PL)		2025
Poland	Modernisation of the 220 kV Łagisza–Jamki line	Łagisza (PL)	Jamki (PL)	2026
Poland	Modernisation of the 400 kV Rzeszów–Krosno Iskrzynia line	Rzeszow (PL)	Krosno–Iskrzynia (PL)	2025
Poland	Construction of a 400 kV line between Dobrzeń and the Pasikurowice–Ostrów line cut	Dobrzeń (PL)	Pasikurowice–Ostrów (PL)	2027
Poland	Construction of a 400 kV line between Trębaczew and the Joachimów (Rokitnica)–Wielopole line cut	Trębaczewo (PL)	Joachimów (Rokitnica)–Wielopole (PL)	2027
Poland	Expansion and modernisation of the 400/220 kV Joachimów substation	Joachimów (PL)		2031
Poland	Expansion of the 400 kV Gdańsk Przyjaźń substation and the 400(220)/110 kV Żydowo substation	Gdańsk Przyjaźń and Żydowo Kierzkowo (PL)		2025–2028
Poland	Modernisation (reconstruction) of the 400 kV Rogowiec–Joachimów, Rogowiec–Tucznawa (Joachimów) lines	Rogowiec (PL)	Joachimów/ Tucznawa (PL)	2028
Poland	Modernisation of the 220 kV Świebodzice–Ząbkowice line	Świebodzice (PL)	Ząbkowice (PL)	2026
Poland	Modernisation (reconstruction) of the 220 kV Groszowice–Ząbkowice line	Groszowice (PL)	Ząbkowice (PL)	2028
Poland	Construction of the 400/220/110 kV Podborze substation along with the introduction of 220 and 400 kV lines	Podborze (PL)	Kopanina (PL)–Liskovec (CZ), Bujaków (PL)–Liskovec (CZ), Bieruń (PL)–Komorowice (PL), Czeczott (PL)–Moszczenica (PL), Nosovice (CZ)–Wielopole (PL), Dobrzeń (PL)–Detmarovice (CZ)	2030

	Description	Main drivers	In RegIP 2022?	Status
	Construction of the 400 kV Mikułowa–Świebodzice line along with the expansion of the 400/220/110 kV Świebodzice substation and the 400/220/110 kV Mikułowa substation	Cross-border exchange with Germany	No	Under construction
	Expansion of the 400/220/110 kV Pątnów substation along with the connection of the 400 kV Kromolice–Pątnów line	Cross-border exchange with Germany	No	Under construction
	Modernisation of the 220 kV Łagisza–Jamki line	Elimination of transmission constraints for cross-border exchange	No	Planned
	Modernisation of the 400 kV Rzeszów–Krosno Iskrzynia line	Cross-border exchange with Slovakia	Yes	Under construction
	Construction of a 400 kV line between Dobrzeń and the Pasikurowice–Ostrów line cut	Elimination of transmission constraints for cross-border exchange	Yes	Under construction
	Construction of a 400 kV line between Trębaczew and the Joachimów (Rokitnica)–Wielopole line cut	Elimination of transmission constraints for cross-border exchange	Yes	Tender
	Expansion and modernisation of the 400/220 kV Joachimów substation	Elimination of transmission constraints for cross-border exchange	No	Planned
	Expansion of the 400 kV Gdańsk Przyjaźń substation and the 400(220)/110 kV Żydowo Kierzkowo substation along with the installation of reactive power compensation equipment and adaptation of the 400/220/110 kV Gdańsk I substation to switch the 400 kV Dunowo–Żydowo Kierzkowo–Gdańsk I and Piła Krzewina–Żydowo Kierzkowo lines to 400 kV	Elimination of transmission constraints for cross-border exchange	No	Under construction
	Modernisation (reconstruction) of the 400 kV Rogowiec–Joachimów, Rogowiec–Tucznawa (Joachimów) lines	Elimination of transmission constraints for cross-border exchange	No	Planned
	Modernisation of the 220 kV Świebodzice–Ząbkowice line	Elimination of transmission constraints for cross-border exchange	No	Under construction
	Modernisation (reconstruction) of the 220 kV Groszowice–Ząbkowice line	Elimination of transmission constraints for cross-border exchange	No	Planned
	Construction of the 220 kV Podborze–Kopanina-Liskovec, Podborze–Bujaków-Liskovec, Podborze–Bieruń-Komorowice, and Podborze–Czeczott-Moszczenica sections and the 400 kV Podborze–Nosovice-Wielopole and Podborze–Dobrzeń-Detmarovice sections along with the construction of the 400/220/110 kV Podborze substation	Elimination of transmission constraints for cross-border exchange	No	Planned

Country	Project name	Investment		Expected commissioning year
		From	To	
Poland	Modernisation of the AC/DC converter station in Słupsk	Slupsk (PL)		2025
Poland	Modernisation (reconstruction) of the 220 kV Joachimów–Łośnice line	Joachimów (PL)	Łośnice (PL)	2028
Poland	Switching of the 400 kV Ostrołęka–Wyszków-Stanisławów line circuit operating at 220 kV to 400 kV	Ostrołęka (PL)	Wyszków-Stanisławów (PL)	2023–2027
Romania	New 400 kV OHL Suceava (RO)–Balti (MD)	Suceava (RO)	Balti (MD)	2030
Romania	New 400 kV OHL Suceava (RO)–Gadalin (RO)	Suceava (RO)	Gadalin (RO)	2030
Romania	Upgrade OHL 400 kV Isaccea (RO)–Tulcea (RO)	Isaccea (RO)	Tulcea (RO)	2029
Romania	New 400 kV OHL Stalpu (RO)–Brasov (RO)	Stalpu (RO)	Brasov (RO)	2031
Romania	New 400 kV OHL Constanta Nord (RO)–Medgidia Sud (RO)	Constanta Nord (RO)	Medgidia Sud (RO)	2028
Romania	New 400 kV OHL Stalpu (RO)–Teleajen (RO)–Brazi (RO)	Stalpu (RO)–Teleajen (RO)–Brazi (RO)		2026
Romania	400 kV substation Teleajen (RO)	Teleajen (RO)		2028
Romania	400 kV substation Brazi Vest (RO)	Brazi Vest (RO)		2027
Romania	220 kV OHL Stejaru (RO)–Gheorgheni (RO)	Stejaru (RO)	Gheorgheni (RO)	2025

Description	Main drivers	In RegIP 2022?	Status
Modernisation of the AC/DC converter station in Słupsk	Cross-border exchange with Sweden	No	Under construction
Modernisation (reconstruction) of the 220 kV Joachimów–Łośnice line	Elimination of transmission constraints for cross-border exchange	No	Planned
Switching of the 400 kV Ostrołęka–Wyszków–Stanisławów line circuit operating at 220 kV to 400 kV along with replacement of the 220/110 kV transformer at the Wyszków substation with a 400/110 kV unit	Cross-border exchange with Lithuania	No	Planned
New 400 kV OHL (139 km) to increase capacity of transfer between Romania and Moldova	Market integration	Yes	In permitting
New 400 kV simple-circuit OHL between existing substations with a line length of 260 km	RES integration	Yes	In permitting
Upgrade of existing OHL 400 kV Isaccea–Tulcea from simple-circuit to double-circuit	RES integration	Yes	Planned but not yet permitting
New 400 kV OHL, double-circuit (initially one circuit wired), 170 km length between existing 400 kV substations Stalpu and Brasov	RES integration	Yes	Planned but not yet permitting
New 400 kV double-circuit (one circuit wired) OHL between existing stations with a line length of 75 km	RES integration	Yes	In permitting
Reinforcement of the cross-section between a wind generation hub in Eastern Romania and Bulgaria and the rest of the system. Upgrade of an existing 220 kV single-circuit line to 400 kV. New 400 kV substations: Stalpu (400/110 kV, 1 x 250 MVA) and Teleajen (400/110 kV, 1 x 400 MVA)	RES integration	Yes	Under construction
The 220/110 kV substation Teleajen will be upgraded to 400/110 kV (1 x 400 MVA). The new 400 kV OHL Cernavoda–Stalpu is continued by the OHL Stalpu–Teleajen–Brazi Vest and will be upgraded to 400 kV from 220 kV, reinforcing the E–W cross-section. The 220 kV substations on the path are upgraded to 400 kV. Security of supply in supplied area increases.	RES integration	Yes	In permitting
Installation of a new transformer 400/220 kV 400 MVA and extension of the substation Brazi Vest for the new 400 kV OHL Teleajean (RO)–Brazi (RO) and for the new transformer	RES integration	Yes	Under construction
Increasing transmission capacity	RES integration	Yes	Under construction

Country	Project name	Investment		Expected commissioning year
		From	To	
Romania	220 kV OHL Gheorgheni (RO)–Fantanele (RO)	Gheorgheni (RO)	Fantanele (RO)	2025
Romania	220 kV OHL Gutinaş (RO)–Dumbrava (RO)	Gutinaş (RO)	Dumbrava (RO)	2028
Romania	220 kV OHL Dumbrava (RO)–Stejaru (RO)	Dumbrava (RO)	Stejaru (RO)	2028
Romania	220 kV OHL Fântânele (RO)–Ungheni (RO)	Fântânele (RO)	Ungheni (RO)	2029
Romania	440 kV OHL Smardan (RO)–Gutinas (RO)	Smardan (RO)	Gutinas (RO)	2028
Romania	440 kV OHL Gura Ialomiței (RO)–București Sud (RO)	Gura Ialomiței (RO)	București Sud (RO)	2028
Romania	440 kV OHL Cernavodă (RO)–Pelicanu (RO)	Cernavodă (RO)	Pelicanu (RO)	2030
Romania	440 kV OHL Pelicanu (RO)–București Sud (RO)	Pelicanu (RO)	București Sud (RO)	2025
Romania	440 kV OHL Brașov (RO)–Gutinas (RO)	Brașov (RO)	Gutinas (RO)	2030
Romania	220 kV OHL București Sud (RO)–Fundeni (RO)	București Sud (RO)	Fundeni (RO)	2030
Romania	220 kV OHL București Sud (RO)–Ghizdaru (RO)	București Sud (RO)	Ghizdaru (RO)	2028
Romania	220 kV OHL Turnu Magurele (RO)–Ghizdaru (RO)	Turnu Magurele (RO)	Ghizdaru (RO)	2028
Romania	220 kV OHL Turnu Magurele (RO)–Craiova Nord (RO)	Turnu Magurele (RO)	Craiova Nord (RO)	2029
Romania	SVC in Sibiu Sud SS and Bradu SS			2026
Romania	Third transformer 400/110 kV Medgidia Sud			2029
Romania	Third transformer 400/110 kV Smardan			2029
Romania	Second transformer 400/110 kV Suceava			2033
Romania	Second transformer 400/110 kV Rosiori			2028

Description	Main drivers	In RegIP 2022?	Status
Increasing transmission capacity	RES integration	Yes	Under construction
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
New double-circuit of the 400 kV OHL (second circuit)	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Under construction
Increasing transmission capacity	RES integration	No	Planned but not yet in permitting
Increasing transmission capacity	RES integration	No	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Increasing transmission capacity	RES integration	Yes	Planned but not yet in permitting
Install SVC in Sibiu Sud SS and Bradu SS to allow power transmission to faraway consumption nodes	RES integration	Yes	In permitting
Third transformer 400/110 kV Medgidia Sud	RES integration	Yes	Planned but not yet in permitting
Third transformer 400/110 kV Smardan	RES integration	Yes	Planned but not yet in permitting
Third transformer 400/110 kV Suceava	RES integration	No	Planned but not yet in permitting
Second transformer 400/110 kV Rosiori	Interconnection capacity, security of supply	Yes	In permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Romania	New 220 kV substation Dej			2028
Romania	SVC in Gutinas, Suceava, Rosiori SS			2028
Romania	Flexible AC transmission systems			2025
Romania	SVC in 400 kV Gura Ialomiței, 400 kV Arad, 220 kV Brazi Vest			2028
Romania	New 400 kV substation Arefu			2025
Romania	New 400 kV substation Grozavesti			2031
Romania	New 400 kV substation Fundeni			2033
Romania	New 400 kV substation Bistrita			2029
Romania	New 400 kV substation Botosani			2030
Romania	Second transformer 400/110 kV Calea Aradului			2027
Romania	Double-circuit 220 kV OHL Portile de Fier–Resita			2028
Slovakia	New 400 kV substation Senica (SK)	Senica (SK)		2025
Slovakia	New 400 kV OHL Horná Ždaňa (SK)–Oslany area	Horná Ždaňa (SK)	Oslany area	2028

	Description	Main drivers	In RegIP 2022?	Status
	Building new 220 kV SS Dej in/out 220 kV OHL Baia Mare–Iernut	Security of supply	Yes	Planned but not yet in permitting
	Install SVC in Gutinas, Suceava, Rosiori SS, to allow power transmission to faraway consumption nodes	RES integration	Yes	In permitting
	Install flexible AC transmission systems to control power flows on 220 kV OHL București Sud–Fundeni and 220 kV OHL Urechești–Tg. Jiu Nord–Paroșeni–Baru Mare–Hășdat	RES integration, market integration	Yes	Planned but not yet in permitting
	Install SVC in 400 kV Gura Ialomiței, 400 kV Arad, 220 kV Brazi Vest SS, to allow power transmission to faraway consumption nodes	RES integration	Yes	Planned but not yet in permitting
	Building new 400 kV SS Arefu and new autotrans-former 400 MVA, 400/220 kV	Security of supply	Yes	Under construction
	Building new 400 kV SS Grozavesti and two new 100 MVA switched shunts, and 400 kV cable to Bucuresti Sud SS and Domnesti SS	Security of supply	Yes	Planned but not yet in permitting
	Building new 400 kV SS Fundeni and one new 100 MVA switched shunts	Security of supply	Yes	Planned but not yet in permitting
	Building new 400 kV SS Bistrita IN/OUT in 400 kV Suceava–Gadalin	Security of supply	Yes	Planned but not yet in permitting
	Building new 400 kV SS Bistrita IN/OUT in 400 kV Suceava–Balti	Security of supply	No	Planned but not yet in permitting
	Second transformer 400/110 kV Calea Aradului	Interconnection capacity, security of supply	Yes	In permitting
	Increasing transmission capacity	Interconnection capacity	Yes	Planned but not yet in permitting
	Replacement of existing 220 kV substation Senica (SK) with the new 400 kV substation, which will be connected to the existing 400 kV cross-border OHL Sokolnice (CZ)–Križovany (SK)	Security of supply, RES integration	Yes	Under construction
	Looping of the existing 2x400 kV OHL Križovany (SK)–Bystričany (SK) into the substation Horná Ždaňa (SK) as a final step towards replacement of existing 220 kV infrastructure in Bystričany area with 400 kV infrastructure. This investment will ensure the operational safety and reliability of the new 400 kV substation Bystričany (SK), in operation from 2021. Long-term issue with public acceptance.	Security of supply	Yes	In permitting

Country	Project name	Investment		Expected commissioning year
		From	To	
Slovakia	New 400 kV substation Ladce (SK)	Ladce (SK)		2028
Slovakia	New 400 kV OHL Ladce (SK)–Bystričany (SK)	Ladce (SK)	Bystričany (SK)	2032
Slovakia	Looping of the existing line Veľký Ďur (SK)–Horná Ždaňa (SK) into the Levice substation	Veľký Ďur (SK)	Horná Ždaňa (SK)	2028
Slovakia	Transformer replacement and new shunt reactors installation in substation Varín (SK)	Varín (SK)		2025
Slovenia	SS 220/110 kV Ravne	–	–	2027
Slovenia, Croatia	GreenSwitch	–	–	2028

	Description	Main drivers	In RegIP 2022?	Status
	Replacement of existing 220 kV substation Považská Bystrica (SK) with a new 400 kV substation, which will be connected to the existing 400 kV OHL Bošáca (SK)–Varín (SK). This project is a pre-condition to building the new SK–CZ 400 kV interconnector from Ladce (SK) to Otrokovice (CZ).	Security of supply, RES integration	Yes	In permitting
	This project aims mainly to increase the security of supply of substation Bystričany (SK), currently supplied only by double-circuit radial OHL from substation Križovany (SK). SEPS has ongoing difficulties with public acceptance regarding the building of a new 400 kV OHL Horná Ždaňa (SK)–Oslany area that will interconnect substations Bystričany (SK) and Horná Ždaňa (SK). This project also aims to support transit flows in the north–south direction and vice versa.	Security of supply	No	Under consideration
	The investment consists of looping the existing 400 kV line Veľký Ďur (SK)–Horná Ždaňa (SK) into the Levice substation. At the same time, the existing 400 kV interconnector Levice (SK)–Gyor (HU) will be connected to the Veľký Ďur (SK) substation, creating a new cross border line Veľký Ďur (SK)–Gyor (HU).	Security of supply, RES integration	Yes	In permitting
	Replacement of existing 400/110 kV transformer in substation Varín (SK) and installation of shunt reactors with installed capacity 2x45 MVAr that will help reduce operational voltage level on SK–CZ cross-border line Varín (SK)–Nošovice (CZ)	Security of supply, RES integration	Yes	Under construction
	Connection of new SS 220/110 kV Ravne to existing OHL Podlog–Obersielach	Security of supply	Yes	
	The GreenSwitch project will contribute to the more efficient use of existing energy infrastructure and enable the integration of new technologies and advanced functionalities into transmission and distribution networks in Austria, Croatia, and Slovenia.	RES integration, security of supply	No	

Appendix III: Links to national development plans

Country	TSO	Link
Austria	APG AG VUEN GmbH	APG: Network Development Plan 2023 VUEN: Network Development Plan 2023
Croatia	HOPS Plc.	Ten-Year Development Plan 2022–2031
Czechia	ČEPS, a.s.	Ten-Year Transmission System Development Plan 2023–2032
Germany	50Hertz Transmission GmbH Amprion GmbH TenneT TSO GmbH TransnetBW GmbH	Network Development Plan Electricity
Hungary	MAVIR ZRt.	Network Development Plans since 2021
Poland	PSE S.A.	Development plan for meeting current and future electricity demand for the years 2025–2034
Romania	Transelectrica S.A.	Network Development Plan 2024–2033
Slovakia	SEPS	Ten-Year Network Development Plan for the Period 2024–2033
Slovenia	ELES, d.o.o.	Slovenian Network Development Plan 2023–2034
Ukraine	NPC Ukrenergo	Ten-Year Network Development Plan 2025–2034* * sensitive information taking into account the war situation in Ukraine.

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		21^{st} 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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