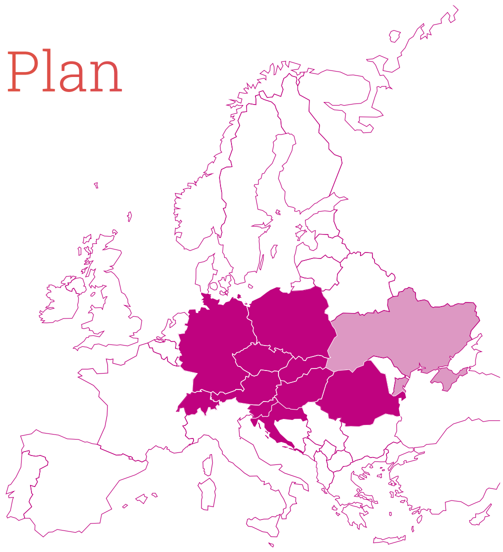
TYNDP 2022

Regional Investment Plan

Continental Central East



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ENTSO-E Mission Statement

Who we are

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

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

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the security of the inter-connected 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 a professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by optimising social welfare in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and innovative responses to prepare for the future and overcome 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 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.

CONTENTS

1.EXECUTIVE SUMMARY

At the time when this Continental Central East Regional Investment Plan 2022 is adopted, the main topic for European energy policy is the overarching political goal of European climate neutrality by 2050. This goal is shared by most European countries, aiming at climate neutrality of the whole European economy by 2050 at the latest. This objective implies a unique transformation of the European Energy System, underpinned by a challenging geopolitical context. Furthermore, **the conflict in Ukraine highlights the urgent need for Europe to become independent from fossil fuels as soon as possible**. To facilitate the 2050 Carbon Neutrality goal, the evolution of EU legislation on climate change has set and adopted ambitious targets for 2030. **One of the major changes in the electricity sectors in CCE is the shift of the power generation mix mainly from traditional coal-based generation to massive integration of renewable energy sources (RES) in the generating capacity of the entire Europe including the CCE region at large**.

The CCE RG generation mix evolution:

Statistical data indicate that the transformation is already underway: the total installed net generating capacity in the CCE region rose by approximately 33 % between 2010 and 2020. Net power generation itself decreased by approximately 7.8 %. This shows that the evolution of net generating capacities is not in line with capacity usage, i.e., power generation in the CCE region. The decrease in power generation may be caused by the replacement of stable power generation from nuclear and fossil fuels by RES. Yearly energy consumption in 2020 was almost the same as in 2010 after a decrease of 3.5 % compared to the year 2019. This decrease from 2019 to 2020 was most likely caused by the global COVID pandemic that afflicted all member countries of the CCE region. Despite the decrease in consumption, the yearly balance of the CCE region switched from exporting slightly to importing slightly. 2 % of total yearly generation was exported in 2010, while 7 % atop of total yearly generation was imported in 2020. This may have been caused by the replacement of coal and nuclear power plants with intermittent RES. Between 2010 and 2020, **wind and solar power plants doubled their share of the total installed capacity of the region**, from 18% to 37%, and it is expected to reach as much as 57% by 2030 according to the NECPs of the CCE countries. This is reflected in the NT 2030 scenario. **During this transformation period, the fossil fuel share will continue to decrease from the dominant figure of 55% in 2010, to 42% in 2020 and 27% in 2030**.

Energy infrastructure and investments:

The energy system of 2050 will be vastly different from the present one, **with a steady transformation that will become more and more visible as early as 2030**. As electricity will be the main energy carrier and the most efficient one in the majority of use cases, **the electricity transmission grid will be the backbone of regional RES and other energy resources integration**. The energy mix will be strongly dependent on the geographical availability of RES. To avoid imbalances and local scarcity, **the role of interconnections will be even more important than today**. The current infrastructure system, combined with the planned new infrastructure, has the capability to drive the energy transition. Significant investments will be needed to ensure a well-paced evolution toward achievement of the climate targets. These investments will be directed towards the innovation of the **existing grid, aiming at the expansion of its lifetime and technical**

capabilities. Additionally, the **realisation of new infrastructure** for a stronger and more resilient system will enable fast adaptations to fast-changing future energy scenarios. **To cope with the energy transformation, to facilitate the internal energy market and to ensure the security of the transmission systems' operation, several cross-border and internal transmission system projects have been commissioned in the CCE between 2015 and 2021**.

Furthermore, the Identification of System Needs (IoSN) exercise identified beneficial capacity increases between 500 MW and 3200 MW at the borders of the CCE region for the 2030 and 2040 time horizons. These potential capacity increases are subject to further investigation by respective TSOs.

CCE RG Sensitivity analyses:

As a complementary measure for the IoSN, the CCE RG has performed additional regional studies related to market sensitivity analyses focusing on two aspects. The first examined the change in gas and CO_2 price, and the second investigated thermal capacity changes in the CCE region for the NT2030 scenario. During the analyses, a brief comparison of the two base cases from TYNDP 2020 and TYNDP 2022 of the NT 2030 scenario focusing on assumption changes (installed capacities for the 2030 horizon in the CCE region, CO_2 cost, etc.) and the impact of the merit order switch on different categories of generation, as well as a comparison of the market node balances, was carried out. **From a market perspective, none of the sensitivity analyses led to a load coverage problem in the CCE region. The region remains an importer in every sensitivity study ranging from 12 to 64 TWh**. The energy missing in the CCE region is substituted by increased generation from nuclear power in France due to the relaxing of must-run constraints on decommissioned thermal plants in Germany and Romania. This situation may cause the CCE region to rely heavily on one country. This might be risky in case of unexpected outages. Each of the sensitivities indicates a different additional transport need in the CCE region and **demonstrates the importance of robustly planned infrastructure that should enable and facilitate the accommodation of both options (coal generation before gas and vice versa)**. Other aspects like system cost and CCE RG import/export characteristics were also explored during the analyses.

Influence of Russia – Ukraine war on the electricity sector

The outbreak of the war between Russia and Ukraine in 2022 resulted in the imposition of a series of sanctions on the Russian aggressor by the international community and an acceleration of ambitions for the synchronous connection of the Ukrainian power system to the Continental Europe power system.

Based on a synchronous project which involved different studies in February 2022, isolated operation tests were performed. In March 2022 emergency synchronisation took place between the Ukrainian, Moldovan and Continental Europe power systems.

Since the emergency synchronisation on 16 March 2022, Continental Europe TSOs together with Ukrenergo and Moldelectrica have successfully ensured the security of the two interconnected power systems. Following a request from Ukrenergo, Continental Europe TSOs have analysed the technical pre-conditions for allowing the reopening of electricity trade through the interconnections with Ukraine.

On 7 June 2022, Continental Europe TSOs decided to positively address Ukrenergo's request and confirmed the key conditions that, once met, will enable a gradual opening of electricity trade with Ukraine. Ukrenergo and the Continental Europe TSOs will work together to implement these

conditions. The full implementation of these technical conditions is necessary to guarantee the security and stability of the extended power system. The first cross-border power interchange after the interconnection started on 30 June 2022.
Furthermore, besides facilitation of the synchronous connection of the Ukrainian transmission system with the Continental Europe system, TSOs of the CCE region have initiated several activities in system development planning:

- PSE has started discussion with Ukrenergo on preparations for possible actions on the common profile. Initial preparatory work will be carried out aiming at refurbishment and switching of the existing interconnector, which was out of operation between PL and UA, from 750 kV to 400 kV.
- In 2018 SEPS and Ukrenergo performed a bilateral common study to evaluate future system needs for the reinforcement of the Slovakia-Ukraine common profile when the lifetime of the current interconnector is reached. Based on additional studies, it will be decided whether the existing line will be either reconstructed as a single circuit line with increased load capacity or as a double circuit line.
- MAVIR informed that an upgrade of the existing 220 kV line which is not part of the synchronization is foreseen.
- Transelectrica informally agreed with Ukrenergo to include the 400 kV (former 750 kV) OHL Pivdennoukrainska NPP (Ukraine) – Isaccea (Romania) in the next edition of the TYNDP and National Development Plans. This line is already included in PMI list of Energy Community.

Moreover, the war in Ukraine and the sanctions imposed on Russia have resulted in a significant increase in the prices of fuels and raw materials, influencing the pace of transformation of the manufacturing sector towards RES. This situation threatened the continuity of energy supplies, in particular when gas sources were mostly based on fuel imported from Russia, supplies of which were cut off. The implications of the impact of gas price increases on the generation sector have been analysed in RegIP 2022 (ref. to chapter 4.3 on sensitivity analyses). Changes in gas prices have a big influence on total system costs and can result in a shift of the merit order (coal before gas).

The Baltic power system's synchronous connection to the CE synchronous area:

The Baltic countries are currently synchronized with the Russian/Belorussian IPS/UPS system. Interconnection through direct current lines is achieved via the Nordic synchronous area and Poland. The Baltic countries have expressed their intention to synchronously connect to the CE synchronous area by 2025.

The synchronization project started on 28 June 2018 when the President of the Commission Jean-Claude Juncker, together with the Heads of State or Government of Lithuania, Latvia, Estonia, and Poland, agreed on the Political Roadmap on the synchronization of the Baltic States' electricity networks with the Continental European Network via Poland by the target date of 2025. In line with the Political Roadmap on 14 September 2018 the BEMIP High Level Group (senior-official level) on the synchronization project agreed on the technical and economic feasibility of the synchronization option consisting of the existing double-circuit AC line between Poland and Lithuania (LitPol Link), complemented by the construction of an offshore HVDC link together with other optimisation measures, including synchronous condensers.

2.INTRODUCTION AND REGIONAL CONTEXT

2.1.About Regional Investment Plans

2.1.1.Legal requirements and link to the TYNDP package

The Regional Investments Plans are part of the TYNDP package and comply with Regulation (EU) 2019/943 (Article 34 and Article 48), which requests that TSOs establish regional cooperation within ENTSO-E and publish a Regional Investment Plan biennially. In addition, TSOs may take investment decisions based on that Plan.

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

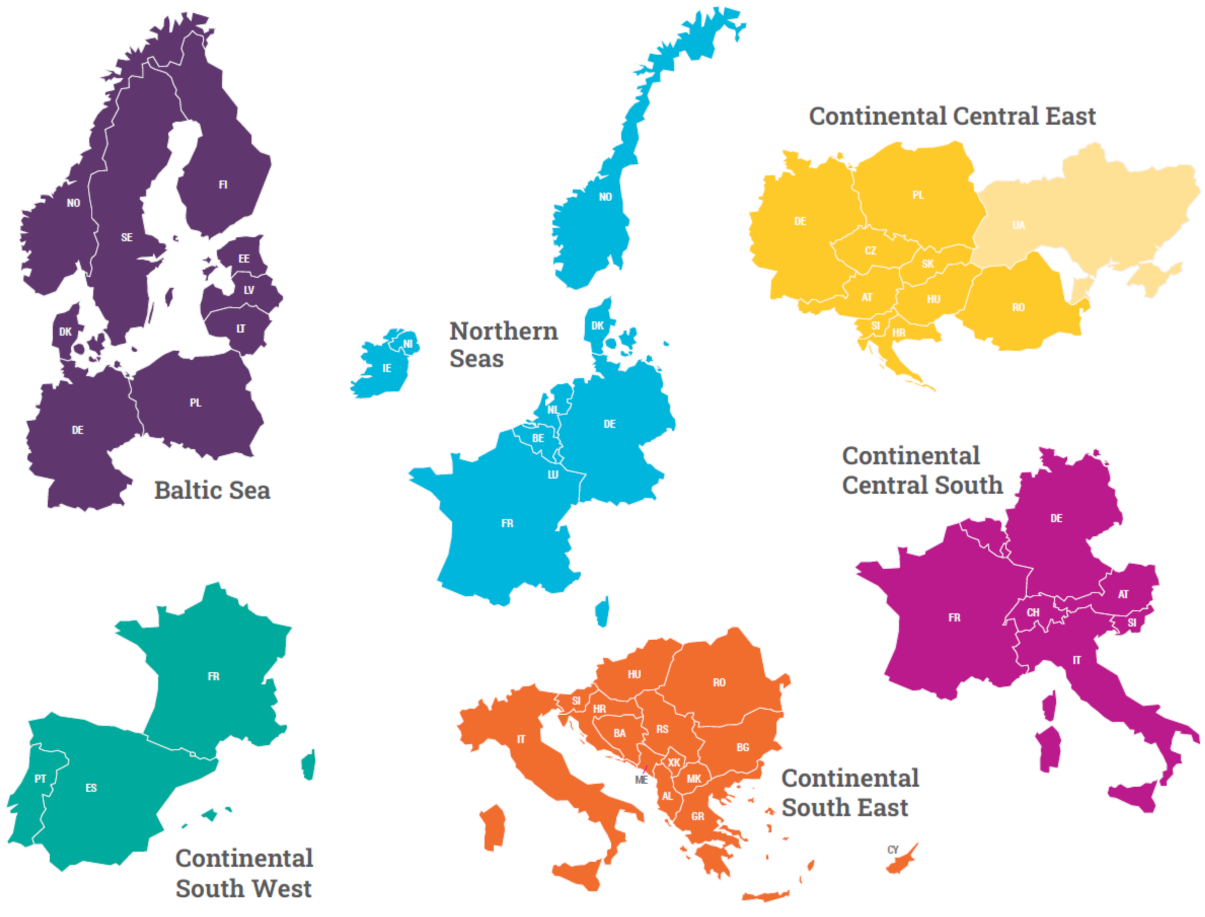


Figure 1 ENTSO-E's System Development regions. Each region is covered by one Regional Investment Plan.

2.1.2.Scope of the RegIPs 2022

Regional investment plans describe the present situation in each region as well as future regional challenges, considering 2030 and 2040 time horizons. The Regional Investment Plan 2022 also investigates solutions that can help mitigate future challenges as well as projections of internal network reinforcements. In addition, this edition of the Plan includes a study roadmap for the region with ongoing and future studies that cover the priorities stemming from the 2040 System Needs Analysis.

The present document comprises the following chapters:

- **Chapter 1** gathers the key messages of the region.
- **Chapter 2** outlines the legal requirements and scope of the Regional Investment Plans. An overview of the present situation of the regions is also presented.
- **Chapter 3** covers a description of the identified regional system needs depending on the regional challenges.
- **Chapter 4** is dedicated to additional analyses specific to the region.
- **Chapter 5** presents the future challenges in the region, the necessary mitigation steps, and projections of internal reinforcements. The study roadmap for the region is also included.

The Appendix includes the abbreviations and terminology used in the report as well as the list of projects relevant to the region, links to National Development Plans, links to simulation results, and additional content depending on the region.

2.2.Overview of the region and present situation

The RG CCE consists of the following countries: Austria, Croatia, Czechia, Germany, Hungary, Poland, Romania, Slovakia, and Slovenia. It is characterized by an interconnected and highly meshed system where all countries have at least four connections to adjacent TSOs (including DC connections). Figure 2 presents an interconnected network of the CCE region (where only 50Hertz and TenneT TSOs are German members in the CCE region). Some border countries of the CCE region are also members of another ENTSO-E regional groups. Since 26 April 2022 Ukrenergo received an ENTSO-E Observer Membership and in the area of system development will be represented in the SDC entities (RG CCE, RG CSE WG Data & Models).

Figure 2 Interconnected network of the CCE region (time horizon of the depicted grid is Q1/2019)

Figure 3 is a map of the CCE region showing only cross border interconnectors between countries of the CCE region and neighbouring countries, for greater visibility.

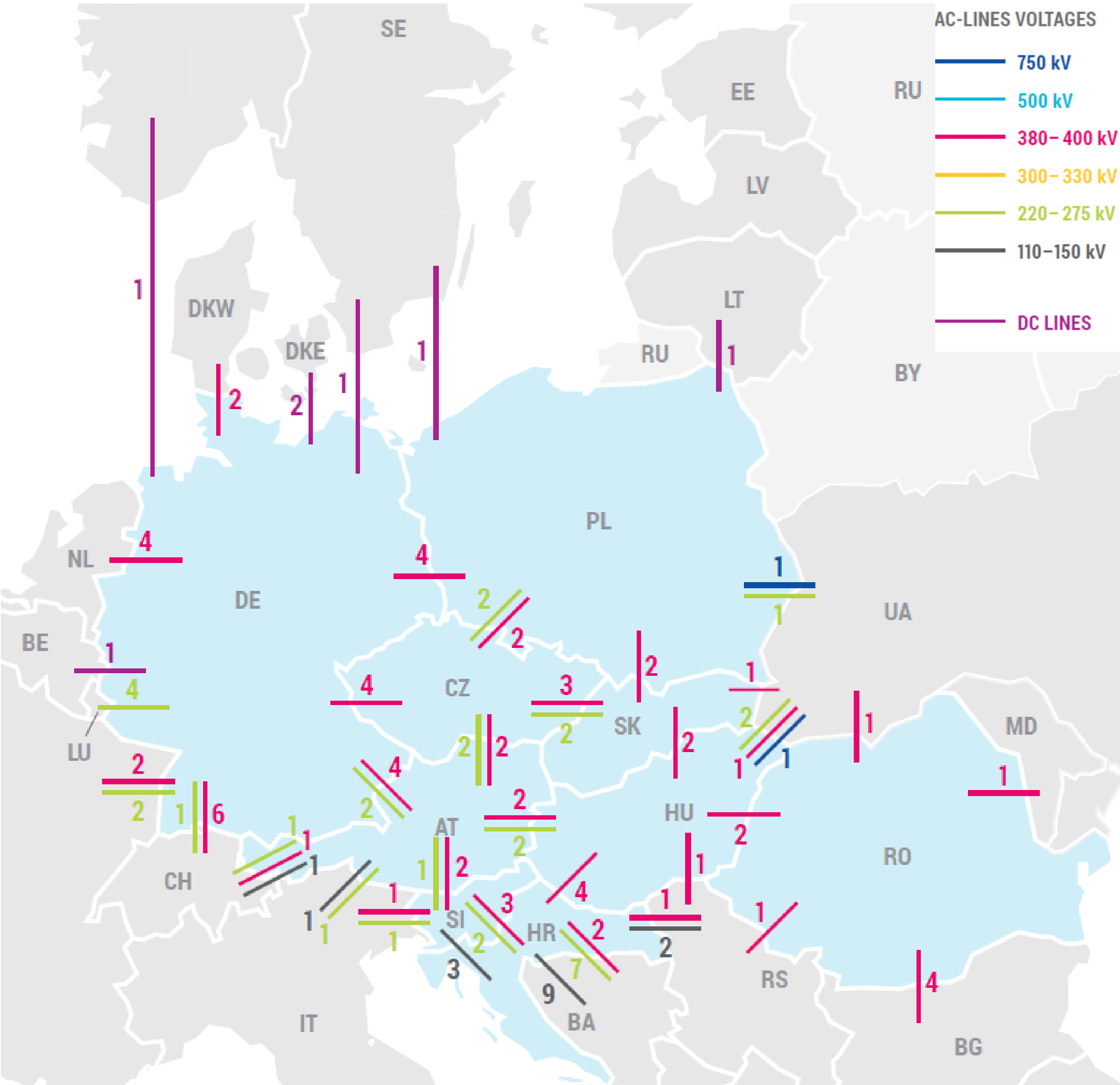


Figure 3 Cross-border interconnectors of the CCE region

Table 1 lists the important cross-border and internal transmission projects that have been commissioned in the CCE region between 2015 and 2021, some of which are not included in Figure 2 and Figure 3 and are improving the operational security of the IPSs in Europe, especially in the CCE region.

Table 1 Transmission system infrastructure projects with cross-border impact commissioned until 2021

Location	Transmission system infrastructure project
DE-PL	New PST transformers on the double 400 kV OHL Mikulowa – Hagenwerder, finally commissioned in December 2015.

DE-PL	The 2 x 220 kV OHL Krajnik – Vierraden was upgraded to 2 x 400 kV with the installation of the first PST transformers in Vierraden substation in March 2019. (The second PST, on the new 2 x 400 kV OHL Krajnik – Vierraden system, will be commissioned in 2025)
DE	A new double 400 kV OHL Altenfeld – Redwitz system is being installed, with the first circuit commissioned in 2015 and the second one in September 2017.
CZ-DE	New PST transformers on the double 400 kV OHL Hradec Východ – Röhrsdorf, on the ČEPS side. The first was commissioned in December 2016 and the second in July 2017. The PSTs on the 50Hertz side were commissioned in 2018. A new substation, Vernerov, which is part of PCI, was commissioned in October 2017. A loop to Mirovka substation from the existing 400 kV between substation Reporyje and Prosenice was commissioned in 2019. In 2020 the double circuit 400 kV line Vitkov – Prestice (including a new 420 kV substation, Vitkov) was commissioned as a replacement of existing 2 x 220 kV lines. This was also part of a PCI project.
SK	A new double 400 kV OHL Veľký Ďur – Gabčíkovo system was commissioned at the end of 2016.
SK-HU	New SK-HU lines, double 400 kV OHL Gabčíkovo – Gönyű – Veľký Ďur and 400 kV OHL Rimavská Sobota – Sajóivánka, were commissioned in 2021.
HR	A new variable shunt reactor (VSR) with installed capacity 100 MVAR in substation 220/110/10 kV Mraclin was commissioned in 2020.
HR-BA	An interpolation of 220 kV TPP Sisak on the existing 220 kV interconnection line Mraclin (HR) – Prijedor (BA) was commissioned in 2019.
HU-UA	The HU terminal of the 750 kV line to Zakhidnoukrainska (UA) was moved to new substation, Szabolcsbáka, in 2019.
HR	A new variable shunt reactor (VSR) with installed capacity 200 MVAR in substation 400/220/110/ kV Melina was commissioned in 2021. A new static var compensator (SVC) with installed capacity 250 MVAR in substation 400/220/110/ kV Konjsko was commissioned in 2021.
SI	New compensation devices on 400 kV voltage level were included in the scope of SINCRO. A GRID project, namely a variable shunt reactor (VSR) with installed capacity 150 MVAr and mechanically switched capacitors (MSC) with installed capacity 100 MVAr in substation Divača, was commissioned in 2020 and a VSR (150 MVAr) in substation Cirkovce was commissioned in 2021.
RO	400 kV OHL Oradea Sud (RO) - Nadab (RO) was commissioned in 2020, with an impact on the RO-HU border.

The majority of the TSOs' control areas are inner AC systems, and thus their systems and capacities are influenced by unscheduled physical flows which differ from the planned market flows. These differences have been noted in the recent past due to the fact that the changes in the power generation mix of the CCE region have already begun. The RES are being developed mainly in the northern part of the region (mainly offshore and onshore wind turbines in the northern part of Germany) and are replacing nuclear and thermal power plants, which is what causes the changes in generation location in comparison with previous locations and with the main power consumption centres. These changes in the power generation mix are relatively rapid in contrast with the relatively slow development of transmission infrastructure, meaning that the current grid may not be able to absorb the load-flow pattern changes, which could lead to some very complicated operational cases for the transmission system. A comparison of the physical exchanges on the CCE cross-border profiles between 2010, 2019 and 2020 is depicted in Figure 4.

The main load-flow pattern in the CCE region is in the north-south direction, as the northern part of the region has an export energy balance and the southern part of the region has an import balance. The cross-border physical flows in the CCE region in the north-west to south-east direction have increased significantly and have more than doubled on the borders of Germany and the Netherlands, Germany and Poland, Germany and Czechia, Romania and Bulgaria, Poland and Slovakia, Austria and Slovenia, Austria and Hungary, Hungary and Serbia, and Hungary and Romania. These changes in cross-border physical flows are a result of the changing power generation mix in the CCE region. The development of the grid should reflect these changes in order to maintain the security of the transmission systems' operation. Graphical representations of the cross-border exchanges in 2020 are depicted in Figure 5.

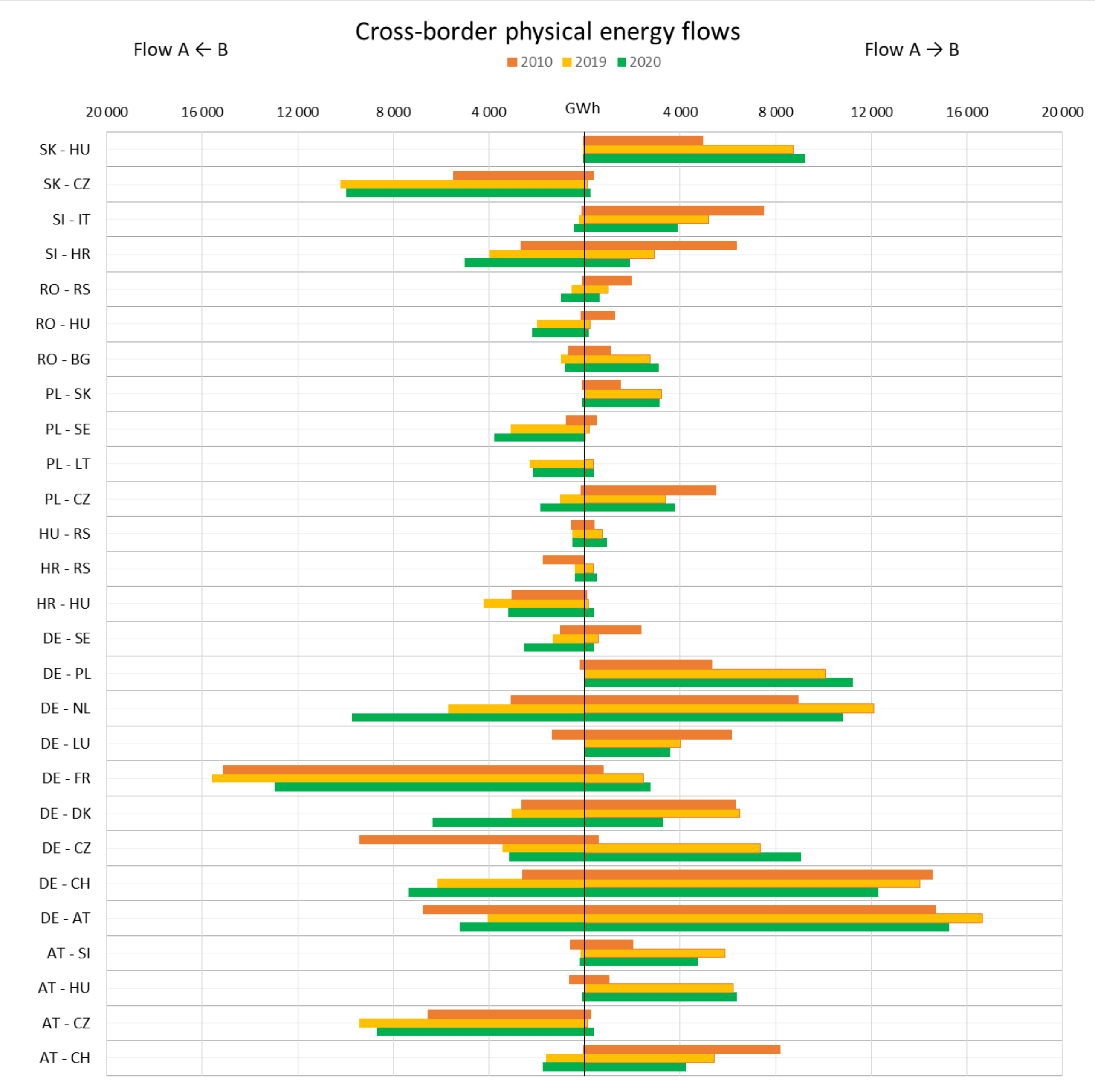


Figure 4 Physical cross-border physical energy flows in the CCE region in 2010, 2019 and 2020

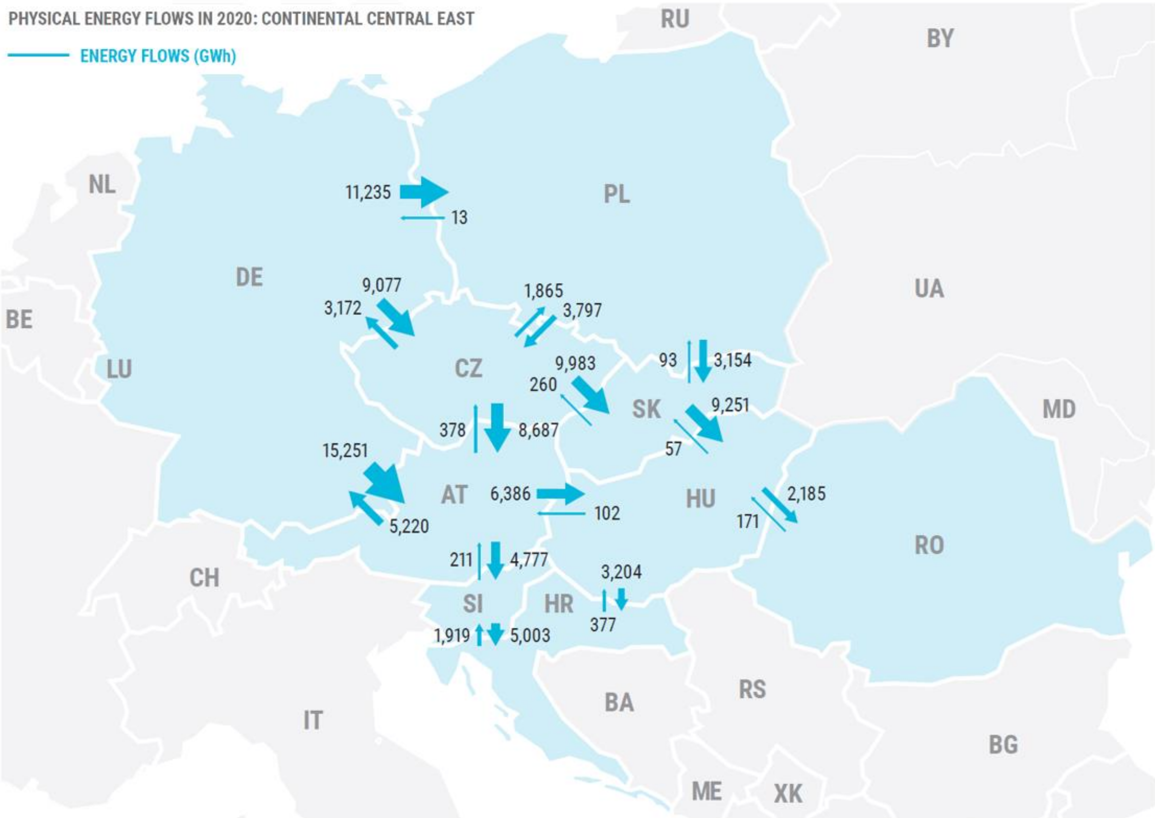


Figure 5 Physical cross-border flows in the CCE region in 2020

The maximal net transfer capacities in 2020 are depicted in Figure 6 in order to illustrate the interconnection levels of particular CCE countries. The Net Transfer Capacity (NTC) values marked with an asterisk (*) present the synchronous profile of PL-(DE+CZ+SK) and (DE+CZ+SK)-PL.

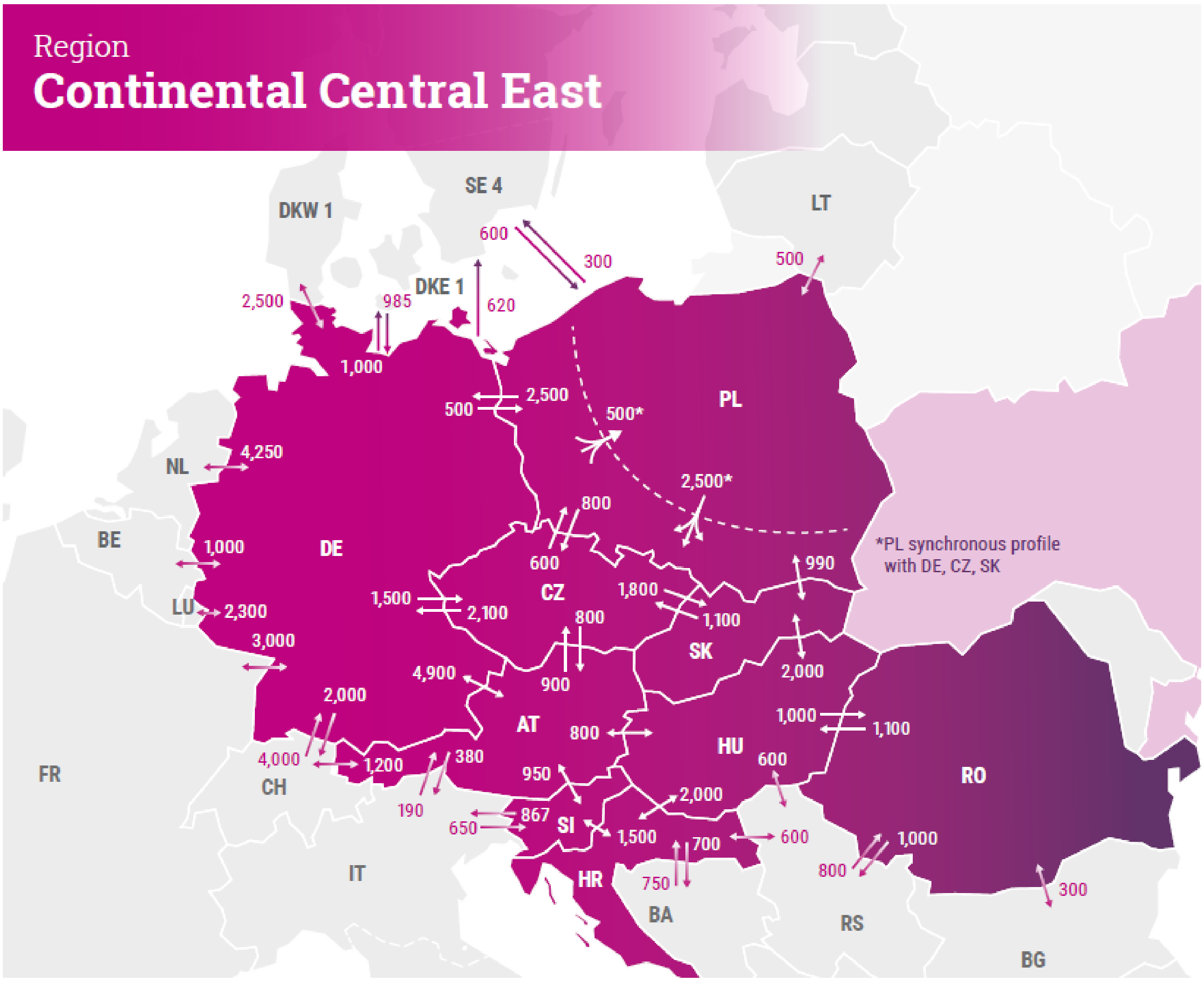


Figure 6 Maximum net transfer capacities on the CCE cross-border profiles in 2020

The above-mentioned facts regarding the changes in the power generation mix that are already underway are shown by Figure 7 and Figure 8, which compare installed net generation capacities [GW] and net generation [TWh] with consumption [TWh] between 2010 and 2020, in order to show the changes in the power generation mix in the CCE region over the past seven years.

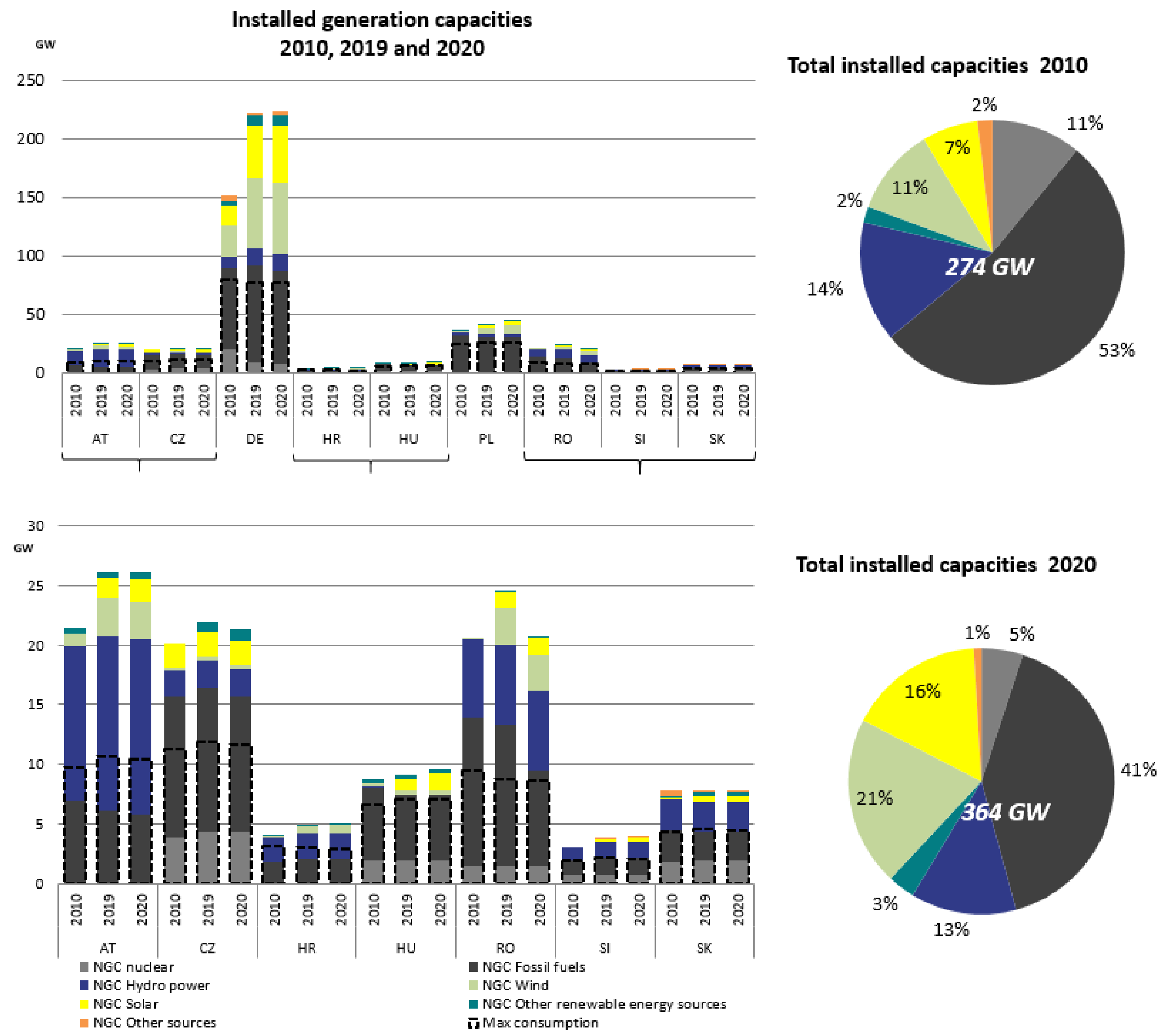


Figure 7 Comparison of installed net generation and load capacities in the CCE region between 2010, 2019 and 2020

The total installed net generating capacity in the CCE region rose by approximately 33 % between 2010 and 2020. Basically, in all CCE countries, there was an increase in net generating capacity from 2010 to 2020. Net power generation itself decreased by approximately 7.8 %. This shows that the evolution of net generating capacities is not in line with capacity usage, i.e., power generation in the CCE region. The decrease in power generation may have been caused by replacement of stable power generation from nuclear and fossil fuels by RES.

Maximum consumption in 2020 was almost the same as in 2010. Yearly consumption in TWh in 2020 was also almost the same as in 2010 after a decrease of 3.5 % compared to the year 2019. This decrease from 2019 to 2020 was most likely caused by the global pandemic that afflicted all member countries of the CCE region.

Despite a decrease in consumption, the yearly balance of the CCE region switched from being exporting slightly to importing slightly. 2 % of total yearly generation was exported in 2010, while

7 % atop of total yearly generation was imported in 2020. This could be caused by the replacement of coal and nuclear power plants with less reliable RES.

An important fact can be seen in Figure 7 and Figure 8 – namely, that Germany's net generating capacities, as well as its generation and consumption shares of the total CCE numbers, are dominant and accounted for approximately 50% of regional totals in both 2010 and 2020.

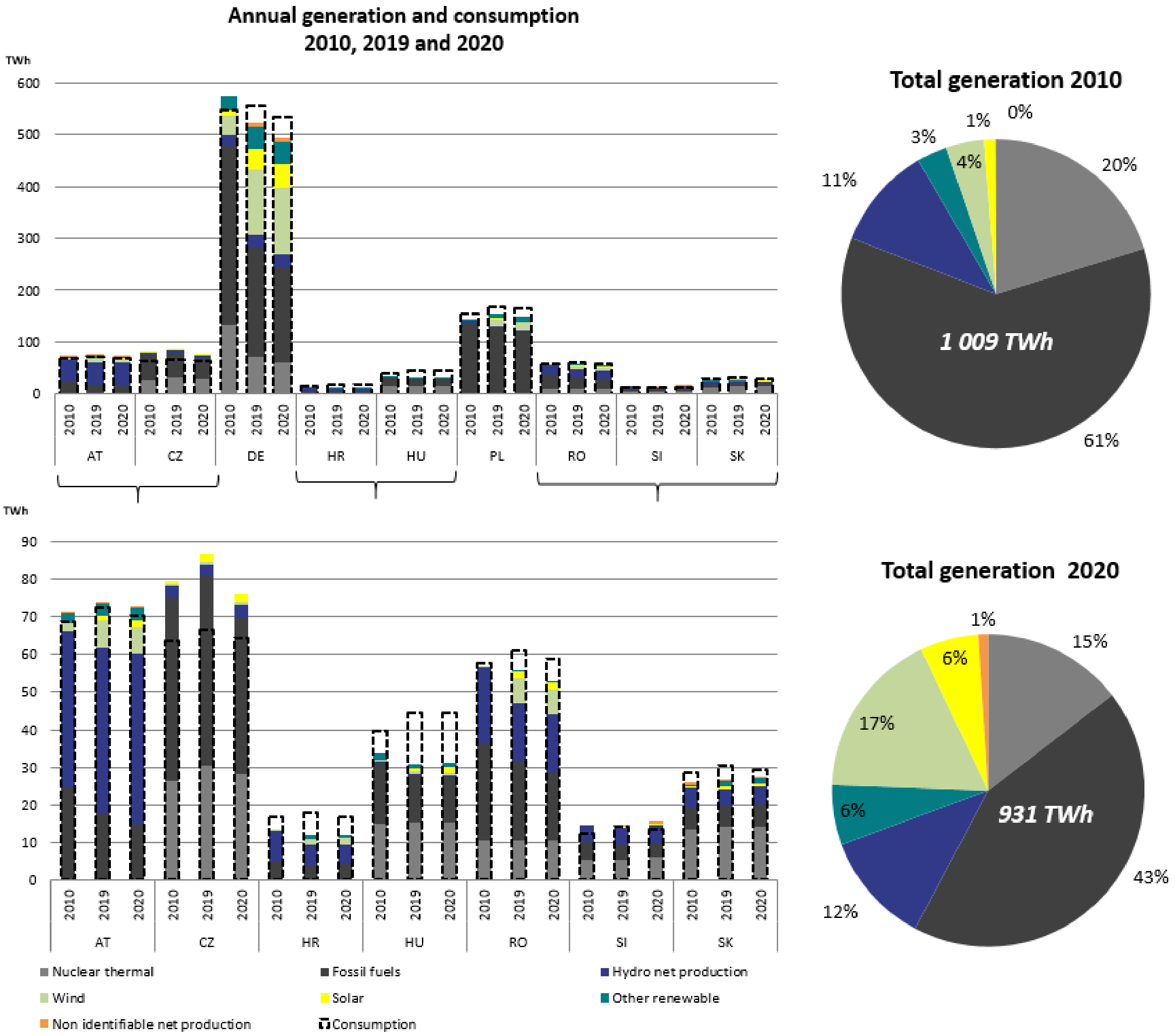


Figure 8 Comparison of net generation and consumption in the CCE region between 2010, 2019 and 2020 [TWh]

2.3.Evolution compared to RegIP 2020

Climate goals

The EU has agreed a comprehensive update of its energy policy framework to facilitate the transition away from fossil fuels towards carbon-neutral energy. The EU has set an ambitious, binding target of 32% for renewable energy sources in the EU's energy mix by 2030. The development of renewable sources also leads to greater energy independence. In the National Trends 2030 scenario used in the analyses performed under RegIP 2022 of RG CCE assumes a progressive reduction of CO_2 emissions by 31%, compared to the previous edition RegIP 2020. This effect is achieved thanks to an 11% increase in the production of energy from renewable sources with a 61% reduction in the constraints of power output from RES.

Power to gas

The hydrogen strategy presented by the European Commission in July 2020 outlines, amongst other elements, how to upscale the supply and demand of renewable hydrogen. It has set a strategic objective of installing at least 40 GW of renewable hydrogen electrolyser capacity within the EU (producing about 5 Mt of renewable hydrogen) based on an estimated demand of up to 10 Mt per year for renewable hydrogen in the EU by 2030. In the National Trends 2030 scenario used in the analyses performed under RegIP 2022 of RG CCE, there is an increase of 9% in the energy used for hydrogen production by electrolysers compared to the previous edition, RegIP 2020.

Flexibility

Currently, 20% of all energy in the European Union comes from renewable sources; achieving the Fit for 55 goal would mean a doubling of renewable energy sources by 2030. For the energy sector, achieving this target will entail shifting from conventional to renewable energy sources at an increased pace. Most renewable energy sources, such as wind and solar, are fluctuating and non-dispatchable; that is, they cannot be controlled by grid operators or market needs but instead are weather-dependent. This fluctuation in supply can create mismatches between generation and demand that require additional flexibility to equilibrate the power system. From the point of view of the power grid, the installation of battery energy storage is a very helpful technological solution. Batteries allow variability of energy production from renewable sources to be stabilised and to respond to changing demand. In the National Trends 2030 scenario used in the analyses carried out under RegIP 2022 of RG CCE, there is an increase of 24% in the use of energy stored in battery systems compared to the previous edition, RegIP 2020.

Moreover, of the increase in RES is much faster than the necessary grid expansion required to transport it. Consequently, this is creating bottlenecks in transmission systems. To solve the resulting congestions, conventional power plants are used for preventive redispatch. Alternative solutions must be implemented as the availability of conventional power plants will decrease or even be phased out, and the costs for redispatch will increase tremendously. To help TSOs to solve these congestions, two courses of action may offer solutions. Firstly, the available grid may be balanced by the use of controllable devices as High Voltage Direct Current (HVDC) or Phase Shift Transformers (PST) to bypass these congested areas. Secondly, technical solutions for higher utilisation of the existing grid may be implemented. TSOs have already implemented Dynamic Line Rating (DLR) which is weather dependent and in certain situation allows the rating of the lines to be adjusted, and furthermore have developed concepts for a system-wide usage of congestion management. Additionally, new planned and implemented controllable devices are available, such as for example the Gridbooster, which offers significantly faster reaction times in grid events which may lead to congestions. Taking into account these faster reaction times and free thermal short-time capacities within the assets and lines, curative congestion management may unleash the unused potential of the grid. With respect to a coordinated system operation process, the curative usage of the above-mentioned devices may enable the higher utilisation of the grid. The potential of these approaches was examined by the German research project InnoSys 2030, which developed concepts for curative measures and published a roadmap for implementation. An initial Gridbooster pilot system in Germany (Audorf/Süd and Ottenhofen) should start operation in 2023. This will be used to test the innovative concept for higher utilisation of the transmission grid.

Influence of Russian – Ukraine war on the electricity sector

The outbreak of the war between Russia and Ukraine in 2022 resulted in the imposition of a series of sanctions on the Russian aggressor by the international community. The TSOs of the CCE region also supported the Ukrainian transmission system through its synchronization with the Continental Europe system and undertook the following activities:

- PSE has started discussion with Ukrenergo on preparations for possible actions on the common profile. Initial preparatory work will be carried out aiming at refurbishment and switching of the existing interconnector, which was out of operation between PL and UA, from 750 kV to 400 kV.
- In 2018 SEPS and Ukrenergo performed a bilateral common study to evaluate future system needs for the reinforcement of the Slovakia-Ukraine common profile when the lifetime of the current interconnector is reached. It will be decided whether the existing line will be either reconstructed as a single circuit line with increased load capacity or as a double circuit line after additional studies are performed.
- MAVIR informed that an upgrade of the existing 220 kV line which is not part of the synchronization is foreseen.
- Transelectrica informally agreed with Ukrenergo to include the 400 kV (former 750 kV) OHL Pivdennoukrainska NPP (Ukraine) – Isaccea (Romania) in the next edition of the TYNDP and National Development Plans. This line is already included in the PMI list of Energy Community.

Moreover, the war in Ukraine and the sanctions imposed on Russia have resulted in a significant increase in the prices of fuels and raw materials, influencing the pace of transformation of the manufacturing sector towards renewable energy sources. This situation threatened the continuity of energy supplies, in particular when gas sources were mostly based on fuel imported from Russia, supplies of which were cut off. The implications of the impact of gas price increases on the generation sector have been analysed in RegIP 2022 of RG CCE, the results of which are presented in Chapter 4.3 where it can be found that the change in gas price has a big influence on total system costs and produces a shift in merit order (coal before gas).

3.REGIONAL SYSTEM NEEDS

In TYNDP 2022, the IoSN study considered two-time horizons (2030 and 2040). The National Trends (NT) scenario was used for both of them, which is a bottom-up approach. The input data was provided by the TSOs themselves. The following chapter is divided into two sections covering each of the above-mentioned time horizons. The first subchapter will provide insight into identified system needs in the CCE region for 2030. A discussion of the results for 2040 can be found in the following subchapter. Furthermore, some of the more prominent parameters of system operation for both observed horizons are provided.

3.1.IoSN 2030 results

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

- 2025 grid (No investment after 2025),
- Grid expansion state considering existing projects in TYNDP (Existing projects are built),
- 2030 optimal grid (Economic needs).

This variation was carried out in order to see how the identified cross-border capacity increases will improve the situation in the power systems in terms of market indicators. The results of the IoSN 2030 study of the NTC increases in the CCE region are shown in Figure 9.

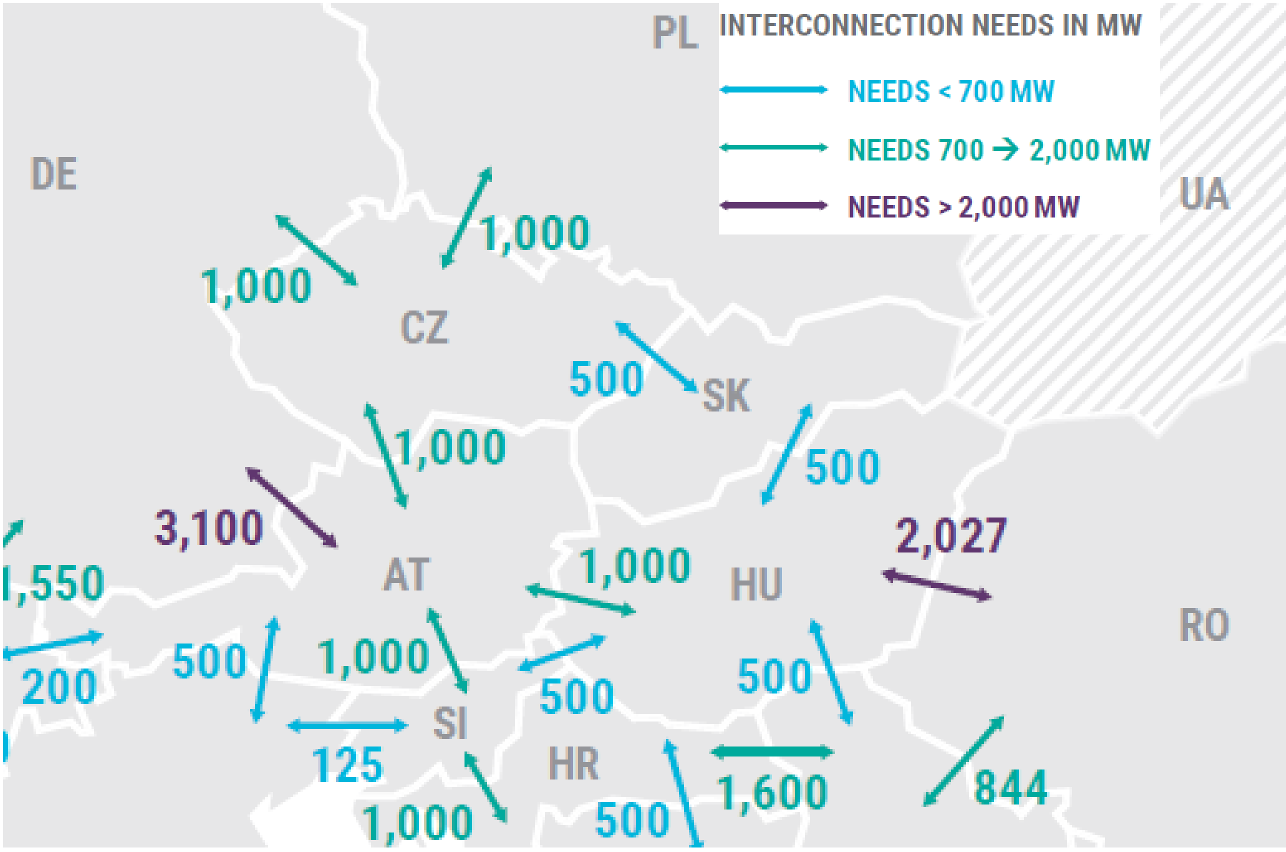


Figure 9 Map of identified capacity increases at the borders of the CCE region in 2030 time horizon

In Figure 10, the system costs (in M€ per country) for the NT 2030 scenario are compared for the different IoSN scenarios. The reduction of system costs is mostly visible for Poland and Germany, and is caused by a reduction of energy produced from coal. The needed energy is mostly substituted by imports from other regions. For CCE region a total system cost reduction of 1314 M€/year was calculated by comparing the economic needs grid and the case in which there is no additional investment after 2025.

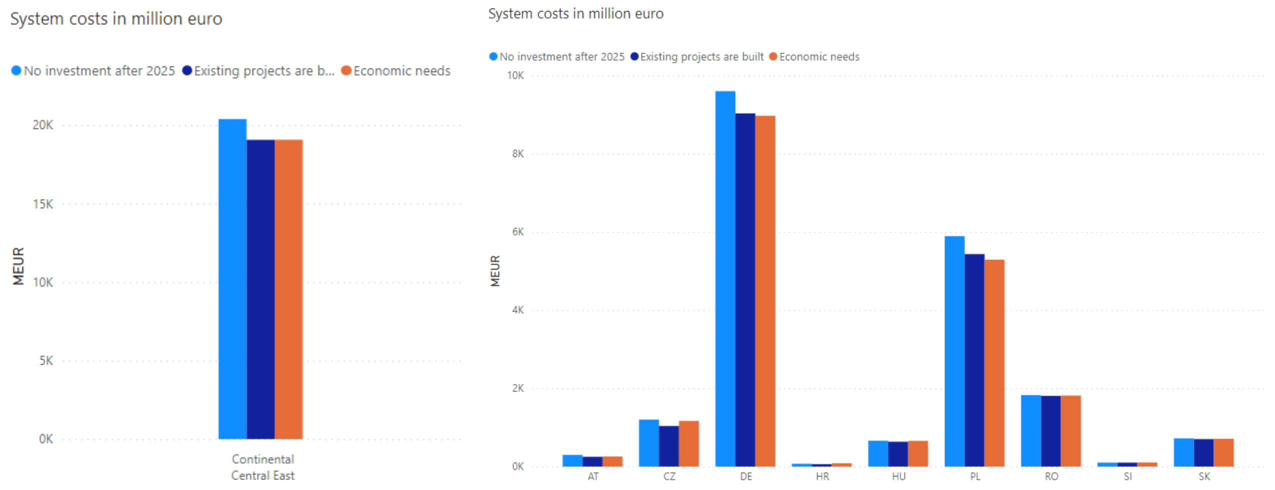
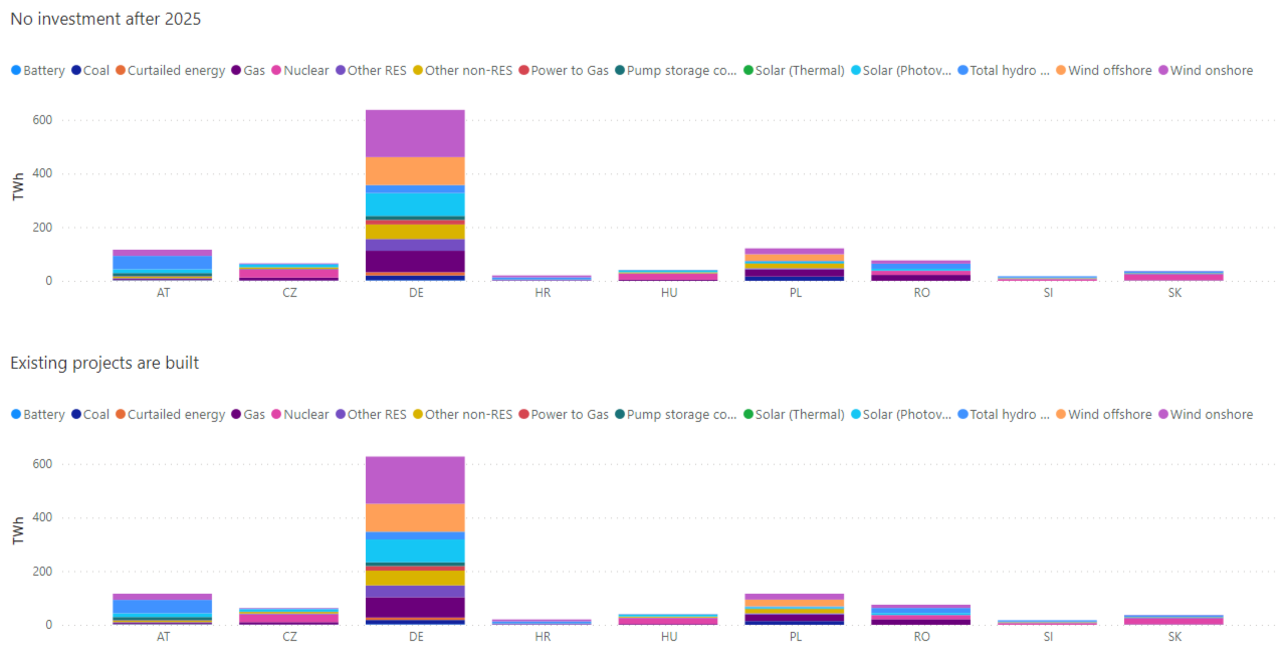


Figure 10 System Costs reduction in the CCE region in the NT 2030 scenario with identified capacity increases

The generation mix changes are shown in Figure 11. A noticeable decrease of generation from fossil fuels in Poland and Germany can be seen. There is higher usage of hydro generation in Austria, Poland, and Germany. Higher utilisation of RES is accompanied by the decrease of curtailed energy in Austria and Germany. In total (for the CCE region), there is a reduction of 12 TWh of thermal generation resulting from coal (5 TWh) and gas (7 TWh).



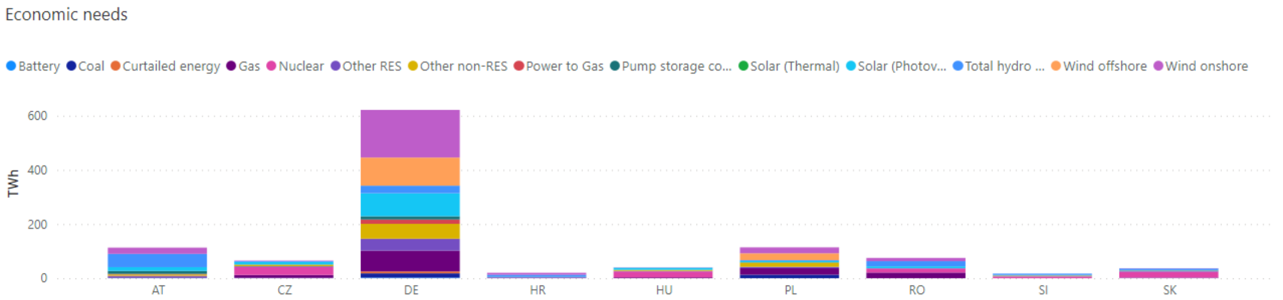


Figure 11 Generation Mix in the CCE region in the NT 2030 scenario with identified capacity increases

The curtailed energy for the NT 2030 scenario is compared with three different NTC values (Figure 12). Curtailed energy can be defined as a lack of storage capacities or adequate transmission capacities for export in a particular country due to a high level of non-dispatchable generation (e.g., wind or PV). In Germany, the values are relatively high and are largely dependent on scenario assumptions. This is a key indicator for the integration of RES into the future electricity system. The following figure clearly shows the importance of the expansion of the transmission grid and its positive impact on RES integration based on the reduced amount of curtailed energy.

Figure 12 Curtailed energy in the CCE region in the NT 2030 scenario with identified capacity increases

In Figure 13 the CO_2 emissions per country in the CCE region in MT are shown. Due to high thermal capacity in Germany, correspondingly high CO_2 emissions can be seen. The high CO_2 emissions in Poland can be explained by the high number of coal-fired power plants resulting in high levels of CO_2 emissions. The same reasons are valid for both the Czechia and Romania as well. The other countries in the CCE region are relatively small and do not have such a high demand for power, so their corresponding CO_2 emissions are lower compared to the other countries.

Figure 13 also illustrates the link between CO_2 emissions, the level of total generation and the CO_2 intensity of the power plants in the individual countries and the whole CCE region. As a result, the level of CO_2 emissions depends primarily on the scenario assumptions. Furthermore, it can be seen that network expansion can lead to a significant reduction in CO_2 emissions. This effect is independent of the chosen framework conditions for the future power system. It also demonstrates the importance of network expansion for achieving the climate targets, irrespective of the scenarios and their uncertainties.

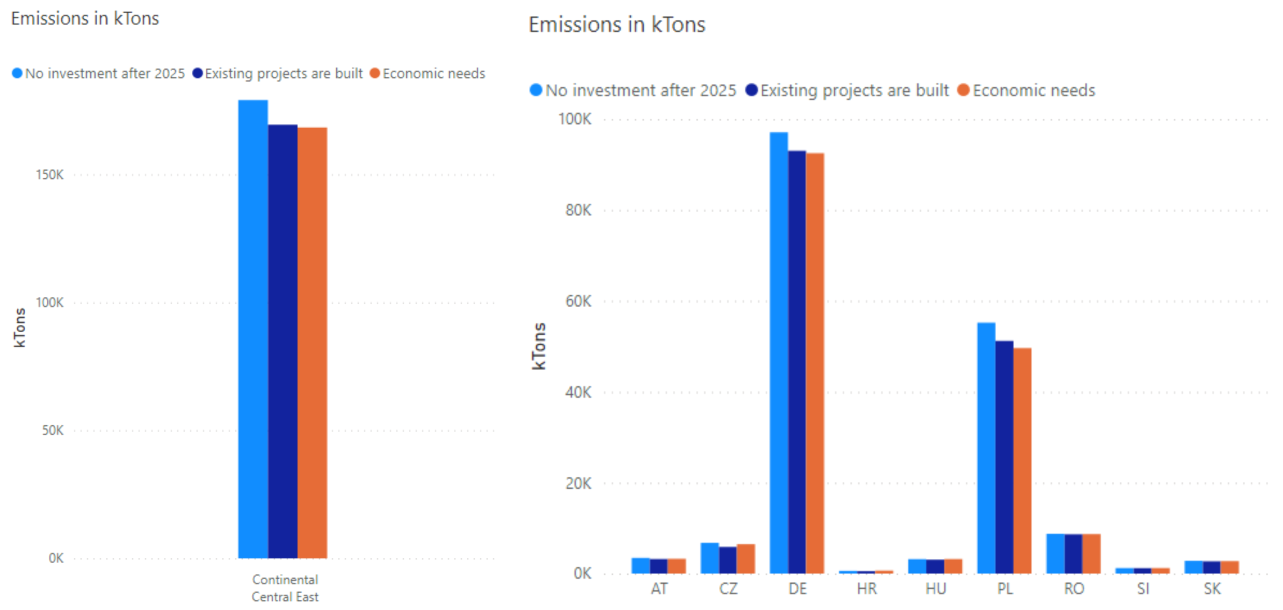


Figure 13 CO_2 emissions in the CCE region in the NT 2030 scenario with identified capacity increases

In Figure 14, yearly average marginal costs per country in the CCE region are shown. Average costs are lower in Germany than in neighbouring countries due to Germany's higher percentage of installed RES capacities in the 2030 scenario and a high amount of curtailed energy. For Austria, the average costs are lower due to a higher percentage of generation capacity from hydropower plants.

From this it can be derived, that a high proportion of old and new renewable energies leads to a lower absolute energy price for electricity – a clear competitive advantage for the region as a business location. The expansion of the grid has a strong reducing effect on marginal costs as well. This shows how important a strong and secure electricity transmission infrastructure is for the future economic development of the CCE region.

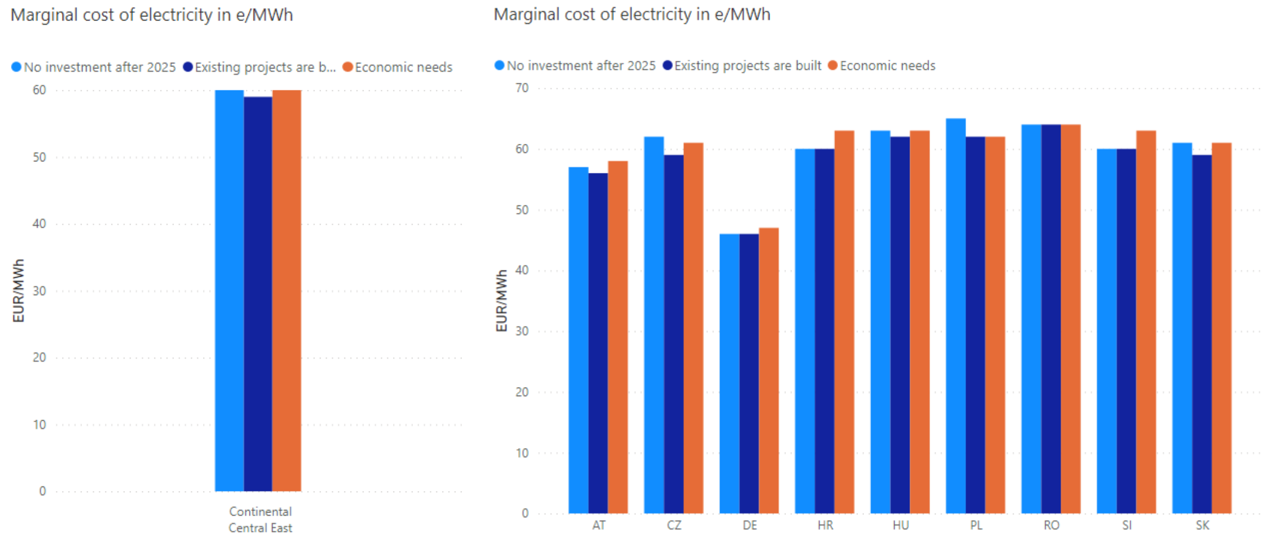


Figure 14 Yearly average of marginal cost in the CCE region in the NT 2030 scenario with identified capacity increases

Differences in the net annual country balance in the CCE region (see Figure 15) result from the optimisation of generation due to higher transfer capacities in the different grid expansion states. Due to the reduction of thermal power plants, the CCE region is increasingly an importer of energy. Poland tends to be a major importer.

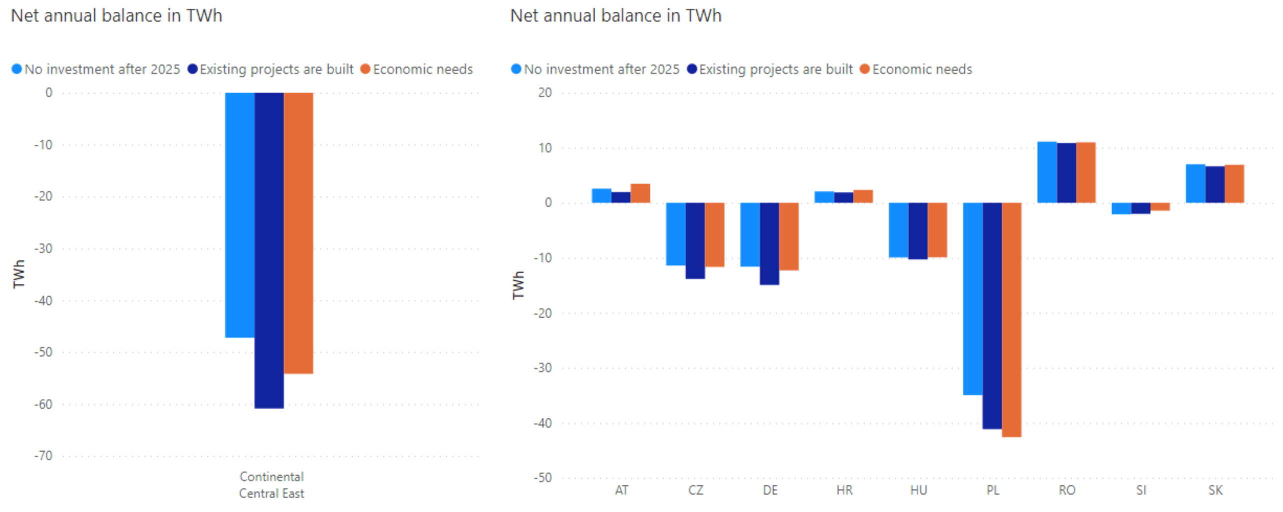


Figure 15 Net annual country balance in CCE region in NT 2030 scenario with identified capacity increases

3.2.IoSN 2040 results

In this section, the following figures and charts show the results of the final pan-European market studies of the NT 2040 scenario. The grid expansion states are equivalent to the analysis in chapter 3.1:

- 2025 grid (No investment after 2025),
- Grid expansion state considering existing projects in TYNDP (Existing projects are built),
- 2040 optimal grid (Economic needs).

This variation is carried out in order to see how the identified cross-border capacity increases will improve the situation in the power systems in terms of market indicators. The results of the IoSN 2040 study regarding capacity increases in the CCE region are shown in Figure 16.

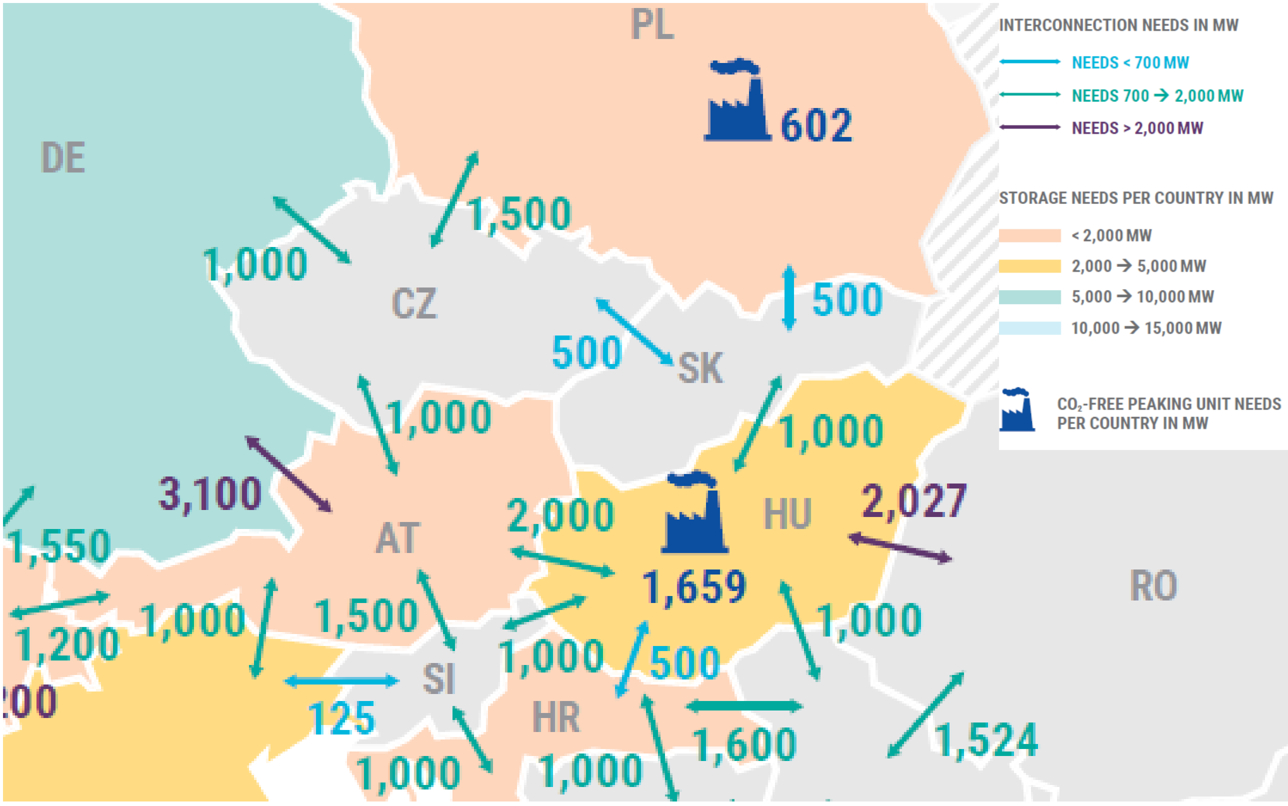


Figure 16 Map of identified capacity increases at the CCE region borders in the 2040 time horizon

In Figure 17, the system costs for the NT 2040 scenario are compared with reference to different cross border capacities. The first case shows a grid expansion state with no investments after 2025, the second one assumes that existing planned projects are built, and the third one is based on the Economic Needs scenario. The reduction of system costs is mostly visible for Germany, Poland, and Czechia. This is caused by a reduction of energy produced from thermal plants and by the enabled usage of curtailed energy. The needed energy is substituted mostly by renewables from Germany and by imports. The highest system cost reduction (2620 M€/year) for the CCE region was calculated for the comparison between the Economic Needs grid and the 2025 grid.

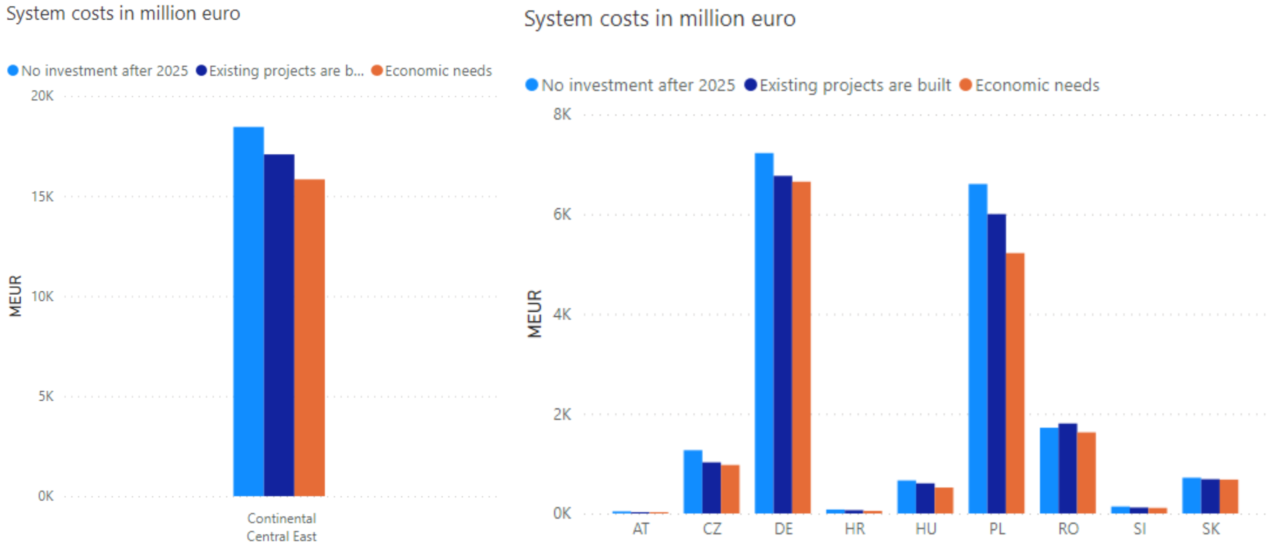


Figure 17 System costs reduction in the CCE region in the NT 2040 scenario with identified capacity increases

The generation mix changes are shown in Figure 18. A noticeable decrease of generation from fossil fuels mainly in Czechia, Poland and Germany can be seen. There is higher usage of hydro power plants in Austria and Germany. Higher utilisation of RES results in a decrease of curtailed energy in Austria and Germany. In total, there is a reduction of 26 TWh of thermal generation: 5 TWh from coal and 21 TWh from gas.

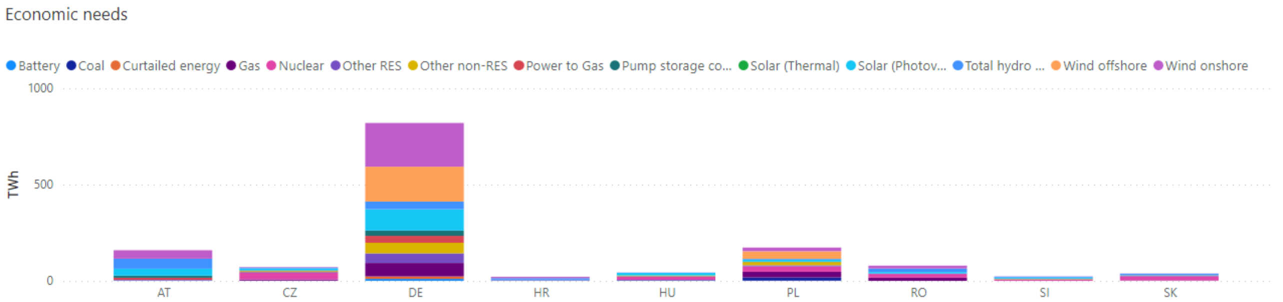


Figure 18 Generation mix in the CCE region in the NT 2040 scenario with identified capacity increases

In Figure 19, the curtailed energy for the NT 2040 scenario is shown for different cross border capacity values. In Germany and Austria, the values are relatively high and are largely dependent on scenario assumptions. The figure clearly shows the importance, as a key indicator for the integration of RES into the future electricity system, of the expansion of the transmission grid and its positive impact on RES integration resulting from a reduced amount of curtailed energy.

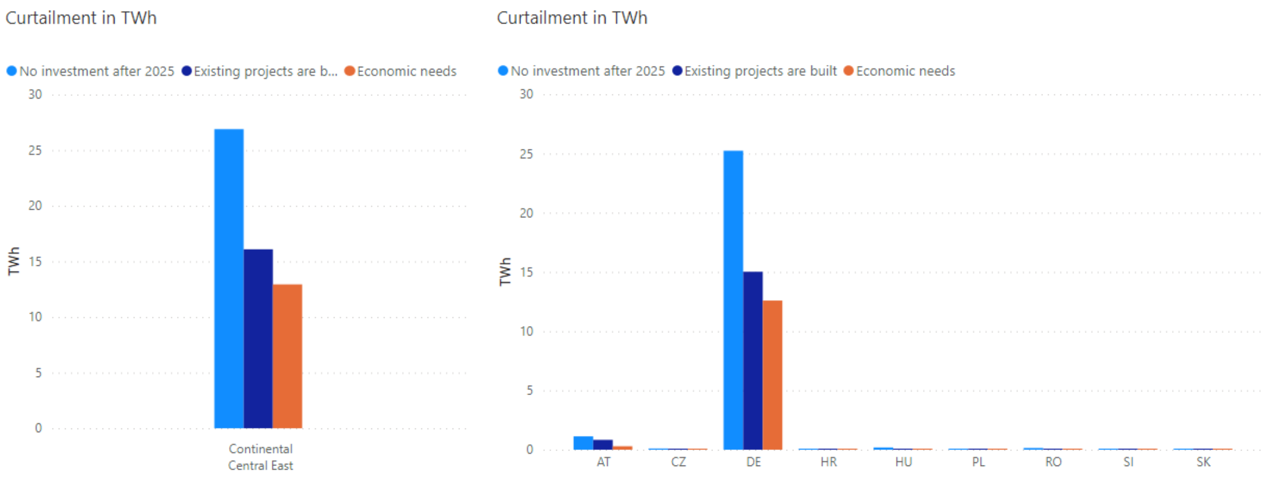


Figure 19 Curtailed energy in the CCE region in the NT 2040 scenario with identified capacity increases

Figure 20 shows the CO_2 emissions per country in the CCE region. Due to high thermal capacity in Germany and Poland, correspondingly high CO_2 emissions can be seen. The high CO_2 emissions in Poland and Germany can be explained by the high number of coal- and gas-fired power plants, respectively. The same reasons are valid for both Czechia and Romania as well. The other countries in the CCE region are relatively small and do not have such a high demand for power, so their corresponding CO_2 emissions are lower.

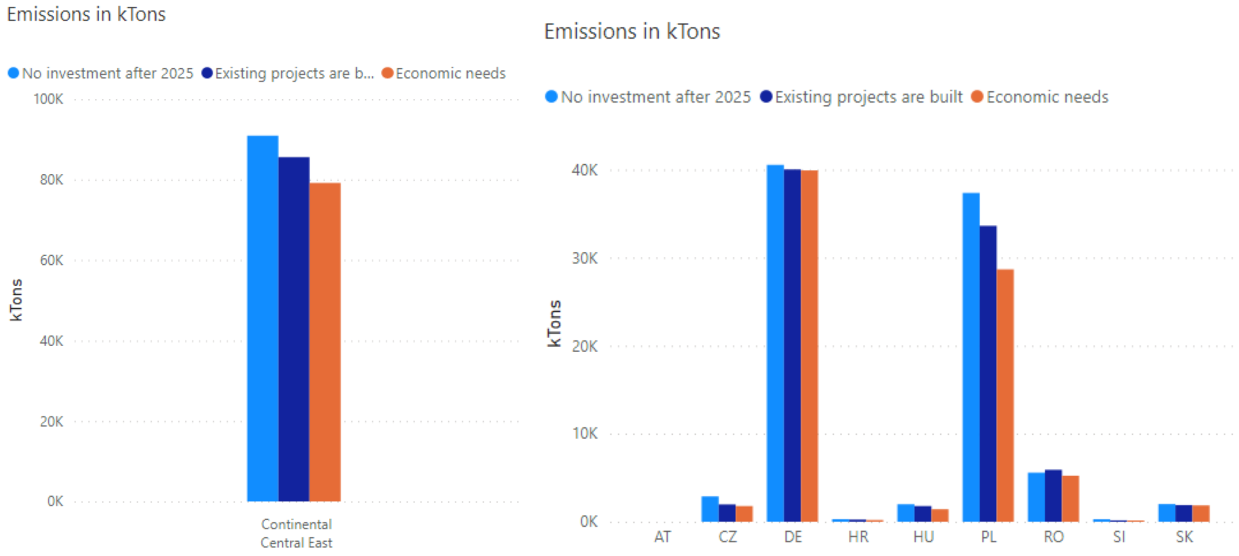


Figure 20 CO_2 emissions in the CCE region in the NT 2040 scenario with identified capacity increases

In Figure 21, the yearly average marginal costs per country in the CCE region are shown in €/MWh. With no investment in the grid after 2025, the average costs are lowest in Germany, compared to the other CCE countries, due to high RES generation in the NT 2040 scenario. With investments in SEW-based needs, a much lower spread of the marginal costs in the region can be noticed.

From this it can be derived that a high proportion of old and new renewable energies lead to a lower absolute energy price for electricity – a clear competitive advantage for the region as a business location. The expansion of the grid has a strong reducing effect on marginal costs as well. This shows how important a strong and secure electricity transmission infrastructure is for the future economic development of the CCE region.

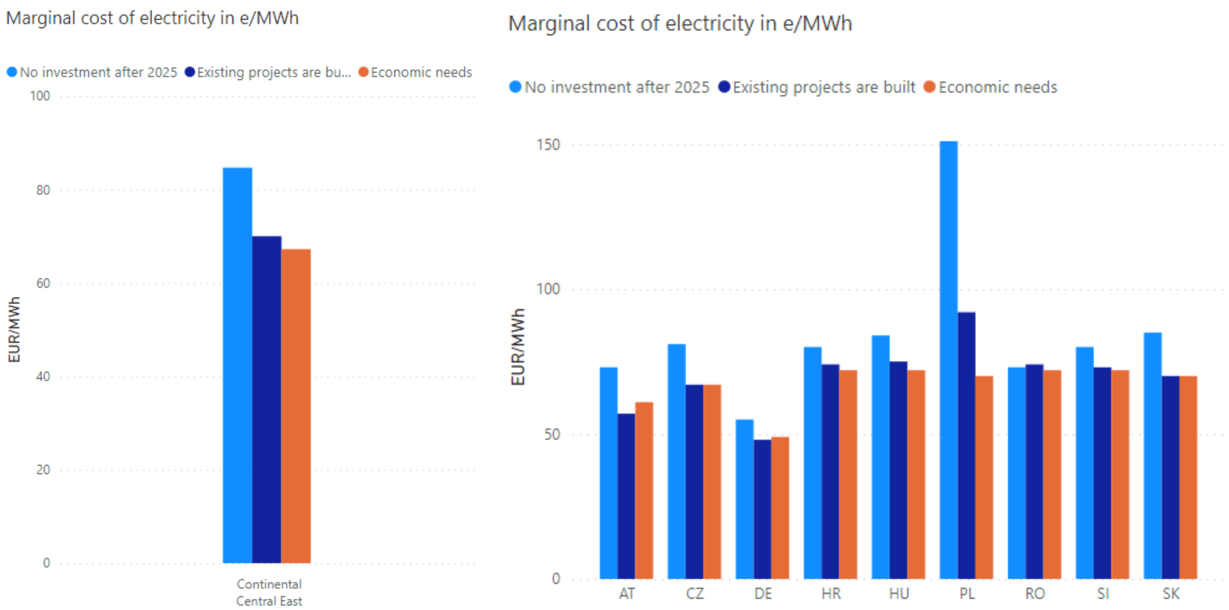


Figure 21 Yearly average of marginal cost in the CCE region in the NT 2040 scenario with identified capacity increases

In Figure 22, the net annual country balances in the CCE region are shown. The difference of the net annual country balance in the CCE region power systems between NT 2040 (2025 grid) and NT 2040 (Economic Needs grid) results from an optimisation of generation empowered by higher transport capacities (grid expansion). Due to the reduction of curtailed energy mostly in Germany and a reduction of thermal generation mainly in Poland, Germany and Czechia, a decrease in energy exported by the CCE region can be seen. Germany together with Austria and Romania become the main exporters in the region while Czech, Hungary and Poland tend to be major importing countries.

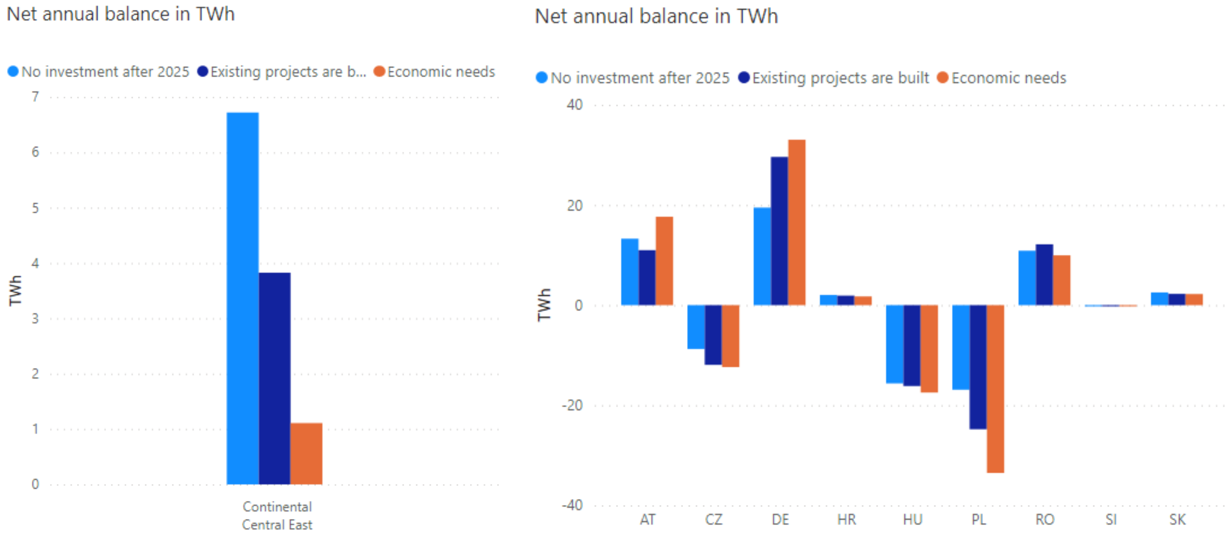


Figure 22 Net annual country balance in CCE region in the NT 2040 scenario with identified capacity increases

4.REGIONAL STUDIES

In order to demonstrate the challenges faced by the CCE region's power systems in the future time horizons, additional regional studies have been carried out. A detailed analysis of the evolution of the electricity sector in CCE region has been carried out, followed by a comparison of the future generation mix assumptions in the two most recent TYNDPs (TYNDP2020 and TYNDP2022). Other studies have analysed the impact of gas and CO_2 prices on the CCE region and respectively, the reduction or scarcity of some vulnerable generating capacities such as nuclear, gas and lignite with coal (defined by each RG CCE member), on the overall results obtained for the 2030 NT scenario conducted at ENTSO-E level. The detailed specifications of the sensitivity studies are discussed below.

4.1.Detailed analysis of the evolution of electricity sector in the CCE region

Following the evolution of the EU legislation on climate change and its ambitious targets for 2030, one of the major changes in the electricity sectors in the CCE region is represented by the massive integration of renewable sources into the generating capacity of the region. Between 2010 and 2020, wind and solar power plants doubled their participation in the total installed capacity of the region from 18% to 37%, and this is expected to reach as much as 57% by 2030 according to the NECPs of the CCE countries. This is reflected in the NT 2030 scenario.

In the same context, the negative trend of the fossil fuel share of total installed capacity will continue, from the dominant figure of 55% in 2010 to 42% in 2020 and 27% in 2030.

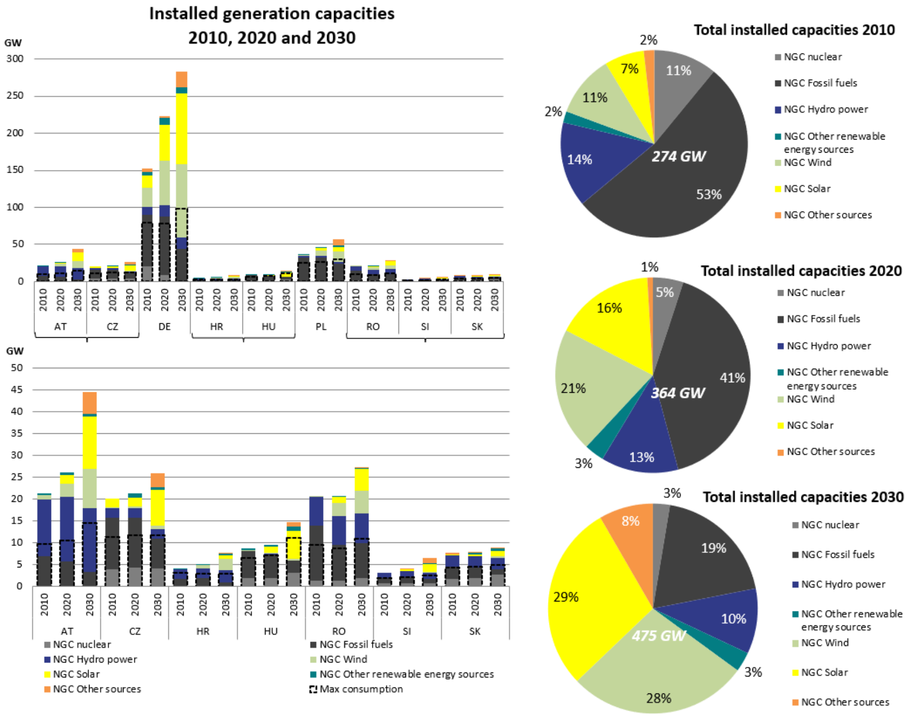


Figure 23 Comparison of installed net generation and load capacities in the CCE region between 2010, 2020 and 2030

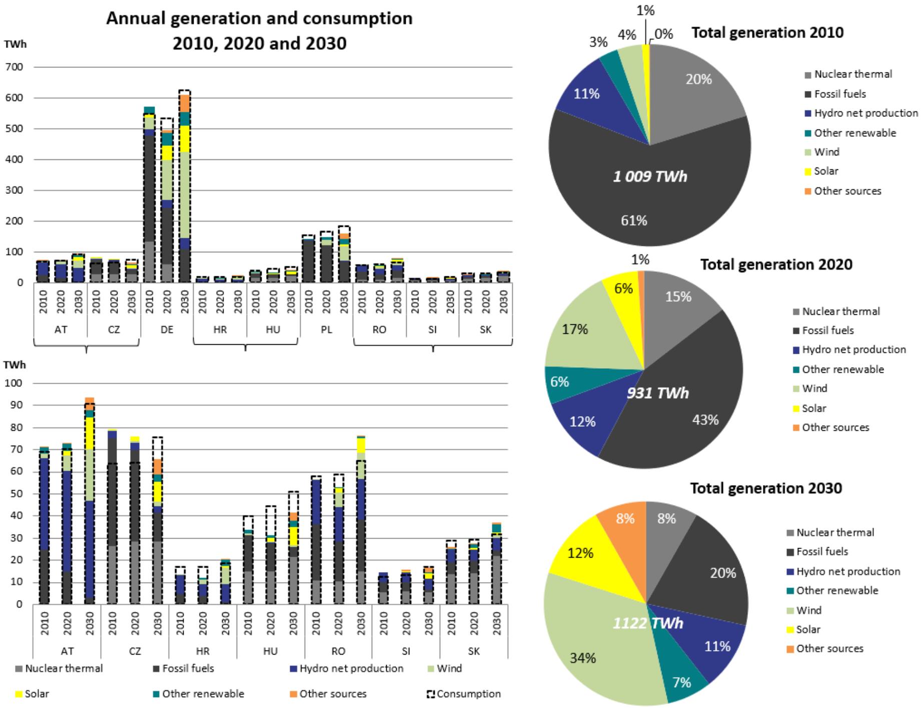


Figure 24 Comparison of annual generation and consumption in the CCE region between 2010, 2020 and 2030

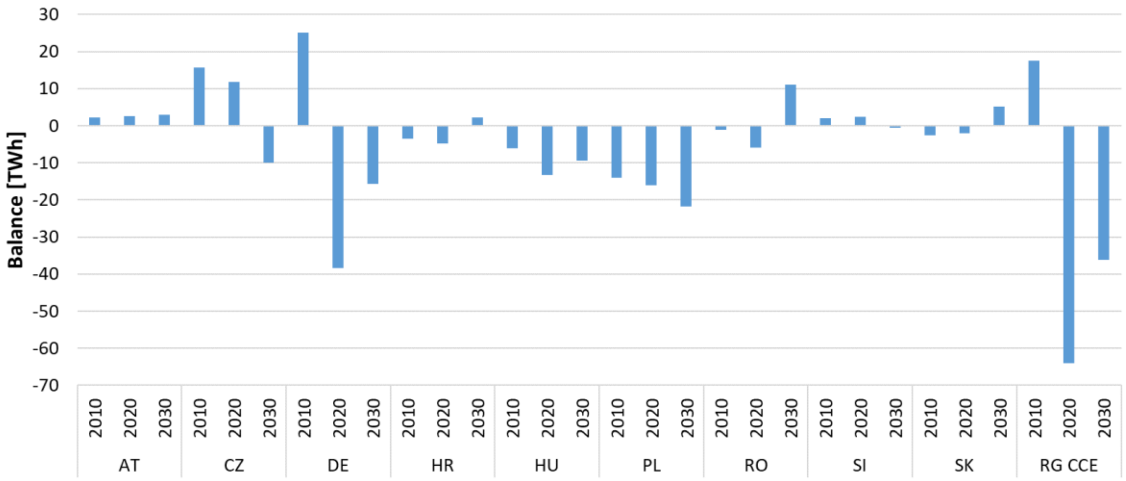


Figure 25 Comparison of annual net balance in the CCE region between 2010, 2020 and 2030

Consistent with these changes in generation capacity, the share of carbon-free electricity in the total production of the region has increased from 39% in 2010 to 56% in 2020 and it is projected to reach **72%** by 2030.

Although electricity consumption was approximately the same between 2010 and 2020, showing a 0.3% historical increase in this period, the region turned from a net exporter (+17.4 TWh in 2010) to a net importer (-64 TWh in 2020).

The projections for the 2020–2030 period, however, indicate an overall 16.4% demand increase in the region, with 3% of the total electricity consumption in 2030 being covered by imports.

4.2.Detailed analysis of the data in the TYNDP 2020 and TYNDP 2022

This analysis focuses on the evolution of the NT 2030 scenario between TYNDP 2020 and TYNDP 2022. The main objective is to compare assumption changes (installed capacities for the 2030 horizon in the CCE region, CO_2 cost, etc.) and the impact of the merit order switch on different categories of power generation and on market node balances. The aim of this analysis is to check the effect of possible differences in the parameters mentioned above.

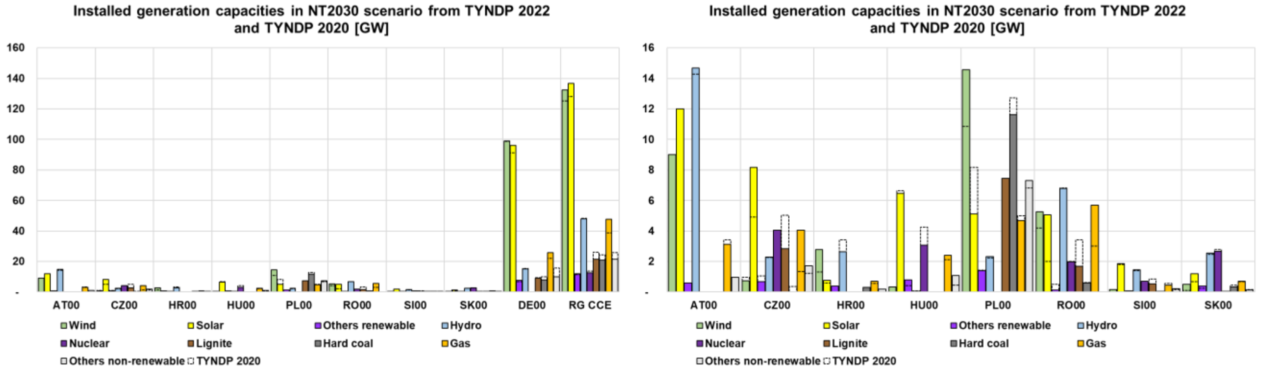
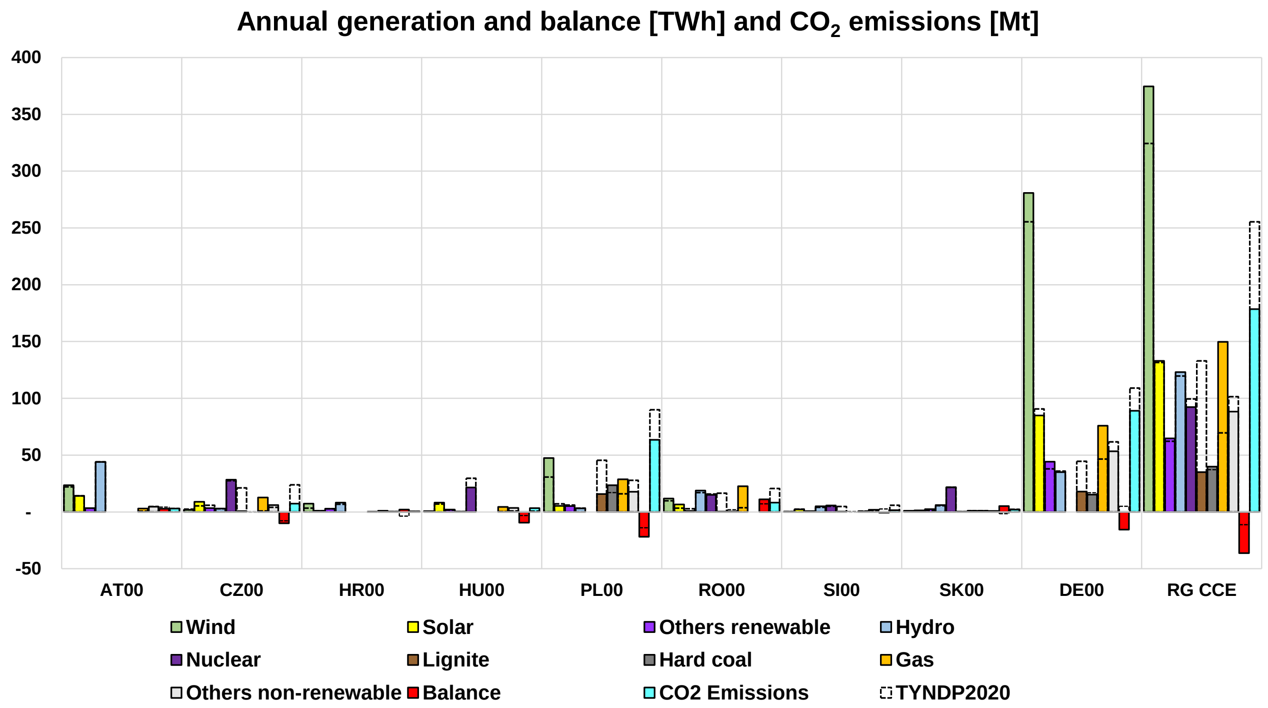


Figure 26 Comparison of install generation capacities in NT 2030 scenario from TYNDP 2020 and TYNDP 2022

A comparison of installed capacities in the CCE region shows a consistent approach in the 2030 outlook. Slightly higher targets for RES, plus decommissioning of fossil generation, indicate the goal to achieve climate neutrality by 2050.



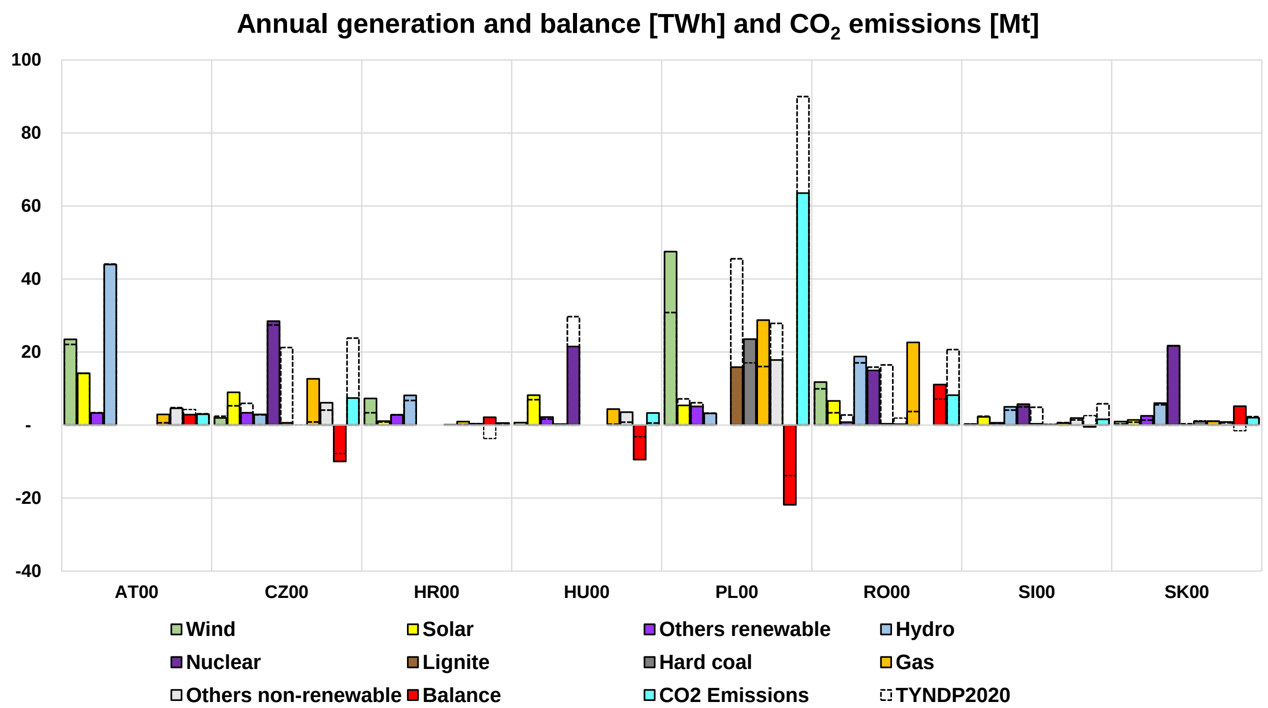


Figure 27 Generation, balance, and CO_2 emissions in TYNDP2022 NT2030 and TYNDP2020 NT2030

The merit order switch between gas and coal is apparent from the generation comparison. This is a result of higher CO_2 prices in the TYNDP 2022 scenario. These assumptions cause a higher import of energy to the CCE region in TYNDP 2022 in comparison to TYNDP 2020, but with much less CO_2 emissions.

4.3.Gas and CO_2 price sensitivity analysis

Thermal power plants based on fossil fuels that produce high levels of CO_2 make up the most substantial part of the power generation mix in some CCE power systems. Furthermore, the clean energy transformation was foreseen as involving gas power plants playing a significant role. Therefore, changes in CO_2 and gas prices significantly affect balances and load-flow patterns in the CCE region.

This sensitivity analysis was executed for scenario NT2030 from TYNDP2022. The CO_2 price of scenario NT2030 (70 €/ton) was changed to a price reflecting recent trends (90 €/ton) and the gas price was also increased from 6.77 €/net GJ to 22.22 €/net GJ.

These simulations were carried out to show how balances and cross-border flows in the CCE region could be affected by changes in CO_2 and gas prices.

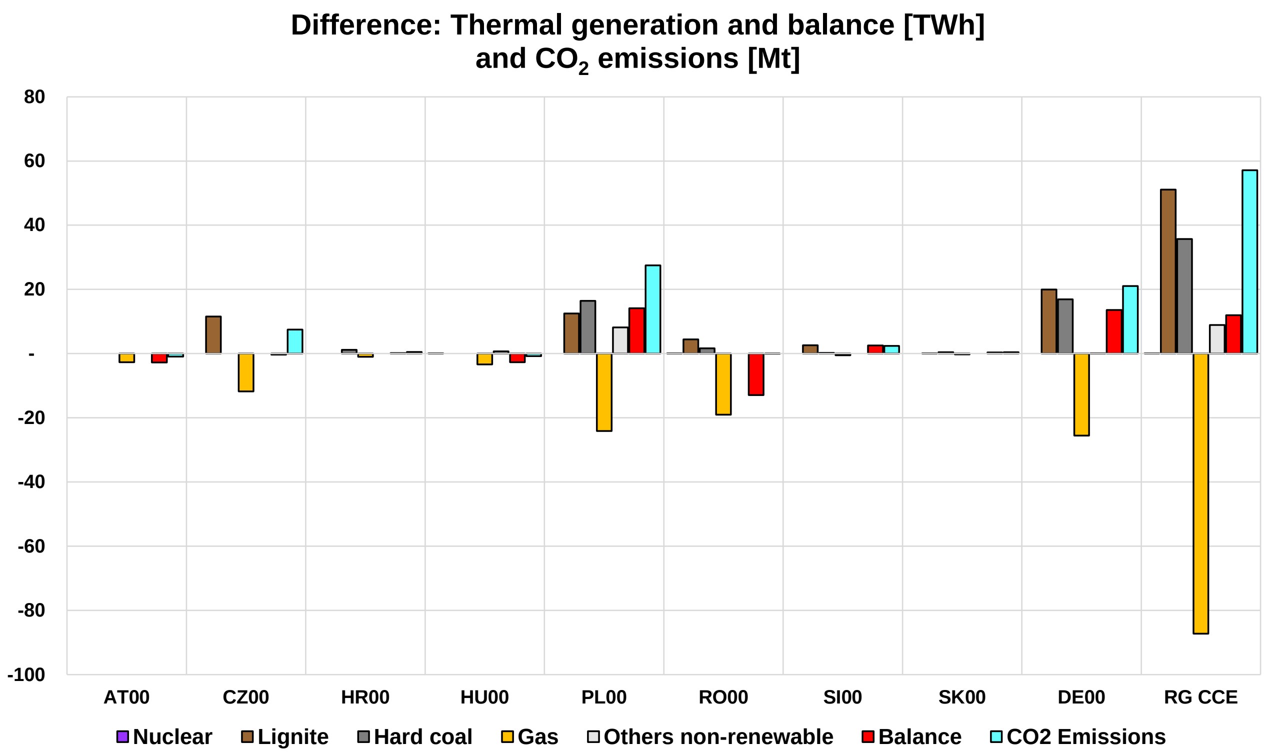


Figure 28 Thermal generation, balance, and CO_2 emissions differences – price sensitivity case as the reference case

This sensitivity shows a merit order switch to coal/lignite powerplants due to the higher dispatch costs of gas powerplants. The total balance of the CCE region changes only slightly, because active coal and lignite powerplants which were not fully utilised in the reference scenario exist. This change also increases the total CO_2 emissions of the CCE region.

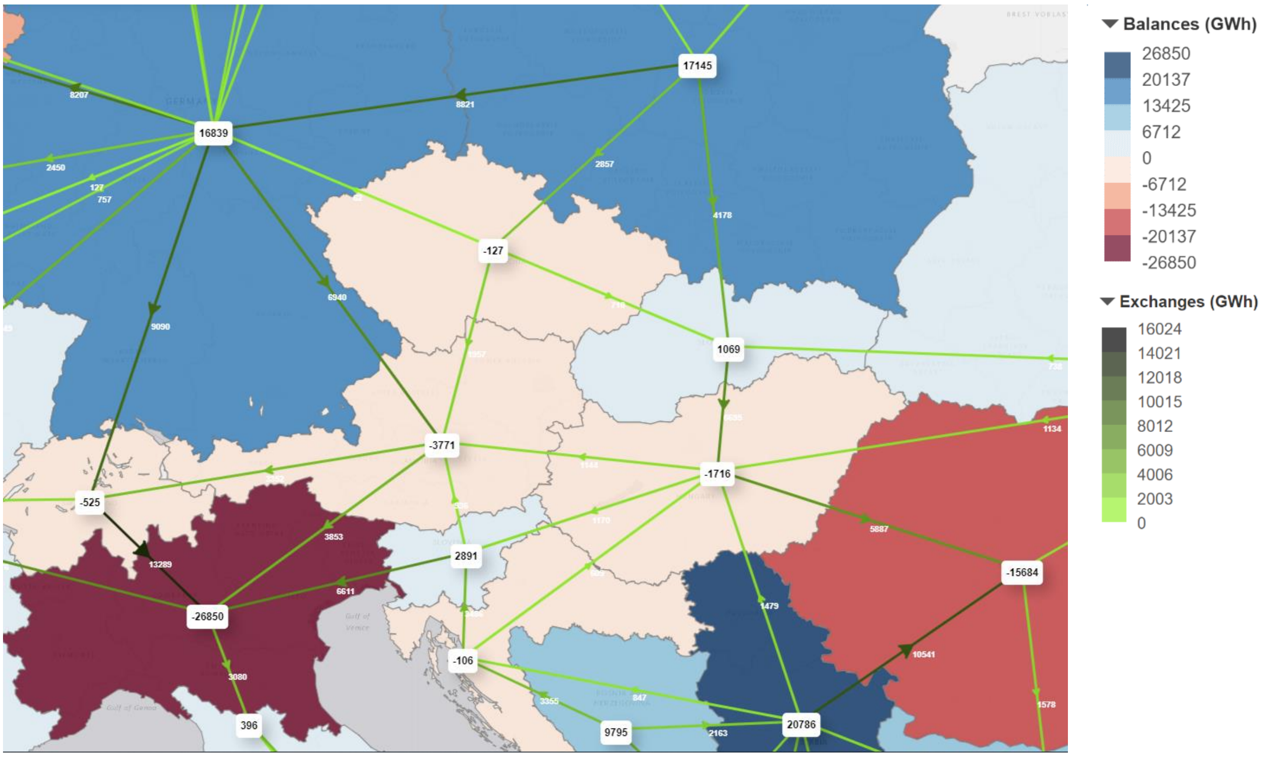


Figure 29 Market flows and bidding zone balance differences – price sensitivity case as the reference case, one tool, climate year 2009

4.4.Thermal capacity sensitivity analysis

Since the coal phase-out is only partially taken into account in the base 2030NT scenario, the challenges of more coal power plant retirements (in DE, RO) combined with the uncertainties related to the commissioning dates of the new gas (CZ, HU, RO) and nuclear (RO) power plants have been addressed, in order to expand the picture of the energy security challenges faced by the RG CCE countries in the long term.

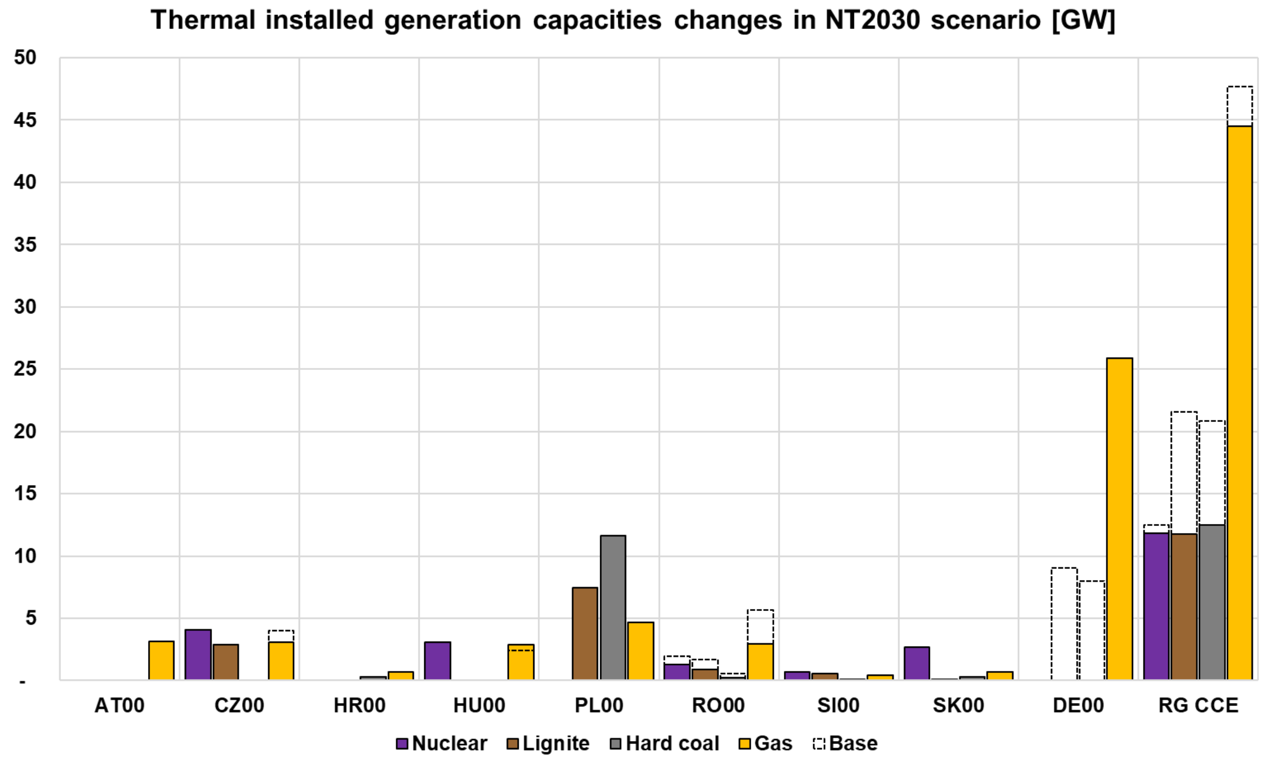


Figure 30 Comparison of thermal installed capacities between the base case and the sensitivity

Thus, a generation capacity decrease of more than 22 GW may be expected in the region by 2030. The accelerated coal phase-out in DE and RO will lead to an additional retired capacity of about 9.8 GW on lignite and 8.4 GW on hard coal, representing a reduction of more than 17% of the total thermal capacity available within RG CCE in the 2030 NT base case scenario.

Given this reduction and the delay in the commissioning of one new nuclear unit of 665 MW in Romania, the nuclear power plants in the region reach a 14% share in the generation capacity mix.

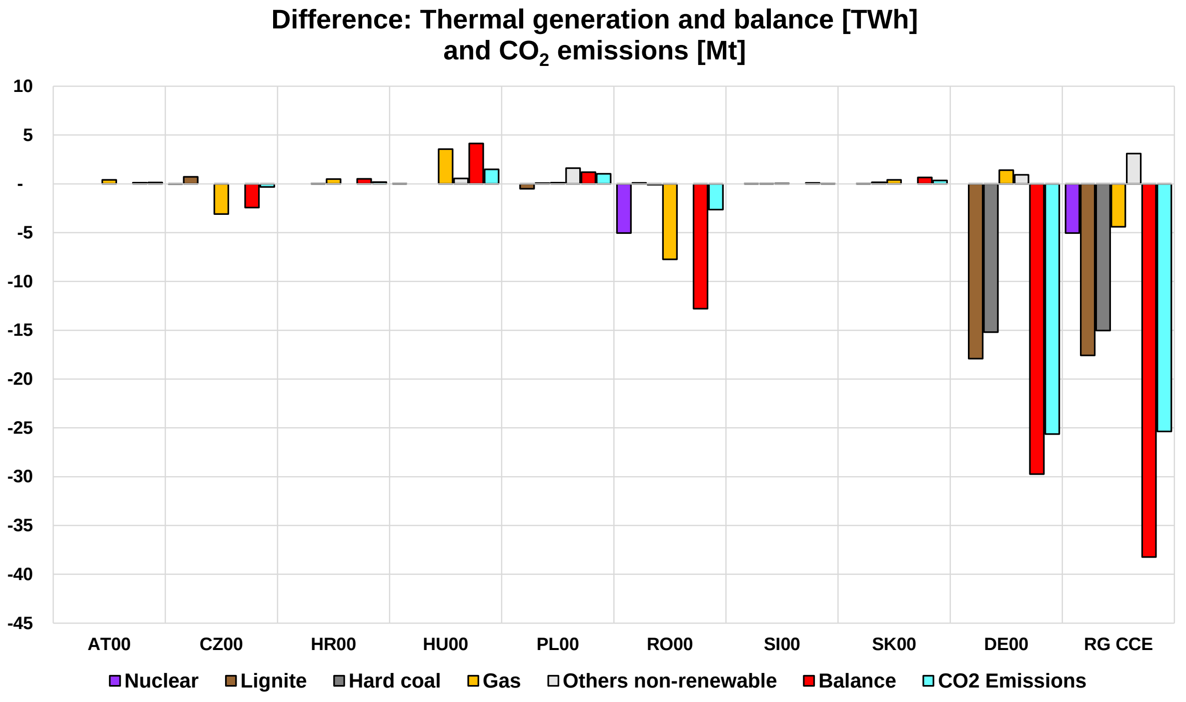


Figure 31 Thermal generation, balance, and CO_2 emissions differences – thermal PP sensitivity case as the reference case

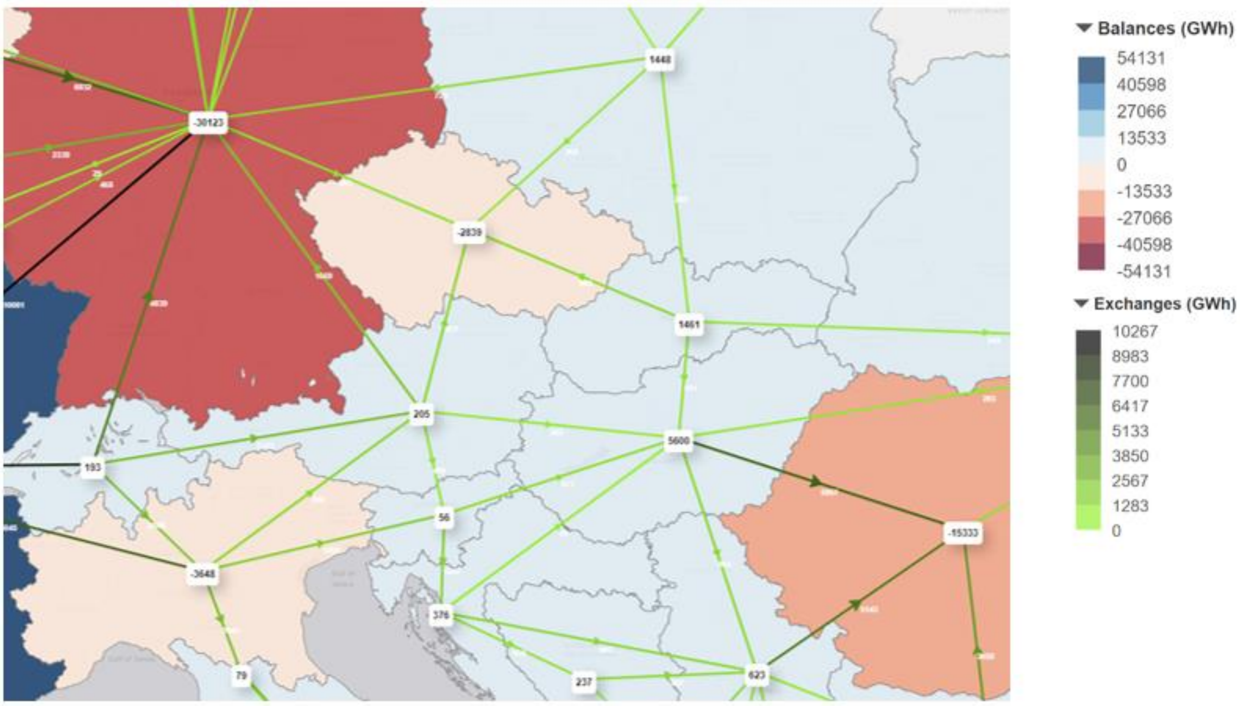


Figure 32 Market flows and bidding zone balance differences - thermal PP sensitivity case as the reference case, one tool, climate year 2009

Figure 31 shows the thermal generation, balance, and CO_2 emissions differences for the thermal capacity sensitivity. The current character of the region causes it to increasingly import energy due to the phasing out of traditional thermal plants. There is also a noticeable reduction of CO_2 emissions in the CCE region. Furthermore, market simulations show the reduction of thermal capacities not causing adequacy issues. This will be only possible if there will be enough investment for the development and modernisation of the network grid.

A shift of market flows and balances is shown in Figure 32. The energy missing in the CCE region is substituted by increased generation from nuclear power in France due to the relaxation of must-run constraints on decommissioned thermal powerplants in Germany and Romania. This situation may cause the CCE region to rely heavily on one country, which might be risky in case of unexpected outages.

4.5.Conclusion

From a market perspective, none of the sensitivity analyses leads to a load coverage problem in the CCE region. The region remains an importer in the base case and all the sensitivities.

Due to higher CO_2 and gas prices, a merit order switch to coal/lignite resulting from the higher dispatch costs of gas powerplants is observed. This change heavily increases the total CO_2 emissions of the CCE region by up to 60 Mt.

The current character of the CCE region causes it to increasingly import energy due to the phasing out of traditional thermal plants. There is also a noticeable reduction of CO_2 emissions in CCE region. This will be only possible if enough investment is made in the development and modernisation of the network grid.

Each of the sensitivities indicates a different additional transport need in the CCE region and demonstrates the importance of robustly planned infrastructure.

5.FUTURE CHALLENGES IN THE REGION

In this chapter the main future challenges in the CCE region are presented and analysed. These challenges are causing the changes in the balances of CCE countries and impact load-flow patterns in the region. This is then the main driver for grid development, which needs to be robust enough to capture all the potential challenges discussed below.

5.1.Generation mix change

The main future challenge facing the CCE region will be the change in the generation mix in the TSOs in a future development scenario. This is mainly due to the development in RES and their integration into European power systems, as this is one of the EU's most important future goals. Another very important reason is the differences in the energy policies of the CCE countries and open, long-term perspectives regarding the structure of the generation mix.

All generation mix changes (compared to the current situation) discussed below are already captured in the TYNDP 2022 scenarios. Therefore, their impact will be seen in "TYNDP 2022 – Identification of System Needs" (IoSN) as well as in the CBA analysis of the process.

The development of RES and their integration into European power systems is one of the key goals of the Commission's broader energy and climate objectives, which needs to be met in order to reduce greenhouse gas emissions, diversify energy supplies and improve Europe's industrial competitiveness. All EU members have to follow these guidelines and have to fulfil the binding targets set by 2030. These facts also have to be taken into consideration by TSOs, which have to cope with increasing RES capacities and generation in the future development scenarios, mainly by means of transmission system development.

Figure 33 shows comparisons of the installed RES capacities in 2020, 2030 and 2040. For the 2030 and 2040 scenarios, the ranges of the installed RES capacity values are derived from the minimum and maximum value of RES capacity in the three scenarios. A clear picture of increasing RES capacity in all the future scenarios can be seen, as throughout the whole CCE region there is expected to be an increase in RES of approximately 70–125% between 2020 and 2030 and 125–300% between 2020 and 2040. In most CCE countries, RES installed capacity is expected to double from today's levels by 2030 at minimum and is expected to increase further by 2040.

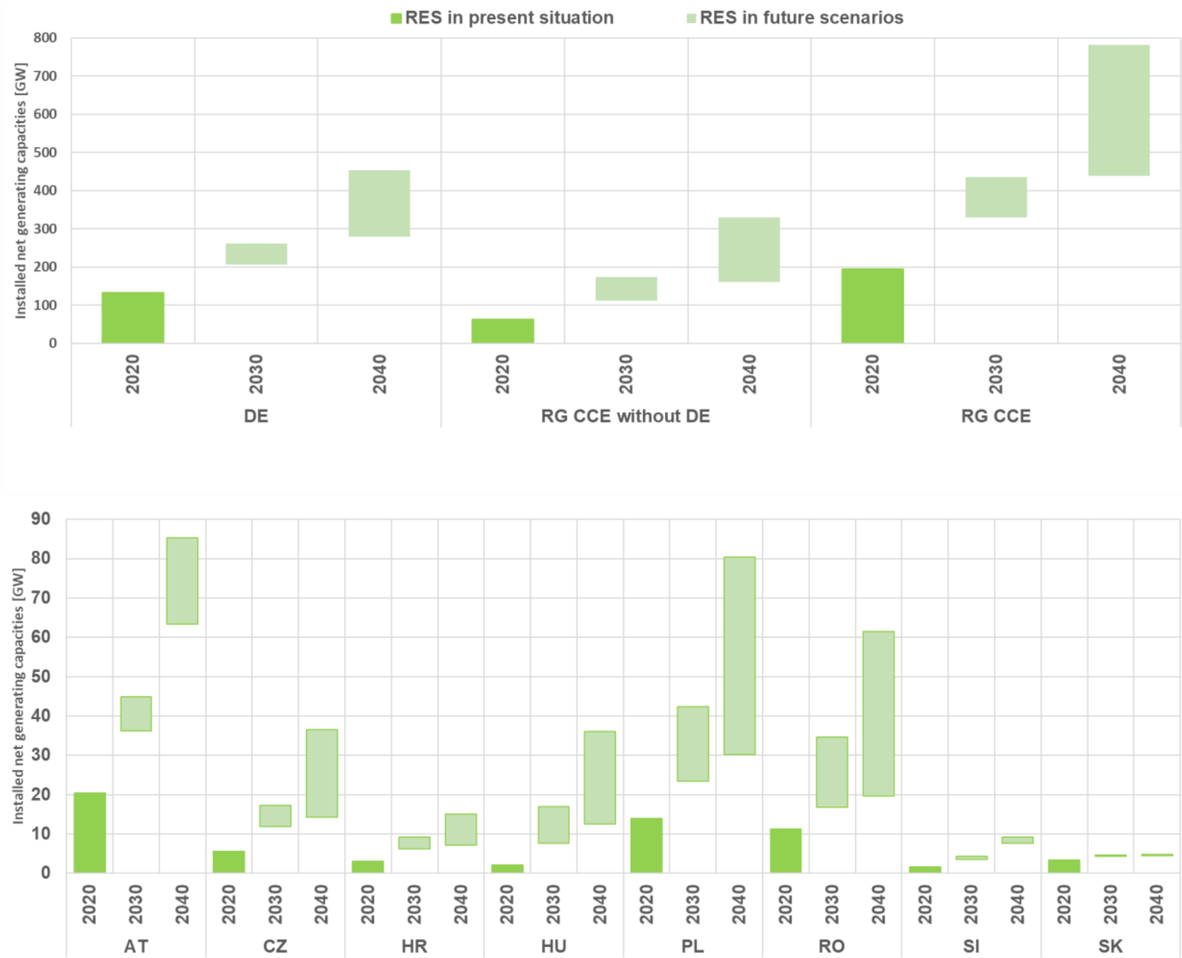


Figure 33 Development of installed RES capacity between 2020, 2030 and 2040 in the CCE region

The differences in the energy policies of CCE countries and open long-term perspectives regarding generation mix structure are also key elements in generation mix change in future scenarios. On the one hand, Germany is aiming to shut down all its nuclear plants by 2022, while Austria does not countenance having nuclear power in its energy portfolio at all. On the other hand, the future energy portfolios of countries like Czechia, Hungary, Romania, Slovakia, Slovenia and Poland all contain a certain share of nuclear power in future scenarios. However, every new nuclear power plant project is always subjected to thorough scrutiny by governments, NRAs, TSOs, neighbouring countries, etc.

The above-mentioned facts are supported by the exact values for installed nuclear power plant capacities given in Figure 34, mainly with regard to Germany's nuclear phase-out from 10 GW in 2018 to 0 GW in 2022 and future development of nuclear capacities in Poland with approximately 4.5 GW possible in 2040. In Czechia, Hungary, Romania, Slovenia, and Slovakia, both minor and major nuclear power projects are being considered. A decrease of installed nuclear capacities in the CCE region is expected by 2030 due to Germany's nuclear phase-out. Since the completion of new nuclear power plants comes with huge uncertainty, due to reasons mentioned above, significant decreases and slight increases (compared to 2020) by 2040 are considered.

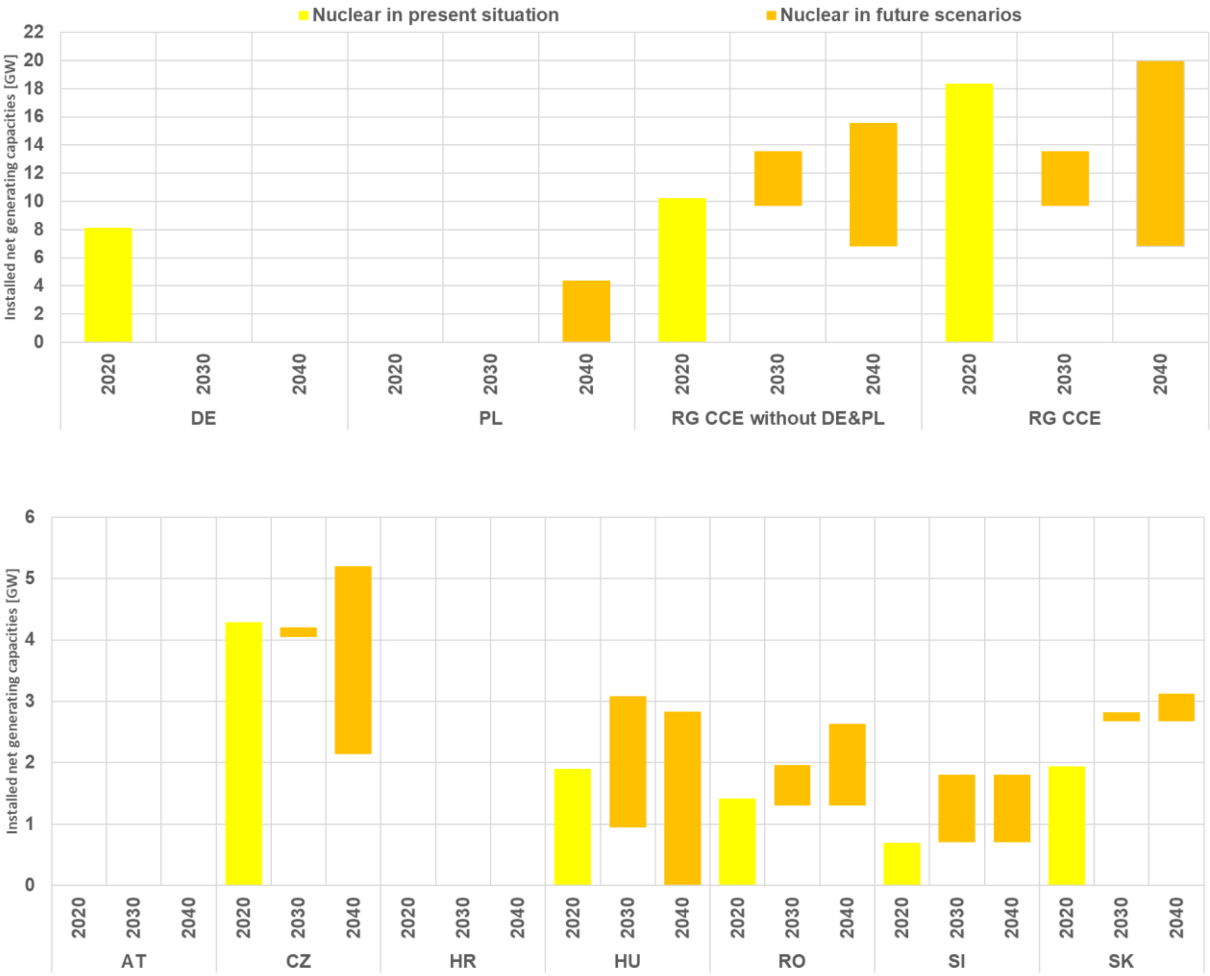


Figure 34 Development of installed nuclear capacity between 2020, 2030 and 2040 in the CCE region

With regard to fossil power plants in particular, there is no common policy for the use of coal and lignite power plants in the CCE countries. Some of the countries expect to shut down their thermal power plants as soon as is feasible, as investments into their modernisation are not beneficial. Other countries, meanwhile, are considering them in their future energy portfolios as they will be needed in order to maintain the secure operation of their energy networks. Figure 35 shows that slight or significant decrease is considered by 2030 and 2040 in each CCE power system in future scenarios, while in Austria a possible phase-out in fossil fuel power plants is considered by 2040. In the CCE region as a whole, an overall decrease in fossil fuels is expected.

The increase in installed RES capacities also has big impacts on the use of already installed conventional, nuclear and hydropower plants, and their generation depends on market prices. In the past, market prices were mainly driven by energy load, but in recent years market prices are being increasingly influenced by variable renewables (like wind). Due to the likely further increase in RES capacity, this influence will continue to increase, leading to changes in the infeed pattern of the other power plants. For these power plants, it will be challenging to be flexible and rentable.

A more detailed description of the potential evolution of the power generation mix in the CCE region in future scenarios is discussed in Chapter 3.2.

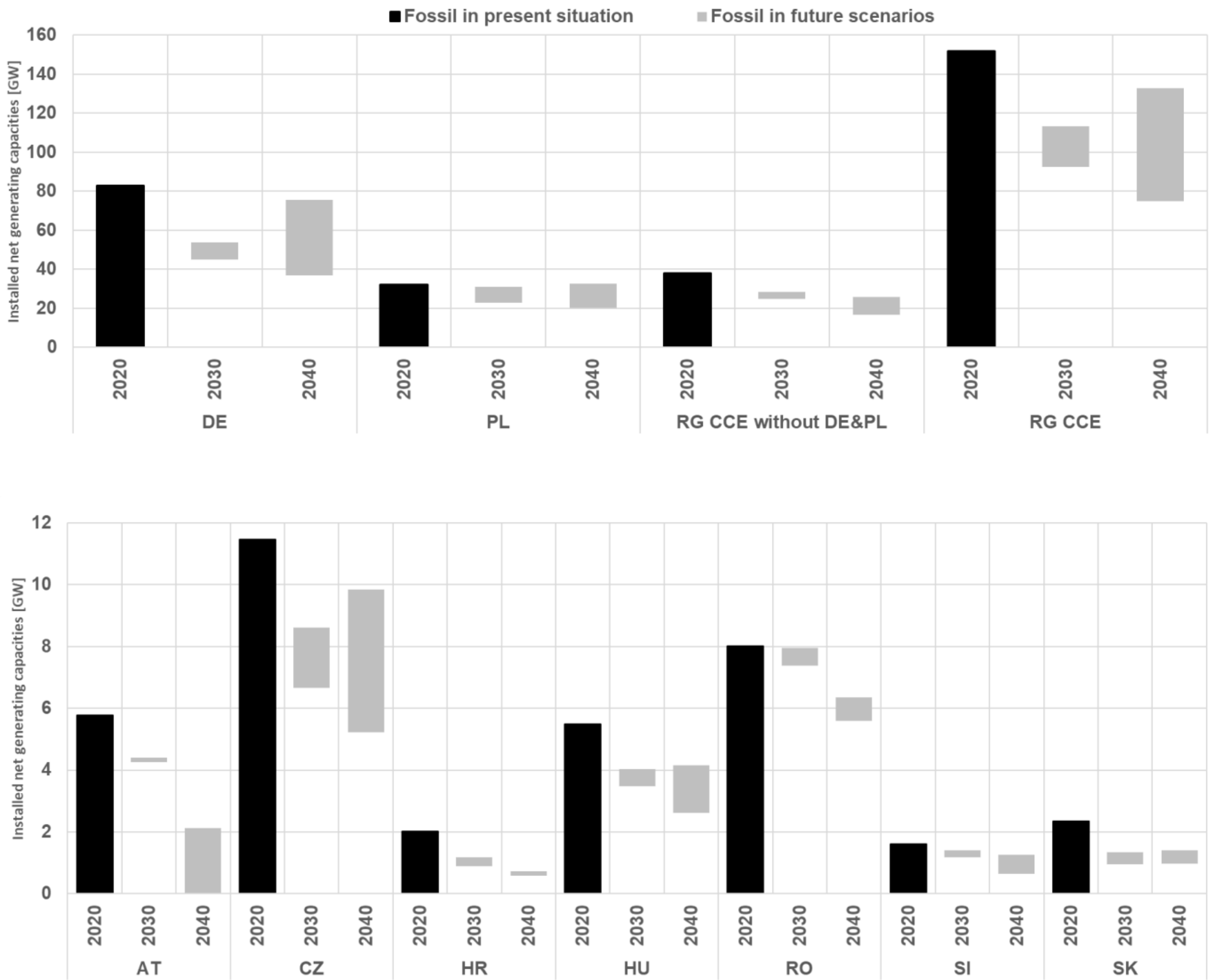


Figure 35 Development of installed fossil fuel capacity between 2020, 2030 and 2040 in the CCE region

5.2.Future infrastructure projects – gap analyses

The European power system began a large transformation process over the last 10 years. One of the main drivers for this transformation is the need to change the power generation mix, i.e., to replace conventional power generation (thermal and partly nuclear decommissioning) with renewables (wind, solar and water generation in several countries). This leads to more climate dependent power generation with a high fluctuating power infeed into the grid. Finally, there will be a greater need for more flexible solutions. A part of the solution could be the increase of interconnector capacities between countries and between synchronous systems. Other drivers for grid development could be the system enlargement project known as the "Synchronisation of Ukraine and Moldova".

Two important tasks for the TYNDP package (including the RegIP) are:

- The identification of future transmission needs (i.e. by 2030/40)
- The qualification of relevant transmission projects for the next PCI-list

Both tasks have been carried out in relation to the TYNDP process. In TYNDP 2016, ENTSO-E started the investigation of future System Needs analyses (i.e., IoSN - Identification of System Needs). The aim is to show future system needs for the transmission system with a specific focus on climate goals, security of supply and socio-economic benefits. These analyses will be performed every second year and are based on the latest updated assumptions and scenarios.

Figure 36 displays the identified capacity increase for the CCE region's borders in 2030 (left) and 2040 (right).

To close the gap towards future system needs, as indicated in the "System-needs-analyses", investment decisions for several transmission projects have been taken over the last decade. The overview "Detailed analyses per border" below discusses some relevant cross-border transmission projects in the CCE region. These project development activities will help close the indicated gap.

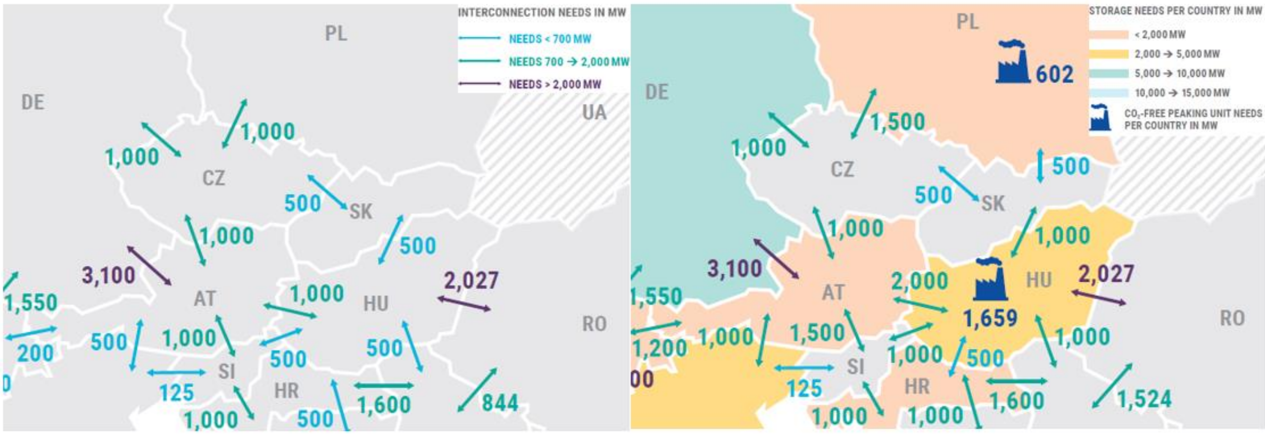


Figure 36 Identified capacity increases at the CCE region borders in 2030 (left) and 2040 (right) time horizons

Detailed analysis per border

Capacity increases on the Polish-Czech border

Considering specific drivers, for instance the phase-out of the 220 kV grid in some of the CCE countries (e.g. Slovakia, Czechia), there is potential that in future TYNDPs some borders, e.g. the Czech-Polish border, may be subjected to consideration of new projects in order to cope with the phasing out of the 220 kV grid in Czechia, which will involve the existing two interconnectors on the common CZ-PL cross-border file and may be completed by 2035. This potential cross-border project, which currently has not yet been agreed, from that perspective could be seen as a replacement of the 220 kV interconnectors and would aim to maintain the security and reliability of the power exchange on the common CZ-PL cross-border profile. There is an ongoing bilateral study to investigate the impact on the two TSOs.

Capacity increase on the Hungarian-Romanian border

In both the 2030 and 2040 NT scenarios, a capacity increase need was identified for the Hungarian-Romanian border in the IoSN process. The capacity increase identified can be fully covered by the future project HU-RO (Project 259). As the project was included in the last two TYNDPs as a future project, MAVIR and Transelectrica have decided to include this project once again as a future project to be assessed in the CBA phase of TYNDP 2020. The project consists of a new 400 kV interconnection line between Hungary and Romania and several internal investments in Romania.

Capacity increase on the Czech-Slovak border

In both the 2030 and 2040 NT scenarios, the need to increase the capacity by 500 MW at the Czech-Slovak border has been identified. This capacity increase need will be fully covered by the TYNDP 2022 project “330 4th 400 kV interconnector on the SK-CZ border”, the status of which is “under consideration”. This new 400 kV cross-border overhead line between the Otrokovice (CZ) and Ladce (SK) substations will strengthen transmission capacity between the Slovak and Czech transmission systems, aiming to maintain secure operation of both transmission systems.

Capacity increases on the Czech-Austrian border

The IoSN exercise for the 2030 and 2040 scenarios has identified a need for a capacity increase of 1000 MW on the common profile, which is not covered by any TYNDP 2020 project. Due to the geographical location of Austria and Czechia in the centre of Europe, such a need is identified on all borders of both countries. These needs between Austria and Czechia must therefore always be considered in a regional context and reflect future evolutions in the grid structures of both countries with particular attention being paid to the 220 kV phasing-out programme in Czechia, which is projected to occur on the 2035–2040 time horizon. Further analyses enabling a coordinated overall approach that takes into account both national strategies and European needs are therefore necessary. Thanks to the RgIP, an ideal platform for such further analysis is available to verify such a need.

Capacity increase on the Austrian-German border

The identified capacity increase of 3100 MW for the time horizon 2030 is primarily covered by the TYNDP 2020 projects 47 “Westtirol (AT) – Vöhringen (DE)” and 187 “St. Peter (AT) – Pleinting (DE)”. These projects together with project 263 “Lake Constance East” also cover the identified capacity increase for the time horizon 2040.

Capacity increase on the Czech-German border

The identified capacity increase of 500 MW in the 2030 scenario will be fully covered by the TYNDP 2020 project 35 "CZ Southwest-east corridor". For time horizon 2040 the identified capacity increase is 1650 MW and is only partially covered by TYNDP 2020 project 35 "CZ Southwest-east corridor". To cover the extra need for +1000 MW, upgrades of the Czech part of the cross-border lines are planned. These upgrades are currently not part of the TYNDP 2020 project portfolio but are planned before 2040.

Capacity increases on the Polish-Slovak border

The identified capacity increase of 500 MW in the 2040 scenario is subject to further discussion and analysis since there is no existing agreement or planned project at this stage.

Capacity increases on the Hungarian-Slovak border

The identified capacity increase of 500 MW in the 2030 scenario and 1000 MW in the 2040 scenario is subject to further discussion and analysis since there is no existing agreement or planned project at this stage.

It should be noted and emphasised that, at present, all the above-mentioned projects are only possible grid development options that are going to fully or partly cover the future identified capacity increases and system needs. They are all subject to change based on the assumptions in future scenarios.

The future capacity increases which do not have any TYNDP 2022 project to cover them will be bilaterally analysed in further detail, by TSOs, which may possibly come up with projects in future TYNDPs.

6.APPENDICES

6.1.Pan-European projects

The following projects were collected during the project calls. They represent the most important projects for the region. Projects must meet several criteria to be included in the analysis. These criteria are described in the ENTSO-E practical implementation of the guidelines for inclusion in TYNDP 2022.

The map below (Figure 37) shows all project applications submitted by a project promoter during the TYNDP 2022 call for projects. In the final version of this document (after the consultation phase), the map will be updated to show the approved projects. The projects are in different states, which are described in the CBA-guidelines.

Depending on the state of a project, it will be assessed according to a cost-benefit analysis.

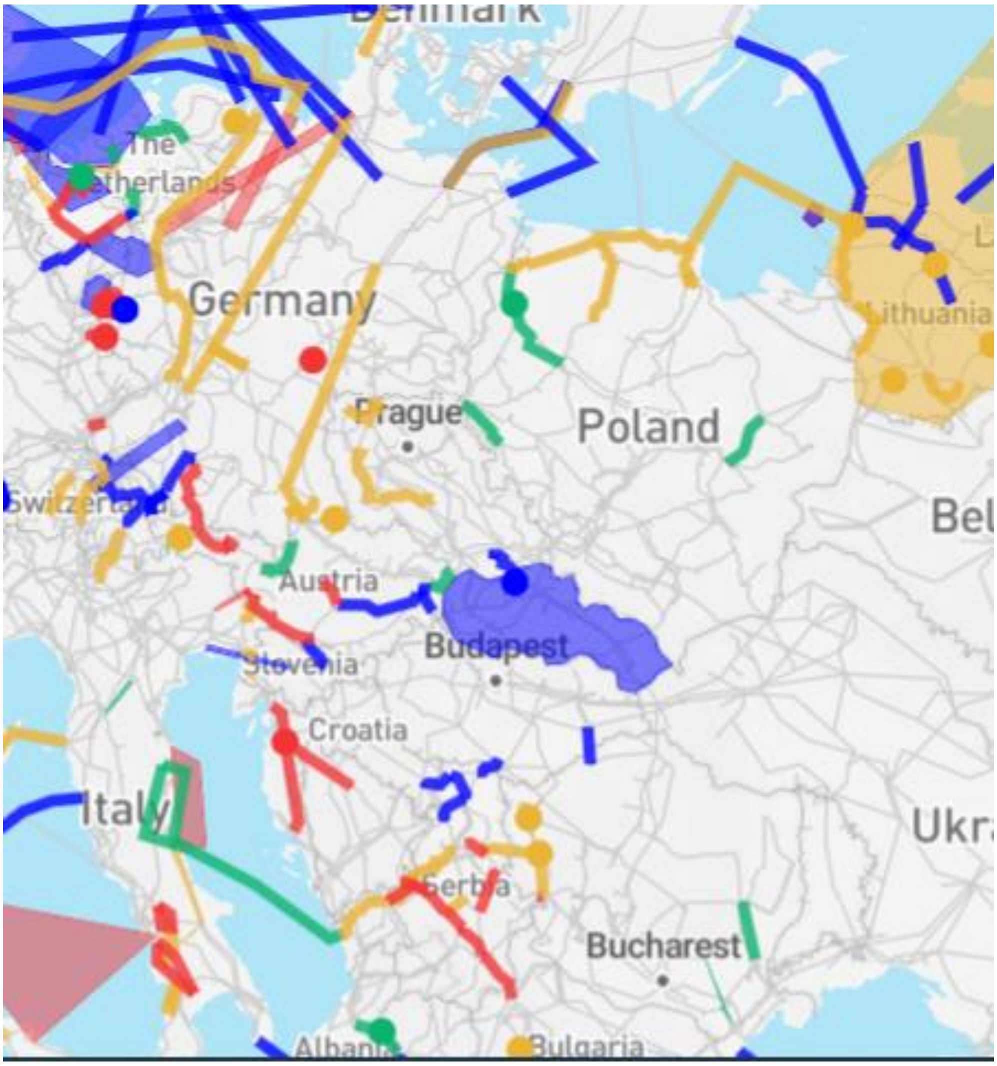


Figure 37 TYNDP 2022 Project: Regional Group

6.2.Links to National Development Plans

In the table below (Table 2), the links to the latest versions of the NDPs of each CCE member are listed in order to compare national processes of transmission grid development. The listed NDPs are both similar, due to the common issues in the region, and unique due to the uniqueness of the particular power systems.

Table 2 Links for the latest versions of the CCE TSOs National Development Plans

Country	Company/TSO	National Development Plan
AT	APG – Austrian Power Grid AG	Network Development Plan 2021
HR	HOPS	Ten-Year Network Development Plan for the Period 2022–2031
CZ	ČEPS, a.s.	Ten-Year Transmission System Development Plan of the Czechia 2021–2030
DE	50Hertz Transmission GmbH	Grid Development Plan Power
	TenneT TSO GmbH	
HU	MAVIR	Network Development Plan for Period 2019–2034
PL	PSE S.A.	Development Plan for meeting the current and future electricity demand for 2021–2030
RO	C. N. Transelectrica S. A.	Ten-Year Network Development Plan for the Period 2020–2029
SK	Slovenská elektrizačná prenosová sústava, a. s.	National Ten-Year Network Development Plan
SI	ELES, d.o.o.	Slovenian NDP 2021–2030

6.3.Regional projects

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

There are no criteria for the regional significance projects included in this list. They are included based purely on the project promoter's decision as to whether the project is relevant.

In the Table 3 below, projects of regional and national significance in the CCE region are listed.

Table 3 List of regional projects

Country	Project Name	Investment		Expected commissioning year	Description	Main drivers	Status in RgIP 2020	Status in RgIP 2022
		From	To					
Poland	**Modernization of the 400 kV Rzeszów - Krosno Iskrzynia line**	**Rzeszów**	**Krosno Iskrzynia**	**2026**	**Increasing the current capacity of the line**	**Security of supply, facilitation of power evacuation and exchange (in connection with the regulation of the European Parliament and the Council 2019/943 of 5 June 2019 on the internal electricity market)**		**In Permitting**
Poland	Construction of 400 kV line from Dobrzeń to Pasikurowice - Ostrów line tap	Dobrzeń	the incision of the Pasikurowice - Ostrów line	2027	Construction of double circuit 400 kV line	Security of supply, facilitation of power evacuation and exchange (in connection with the regulation of the European Parliament and the Council 2019/943 of 5 June 2019 on the internal electricity market)		In Permitting

Poland	Construction of a 400 kV line Trębaczew - Rokitnica	Trębaczew	Rokitnica	2027	Construction of double circuit 400 kV line	Security of supply, facilitation of power evacuation and exchange (in connection with the regulation of the European Parliament and the Council 2019/943 of 5 June 2019 on the internal electricity market)		In Permitting
Poland	Suspension of the second 400 kV line on the Ostrów - Kromolice line together with the expansion of the substation in this line	Ostrów	Kromolice	2023	Increasing the current capacity of the line	Security of supply, facilitation of power evacuation and exchange (in connection with the regulation of the European Parliament and the Council 2019/943 of 5 June 2019 on the internal electricity market)		Under Constructio n
Slovenia	Substation Ravne (SI)	Ravne (SI)		2027	Construction of the new substation 220/110 kV Ravne with new double 220 kV OHL Ravne – Zagrad (approximately 4 km length). It will be included in the existing interconnection 220 kV OHL 220 kV Podlog (SI) – Obersielach (AT). Expected commissioning date 2027.	Flicker, high load growth	In Permitting	In Permitting
Slovenia	New compensation device on 400 kV voltage level in scope of SINCRO.GRID project	Beričevo (SI)		2022	Installation of STATCOM (150 MVAr) in substation Beričevo on 400 kV voltage level	RES integration, security of supply	Under Constructi on	Under Constructio n
Romania	New 400 kV OHL Suceava (RO) – Balti (MD)	Suceava (RO)	Balti (MD)	2030	New 400 kV OHL (139 km) to increase capacity of transfer between Romania and Moldova.	Market integration	Planned, But Not Yet Permitting	Planned, But Not Yet Permitting
Romania	New 400 kV OHL Suceava (RO) – Gadalin (RO)	Suceava (RO)	Gadalin (RO)	2030	New 400 kV simple circuit OHL between existing substations. Line length: 260km.	RES integration	Planned, But Not Yet Permitting	Planned, But Not Yet Permitting
Romania	Upgrade OHL 400 kV Isaccea (RO) -Tulcea (RO)	Isaccea (RO)	Tulcea (RO)	2030	Upgrade of existing OHL 400 kV Isaccea – Tulcea from simple circuit to double circuit	RES integration	Planned, But Not Yet Permitting	Planned, But Not Yet Permitting

Romania	New 400 kV OHL Stalpu (RO) – Brasov (RO)	Stalpu (RO)	Brasov (RO)	2036	New 400 kV OHL, double circuit (initially one circuit wired), 170 km length between existing 400 kV substations Stalpu and Brasov.	RES integration	Under Considera tion	Planned, But Not Yet Permitting
Romania	New 400 kV OHL Constanta Nord (RO) - Medgidia Sud (RO)	Constanta Nord (RO)	Medgidia Sud (RO)	2028	New 400 kV double-circuit (one circuit wired) OHL between existing stations. Line length: 75 km.	RES integration	Planned, But Not Yet Permitting	In Permitting
Romania	New 400 kV OHL Stalpu (RO) – Teleajen (RO) – Brazi (RO)	Stalpu (RO) – Teleajen (RO) – Brazi (RO)		2025	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 400kV. New 400 kV substations: Stalpu (400/110 kV, 1x250 MVA) and Teleajen (400/110 kV, 1x 400 MVA).	RES integration	Planned, But Not Yet Permitting	In Permitting
Romania	400 kV substation Teleajen (RO)	Teleajen (RO)		2025	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. SoS in supplied area increases.	RES integration	Planned, But Not Yet Permitting	In Permitting
Romania	400 kV substation Brazi Vest (RO)	Brazi Vest (RO)		2025	The investment consists in 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	Planned, But Not Yet Permitting	In Permitting
Romania	400 kV substation Medgidia Sud (RO)	Medgidia Sud (RO)		2022	Substation Medgidia Sud 400 kV extended with new connections (400 kV OHL Rahmanu (RO) – Dobrudja (BG), 400 kV OHL Stupina (RO)) – Varna (BG) and refurbished with GIS technology to provide the necessary space.	RES integration	Under Constructi on	Under Constructio n

Romania	400 kV OHL Medgidia Sud (RO) – Dobrudja (BG)	Medgidia Sud (RO)	Dodrudja (BG)	2024	In-out connection of the existing OHL of 400 kV Rahman – Dobrudja in the existing 400 kV substation Medgidia Sud.	RES integration	Under Constructi on	Under Constructio n
Romania	400 kV OHL Medgidia Sud (RO) - Varna (BG)	Medgidia Sud (RO)	Varna (BG)	2024	In-out connection of the existing OHL of 400 kV Stupina – Varna in the existing 400 kV substation Medgidia Sud.	RES integration	Under Constructi on	Under Constructio n
Romania	220 kV OHL Stejaru (RO) – Gheorghieni (RO)	Stejaru (RO)	Gheorghieni (RO)	2025	Increasing the transmission capacity by replacing the wires on the 220 kV OHL Stejaru – Gheorghieni with a high thermal capacity.	RES integration	In Permitting	Under Constructio n
Romania	220 kV OHL Gheorghieni (RO) - Fantanele (RO)	Gheorghieni (RO)	Fantanele (RO)	2025	Increasing the transmission capacity by replacing the wires on the 220 kV OHL Gheorghieni – Fantanele with a high thermal capacity.	RES integration	In Permitting	Under Constructio n
Romania	220 kV OHL Gutinaș (RO) – Dumbrava (RO)	Gutinaș (RO)	Dumbrava (RO)	2028	Increasing the transmission capacity by replacing the wires on the 220 kV OHL with a high thermal capacity.	RES integration		In permitting
Romania	220 kV OHL Dumbrava (RO) – Stejaru (RO)	Dumbrava (RO)	Stejaru (RO)	2028	Increasing the transmission capacity by replacing the wires on the 220 kV OHL with a high thermal capacity.	RES integration		In permitting
Romania	220 kV OHL Fântânele (RO) – Ungheni (RO)	Fântânele (RO)	Ungheni (RO)	2028	Increasing the transmission capacity by replacing the wires on the 220 kV OHL with a high thermal capacity.	RES integration		In permitting
Romania	440 kV OHL Gura Ialomiței (RO) – București Sud (RO)	Gura Ialomiței (RO)	București Sud (RO)	2028	Increasing the transmission capacity by replacing the wires on the 400 kV OHL with a high thermal capacity.	RES integration		In permitting
Romania	440 kV OHL Cernavodă (RO) – Pelicanu (RO)	Cernavodă (RO)	Pelicanu (RO)	2029	Increasing the transmission capacity by replacing the wires on the 400 kV OHL with a high thermal capacity.	RES integration		In permitting
Romania	440 kV OHL Pelicanu (RO) – București Sud (RO)	Pelicanu (RO)	București Sud (RO)	2024	Increasing the transmission capacity by replacing the wires on the 400 kV OHL with a high thermal capacity.	RES integration		Planned but not yet in permitting

Romania	Static VAR compensators (SVC)			2028	Install Static VAR compensators (SVC) to allow power transmission to far-away consumption nodes	RES integration		Planned but not yet in permitting
Romania	Flexible AC transmission systems			2025	Install flexible AC transmission systems to control power flows	RES integration Market integration		Planned but not yet in permitting
Slovakia	New 400 kV substation Senica (SK)	Senica (SK)		2024	Replacement of existing 220 kV substation Senica (SK) by 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	In Permitting	Under Constructio n
Slovakia	New 400 kV substation Bystričany (SK)	Bystričany (SK)		2021	Replacement of existing 220 kV substation Bystričany (SK) by the new 400 kV substation, which will be connected by the new double 400 kV OHL Križovany (SK) – Horná Ždaňa (SK), with one circuit connected to the new 400 kV substation Bystričany (SK).	Security of supply, RES integration	Under Constructi on	Commission ed
Slovakia	New 400 kV OHL Horná Ždaňa (SK) - Oslany area (SK)	Horná Ždaňa (SK)	Oslany area (SK)	2025	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 by the 400 kV infrastructure. This investment will ensure the operational safety and reliability of the new 400 kV substation Bystričany (SK), in operation from 2021.	Security of supply		In Permitting
Slovakia	New 400 kV substation Ladce (SK)	Ladce (SK)		2028	Replacement of existing 220 kV substation Považská Bystrica (SK) by the new 400 kV substation, which will be connected to the existing 400 kV OHL Bošáca (SK) – Varín (SK). This project is a precondition to building the new SK-CZ 400 kV interconnector from Ladce (SK) to Otrokovice (CZ).	Security of supply, RES integration	Planned, But Not Yet Permitting	Planned, But Not Yet Permitting

Slovakia	Looping of the existing line Veľký Ďur (SK) – Horná Ždaňa (SK) into the Levice substation	Veľký Ďur (SK)	Horná Ždaňa (SK)	up to 2030	The investment consists of the looping the existing 400kV line Veľký Ďur (SK) – Horná Ždaňa (SK) into the Levice substation. At the same time, the existing 400kV interconnector Levice (SK) – Gyor (HU) will be connected to the Veľký Ďur (SK) substation resulting in creation of the new cross border line Veľký Ďur (SK) – Gyor (HU).	Security of supply, RES integration		Under Considerati on
Slovakia	Transformer replacement and new shunt reactors installation in substation Varín (SK)	Varín (SK)		2024	Replacement of existing 400/110 kV transformer in substation Varín (SK) and installation of shunt reactors with installed capacity 2x45 MVAr that will help to reduce operational voltage level on SK – CZ cross border line Varín (SK) – Nošovice (CZ)	Security of supply, RES integration		In Permitting
Hungary	Substation Buj, formerly Nyíregyháza (HU)	Buj (HU)		2021	New substation Buj (HU) with a 2*250 MVA 400/120 kV transformation, which is connected by splitting the existing 400kV Sajószöged – Mukachevo line.	Security of supply	In Permitting	Commission ed
Hungary	New voltage level (220 kV) and transformer in substation Kerepes (HU)	Kerepes (HU)		2023	Upgrade of substation Kerepes (HU) with 500 MVA 400/220 kV transformation, connected by splitting existing line Ócsa – Zugló.	Security of supply	Planned, But Not Yet Permitting	Under Constructio n
Hungary	Kerepes (HU) - Zugló (HU) reconstruction	Kerepes (HU)	Zugló (HU)	2023	Reconstruction of 220 kV line Kerepes – Zugló (HU) line to a double circuit.	Security of supply	Planned, But Not Yet Permitting	Under Constructio n
Hungary	Substation Biritó (formerly Paks II) (HU)	Biritó (HU)		2027	New 400 kV substation Biritó (HU) for the connection of the new units of Paks Nuclear Power Plant.	Connection of generation	Planned, But Not Yet Permitting	In Permitting
Hungary	400 kV line Biritó (HU)-Albertirsa (HU)	Biritó (HU)	Albertirsa (HU)	2027	New 400 kV double-circuit transmission line between new substation Biritó (HU) and existing substation Albertirsa (HU).	Connection of generation	Planned, But Not Yet Permitting	In Permitting
Hungary	400 kV line Biritó (HU)-Paks (HU)	Biritó (HU)	Paks (HU)	2027	New 400 kV double-circuit transmission line between new substation Biritó (HU) and existing	Connection of generation	Planned, But Not Yet	In Permitting

					substation Paks (HU).		Permitting	
Hungary	Substation Kecskemét Törökfái (HU)	Kecskemét Törökfái (HU)		2024	New substation Kecskemét Törökfái (HU) with 2x250 MVA 400/120 kV transformation, connected by a new 400 kV double-circuit line Albertirsa-Kecskemét.	Security of supply	Under Constructi on	In Permitting
Hungary	Substation Kimle (HU)	Kimle (HU)		2025	New substation Kimle (HU) with 2x250 MVA 400/120 kV transformation, connected by splitting 400 kV cross-border lines Szombathely (HU) – Zurndorf (AT) and Győr (HU) – Zurndorf (AT).	Security of supply	Planned, But Not Yet Permitting	Cancelled
Hungary	New transformer in substation Sándorfalva (HU)	Sándorfalva (HU)		2022	Installation of the 3rd 400/132 kV transformer in substation Sándorfalva (HU).	Security of supply	Planned, But Not Yet Permitting	Under Constructio n
Hungary	New transformer in substation Göd (HU), elimination of 220 kV voltage level	Göd (HU)		2024	Installation of new 400/120 kV transformer in substation Göd (HU), replacing the existing 400/220 kV transformer. Utilisation of Göd – Zugló 220 kV line at 132 kV.	Security of supply	Planned, But Not Yet Permitting	Cancelled
Hungary	New transformer in Bicske Dél (HU)	Bicske Dél (HU)		2022	Installation of 3rd 400/132 kV transformer in Bicske Dél (HU).	Security of supply		Under Constructio n
Hungary	New transformer in Debrecen Józsa (HU)	Debrecen Józsa (HU)		2022	Installation of 3rd 400/132 kV transformer in Debrecen Józsa (HU).	Security of supply		Cancelled
Hungary	New transformer in Sándorfalva (HU)	Sándorfalva (HU)		2022	Installation of 3rd 400/132 kV transformer in Sándorfalva (HU).	Security of supply		Under Constructio n
Hungary	New transformer in Sajóivánka (HU)	Sajóivánka (HU)		2027	Installation of 3rd 400/132 kV transformer in Sajóivánka (HU).	Security of supply		Cancelled
Hungary	Substation Göd Kelet (HU)	Göd Kelet (HU)		2024	New substation Göd Kelet (HU) with 2*250 MVA 400/120 kV transformation, connected by splitting existing 400 kV line Sajószöged (HU) – Göd (HU).	Security of supply		In Permitting
Hungary	New transformer in Kerepes (HU)	Kerepes (HU)		2032	Installation of 2nd 400/132 kV transformer in Kerepes (HU).	Security of supply		Cancelled

Hungary	Substation Mezőcsát (HU)	Mezőcsát (HU)		2021	New substation Mezőcsát (HU) connected by splitting existing 220 kV line Sajószöged (HU)-Szolnok (HU), for the connection of 5*47.6 MW PV generation.	RES integration, Connection of generation		Under Construction
Hungary	Substation Oroszlány (HU)	Oroszlány (HU)		2021	Installation of 3rd 220/132 kV transformer in Oroszlány (HU).			Commissioned
Hungary	Substation Perkáta (HU)	Perkáta (HU)		2023	Installation of 3rd 400/132 kV transformer in Perkáta (HU).			Under Construction
Hungary	Oroszlány (HU) – Győr (HU) uprating	Oroszlány (HU)	Győr (HU)	2023	Uprating of 220 kV line Oroszlány (HU)-Győr (HU) with HTLS.			Under Construction
Hungary	Győr (HU)-AT border uprating	Győr (HU)	AT border (Wien/Neusiedl)	2023	Uprating of 220 kV double circuit line Győr (HU)-AT border.			Under Construction
Hungary	Mezőcsát (HU)-Sajószöged (HU)	Mezőcsát (HU)	Sajószöged (HU)	2024	Uprating of 220 kV line Mezőcsát (HU)-Sajószöged (HU).			Planned, But Not Yet Permitting
Hungary	Substation Pécs (HU)	Pécs (HU)		2025	Installation of 3rd 400/132 kV transformer in Pécs (HU).			Under Consideration
Hungary	Substation Hévíz (HU)	Hévíz (HU)		2025	Installation of 3rd 400/132 kV transformer in Hévíz (HU).			Under Consideration
Hungary	Paks (HU)-Birító (HU)	Paks (HU)	Birító (HU)	2027	Switching on second line between Paks (HU) and Birító (HU), installation of series reactor.			Under Consideration
Hungary	Kisvárda (HU)-UA border	Kisvárda (HU)	UA border (Mukachevo)	2027	Uprating of 220 kV line Kisvárda (HU)-UA border.			Under consideration
Croatia	New transformer in SS Konjsko (HR)	Konjsko (HR)		2024	Installation of 3rd 400/220 kV transformer in SS Konjsko	Security of supply, RES Integration		Under Consideration/In Permitting

Croatia	220 kV OHL SS Senj (HR) – SS Melina (HR)	Senj (HR)	Melina (HR)	2024	Increasing the transmission capacity by replacing the wires on the 220 kV OHL SS Senj – SS Melina with a high thermal capacity.	RES Integration	-	In Permitting
Croatia	220 kV OHL SS Konjsko (HR) – SS Krš Pađene (HR)	Konjsko (HR)	Brinje (HR)	2024	Increasing the transmission capacity by replacing the wires on the 220 kV OHL SS Konjsko – SS Krš Pađene with a high thermal capacity.	RES Integration	-	In Permitting
Croatia	220 kV OHL SS Krš Pađene (HR) – SS Brinje (HR)	Krš Pađene (HR)	Brinje (HR)	2024	Increasing the transmission capacity by replacing the wires on the 220 kV OHL SS Krš Pađene – SS Brinje with a high thermal capacity.	RES Integration	-	In Permitting
Croatia	New 2x400 kV OHL SS Tumbri (HR) – SS Veleševec (HR)	Tumbri (HR)	Veleševec (HR	2030	New 2x400 kV OHL SS Tumbri SS Veleševec.	Security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Croatia	New 400/220 kV substation Lika (HR)	Lika (HR)		2030	New 400/220 kV substation.	RES integration, Security of supply	Under Considera tion	Planned, but not yet in permitting
Croatia	New 400 kV OHL Lika (HR) - SS Melina 2 (HR)	Lika (HR)	Melina (HR)	2030	New 400 kV OHL.	RES integration, Security of supply	Under Considera tion	Planned, but not yet in permitting
Croatia	New 400 kV OHL SS Lika (HR) – SS Konjsko (HR)	Lika (HR)	Konjsko (HR)	2030	New 400 kV OHL.	RES integration, Security of supply	Under Considera tion	Planned, but not yet in permitting
Croatia	New 400 kV OHL SS Lika (HR) – SS Banja Luka (BA)	Lika (HR)	Banja Luka (BA)	2033	New 400 kV OHL.	RES integration, Security of supply	Under Considera tion	Planned, but not yet in permitting
Croatia	New 220/110 kV substation Vodnjan (HR)	Vodnjan (HR)		2032	New 220/110 kV substation.	Security of supply	Under Considera tion	Under Considerati on
Czechia	New 420 KV substation Praha Sever	Praha Sever (CZ)		2027	New 400/110 kV substation equipped with transformers 2x350 MVA.	Security of supply	In Permitting	In Permitting
Czechia	New loop 400 kV OHL from Vyskov - Cechy Stred to Praha Sever	A line Vyskov - Cechy Stred (CZ)	Praha Sever (CZ)	2027	A new loop from the OHL Vyskov - Cechy Stred to Praha Sever of 13 km in length. Target capacity	Security of supply	In Permitting	In Permitting

					2x1730 MVA.			
Czechia	New 400 kV OHL Chodov - Cechy Stred	Chodov (CZ)	Cechy Stred (CZ)	1. phase: 2025 2. phase: 2027	New OHL involving changing the existing single-circuit line to a double-circuit line 35.1 km long. Target capacity 2x1700 MVA.	Security of supply	In Permitting	In Permitting
Czechia	Modernisation of 400 kV OHL Tynec - Krasikov	Tynec (CZ)	Krasikov (CZ)	2021	Upgrading the existing 103.8km single-circuit line. Target capacity 1385 MVA.	Security of supply	In Permitting	Commission ed
Czechia	New 400 kV OHL Prosenice - Nosovice	Prosenice (CZ)	Nosovice (CZ)	2024	New OHL involving changing the existing single-circuit line to a double-circuit line, 80 km long. Target capacity 2x1700 MVA.	Security of supply	In Permitting	In Permitting
Czechia	New 420 KV substation Detmarovice	Detmarovice (CZ)		2024	New 400/110 kV substation equipped with transformers 2x350 MVA.	Security of supply	In Permitting	In Permitting
Czechia	New loop 400 kV OHL from Albrechtice - Dobrzen to Detmarovice	A line Albrechtice (CZ) – Dobrzen (PL)	Detmarovice (CZ)	2024	A new loop from the OHL Albrechtice – Dobrzen to Detmarovice, 1.2 km long. Target capacity 2x1730 MVA.	Security of supply	In Permitting	In Permitting
Czechia	New 400 kV OHL Hradec - Vyskov	Hradec (CZ)	Vyskov (CZ)	2027	New OHL involving changing the existing single-circuit line to a double-circuit line, 45.3 km long. Target capacity 2x1730 MVA.	Security of supply, facilitation of power evacuation	In Permitting	In Permitting
Czechia	Modernisation of 400 kV OHL Prosenice - Krasikov	Prosenice (CZ)	Krasikov (CZ)	2020	Upgrading the existing single-circuit line of 87.5 km in length. Target capacity 1385 MVA.	Security of supply	In Permitting	Commission ed
Czechia	A New loop 400 kV OHL from Prosenice - Nosovice to Kletne	A line Prosenice-Nosovice (CZ)	Kletne (CZ)	2031	A new loop from the OHL Prosenice – Nosovice to Kletne of 29 km in length. Target capacity 2x1730 MVA.	Security of supply	In Permitting	In Permitting
Czechia	New 400 kV OHL Hradec - Chrast	Hradec (CZ)	Chrast (CZ)	2029	New OHL involving changing the existing single-circuit line to a double-circuit line of 82.4 km in length. Target capacity 2x1730 MVA.	Security of supply, facilitation of power evacuation, RES integration	In Permitting	In Permitting

Czechia	New 400 kV OHL Chrast - Prestice	Chrast (CZ)	Prestice (CZ)	2025	New OHL involving changing the existing single-circuit line to a double-circuit line of 33.4 km in length. Target capacity 2x1730 MVA.	Security of supply, facilitation of power evacuation, RES integration	In Permitting	In Permitting
Czechia	New 400 kV OHL Vyskov - Babylon	Vyskov (CZ)	Babylon (CZ)	2022	New OHL involving changing the existing single-circuit line to a double-circuit line of 73 km in length. Target capacity 2x1700 MVA.	Security of supply, facilitation of power evacuation	In Permitting	Under Constructio n
Czechia	New 400 kV OHL Slavetice - Cebin	Slavetice (CZ)	Cebin (CZ)	2033	New OHL involving changing the existing single-circuit line to a double-circuit line of 52 km in length. Target capacity 2x1700 MVA.	Security of supply, facilitation of power evacuation	In Permitting	In Permitting
Czechia	New 400 kV OHL Babylon - Bezdecin	Babylon (CZ)	Bezdecin (CZ)	2025	New OHL involving changing the existing single-circuit line to a double-circuit line of 54 km in length. Target capacity 2x1700 MVA.	Security of supply, facilitation of power evacuation	In Permitting	In Permitting
Czechia	New 420 KV substation Milin	Milin (CZ)		2025	New 400/110 kV substation equipped with 2 x 350 MVA transformers.	Security of supply	In Permitting	In Permitting
Czechia	New loop 400 kV OHL from Reporyje - Kocin to Milin	A line Reporyje – Kocin (CZ)	Milin (CZ)	2025	A new loop from the OHL Reporyje– Kocin Stred to Milin of 1 km in length. Target capacity 2x1730 MVA.	Security of supply	In Permitting	In Permitting
Czechia	Upgrading of OHL Reporyje - Mirovka	Reporyje (CZ)	Mirovka (CZ)	2025	Upgrading of the existing OHL of 146 km in length. Target capacity 1385 MVA.	Security of supply, facilitation of power evacuation and exchange	In Permitting	In Permitting
Czechia	Upgrading of OHL Nosovice - Albrechtice	Nosovice (CZ)	Albrechtice (CZ)	2020	Upgrading the existing OHL of 16.5 km in length. Target capacity 1385 MVA.	Security of supply, facilitation of power exchange	In Permitting	Commission ed

Czechia	Upgrading of 420 kV substation Hradec	Hradec (CZ)		2033	Upgrading the existing 420 kV substation Hradec to short circuit power 63 kA.	Security of supply, facilitation of generation connection, line connection	In Permitting	In Permitting
Czechia	Upgrading of 420 kV substation Chrast	Chrast (CZ)		2026	Upgrading of the existing 420 kV substation Chrast to short circuit power 50 kA.	Security of supply, facilitation of line connection	In Permitting	In Permitting
Czechia	Upgrading of 420 kV substation Slavetice	Slavetice (CZ)		2032	Upgrading of the existing 420 kV substation Slavetice to short circuit power 63 kA.	Security of supply, facilitation of generation connection, line connection	In Permitting	In Permitting
Czechia	Upgrading of 420 kV substation Prosenice	Prosenice (CZ)		2023	Upgrading of the existing 420 kV substation Prosenice to short circuit power 50 kA.	Security of supply, facilitation of generation connection, line connection	In Permitting	In Permitting
Czechia	Upgrading substation Malesice 245 kV to 420 kV, A New loop 400 kV OHL from Cechy-Stred - Chodov to Malesice	Malesice (CZ)	Cechy-Stred (CZ)	1. phase: 2032 2. phase: 2032	Increasing transformation capacity by upgrading current 245 kV Malesice substation to 420 kV.	Security of supply, line connection	/	In Permitting
Czechia	New 400 kV OHL Sokolnice-Otrokovice	Sokolnice (CZ)	Otrokovice (CZ)	2032	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, line connection	/	In Permitting
Czechia	New 400 kV OHL Otrokovice-Prosenice	Otrokovice (CZ)	Prosenice (CZ)	2034	New OHL involving changing the existing single-circuit line to a double-circuit line of 37,7 km in length. Target capacity 2x1730 MVA.	Security of supply, line connection	/	In Permitting

Czechia	New 400 kV double OHL Slavetice-Sokolnice	Slavetice (CZ)	Sokolnice (CZ)	2033	New OHL double-circuit line 56 km (x2) long. Target capacity 2x1700 MVA.	Security of supply, facilitation of power evacuation and exchange	/	In Permitting
Czechia	Upgrading of 220 kV OHL to double 400 kV Milin-Orlik	Milin (CZ)	Hydro power plant Orlik (CZ)	2033	Upgrading existing OHL single-circuit 220 kV to double-circuit 400 kV line of 9 km (x2) to secure power transmission from hydro power plant Orlik.	Security of supply, facilitation of power evacuation and exchange	/	In Permitting
Germany	P38-M27a+M27b+M27c	Pulgar (DE)	Vieselbach (DE)		Construction of new 380 kV double-circuit OHL in existing corridor Pulgar - Vieselbach (104 km). Detailed information given in Germany's Grid Development.	RES integration / security of supply	In permitting	In permitting
Germany	P84-M367	Hamburg/Nord (DE)	Hamburg/Ost (DE)		Reinforcement of existing 380 kV OHL Hamburg/Nord - Hamburg/Ost. Detailed information given in Germany's Grid Development.	RES integration	In permitting / under consideration	In permitting / under consideration
Germany	P84-M368mod	Hamburg/Ost (DE)	Ämter Büchen/Breitenfelde/Schwarzenbek-Land (DE)		New 380 kV OHL in existing corridor Krümmel – Hamburg/Ost. Detailed information given in Germany's Grid Development.	RES integration		In permitting / under consideration
Germany	P22-M80	Elsfleht/West (DE)	Ganderkesee (DE)		New 380 kV OHL in existing corridor for RES integration between Elsfleth/West, Niedervieland and Ganderkesee	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P23-M20	Dollern (DE)	Alfstedt (DE)		New 380-kV-OHL in existing corridor in Northern Lower Saxony for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting

Germany	P23-M20	Alfstedt (DE)	Elsfleth/West (DE)		New 380-kV-line Alfstedt - Elsfleth/West in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P20-M69	Emden (DE)	Halbemond (DE)		New 380-kV-line Emden - Halbemond for RES integration. Construction of new substation Halbemond	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P22-M92	Conneforde (DE)	Unterweser (DE)		New 380-kV-OHL in existing corridor for RES integration in Lower Saxony	RES integration		Planned, but not yet in permitting
Germany	P124-M209a	Wolmirstedt (DE)	Klostermansfeld (DE)		New 380 kV OHL in existing corridor for RES integration between Wolmirstedt - Klostermansfeld	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P124-M209b	Klostermannsfeld (DE)	Schraplau/Obhausen – Lauchstädt (DE)		New 380 kV OHL in existing corridor between Klostermannsfeld – Schraplau/Obhausen – Lauchstädt. Detailed information given in Germany's Grid Development.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P47a-M64	Point Kriftel (DE)	Farbwerke Höchst-Süd (DE)		The 220 kV substation Farbwerke Höchst-Süd will be upgraded to 380 kV and integrated into the existing grid.	RES integration / security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P407	Several			Vertical measures in the Amprion zone	RES integration / security of supply	Planned	Planned

Germany	P26-M76	Büttel (DE)	Wilster/West (DE)		New 380-kV-line in existing corridor in Schleswig-Holstein for integration of RES especially on- and off-shore wind	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P26-M432	Brunsbüttel (DE)	Büttel (DE)		New 380-kV-line Brunsbüttel - Büttel in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P26-M89	Wilster/West (DE)	Stade/West (DE)		New 380-kV-line Wilster/West - Stade/West in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany		Junction Mehrum (DE)	Mehrum (DE)		New 380-kV-line junction Mehrum (line Wahle – Grohnde) - Mehrum including a 380/220-kV-transformer in Mehrum	RES integration		Under construction
Germany	P118-M207	Borken (DE)	Mecklar (DE)		New 380-kV-line Borken -–Mecklar in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P133-M253	Borken (DE)	Gießen (DE)		New 380-kV-line Borken – Gießen in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P151-M353	Borken (DE)	Twistetal (DE)		new 380-kV-line Borken – Twistetal in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting

Germany	P159-M62	Bürstadt (DE)	BASF (DE)		New line and extension of existing line to 400 kV double circuit OHL Bürstadt – BASF including extension of existing substations.	RES integration / security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	50HzT-003	Neuenhagen (DE)	Vierraden (DE)		Project for new 380 kV double-circuit OHL Neuenhagen - Vierraden – Bertikow with 125 km length as prerequisite for the planned upgrading of the existing 220 kV double-circuit interconnection Krajnik (PL) – Vierraden (DE Hertz Transmission). Detailed information given in Germany's Grid Development.	RES integration / security of supply	Permitting	Permitting
Germany	50HzT-007	Neuenhagen (DE)	Wustermark (DE)		Construction of new 380 kV double-circuit OHL between the substations Wustermark and Neuenhagen with 75 km length. Support of RES and conventional generation integration, maintaining of security of supply and support of market development. Detailed information given in Germany's Grid Development.	RES integration / security of supply	Permitting / Under constructi on	Permitting / Under construction
Germany	50HzT-P36	Pasewalk (DE)	Bertikow (DE)		Construction of new 380 kV double-circuit OHLs in North-Eastern part of 50HzT control area and decommissioning of existing old 220 kV double-circuit OHLs, incl. 380 kV OHL Bertikow - Pasewalk (30 km). Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development. Detailed information given in Germany's Grid Development.	RES integration / security of supply	Permitting	Permitting

Germany	P39-M29a+M29b	Röhrsdorf (DE)	Remptendorf (DE)		Construction of new double-circuit 380 kV OHL in existing corridor Röhrsdorf – Weida – Remptendorf (103 km)	Security of supply	Permitting	Permitting
Germany	P37-M25a+b	Vieselbach (DE)	Mecklar (DE)		New double circuit OHL 380 kV line in existing OHL corridor. Detailed information given in Germany's Grid Development Plan.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P211-M434	Gießen/Nord (DE)	Karben (DE)		New 380-kV-line Gießen/Nord – Karben in existing corridor for RES integration	RES integration	planned, but not yet permitting	planned, but not yet permitting
Germany	P150-M352a+M352b	Schraplau/Obhausen (DE)	Wolkramshausen (DE)		New 380 kV OHL in existing corridor between Schraplau/Obhausen and Wolkramshausen. Detailed information given in Germany's Grid Development Plan.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P180-M406	Marzahn (DE)	Teufelsbruch (DE)		AC grid reinforcement between Marzahn and Teufelsbruch (380 kV cable in Berlin). Detailed information given in Germany's Grid Development Plan.	Security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P215-M454, M579, M586	Güstrow (DE)	search area communities Sanitz/Dettmannsdorf (DE)		New 380 kV OHL in existing corridor between Güstrow – Bentwisch – search area communities Sanitz/Gnewitz/Dettmannsdorf/town Marlow and M586+M579: cable connection in Papendorf. Detailed information given in Germany's Grid Development Plan.	RES integration		Planned, but not yet in permitting

Germany	P215-M692, M597, M521TR1	Bentwisch, Papendorf, search area Communities Sanitz/Dettmannsdorf (DE)			This investment includes a new 380/220 kV transformer in Bentwisch and a new 380/220 kV transformer in Papendorf and a new 380/220 kV transformer in search area communities Sanitz/Dettmannsdorf. Detailed information given in Germany's Grid Development Plan.	RES integration		Planned, but not yet in permitting
Germany	P216-M455 und M523	Güstrow (DE)	Pasewalk (DE)		New 380 kV OHL in existing corridor between Güstrow – Siedenbrünzow – Iven/Krusenfelde/Krien/Spantekow /Werder/ Bartow – Pasewalk/Nord – Pasewalk. . Detailed information given in Germany's Grid Development Plan.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P150-M463	Wolkramshausen (DE)	Vieselbach (DE)		New 380 kV OHL in existing corridor between Wolkramshausen – Ebeleben – Vieselbach. Detailed information given in Germany's Grid Development Plan.	Security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P310-M485	Bürstadt (DE)	Kühmoos (DE)		An additional 380 kV OHL will be installed on existing power poles.	RES integration / security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	TTG-P33-M24a	Wahle (DE)	Border Saxony/Anhalt - Lower Saxony (DE)		New 380 kV OHL in existing corridor between Wahle – Hattorf – Helmstedt/Ost – Border Saxony/Anhalt – Lower Saxony. Detailed information given in Germany's Grid Development Plan.	RES integration		Planned, but not yet in permitting
Germany	50HzT-P33-M24a2	Wolmirstedt (DE)	Border Saxony/Anhalt - Lower Saxony (DE)		New 380 kV OHL in existing corridor between Wolmirstedt – Border Saxony/Anhalt – Lower Saxony. Detailed information given in Germany's Grid Development Plan.	RES integration		Planned, but not yet in permitting

Germany	P33-M24b	Wolmirstedt (DE)	Gleidingen/Hallendorf (DE)		New 380 kV OHL in existing corridor between Wolmirstedt - Helmstedt – Gleidingen/Hallendorf. Detailed information given in Germany's Grid Development Plan.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P222-M461	Oberbachern (DE)	Ottenhofen (DE)		Upgrade of the existing 380 kV line. Detailed information given in Germany's Grid Development.	RES integration / Security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P72-M49, M50	Kreis Segeberg (DE)	Siems (DE)		New 380-kV-line Kreis Segeberg - Siems in existing corridor for RES integration	RES integration	Permitting	Permitting
Germany	P72-M351	Lübeck (DE)	Göhl (DE)		New 380-kV-line Lübeck – Göhl for RES integration. Construction of new substation in Göhl	RES integration	Permitting	Permitting
Germany	P53-M54, M350	Raitersaich (DE)	Altheim (DE)		New 380-kV-line Raitersaich – Altheim in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	M46	Redwitz (DE)	Schwandorf (DE)		New 380-kV-line Redwitz – Schwandorf in existing corridor for RES integration	RES integration		Permitting / under construction
Germany	50HzT-P34-M22a+M22b+M22c	Güstrow (DE)	Wolmirstedt (DE)		New 380 kV OHL in existing corridor between Güstrow – Parchim/Süd – Perleberg - Stendal/West – Wolmirstedt. Detailed information given in Germany's Grid Development Plan.	RES integration	Permitting / under constructi on	Permitting / under construction

Germany	P113-M212, M202a, M203	Krümmel (DE)	Wahle (DE)		Including ad-hoc Maßnahme Serienkompensation Stadorf – Wahle.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P135-M255	Bechterdissen	Ovenstädt		Reinforcement of existing 380-kV line between Bechterdissen and Ovenstädt	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P161-M91	Großkrotzenburg (DE)	Urberach (DE)		Reinforcement of existing 380-kV line between Großkrotzenburg and Urberach	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P175	Wilhelmshaven 2 (DE)	Fedderwarden (DE)		New 380-kV-line Wilhelmshaven 2 – Fedderwarden for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P200	Point Blatzheim (DE)	Oberzier (DE)		Reinforcement of existing 380-kV line between point Blatzheim and Oberzier	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P228	Landesbergen (DE)	Mehrum/Nord (DE)		New 380-kV line Kreis Segeberg – Siems in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P314				Phase-shifting transformers in the Saarland	RES integration	Planned	Planned

Germany	P315	Hanekenfähr (DE)	Gronau (DE)		Reinforcement of existing/ new 380-kV line between Hanekenfähr and Gronau	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P327				Ad-hoc phase-shifting transformers in the Ruhr region	RES integration	Planned	Planned
Germany	P345-M556	Hamburg/Ost (DE)			Four phase-shifting transformers in substation Hamburg/Ost	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P346	Hanekenfähr (DE)			Ad-hoc phase-shifting transformers in Hanekenfähr	RES integration	Planned	Planned
Germany	P347	Oberzier (DE)			Ad-hoc phase-shifting transformers in Oberzier	RES integration	Planned	Planned
Germany	P348	Krempermarsch (formerly Wilster/West) (DE)			New phase-shifting transformers in Wilster/West	RES integration	Planned, but not yet in permitting	under construction
Germany	P349	Würgau			New phase-shifting transformers in in Würgau	RES integration	Planned, but not yet in permitting	under construction

Germany	P353	Twistetal			New phase-shifting transformers in Twistetal.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P357-M566	Güstrow (DE)			Four phase-shifting transformers in substation Güstrow.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P358-M567	Lauchstädt + Weida (DE)			This investment includes two new 380/220 kV transformers in Lauchstädt and a new 380/220 kV transformer in Weida	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P359-M571+M582b	Stendal/West (DE)	Wolmirstedt (DE)		New 380 kV OHL in existing corridor between Stendal/West – Wolmirstedt. Detailed information given in Germany's Grid Development Plan.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P360-M464+M464b+M595a-q+M605a-c+M685a-g+M686+M695a-c+M752	(Substations in Mitte, Malchow, search area Osterburg, search area Schraplau/Obhausen, search area Schwanbeck, Zeitz, search area Delitzsch, Streumen, Altenfeld, search area Ebenheim, Weida, Wolkramshausen,			Installation of reactive power compensation (e.g. MSCDN, STATCOM, etc.) in 50Hertz control area (substations in Mitte, Malchow, search area Osterburg, search area Schraplau/Obhausen, search area Schwanbeck, Zeitz, search area Delitzsch, Streumen, Altenfeld, search area Ebenheim, Weida, Wolkramshausen, Altdöbern, Bertikow, Preilack, Thyrow, Berlin/South-East, Hamburg/Northeast, Bentwisch, Güstrow, Pasewalk, Parchim/South, Jessen/North, Pulgar, Altöbern, Pulitz/South, Altentreptow/South and Betzsee/North)	RES integration / security of supply		Planned, but not yet in permitting

		Altdöbern, Bertikow, Preilack, Thyrow, Berlin/South-East, Hamburg/Northeast, Bentwisch, Güstrow, Pasewalk, Parchim/South, Jessen/North, Pulgar, Altöbern, Pulitz/South, Altentreptow/South and Betzsee/North (DE)						
Germany	P365-M383	Audorf/Süd	Ottenhofen (DE)		100 MW grid booster in substations Audorf/Süd and Ottenhofen	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P400	Grid of TenneT (DE)			Construction of several reactive power compensation units in grid of TenneT (DE)	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P403-M603	Hattingen (DE)	Linde (DE)		Reinforcement of existing OHL between Hattingen and Linde	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting

Germany	P410-M624	Enniger			Phase-shifting transformers in Enniger	RES integration	Planned	Planned
Germany	P412				Several reactive power compensation systems in the area of the Amprion GmbH	RES integration	Planned	Planned
Germany	P450-M678+M786	Güstrow (DE)	Stendal/West (DE)		Reinforcement of existing 380 kV OHL (M678: Putlitz/Süd – Putlitz – Perleberg – Stendal/West; M786: Güstrow – Siedenbrünzow – Putlitz/Süd)	RES integration		Planned, but not yet in permitting
Germany	P451-M681	Graustein (DE)	Bärwalde (DE)		Reinforcement of existing 380 kV OHL Graustein – Bärwalde	RES integration		Planned, but not yet in permitting
Germany	P450-M683	Ragow (DE)	Streumen (DE)		Reinforcement of existing 380 kV OHL Ragow – Streumen	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P460-M687				Grid reinforcements in the region of Büscherhof	RES integration	Planned	Planned
Germany	P462-M689				Grid reinforcements in the region of Aachen	RES integration	Planned	Planned

Germany	P463-M690				Grid reinforcements in western Rhein region	RES integration	Planned	Planned
Germany	P119-M90, M535	Conneforde (DE)	Samtgemeinde Sottrum (DE)		New 380-kV line Conneforde – Sottrum in existing corridor for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P43	Mecklar (DE)	Bergrheinfeld/ West (DE)		New 380-kV line Mecklar – Bergrheinfeld/West for RES integration	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P24	Dollern (DE)	Landesbergen (DE)		New 380-kV line Dollern – Landesbergen in existing corridor for RES integration	RES integration	In Permitting	In Permitting
Germany	P21	Conneforde (DE)	Cloppenburg (DE)		New 380-kV-line Conneforde – Landkreis Cloppenburg in existing corridor for RES integration	RES integration		In Permitting
Germany	P21	Cloppenburg (DE)	Merzen (DE)		New 380-kV-line Landkreis Cloppenburg – Merzen for RES integration	RES integration		In Permitting
Germany	TTG-006	Wahle (DE)	Mecklar (DE)		New 380-kV-line Wahle – Mecklar for RES integration	RES integration		Under construction

Germany	AMP/TTG 007	Dörpen/West (DE)	Niederrhein (DE)		New 380-kV-line Dörpen/West – Niederrhein for RES integration	RES integration		Under construction
Germany	AMP/TTG 009	Ganderkesee (DE)	Wehrendorf (DE)		New 380-kV-line Ganderkesee – Wehrendorf for RES integration	RES integration		Under construction
Germany	TTG-P25	Husum/Nord (DE)	Klixbühl/Süd (DE)		West coast line Heide/West – Klixbühl for RES integration	RES integration		Under construction
Germany	DC 20	Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin (DE)	Isar (DC)		New HVDC-cable Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin – Isar for RES integration	RES integration		Planned, but not yet in permitting
Germany	DC 31	Hemmingstedt/Lieth/Lohe-Rickelshof/Wöhrden (DE)	Klein Rogahn/Stralendorf/ Warsow/ Holthusen/Schossin (DE)		New HVDC-cable Hemmingstedt/Lieth/Lohe-Rickelshof/ Wöhrden (DE) – Klein Rogahn/Stralendorf/ Warsow/ Holthusen/Schossin for RES integration	RES integration		Planned, but not yet in permitting
Germany	P212	Landesbergen (DE)	Borken (DE)		New 380-kV-line Landesbergen – Borken in existing corridor for RES integration	RES integration		Planned, but not yet in permitting
Germany	P227	Lübeck/West (DE)	Krümmel (DE)		New 380-kV line Lübeck/West – Krümmel for RES integration	RES integration		Planned, but not yet in permitting

Germany	P500	Sombron	Urberach (DE)		New 380-kV line Somborn – Aschaffenburg – Urberach for RES integration	RES integration		Planned, but not yet in permitting
Germany	TNG-P47-M31, M32, M33, M34, M31TR1	Weinheim (DE)	Daxlanden (DE)		Upgrade of existing 380 kV lines in the area from Weinheim to Daxlanden. In addition, a new phase-shifting transformer in Weinheim for the distribution grid is necessary.	RES integration		Permitting
Germany	AMP-P47- M60	Urberach (DE)	Weinheim (DE)		Upgrade of existing 380 kV lines in the region Frankfurt-Karlsruhe	RES integration		Permitting
Germany	TNG-P48-M38a, M39	Grafenrheinfeld (DE)	Großgartach (DE)		Additional 380 kV circuit between Point Rittershausen and Kupferzell incl. the enhancement of substation in Kupferzell. Reinforcements in existing corridor between Kupferzell and Großgartach.	RES integration		Permitting
Germany	TNG-P49	Daxlanden (DE)	Eichstetten (DE)		Upgrade of existing 220 kV lines from Daxlanden via Bühl, Kuppenheim and Weier to Eichstetten to 380 kV. The enhancement of corresponding substations will be carried out.	RES integration	Permitting	Permitting
Germany	TNG-P50-M366SA1	Pulverdingen (DE)			Extension of substation Pulverdingen	RES integration		Planned, but not yet in permitting
Germany	TNG-P70	Birkenfeld (DE)	Ötisheim (DE)		A new 380 kV OHL Birkenfeld-Ötisheim (Mast 115A) incl. new 380 kV GIS-substation in Birkenfeld	Security of supply	Permitting / Under construction	Under construction

Germany	TNG-P90	Grid of TransnetBW			Construction of several reactive power compensation systems in the area of the TransnetBW GmbH	RES integration		Planned, but not yet in permitting
Germany	TNG-P350-M561	Pulverdingen (DE)			New phase-shifting transformer in Pulverdingen	RES integration		Planned, but not yet in permitting
Germany	P51-M37	Großgartach (DE)	Endersbach (DE)		Grid reinforcements in existing corridor between Großgartach and Endersbach. Enhancement of the substations Endersbach and Großgartach is required.	Security of supply		Planned, but not yet in permitting
Germany	P302-M511	Höpfingen (DE)	Hüffenhardt (DE)		Additional 380 kV line between Höpfingen and Huffenhardt incl. grid reinforcements in the corresponding substations.	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P206-M417	Herbertingen/ Area of Constance/Be uren (DE)	Gurtweil/Tiege n (DE)		Increase of transmission capacity in the Hochrhine region by replacement of existing 220 kV infrastructure.	Security of supply	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P428-M700	Kühmoos			Upgrade of 380 kV substation Kühmoos in Southern Germany	RES integration	Planned, but not yet in permitting	Planned, but not yet in permitting
Germany	P430-M646	Kupferzell			250 MW grid booster in substation Kupferzell	RES integration		Planned, but not yet in permitting

Germany	P421-M702	Trossingen			Connection of existing 380kV line Engstlatt – Gurtweil – Villingen to the substation in Trossingen. Enhancement of substation Trossingen and other connected lines is required.	Security of supply		Planned, but not yet in permitting
Germany	P223-M462a	Güstrow (DE)	Krümmel (DE)		New 380 kV OHL in existing corridor between Güstrow – Wessin – Görries – Gemeinden Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin – Gemeinden Talkau/Elmenhorst/Kankelau/Fuhlenhagen – Krümmel. Detailed information given in Germany's Grid Development.	RES integration		Planned, but not yet in permitting
Germany	P252-M534a	Marzahn (DE)	Wuhlheide (DE)		New 380 kV OHL in existing corridor between Marzahn – Wuhlheide. Detailed information given in Germany's Grid Development.	Security of supply		Planned, but not yet in permitting
Germany	P528-M750	Lauchstädt (DE)	Pulgar (DE)		New 380 kV OHL in existing corridor between Lauchstädt – Leuna/Merseburg/Weißenfels – Pulgar. Detailed information given in Germany's Grid Development Plan.	Security of supply		Planned, but not yet in permitting
Germany	P402	Westerkappeln (DE)	Gersteinwerk (DE)		380-kV HL OHL in new corridor between Westerkappeln and Gersteinwerk	RES integration		Planned, but not yet in permitting
Germany	P408	Eiberg (DE)	Emscherbruch (DE)		380-kV HL OHL in existing corridor from Eiberg to Emscherbruch	RES integration		Planned, but not yet in permitting

Germany	P464	Saarland (DE)	Sarwellingen (DE)		New 380/110kV transformers.	Security of supply			Planned, but not yet in permitting
Germany	P501	Gersteinwerk (DE)	Mengede (DE)		380-kV HL OHL in existing corridor from Gersteinwerk to Mengede	RES integration			Planned, but not yet in permitting
Germany	P502	Walsum (DE)	Beeck (DE)		380-kV HL OHL in existing corridor from Walsum to Beeck	RES integration			Planned, but not yet in permitting
Germany	P504	Sechtem (DE)	Weißenthurm (DE)		New 380-kV line reinforcement from Sechtem to Weißenthurm	RES integration			Planned, but not yet in permitting
Germany	P531-M531a/M531b	Thyrow (DE)	Reuter (DE)		New 380 kV OHL in existing corridor between Thyrow – search area Großbeeren/Blankenfelde – Mahlow – Berlin/Südost/search area Stadtbezirk Steglitz-Zehlendorf – search area Stadtbezirke Mitte/Friedrichshain – Kreuzberg M531b: Malchow – search area Stadtbezirke Mitte/Reinickendorf – Reuter. Detailed information given in Germany's Grid Development Plan.	Security of supply			Planned, but not yet in permitting

6.4.The Ukrainian and Moldovan power system synchronous connection

The synchronous connection of the Ukrainian and Moldovan power systems to Continental European power system is one of the most important future challenges for the CCE region, as only one part of the IPS of Ukraine, the so-called 'Burshtynska TPP Island', was synchronously operated with Slovakia, Hungary, and Romania with the 220, 400 kV and 750 kV transmission lines. The 'Island' includes Burshtynska TPP, Kaluska CHPP and Tereblia-Rikska HPP with a total installed capacity of 2,530 MW, maximum export capabilities up to 650 MW, infrastructure of 220–750 kV and distribution networks of electricity suppliers in the Carpathian region.

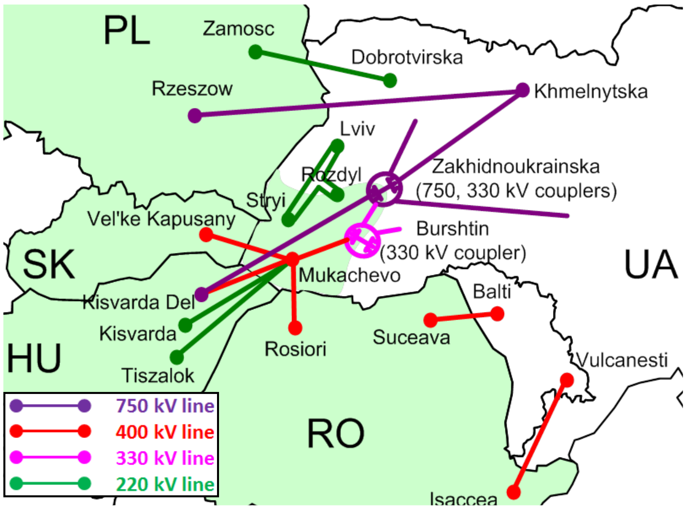


Figure 38 Schematic overview of the Ukrainian and Moldovan power system interconnectors with the surrounding ENTSO-E TSOs

The integration of the whole IPS of Ukraine to the Continental European power system was one of the Ukrainian TSO's key goals in power grid development. It is also important for the energy security, reliability, and balanced performance of the IPS of Ukraine, and will allow the effective use of energy resources and a significant increase in power exchange capabilities. Integration of the IPS of Ukraine into ENTSO-E is stipulated in the EU-Ukraine Association Agreement.

Preparations for the interconnection of the Ukrainian and Moldovan power systems to the Continental European power system started in March 2006, when the TSOs of Ukraine and Moldova filed a request for synchronous interconnection to the UCTE system, now ENTSO-E.

A consortium of ENTSO-E members conducted a feasibility study entitled Synchronous Interconnection of the Ukrainian and Moldovan Power Systems to the ENTSO-E Continental Europe Power System, which was completed in January 2016.

The overall objectives of the feasibility study were:

- To investigate the potential for Ukrainian and Moldovan power systems to be operated in parallel with the Continental European synchronous area, respecting its technical operational standards; and
- To investigate the degree of implementation of ENTSO-E's technical operational standards in the Ukrainian and Moldovan power systems.

The feasibility study presented appropriate recommendations to overcome the main technical, organisational, and possible legal obstacles and supported the work of various appropriate bodies, including ENTSO-E, to decide and agree on the needed measures. The main conclusions from the study are summarised below.

- From a static analysis point of view, the synchronous connection of the Ukrainian and Moldovan power systems to the Continental part of ENTSO-E is feasible, with the infrastructure (existing and planned) expected to be available in the future.
- From a dynamic analysis point of view, the interconnection cannot be feasible without applying proper countermeasures due to the inter-area instability risks identified in the interconnected model. The source of the instability is insufficient damping for low-frequency oscillations at large generators in Ukraine.
- Inter-area stability can be improved if one of the proposed countermeasures is applied. The adopted solutions must be verified by the manufacturers of existing control systems in power plants in Ukraine and Moldova, particularly if they refer to nuclear power plants.
- Only after such revision of proposed measures and on-site testing of selected exciters and governors can the final evaluation of the efficiency of countermeasures and their influence on the small-signal inter-area stability of the interconnected systems be carried out.
- With regard to operational issues, according to the data received and the analysis, the power systems of Ukraine and Moldova are partially prepared for synchronous operation with the Continental Europe System under the rules laid out in the Operation Handbook of ENTSO-E. The main issues that must be covered in order to reach the expected level of compliance are connected to frequency regulation, real-time operations and special protection systems.
- The European legal system for energy, and the Third Energy Package in particular, should be fully implemented in both Ukraine and Moldova. Regarding energy, the information received from Ukraine and Moldova has revealed that the systems in place in Ukraine and Moldova are not currently fully compliant with the system in place in the ENTSO-E countries, although both systems are moving in the right direction.

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

The additional studies started in April 2020 and were finalised in December 2021. They analysed the possibility of synchronously interconnecting the power systems of Ukraine, Moldova, and Continental Europe in the present situation (without development projects). The technical measures to ensure system stability were determined based on dynamics models which take into consideration the results of recent unit tests performed in Ukraine and Moldova.

The main conclusions of the study were:

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

Considering the obtained results, the proposed solution for improvement of damping of the inter-area oscillations was:

- Retuning of selected dual input power system stabilisers (**M1**). The selection should be based on the damping improvement achieved by retuning. Therefore, retuning should apply to units, the generator of which contributes significantly to inter-area oscillations, and at the same time PSS is not properly tuned. It was also found that retuning limited to generators with rated power over 50 MVA (**M1****) may be performed with only a small decrease in effectiveness.

supplemented with additional measures selected from the following:

- Addition of standalone stabilisers to the 1111 MVA nuclear units equipped with REM700 Brushless excitation systems (**M2**),
- AVR retuning on all generators of the nuclear units (**M3**),
- Installation of STATCOMs with POD using a frequency signal or other power electronics device that could provide equivalent damping (**M4**),
- Frequency feedback retuning on generators at Zaporizka NPP (**M5**),
- Frequency feedback retuning and AVR gain reduction on generators at Zaporizka NPP (**M6**).

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

After applying the proposed countermeasures, there will be no inter-area stability constraints for maximum power exports from Ukraine and Moldova obtained in the load flow calculations.

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

The Task Force (TF) determined the minimum requirements and assessed the risks of synchronisation, and defined the necessary actions to be implemented in order to mitigate the identified risks.

Exceptional actions have been implemented with the support of concerned stakeholders and authorities.

On 11 March, Continental European TSOs concluded that the conditions for an emergency synchronisation were met and completed the emergency synchronisation on 16 March. Throughout the process Continental Europe TSOs received support from the European Commission, the Member States and Regulatory Authorities.

Comprehensive 24/7 monitoring of the situation is being performed, and appropriate measures are also planned.

Since the emergency synchronisation on 16 March 2022, Continental European TSOs together with Ukrenergo and Moldelectrica have successfully ensured the security of the two interconnected power systems. Following a request from Ukrenergo, Continental European TSOs have analysed the technical pre-conditions to allow the reopening of electricity trade through the interconnections with Ukraine.

On 7 June 2022, Continental European TSOs decided to positively address Ukrenergo's request and confirmed the key conditions that, once met, will enable a gradual opening of electricity trade with Ukraine. Ukrenergo and the Continental European TSOs will work together to implement these conditions. The full implementation of these technical conditions is necessary to guarantee the security and stability of the extended power system.

The first cross-border power interchange after the interconnection started on 30 June 2022.

6.5.Baltic synchronization

The Baltic States currently operate in synchronous mode with the Russian and Belarussian electricity systems (IPS/UPS – Integrated Power System / Unified Power System), forming the so-called BRELL-ring (Belarus-Russia-Estonia-Latvia-Lithuania). The energy policy of the Baltic States is integrated with the energy strategy of the EU and must comply with major objectives such as sustainable development, electricity market competitiveness and security of supply. In addition to these objectives, the Baltic States must continue developing competitive and fully integrated electricity markets, along with a sufficiently developed energy infrastructure to connect distributed RES (wind, biomass, and biogas, solar etc.) and meet EU energy neutrality targets.

Additionally, all the significant issues mentioned above received a great deal of attention after 24th of February 2022 from EU and Baltic States, since the relationship between Russia and Ukraine and the geopolitical situation has developed into military aggression and war. This resulted in clear reasons to shift from Russian and Belarussian integrated power systems to the Continental European power system even before the set deadline of 2025. Starting from 22nd of May, all electricity imports to the Baltic States and Finland were cut off and the Baltic states ceased electricity trade with Russia. Currently, the TSOs of the Baltic states are technically ready for urgent desynchronisation from IPS/UPS, but the next steps depend on further military activities by the Russian Federation side in Ukraine and even on other potential military activities in the eastern region.

Until 2022, many preparation works and prefeasibility studies were done to prepare for the successful synchronisation of the Baltic states' power systems to the Continental European power system, beginning with the initiation of the project, the signing-off of a general Roadmap, political agreement among EU and Baltic states leaders, various different kinds of studies performed and upgrading of power systems, and work is still in progress to prepare the Baltic states for synchronous operation with Continental Europe by 2025. The project has received European Union co-financing from CEF funds of around €M1,214 for project realisation. The whole Baltic Synchronization project has been divided in two main parts:

- **Phase I** – internal transmission network reinforcements in the Baltic states. The investments are necessary to strengthen the Baltic states' internal grid in order to avoid bottlenecks on the cross-borders of these three countries, regardless of the synchronisation of the Baltic states' power system to Continental European power system.
- **Phase II** – investment items recommended by the dynamic and frequency studies prepared by the Baltic and Polish TSOs, as well as for activities mentioned in the Catalogue of Measures of the CFI Agreement (Agreement on the conditions of the future interconnection of the power system of the Baltic states and the power system of Continental Europe) concluded on the 27th of May 2019 by Baltic and European TSOs.

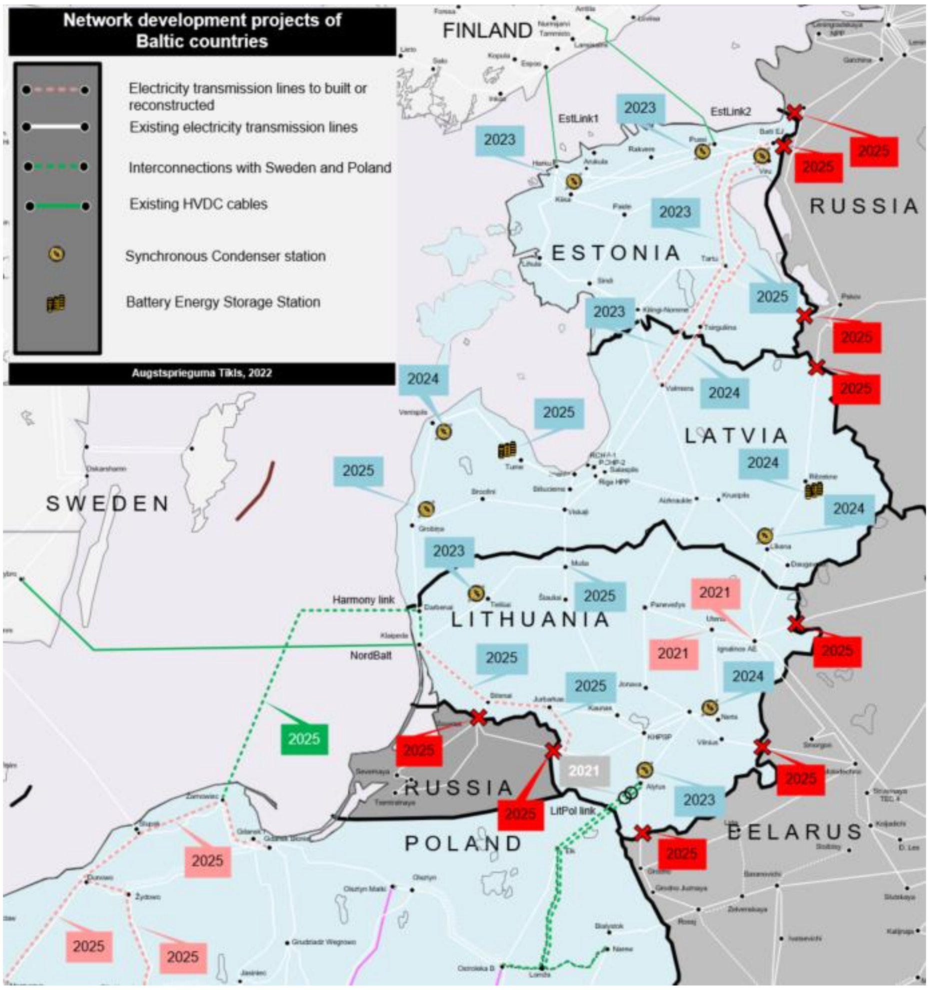


Figure 39 Topology of the investments for Baltic States and Poland included in the Baltic Synchronisation project

The list of Projects of Common Interest has been developed on the basis of the European Parliament and Council Regulation (EU) No. 347/2013 of 17 April 2013, on guidelines for trans-European energy infrastructure, and on the repeal of Decision No. 1364/2006/EC and amendment of Regulations (EC) No. 713/2009, (EC) No. 714/2009 and (EC) No. 715/2009. The Baltic synchronisation cluster is included in the 5th PCI list with No. 4.8 under the corridor, which includes the Baltic Sea region projects of the Nordic countries, the Baltic States, Poland, and Germany. Synchronisation Project 4.8 is titled *Integration and synchronisation of the Baltic States' electricity system with the European network*. The inclusion of synchronisation-related investment items in the list of updated PCIs enhances the importance of the synchronisation project for the whole Baltic Sea region and for Europe as well. In the 5th PCI list, only the most important and beneficial projects for the EU have remained.

In 2021 AST, Litgrid and Elering signed a Service Contract with a consortium of transmission system operators of Continental Europe (CE TSOs) for preparation of synchronisation studies, to facilitate future recommendations on necessary upgrades in Baltic power systems.

The studies are expected to be finalised by the end of 2022. The studies, prepared by the consortium, are crucial for implementation and development of the synchronisation of the Baltic power systems with the Continental European power system. Based on the results and outcomes of the studies, future adjustments of equipment, as well as additional measures not identified and studied previously, in the Baltic power systems will be prepared.

A total of five studies will be prepared, including a Dynamic Stability Study, an Oscillatory Stability Study with a full dynamic model of Baltic and Continental Europe, an Isolated Operation Study, a Frequency Stability Assessment System study, and a Load-Frequency Controller implementation study for the Baltic power systems. The aforementioned list of synchronisation studies is identified in Annex II of the CFI Agreement. The studies necessary for synchronisation have been identified by ENTSO-E Regional Group Continental Europe (RGCE) to ensure secure operation of the Baltic and Continental European power systems after synchronisation and are necessary to evaluate Baltic power systems' ability to fulfil the technical standards binding in Continental Europe. A brief description of studies and their deliverables is as follows:

1. Transient Stability Study – continuation of the transient stability assessment of Baltic power systems after their synchronisation with the power systems of CE with updated dynamic models of the Baltic power systems.
2. Oscillatory Study – Small signal stability assessment of Baltic power systems working synchronously with CE systems. Assessment of oscillation modes both within the area of three Baltic power systems and within CE systems. Continuation of the previous studies with updated dynamic models of three Baltic power systems.
3. Island Operation Study – Operational Stability assessment for Baltic power systems in case of emergency disconnection from the IPS/UPS power system.
4. FSAS Study – Concept development of frequency assessment and monitoring system for three Baltic power systems for synchronous operation with CE power systems or in the isolated island mode. Assessment of current best practices. Development of System Operation tools and data exchange principles.
5. LFC Study – Concept development of Load/Frequency control for the three Baltic power systems.

The remaining projects and investments are proceeding according to schedule and the Baltic States TSOs must hurry to get ready everything according to the set deadline.

6.6.Glossary

Table 4 list of terms

Term	Acronym	Definition
Agency for the Cooperation of Energy Regulators	ACER	EU Agency established in 2011 by the Third Energy Package legislation as an independent body to foster the integration and completion of the European Internal Energy Market both for electricity and natural gas.
Baltic Energy Market Interconnection Plan in electricity	BEMIP Electricity	One of the four priority corridors for electricity identified by the TEN-E Regulation. Interconnections between Member States in the Baltic region and the strengthening of internal grid infrastructure, to end the energy isolation of the Baltic States and to foster market integration; this includes working towards the integration of renewable energy in the region.
Bottom-Up		This approach to the scenario-building process collects supply and demand data from gas and electricity TSOs.
Carbon budget		This is the amount of carbon dioxide the world can emit while still having a reasonable chance of limiting average global temperature rise to 1.5 °C above pre-industrial levels, an internationally agreed-upon target.
Carbon Capture and Storage	CCS	Process of sequestering CO_2 and storing it in such a way that it will not enter the atmosphere.
Carbon Capture and Usage	CCU	The captured CO_2, instead of being stored in geological formations, is used to create other products, such as plastic.
Combined Heat and Power	CHP	Combined heat and power generation.
Congestion revenue / rent		The revenue derived by interconnector owners from the sale of the 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		Means a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned.
	COP21	21st Conference of the Parties to the United Nations Framework Convention on Climate Change, organised in 2015, at which participating states reached the Paris Agreement.
Cost-benefit analysis	CBA	Analysis carried out to define to what extent a project is worthwhile from a social perspective.
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 congestion of transmission or otherwise manage the system or achieve the optimum mix of resources.

Demand-side response	DSR	Consumers play an active role in softening peaks in energy demand by changing their energy consumption according to energy price and availability.
e-Highway2050	EH2050	Study funded by the European Commission aimed at building a modular development plan for the European transmission network from 2020 to 2050, led by a consortium including ENTSO-E and 15 TSOs from 2012 to 2015 (to e-Highway2050 website).
Electricity corridors		Four priority corridors for electricity identified by the TEN-E Regulation: North Sea offshore grid (NSOG); North-south electricity interconnections in western Europe (NSI West Electricity); North-south electricity interconnections in central eastern and south eastern Europe (NSI East Electricity); Baltic Energy Market Interconnection Plan for electricity (BEMIP Electricity).
Energy not served	ENS	Expected amount of energy not being served to consumers by the system during the period considered due to system capacity shortages or unexpected severe power outages.
Grid transfer capacity	GTC	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.
Internal Energy Market	IEM	To harmonise and liberalise the EU's internal energy market, measures have been adopted since 1996 to address market access, transparency and regulation, consumer protection, supporting interconnection, and adequate levels of supply. These measures aim to build a more competitive, customer-centred, flexible, and non-discriminatory EU electricity market with market-based supply prices.
Investment (in the TYNDP)		Individual equipment or facility, such as a transmission line, a cable, or a substation.
Mid-term adequacy forecast	MAF	ENTSO-E's yearly pan-European monitoring assessment of power system resource adequacy spanning a timeframe from one to ten years ahead.
Net transfer capacity	NTC	The maximum total exchange programme between two adjacent control areas compatible with security standards applicable in all control areas of the synchronous area, taking into account the technical uncertainties of future network conditions.
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.
National Energy and Climate Plan	NECP	National Energy and Climate Plans are the new framework within which EU Member States must plan, in an integrated manner, their climate and energy objectives, targets, policies and measures for the European Commission. Countries have to develop NECPs on a ten-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 Union's 2030 targets for greenhouse gas emission reductions, renewable energy, energy efficiency and electricity interconnection are met.
North Seas offshore	NSOG	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

grid		transport electricity from renewable offshore energy sources to centres of consumption and storage and to increase cross-border electricity exchange.
North-south electricity interconnections in central eastern and south eastern Europe	NSI East Electricity	One of the four priority corridors for electricity identified by the TEN-E Regulation. Interconnections and internal lines in north-south and east-west directions to complete the EU internal energy market and integrate renewable energy sources.
North-south electricity interconnections in western Europe	NSI West Electricity	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, in particular to integrate electricity from renewable energy sources and reinforce internal grid infrastructures to promote market integration in the region.
Power to gas	P2G	Technology that uses electricity to produce hydrogen (Power to Hydrogen – P2H2) by splitting water into oxygen and hydrogen (electrolysis). The hydrogen produced can then be combined with CO_2 to obtain synthetic methane (Power to Methane – P2CH4).
Project (in the TYNDP)		Either a single investment or a set of investments, clustered together to form a project, in order to achieve a common goal.
Project of common interest	PCI	A project which meets the general and at least one of the specific criteria defined in Art. 4 of the TEN-E Regulation and which has been granted the label of PCI project according to the provisions of the TEN-E Regulation.
Put IN one at a Time	PINT	Methodology that considers each new network investment/project (line, substation, PST, or other transmission network device) on the given network structure one by one and evaluates the load flows over the lines with and without the examined network reinforcement.
Reference grid		The existing network plus all mature TYNDP developments, allowing the application of the TOOT approach.
Reference capacity		Cross-border capacity of the reference grid used for applying the TOOT/PINT methodology in the assessment according to the CBA.
Scenario		A set of assumptions for modelling purposes related to a specific future situation in which certain conditions regarding electricity and gas demand and supply, infrastructures, fuel prices and global context occur.
Take Out One at the Time	TOOT	Methodology that consists of excluding investment items (lines, substations, PSTs, or other transmission network devices) or complete projects from the forecasted network structure on a one-by-one basis and to evaluate load flows over the lines with and without the examined network reinforcement.
Ten-Year Network	TYNDP	The Union-wide report carried out by ENTSO-E every other year as part of its regulatory obligation as defined under Article 8, para 10 of Regulation (EC) 714 /

Development Plan		2009.
Top-Down		The "Top-Down Carbon Budget" scenario building process is an approach that uses the "bottom-up" model information gathered from the gas and electricity TSOs. The methodologies are developed in line with the Carbon Budget approach.
Trans-European Networks for Energy	TEN-E	Policy focused on linking the energy infrastructure of EU countries. It identifies nine priority corridors (including four for electricity) and three priority thematic areas.

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Authors:

Andrew Kasembe - CEPS, Czech Republic (Convenor)

Anca Antemir - Transelectrica, Romania

Tamás Decsi - MAVIR, Hungary

Aljosa Dezelak - ELES, Slovenia

Glib Didychenko - NPC UKRENERGO, Ukraine

Giorgiana Giosanu - Transelectrica, Romania

David Hampl - CEPS, Czech Republic

Michael Heit - 50Hertz Transmission, Germany

Timothy Hofmann - APG, Austria

Zsolt Zoltan Lengyel - MAVIR, Hungary

Goran Levacic - HOPS, Croatia

Christoph Linhardt - TenneT TSO GmbH, Germany

Stephan Osterbauer - APG, Austria

Ivan Simunic - HOPS, Croatia

Matej Stetka - SEPS, Slovakia

Krzysztof Tokarski - PSE, Poland

Andrzej Tymorek - PSE, Poland

Radek Vrabel - CEPS, Czech Republic

Tomas Vyskoc - SEPS, Slovakia

TYNDP

ENTSO-E . Rue de Spa 8 . 1000 Brussels . Belgium

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