TYNDP 2022

Regional Investment Plan
Continental Central South

Final Version · May 2023

entsoe

ENTSO-E Mission Statement

Who we are

The European Network of Transmission System Operators for Electricity (ENTSO-E) is the association for the cooperation of 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, which is the largest interconnected electrical grid in the world. In addition to its core historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

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

Our mission

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

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, affordable, and 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 for a climate-neutral Europe.

Our values

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

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

ENTSO-E is committed to working with the highest technical rigour 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 the 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 the integration of renewable energy;

› Assessment of system adequacy in different timeframes;

› Coordination of the planning and development of infrastructure at the European level (10-Year Network Development Plans, TYNDPs);

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

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

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

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

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1 EXECUTIVE SUMMARY

The Continental Central South (CCS) region is composed of Austria (AT), France (FR), Germany (DE), Italy (IT), Slovenia (SI) and Switzerland (CH). In the north-south direction, this region covers an area that ranges from the North Sea via the Alps in the very heart of continental Europe to the Mediterranean area. From the west, it connects the French Atlantic coast with the eastern part of Europe.

Country	Company/TSO
Austria	APG
France	RTE
Germany	Amprion, Tennet TSO GmbH, TransnetBW GmbH
Italy	Terna
Slovenia	ELES
Switzerland	Swissgrid

Figure 1 – The Continental Central South region and its TSOs representatives

At present, the CCS region is globally an exporting region, with the sum of all external and internal exchanges representing approximately 50% of the exchanges of the entire ENTSO-E perimeter. The involved countries have a highly meshed transmission system, which leads to intense interaction between neighbouring countries at the energy transmission level.

The main drivers for power system evolution can be summarised as follows:

- **Massive renewable energy source (RES) integration**, which leads to fluctuations in power generation and high utilisation of the transmission network. Moreover, the geographical distribution of RES development leads to amplified power exchanges over a wide transmission area. Thus, a more flexible transmission grid is needed.

- **Efficient integration of storage plants to facilitate the efficient use of RESs.** In this respect, considerable storage potential is available in the very centre of the region, particularly in the form of existing and planned hydro pumped storage and hydro power plants located mainly in the Alps.

- **Nuclear and coal phase-out**, which has a strong impact on the electricity systems and thus the countries' power and energy balances, according to various assumptions. Especially in Germany, the nuclear phase-out until 2023 and the coal phase-out until 2038 will lead to a high decrease in the amount of reliably available generation capacity.

- **Existing thermal capacity dismissing/mothballing**, which is mainly due to increasing RES production. This renders the operation of existing plants uneconomic sooner and leads to structural changes in the power system conditions, especially in the most peripheral areas of the region (e.g., IT). The availability of an adequate grid infrastructure constitutes the basis for coping with such structural changes.

- **Increase in wide-area power flows throughout the region,** which is associated with difficulties in RES integration due to its volatility and varying distances from power consumption centres. For example, in Italy, RESs are mostly located in the south, while consumption occurs in the north. In contrast, in Germany, the high feed-in from RESs—especially wind off-shore energy in the North Sea—and the energy deficit of the consumption centres located in the south result in a large transmission requirement in the north-south direction.

- **Main boundaries due to market integration needs** refer to the integration of the Italian peninsula (northern boundary, borders with the Balkans and Tunisia), the internal bottlenecks among the six different IT price zones, and the integration of Corsica, the Swiss roof, the French north-eastern border and the Austrian-German border.

- **System stability and security of supply (SoS).** Considering the fundamental changes in the entire electricity system summarised in the previous point, these have become key issues. Thus, a broad consideration of all relevant parameters is required. SoS investigations into single demand centres are no longer sufficient. Instead, investigations and improvement projects are urgent in the peripheral and scarcely meshed network areas of the region.

Caused by the main drivers and network constraints explained above, several transmission expansion projects have been already planned and additional needs have been investigated throughout the CCS region.

ENTSO-E's Identification of System Needs (IoSN) investigated increases in cross-border transmission capacity that would maximise overall system cost-efficiency in 2030 and 2040 (considering total network investment and generation costs). The outcomes of the overall analysis validated the need for the existing TYNDP 2022 projects to meet market integration needs, increase the sustainability of the transmission system by integrating more RES generation, and improve the SoS.

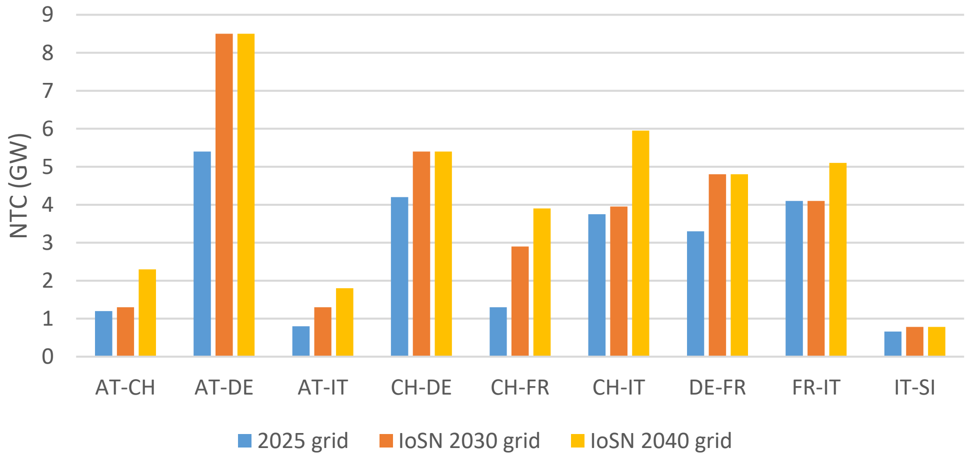

Figure 2 - IoSN investment trajectory in the CCS region from 2025 to 2040

2 INTRODUCTION AND REGIONAL CONTEXT

2.1 Regional Investment Plans

Legal requirements and links to the TYNDP package

Regional Investment Plans are part of the TYNDP package and comply with Regulation (EU) 2019/943 (Article 34 and Article 48), which requests TSOs to establish regional cooperation within ENTSO-E and publish a Regional Investment Plan biennially. Additionally, TSOs can make investment decisions based on these plans.

Regional investment plans are part of the TYNDP 2022 package, which also includes the scenario report and 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 regional investment plan further analysed the capacity increases identified in the system needs study at the regional and country levels.

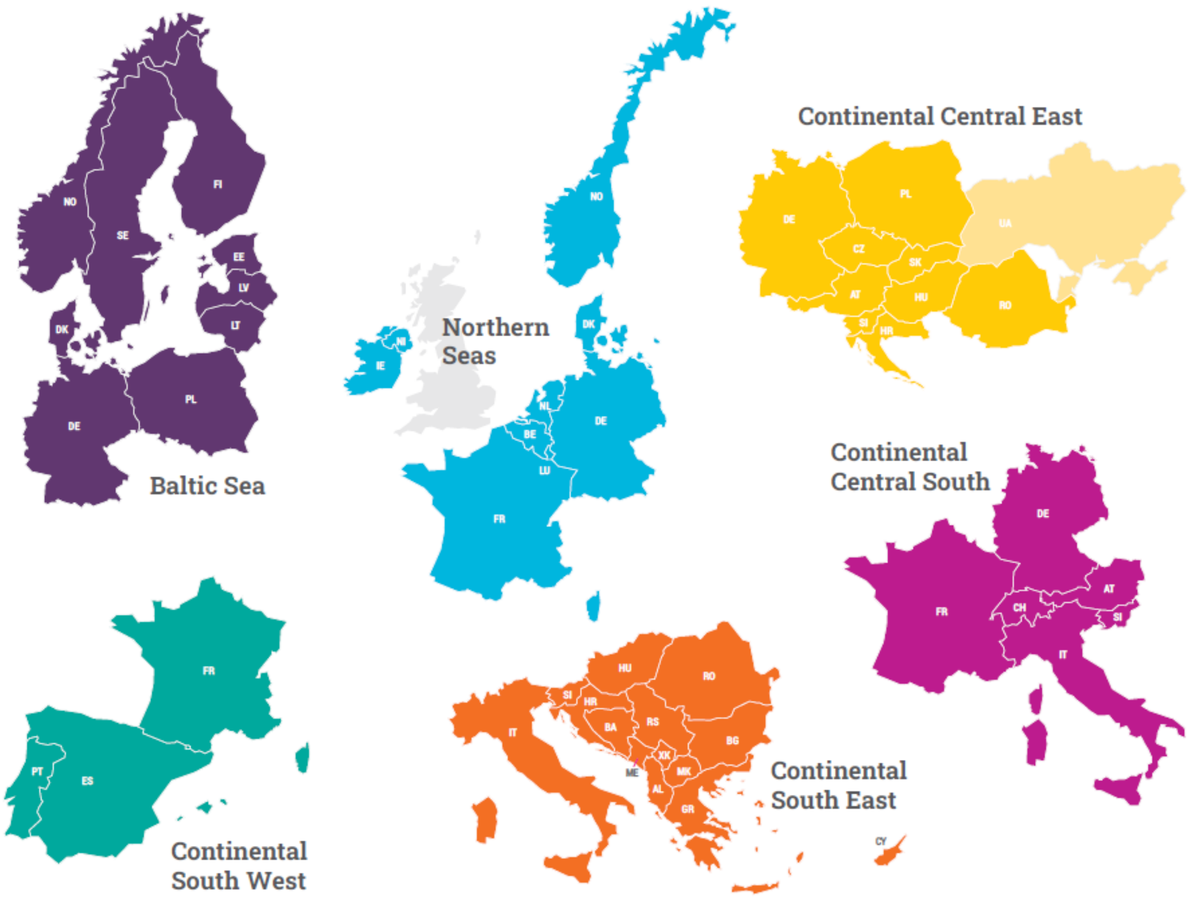

Figure 3 - ENTSO-E's system development regions (each region is covered by one regional investment plan)

Scope of the RegIPs 2022

Regional investment plans describe the present situation in each region as well as future regional challenges while considering the 2030 and 2040 time horizons. The Regional Investment Plan 2022 investigates solutions that can help to mitigate future challenges while also providing projections in terms of internal network reinforcement. Additionally, 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 region is also presented.
- **Chapter 3** covers a description of the identified regional system needs based on the regional challenges.
- **Chapter 4** is dedicated to additional analyses specific to the region.
- **Chapter 5** presents the future challenges of the region, what the necessary mitigation steps are as well as the internal reinforcement projections. The study roadmap for the region is also included.

The Appendix includes the abbreviations and terminology used in the report as well as a list of projects relevant to the region, links to national development plans, links to simulation results, and additional content presented by region.

2.2 Overview of the region and present situation

The RG Continental Central South (CCS) region is located in the centre of Europe. It is characterised by a rather strongly meshed grid that connects renewable energy sources (RESs) at the corners of the region with its rather central load centres whilst also providing a connection to neighbouring RGs. Consequently, wide area load flows across Europe can be observed, which are highly dependent on the situation in the whole of Europe and show various characteristics. In particular, climatic parameters such as temperature and rainfall (low water, floods) have a significant influence on such flows. In this context, a potent grid has to be available in the RG CCS area to avoid critical grid situations.

In the recent past, the entire region has undergone a fundamental transformation. Due to the high expansion of wind energy in the coastal regions of the North Sea, the Mediterranean Sea and the Atlantic, as well as the further integration of photovoltaics across the region, the generation mix in the region has changed significantly. Additionally, baseload power plants such as nuclear or coal are being increasingly reduced due to governmental decisions/environmental reasons and market effects. For Italy, the main scenario assumptions made in the 2030 and 2040 time horizons consider the national target of coal phase-out.

These facts lead to increasingly volatile energy production, which fundamentally changes the characteristic temporal behaviour of the entire generation mix as well as the geographical distances between generation and demand. Additionally, the speed of change is increasing.

Upon comparing the rather rapid transition of generation capacity to the relatively slow pace of transmission infrastructure development, a gap between transmission demand and available transmission capacity appears. Therefore, an extensive analysis must be conducted to provide the correct measures at the appropriate time to mitigate future challenges.

Present situation

Concerning the annual generation in CCS countries, the main energy sources for electricity vary from country to country: in France, nuclear generation; in Austria, hydro and conventional thermal generation; in Switzerland, hydro and nuclear generation; in Slovenia, nuclear, thermal and hydro generation; in Italy, mainly gas and hydro generation.

In the German power system, conventional thermal generation still has an important role. However, the effects of the energy transition are already visible. The generation from RESs accounts for approximately half of the total annual electricity generation in 2021.

The current generation mix shows potential for export in many CCS countries. This is particularly true for France, which has the greatest surplus in generation with respect to local demand. Conversely, Italy has the greatest deficit in generation with respect to local demand.

Power generation, consumption and exchange

The overall increase in installed generation capacity in comparison to rather constant maximum consumption hints at the usage of the power plants. RESs are indeed dependent on the weather and run only as long as the conditions allow. The remaining demand is supplied by conventional thermal power plants. However, the share of conventional generation within the region is constantly decreasing (replaced by the RES generation; see Figure 4). This tendency triggers economic problems for the respective power plant operators, which risks the progressive mothballing and decommissioning of those generation units important to ensuring the secure and stable operation of the transmission grid.

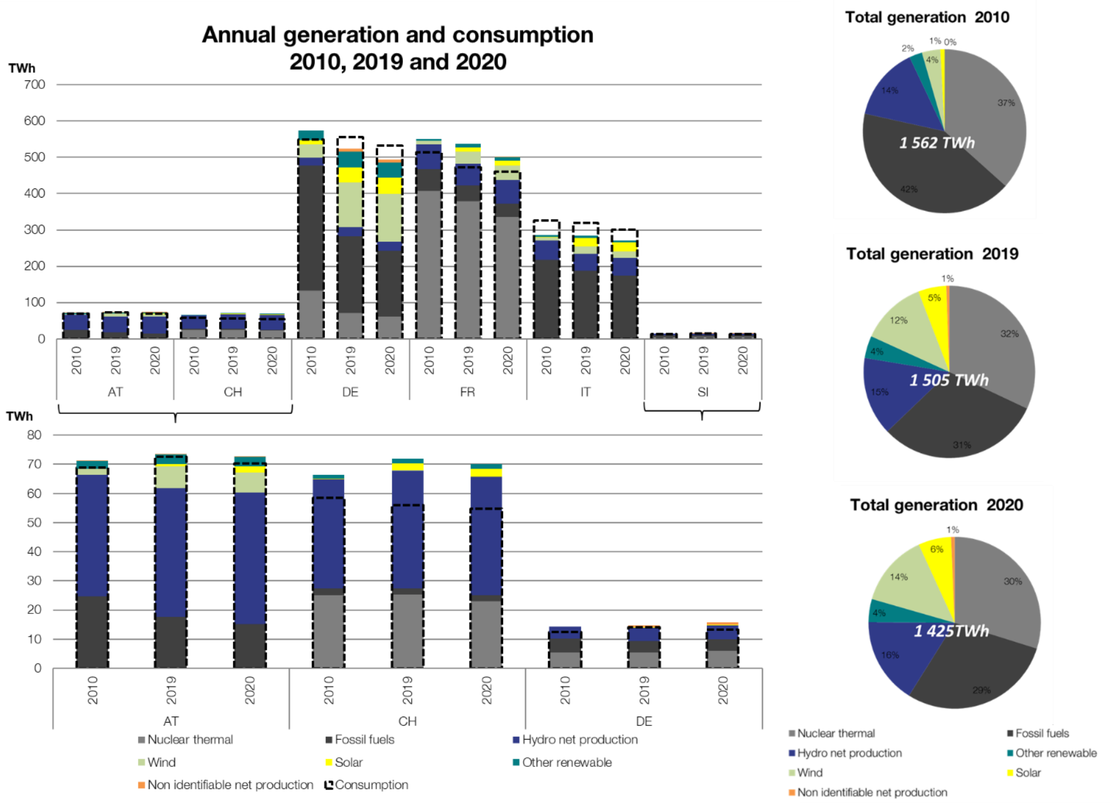

Figure 4 - Annual generation and consumption in the CCS region from 2010 to 2020

In the following figures, another very important aspect of the energy transition—which has a massive consequence for the transmission grid—can be observed. Since the share of installed RES capacity is increasing strongly, the energy gained by these capacities has a lower share. This is caused by the lower factor of full load hours produced by RES due to the limited natural supply (Figure 4).

In other words, to produce the same amount of energy using RESs such as wind and solar, much more installed capacity is necessary when compared to run-of-the-river or conventional thermal power plants. Conventional power plants and their flexibility (i.e., storage and power to gas) are necessary to balance the fluctuations of RES infeed. Therefore, the transmission system must be designed in a far more flexible manner than in the past. Notably, it must handle the future combination of a high amount of RES, flexibility, and the necessary generation capacity of conventional power plants to ensure SoS. Therefore, the energy transition on its own, without even considering load growth, is a trigger for additional transport capacity and significant reinforcement of the current transmission grid.

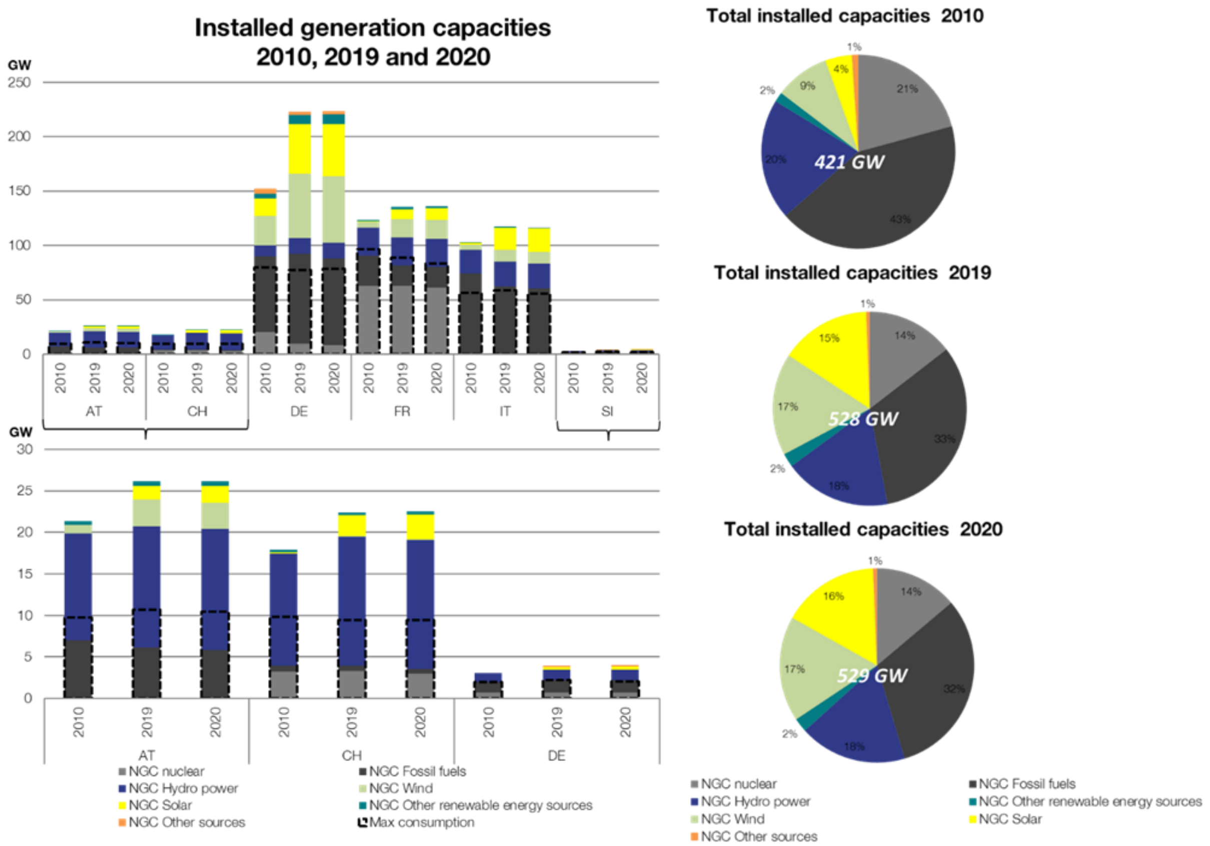

Figure 5 - Annual generation by fuel type and annual consumption in the region in 2010 and 2018 [TWh]

Additionally, due to the increase in the share of RES generation, commercial cross-border exchanges between countries within the region, as well as between regions, are increasing. Graphical illustrations of this scenario are depicted in Figures 6 and 7, where it is obvious that on all borders, the physical exchanged energy between countries was significantly lower in 2010 than in 2020.

Figure 6 - Physical energy flows [GWh] in the CCS region in 2020

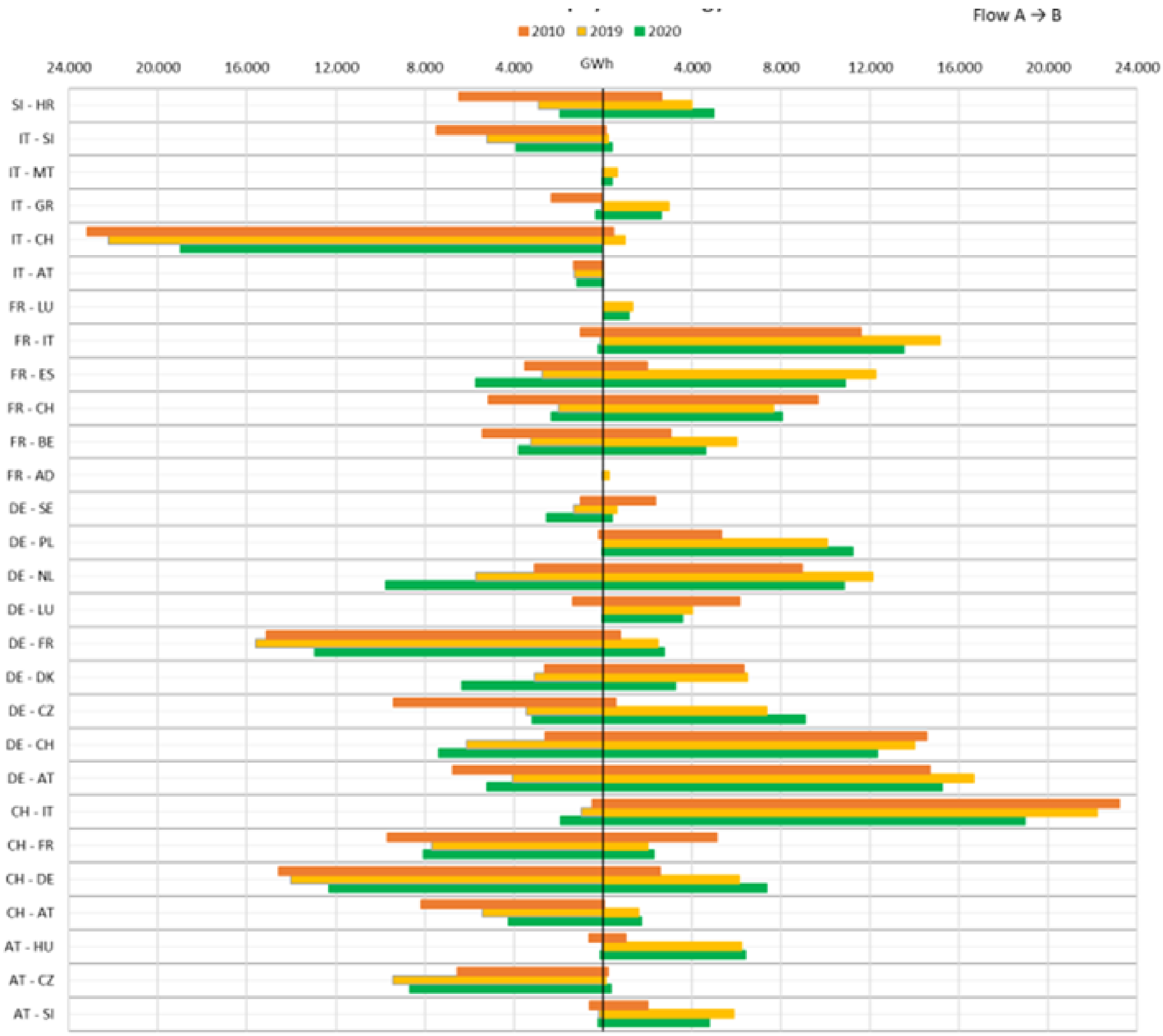

Figure 7 - Cross-border physical energy flows [GWh] in the CCS region from 2010 to 2020

Boundaries are present not only on the borders among different countries but also internally in certain countries, where they affect the market structure. For example, in IT, the day-ahead energy market is split into different bidding zones due to internal congestion from the south-to-north axis and between the main islands and the Italian peninsula.

Transmission grid

In accordance with previously provided statements, it should be repeated that the transmission grid in the region is rather meshed when compared to the rest of Europe, which leads to insufficient or barely adequate transfer capacities. Thus, setting the fulfilment of these transfer capacities' increase as imperative before the planned market integration could be facilitated. This can be seen in the maps below, which present the interconnected[1] network (Figures 8 and 9) of the CCS region and the NTC values (in MW in both directions) in the region (Figure 11). For sake of clarity, the maps were updated to 2018 and do not represent the most recent[2] snapshot of CCS grids.

Figure 8 - Interconnected network of the CCS region in 2020

[1] This map is provided in Figure 4, in which the certain voltage levels are marked with distinctive colours (blue – 750 kV AC, red – 400 kV AC, yellow – 330 kV AC, green – 220 kV AC, purple – HVDC links).
[2] Some additional links came into operation since 2019, such as the first HVDC pole of the Italy-Montenegro interconnection, which makes available a bridge with the Balkans of 600 MW.

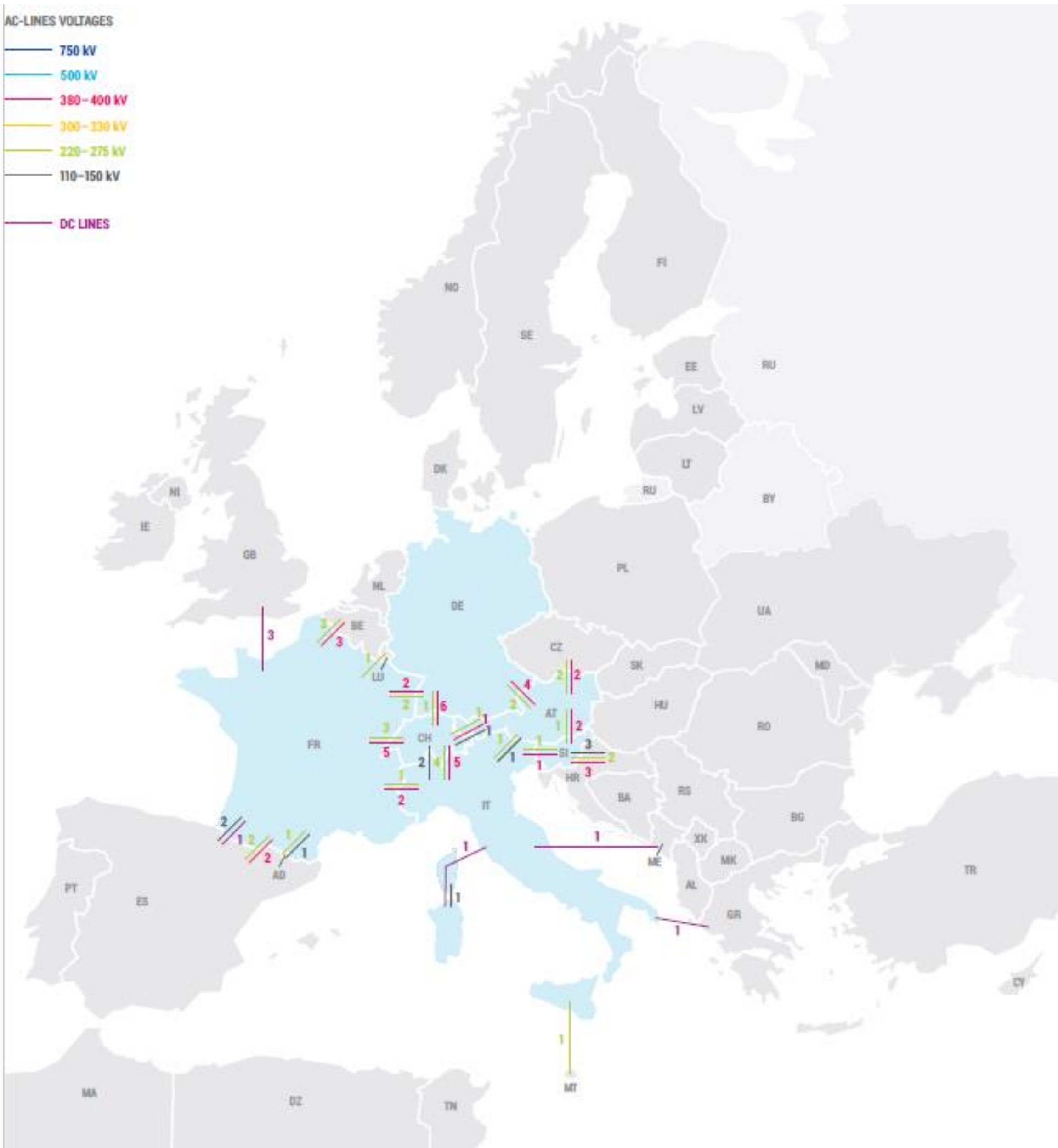

Figure 9 - Existing links, per route, in the CCS region in 2020

For a clear insight into the potential that the interconnected system of the region possesses regarding energy transit, the NTC values (in MW) in the region (taken for the year 2020) are provided in the form of a map in Figure 10. For sake of clarity, the arrows on this map simply symbolise the two different directions in which energy can be transferred across a selected border.

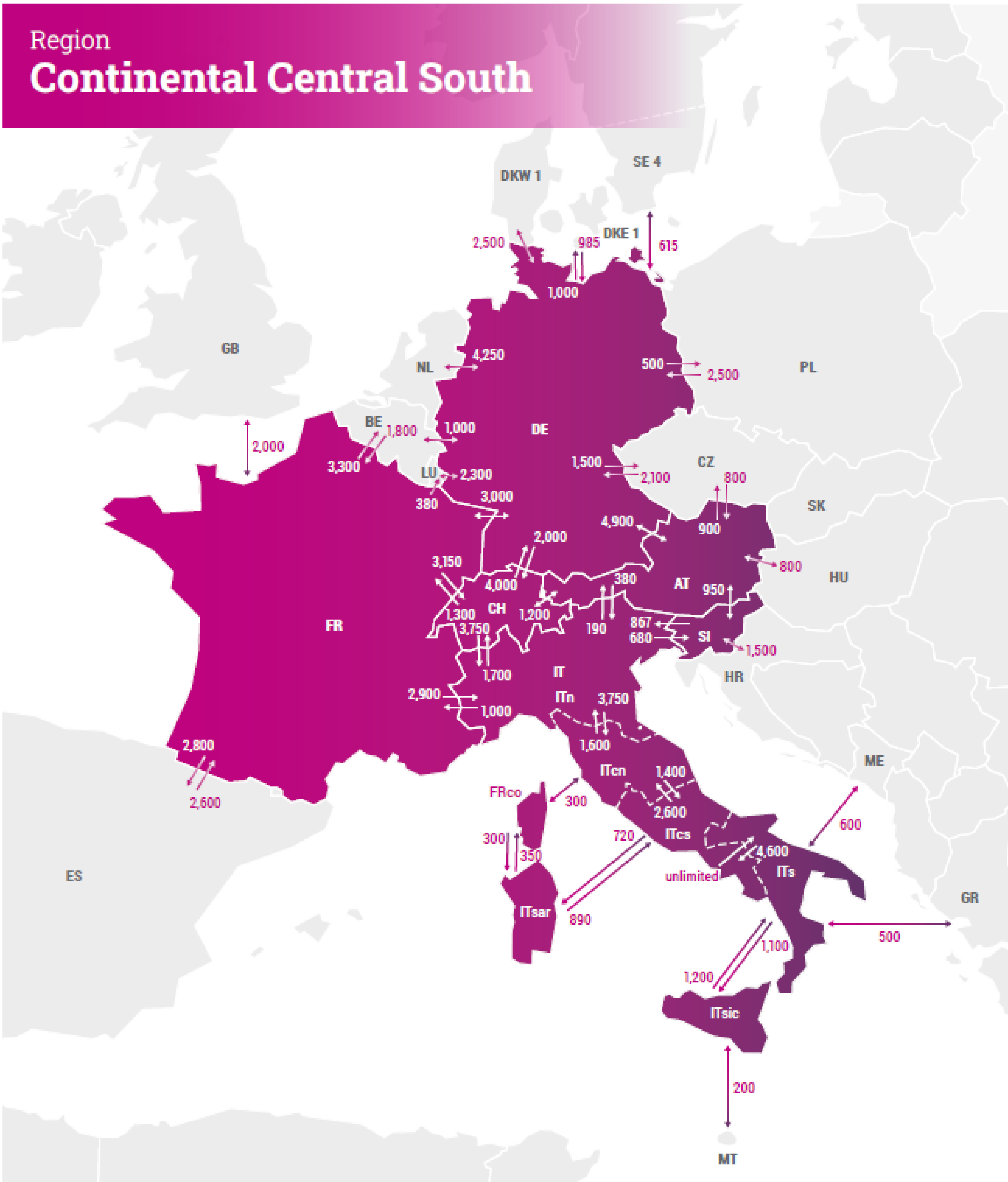

Figure 10 10- NTCs in the CCS region in 2020

Grid constraints

The main boundaries in the CCS region are illustrated in the figure below on the left. They should be intended as infrastructural barriers to the integration of RES, the achievement of current and future security conditions and the full use of generation resources within the electricity market. In the figure on the left, the blue arrows represent the main flows occurring on the main boundaries of the region.

In this respect, it can be observed that one of the main barriers to power exchanges in the region relates to the integration of the Italian peninsula, which implies the need to further develop the transmission capacity at the North-Italian boundary to exploit new generation, which is primarily located in the north of DE and FR (wind), in the south of IT (wind and photovoltaic) and in CH (hydro and photovoltaic). This will enable wider power exchanges, which also make it possible to integrate new generation and pump storage capacity located in the Alps region.

Furthermore, additional needs are linked to new interconnections in the Mediterranean basin, such as from Italy to North Africa and between Italy and Montenegro, to increase pan-European market integration, RES usage and system security. Additionally, connecting the main islands (Sicily, Sardinia and Corsica) with the mainland is of major relevance for the SoS and market integration within the European system.

Additionally, it should be highlighted that energy bottlenecks exist not only at the cross-border level between countries but also internally within some countries, where they affect the market structure. For example, in IT, the day-ahead energy market is divided into seven (previously six) different bidding zones due to internal congestion on the south-to-north axis and between the main islands and the Italian peninsula—as illustrated in the figure below on the right.

Figure 11 - Main boundaries of the CCS region

Figure 12 - Italian market areas

2.3 Evolution compared to RegIP 2020

The RegIP 2022 has developed significantly when compared to the RegIP 2020. This is due to both the rapidly changing energy economy and regulatory framework conditions as well as improvements in methods.

One of the core tasks of the RegIP is the development and planning of concrete projects based on the given scenarios and the results of the system needs study. Another task is the regional coordination of general grid development planning whilst considering all TYNDP projects and projects of regional relevance in the region. Only the combination of European-wide, regional and national grid development planning enables the development of a transmission network that can master the challenges of the future energy system:

- **Under Consideration**
- **Planned but not permitting**
- **Permitting**
- **Under Construction**

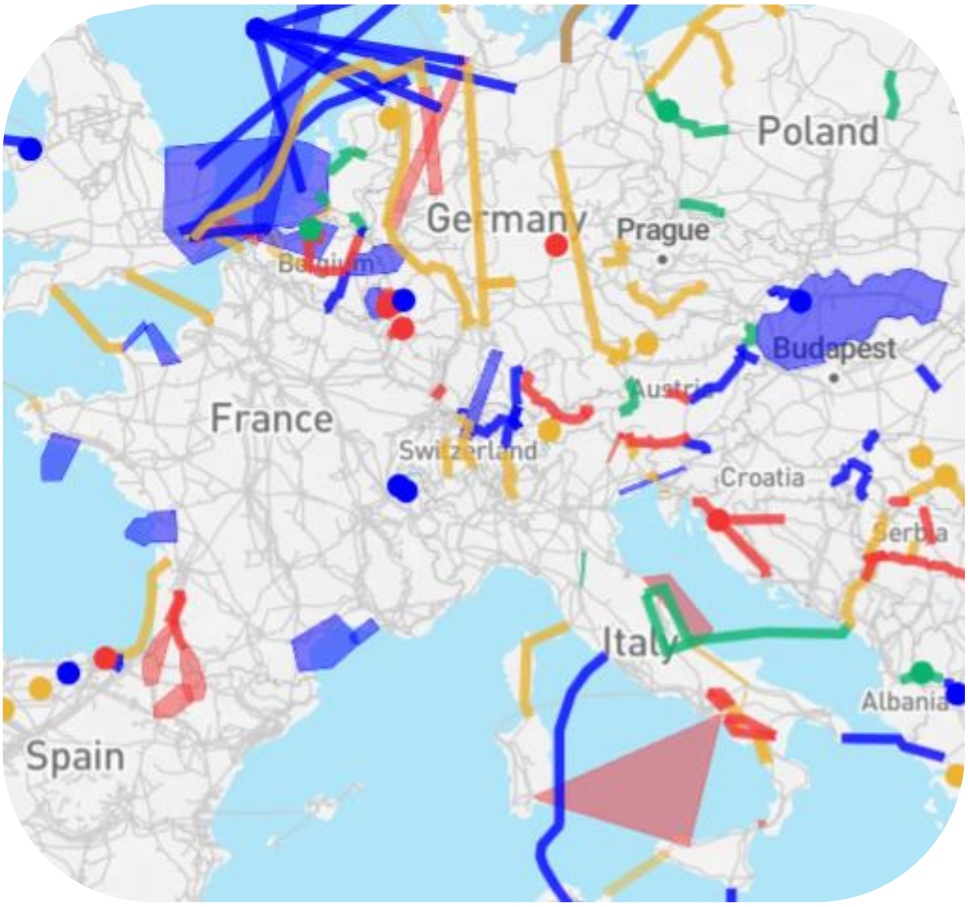

Figure 13 - Map of TYNDP 2020 transmission projects in the CCS region

For this reason, the figures below show the development of projects in the region since TYNDP 2020.

The TYNDP 2022 project portfolio contains 50 transmission projects with different technologies (HVAC/HVDC) and types (OHL, submarine cables, underground cable) in five countries. Among these projects, many of them are 'future projects' addressing power system needs identified in the TYNDP 2022 system needs study.

The CCS TYNDP 2022 portfolio includes 12 projects under consideration, of which 8 are new projects in this TYNDP. Many of these projects aim to address system needs.

A total of 6 transmission projects are currently under construction, while 19 are undergoing the permitting process and 13 are included in the National Development Plan but have not yet started the permitting phase.

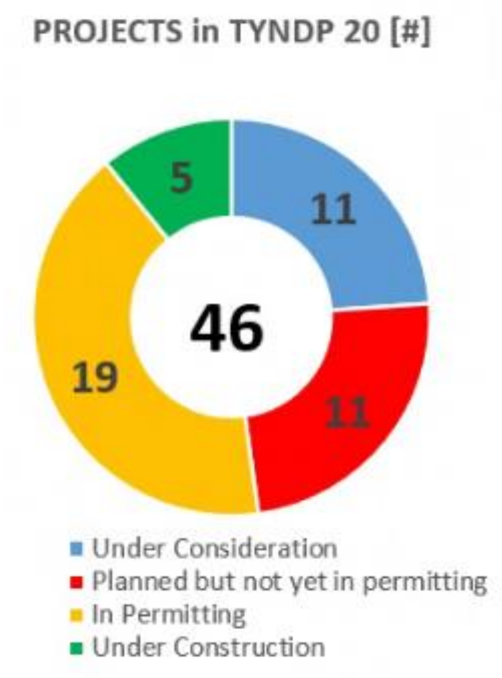

Figure 114 – CCS region projects in TYNDP 2020

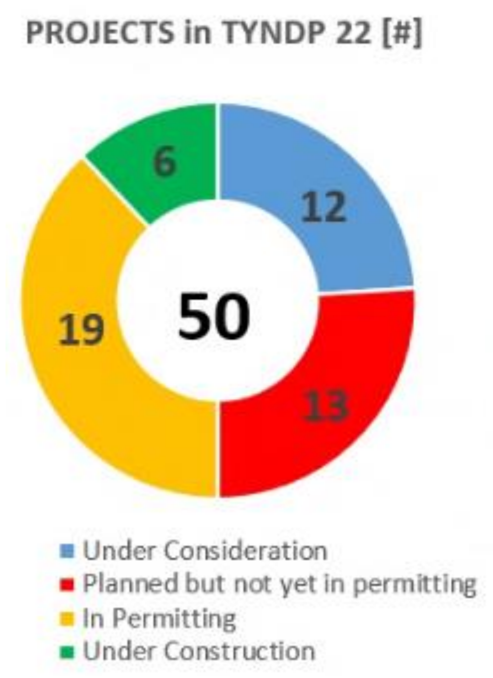

Figure 125 - CCS region projects in TYNDP 2022

If one compares the speed of development in the areas of generation and consumption (see Chapter 2) with the progress of the grid expansion projects, it quickly becomes clear that this is a two-speed development.

In most cases, the expected entry into operation of most projects is often postponed further into the future due to reasons that are out of the control of TSOs. In addition to existing projects, new projects are being identified to meet the future needs of the system (see Chapter 3). The need to accelerate grid expansions, made necessary by the evolution of the energy system, is a challenge faced by every TSO in the region.

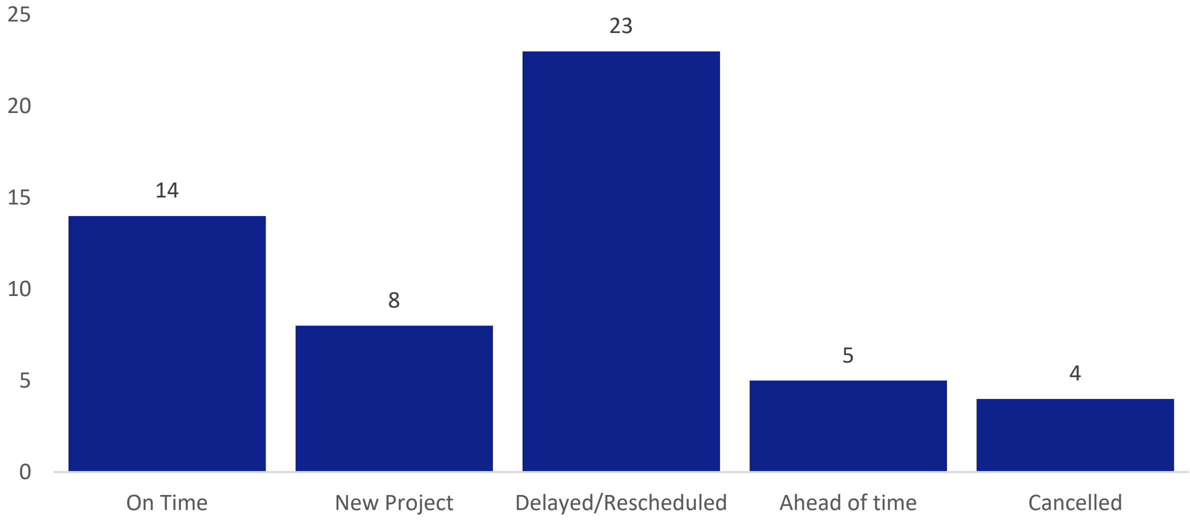

Figure 16 - Evolution of TYNDP 2022 transmission projects since 2020 in the CCS region. 'New Project' signifies projects that are new in TYNDP 2022

Eight of the CCS TYNDP 2022 transmission projects are expected by their promoters to come into service in the coming 3 years, while more than half would be commissioned by 2030, with the small remainder being commissioned over the long-term horizons of 2035/2040.

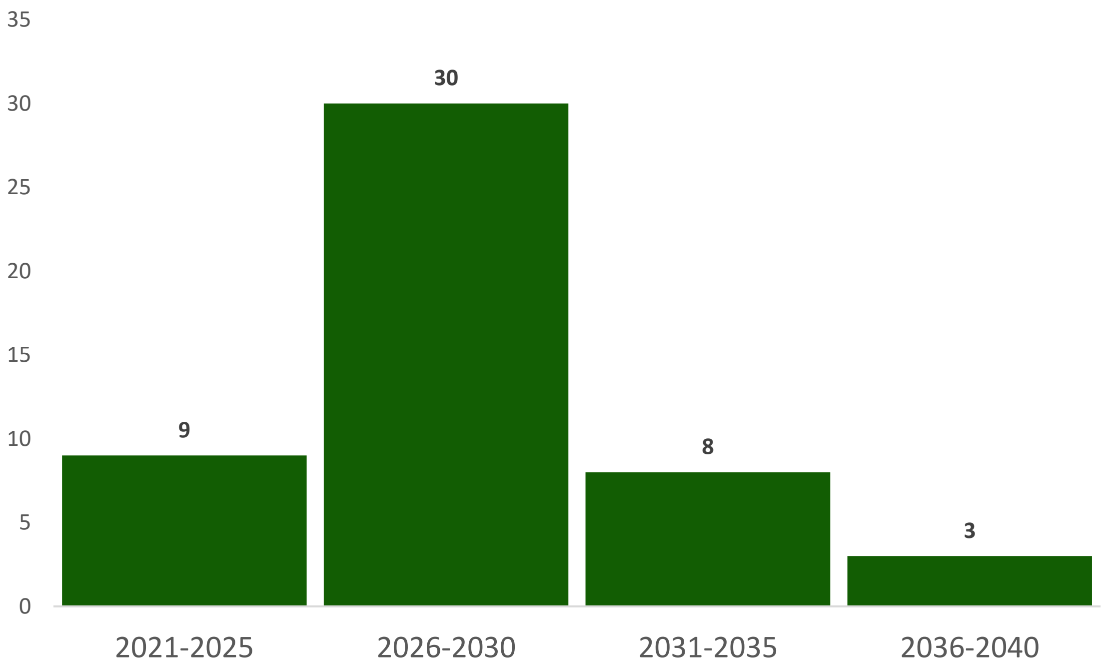

Figure 17 - TYNDP 2022 projects by expected year of commissioning in the CCS region

3 REGIONAL SYSTEM NEEDS

ENTSO-E's Identification of System Needs (IoSN) investigated increases in cross-border transmission capacity that would maximise overall system cost-efficiency in 2030 and 2040 (considering total network investment and generation costs). To achieve this, a cluster of possible network increases was proposed to an optimiser, who chooses the most cost-efficient combination. To consider the mutual influence of capacity increases, the analysis was performed simultaneously for all borders. A European overview of these increases and the methodology is presented in the system needs report.

The outcomes of the investigations confirmed the importance of past projects (from TYNDP 2020) to meet market integration needs, increase the sustainability of the transmission system by integrating more RES generation and improving the SoS. They also highlighted further developments on some borders beyond TYNDP 2022. Notably, borders for which it could be interesting to investigate new projects include:

- Italian northern and southern borders
- Italian eastern border

Projects on the northern Italian boundary are key to evaluating the possibility to implement new strategic north-to-south corridors from Italy toward Europe. Such corridors would enable connections and energy exchanges between available load and generation capacities located in the North Sea region with those in the Mediterranean Sea area. Moreover, they could connect the flexibility potential in the Alps region.

To understand the priority borders for capacity development that are mostly planned for upcoming years, initial analyses adopting the grid 2025 to 2030 time horizon were performed, as depicted in the figure on the right. This figure presents only additional transmission capacity at the cross-border level (only borders between countries were analysed). However, internal projects and reinforcements within each country are also important for the consistent development of the grid. Such internal reinforcements are a matter of further analysis in the scopes of national development plans as well as internal projects.

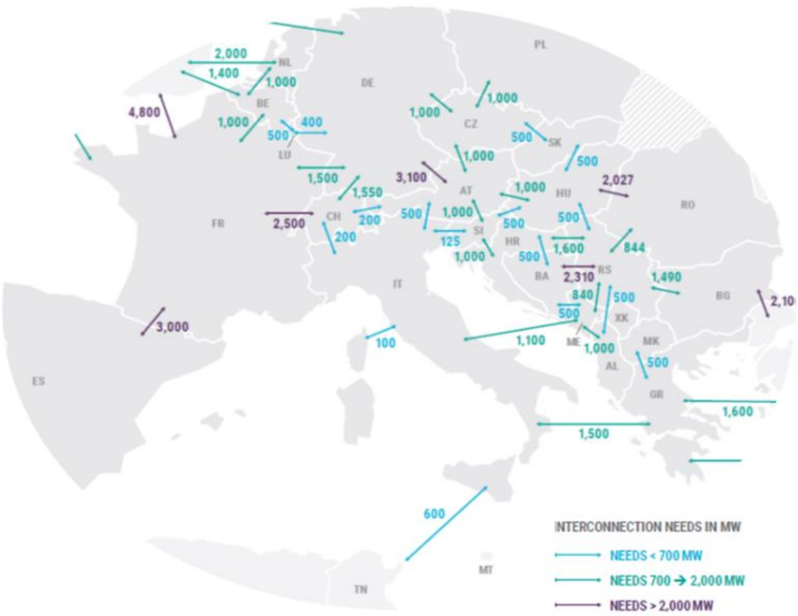

Figure 18 - Identified capacity needs in 2030

However, it should be noted that the 2030 system requires analyses to provide a more complete view of other capacity needs and increases. In this regard, the Italian system grid reveals an additional capacity increase on the North African border by 2030.

Additionally, based also on the results of the 2040 scenario, a few additional projects covering the years leading up to 2040 could be developed for inclusion in the present and/or future TYNDPs. In light of the newly presented (and very ambitious) Green Deal Targets concerning the massive development of off-shore and on-shore RES capacities, all borders of the CCS region shall be investigated.

In the figure below, it can be observed how expected capacity increases from 2030 onward are partially confirmed—and, in some cases, also increased—when looking at the 2040 scenario. Regarding Italy's eastern borders (especially IT-GR and IT-ME), a substantial reduction in the expected capacity increase from 2030 to 2040 can be observed. This is justified by the fact that in 2040, many countries in the eastern area could perform a transition from old thermal units to nuclear or more efficient/less expensive thermal and renewable units, thereby having a potential impact on the eastern border of Italy. However, it should be noted that due to the complexity of the analyses performed, they did not include all the detailed specificities of national systems, especially from the network perspective.

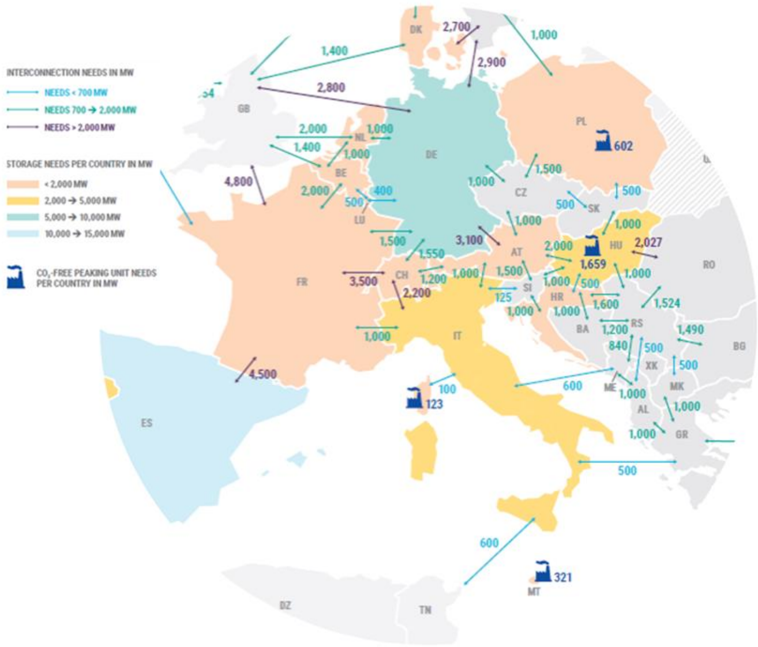

Figure 19 - Identified capacity needs in 2040

As a result, it could not be excluded that the 2040 (but also 2030) results of the IoSN exercise do not capture all the investment needs that could be addressed in the CCS region. The system needs study is a partial exercise that investigates one specific dimension of future system needs, in which increasing cross-border capacity would bring the most economic benefits. Planning electricity transmission infrastructure requires considering a whole area of indicators, including costs, the benefits of projects in terms of frequency system stability, the reduction of CO_2 emissions and other greenhouse gases, etc. Therefore, it is possible for a project to receive a positive cost-benefit analysis even when it is on a border that is not included in the best combination of capacity increases identified by the system needs study.

In summary, identified potential investment needs within the RGCCS-perimeter expressed in terms of transmission capacity increases on top of the 2025 grid (i.e., considering the 2030 and 2040 scenarios) foresee the following:

- Primary investments of 9,8 GW by 2030, of which 8,8 GW are already included in the TYNDP 2022 project portfolio.
- Further transmission developments towards 2040 (on top on 2030 developments) with an additional 6,6 GW.

3.1 Detailed system needs results

The analyses were performed according to the following scheme. Always shown are the individual indicators per country in the CCS region for the national trends (NT) scenario and the two time horizons (2030 and 2040).

Furthermore, the results for the 2030 scenario are always compared to a grid with no investment after 2025, the identified target grid expansion in 2030 ('SEW grid'), and a grid including only TYNDP projects commissioned by 2030 ('Portfolio grid'). For scenario 2040, the grid expansion level for 2025 is always compared to the respective SEW grid 2040 and portfolio grid 2040.

The indicators analysed according to this scheme include:

- CO_2 emissions
- Curtailed energy
- System costs
- Net annual country balance
- Yearly average marginal cost
- Price differentials

In the following analysis, we concentrate on the effects in the region and less on the effects in the individual countries. Countries without an effect are not displayed.

The grid expansion in the case of IoSN 2030 results in an increased export of 17 TWh in the region, while the case of IoSN 2040 results in an increased export of 17 TWh of energy. As a rule, the need for imports from Italy and exports from France increases. With the increasing amount of RESs in Germany between 2030 and 2040, the net annual balance will become positive, resulting in Germany becoming a net exporter. The increase in cross-border capacities due to additional grid development in Germany leads to the better integration of RESs, which results in a higher export from Germany to other EU countries. Therefore, there will be a significant change in generation behaviour and exchange within the region, which will have considerable effects outside the region.

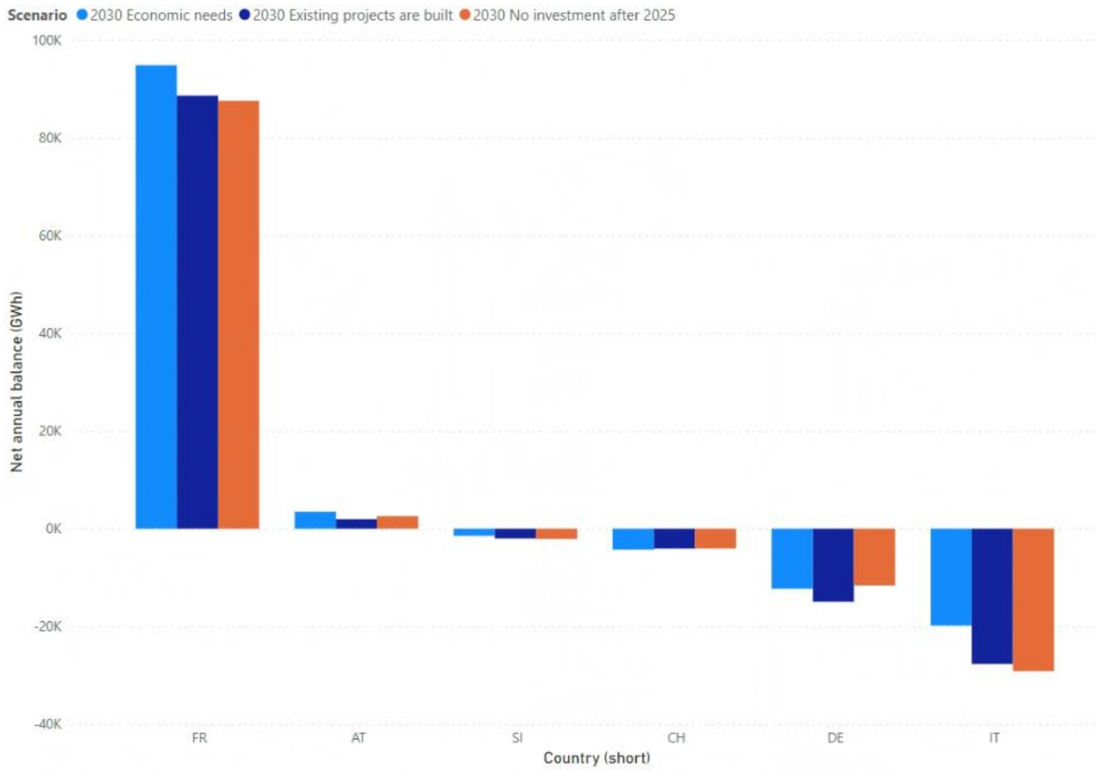

Figure 130 - Net annual balance in the CCS region for the 2030 scenarios (i.e., grid with no investment after 2025, SEW grid 2030 and portfolio grid 2030)

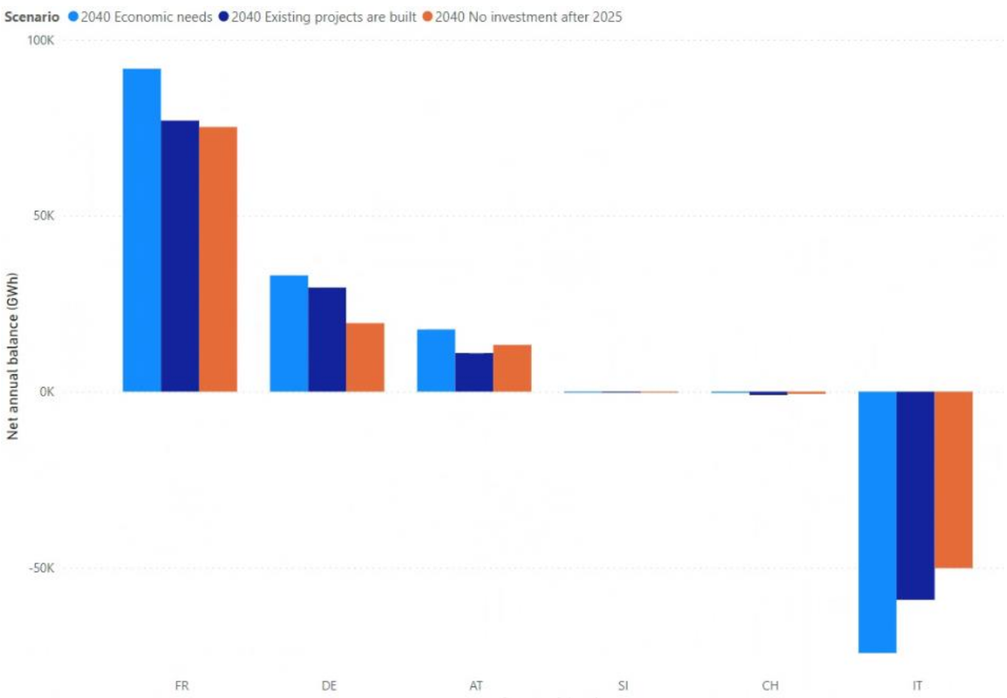

Figure 141 - Net annual balance in the CCS region for the 2040 scenarios (i.e., grid with no investment after 2025, SEW grid 2040 and portfolio grid 2040)

Due to grid expansion, system costs in the region can be reduced both in comparison with grid expansion between 2025 and 2030 and with grid expansion between 2025 and 2040. In the case of IoSN 2030, the system costs are reduced by 1 M€. In the case of IoSN 2040, system costs are reduced by 3 M€. In particular, the network expansion in Italy is leading to a considerable reduction in system costs. In Italy, there is a strong reduction in system costs in the case of IoSN 2040.

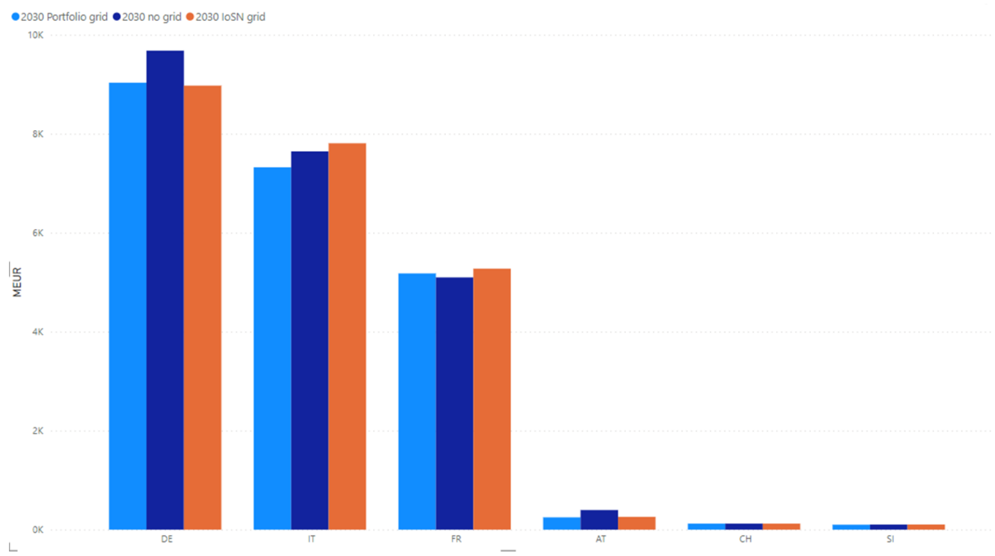

Figure 152 - Reduction of system costs in the CCS region under the 2030 scenario with identified capacity increases (i.e., grid with no investment after 2025, the SEW-based needs grid 2030 and portfolio grid 2030)

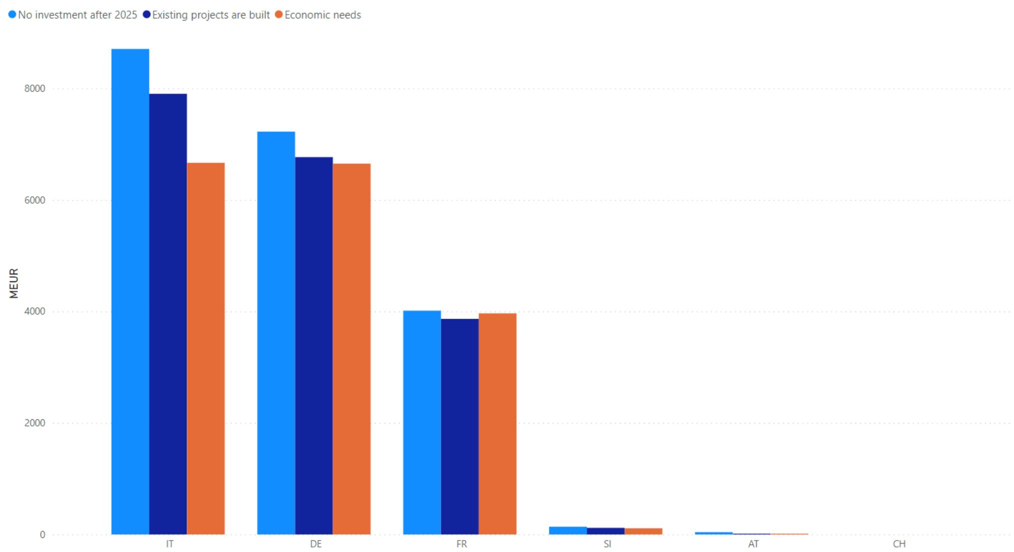

Figure 163 17- Reduction of system costs in the CCS region under the 2040 scenario with identified capacity increases (grid with no investment after 2025, the SEW-based needs grid 2040 and portfolio grid 2040)

Integration of RES

The goal of renewable energy integration is to improve the sustainably of the electric grid whilst also reducing the carbon emissions and emissions of other air pollutants through the increased use of renewable energy. Due to its geographical position and configuration, the RG CCS presents the availability of several renewable sources (mainly sun, wind and water) and has an important role in the transition to a more sustainable system.

According to the analyses performed, the amount of curtailed energy in countries across the region presents remarkable values—especially in Germany, Italy and France, where the amount of energy produced from renewable sources that cannot be fed into the grid is expected to be in the order of several TWh.

Figure presents the amount of curtailed renewable energy in the 2030 and 2040 scenarios if the transmission grid does not evolve beyond 2025.

In DE, energy production has already been dominated by RESs. The energy transition towards RESs creates new challenges for system operators in managing the system in real time. The massive power flows from regions with high RES generation to the load centres lead to widespread congestion in the transmission grids across Europe. Since large controllable power plants are being replaced by distributed energy sources, the further development of transmission infrastructure is crucial to reducing the required amount of RES generation curtailment and conventional redispatch to ensure the growing integration of RESs in the German power system.

In Italy, the maximum value of curtailed energy is up to 3 TWh in the 2040 scenarios (and higher than 3 TWh in the 2030 scenarios), which is mainly concentrated in the south and the islands. RES integration is of primary importance for the country and the values resulting from market analyses clearly demonstrate the need for additional transmission infrastructure to implement the transition towards sustainable energy production. Notably, these results are based on a simplified model that does not consider all local congestion on the internal network interested in the connection of new RES capacity.

Compared to other European countries, the amount of curtailed energy in Switzerland is relatively low. Consistent with the ongoing penetration of the generation mix by volatile renewable generation sources, curtailed energy increases in 2040 when compared to 2030.

Although investments in batteries can also enable RES integration, it is important to note that even if scenarios include a non-negligible amount of batteries, the analyses performed show high values of curtailed energy.

Therefore, investing in transmission infrastructure —especially in Germany— is essential for increasing the amount of integrated RESs due to the possibility of sharing the resources present in one area and exceeding the area’s load in neighbouring zones. The need to improve RES integration in the region can be mostly addressed in the medium term due to the confirmed planned projects of TYNDP 2020. However, according to additional analyses and the expert views of the TSOs of the region, these projects are not completely sufficient to integrate all the renewable energy foreseen in the long-term scenarios.

In particular, planned internal lines in each of the concerned countries, as well as links between the mainland and major islands (e.g., Corsica, Sardinia and Sicily), are important to integrate variable energy sources.

Furthermore, interconnections on the northern Italian boundary will make it possible to integrate new generation, which is mainly located in the north of DE and FR (wind), in IT (wind and photovoltaic) and in East-Central Europe, and enable wider power exchanges to integrate the RES generation and pump storage capacity located in the Alps region (CH and AT).

Links between IT and North Africa, as well as between IT and Montenegro, which would connect areas affected by overgeneration problems, will also contribute to RES usage.

Due to network expansion driven by significant amounts of curtailed energy, this energy can be reintegrated into the system at a low cost. Whilst the entire region could benefit from this, the positive effects are especially significant for Germany, France and Italy.

In the case of IoSN 2030, the region integrates 10 TWh of lost energy into the system. However, in the case of IoSN 2040, even 20 TWh of this energy can be integrated (see following figures).

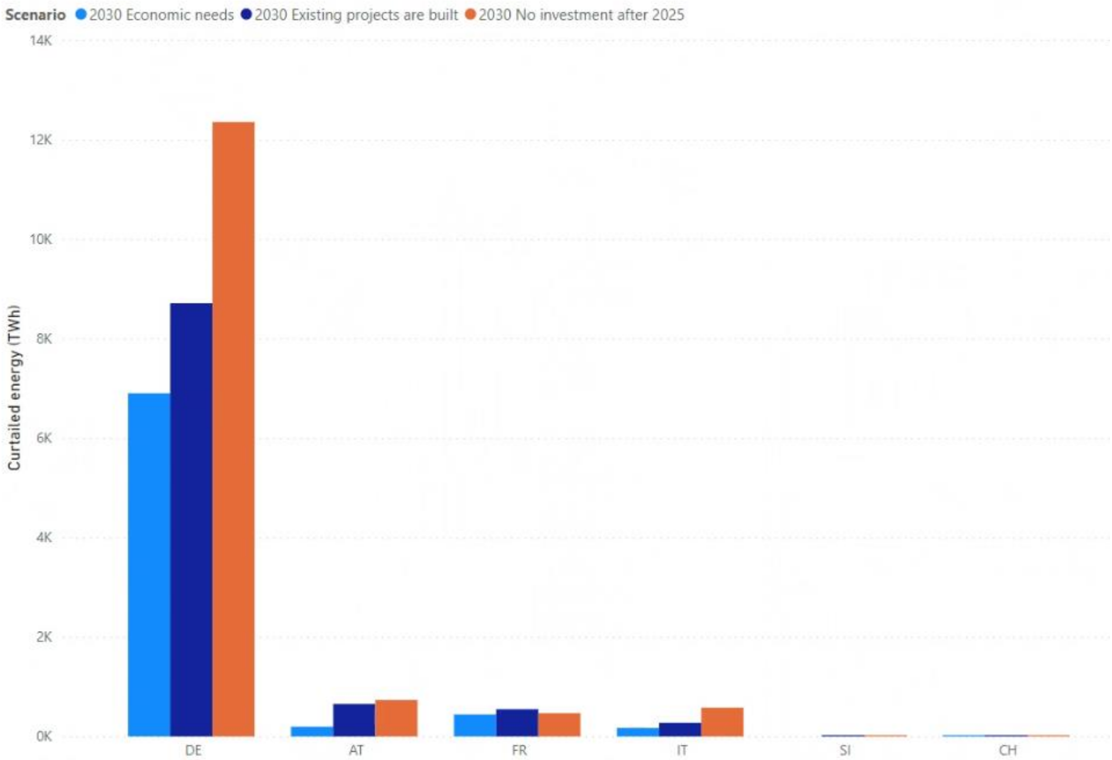

Figure 184 - Curtailed energy in the CCS region for 2030 scenarios with identified capacity increases (i.e., grid with no investment after 2025, SEW grid 2030 and portfolio grid 2030)

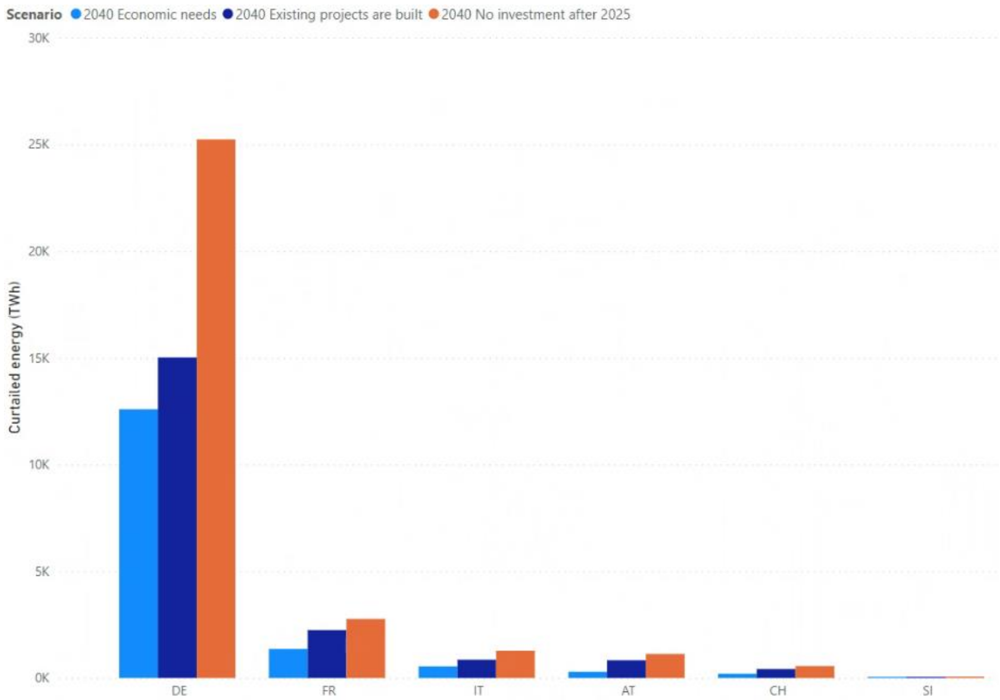

Figure 195 - Curtailed energy in the CCS region for 2040 scenarios with different capacity increases (i.e., grid with no investment after 2025, SEW grid 2040 and portfolio grid 2040)

Sustainability

Notably, CO_2 emissions are strictly connected to RES integration. The figures below present the CO_2 emissions (in Mtons) in the 2030 and 2040 scenarios if the transmission grid does not evolve beyond 2025. In these figures, the bars highlight the average values for each country in all analysed scenarios.

In the region, the highest CO_2 emissions are in DE and IT, mainly due to their higher usage of thermal generation, while the remaining countries present lower—but not negligible—emission values. Also, considering the high curtailment of renewable generation presented above, there is a strong driver for investment in the transmission system.

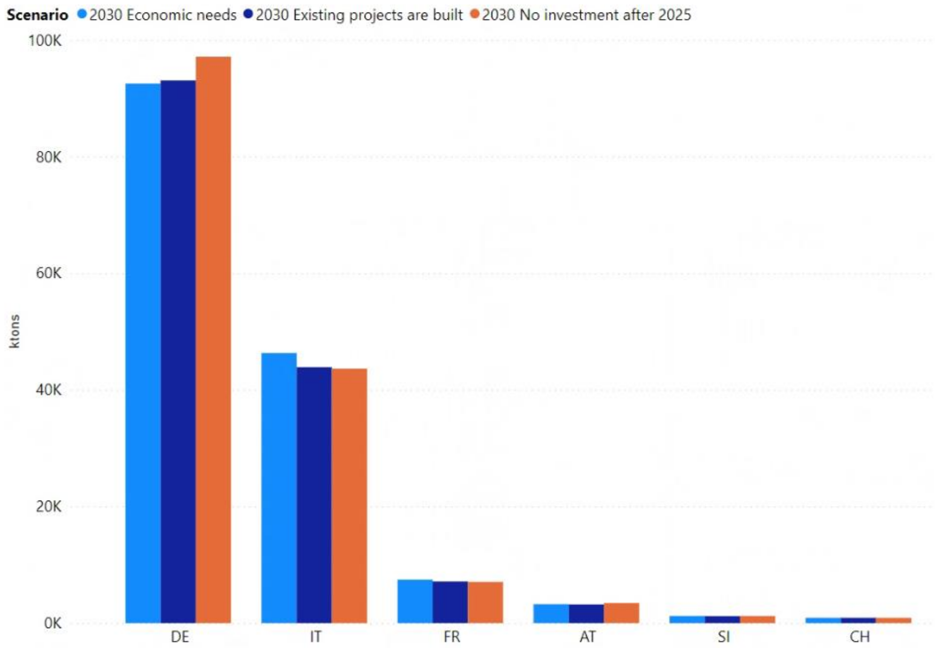

Figure 206 - CO_2 emissions in the CCS region for 2030 scenarios with different capacity increases (i.e., grid with no investment after 2025, SEW grid 2030 and portfolio grid 2030)

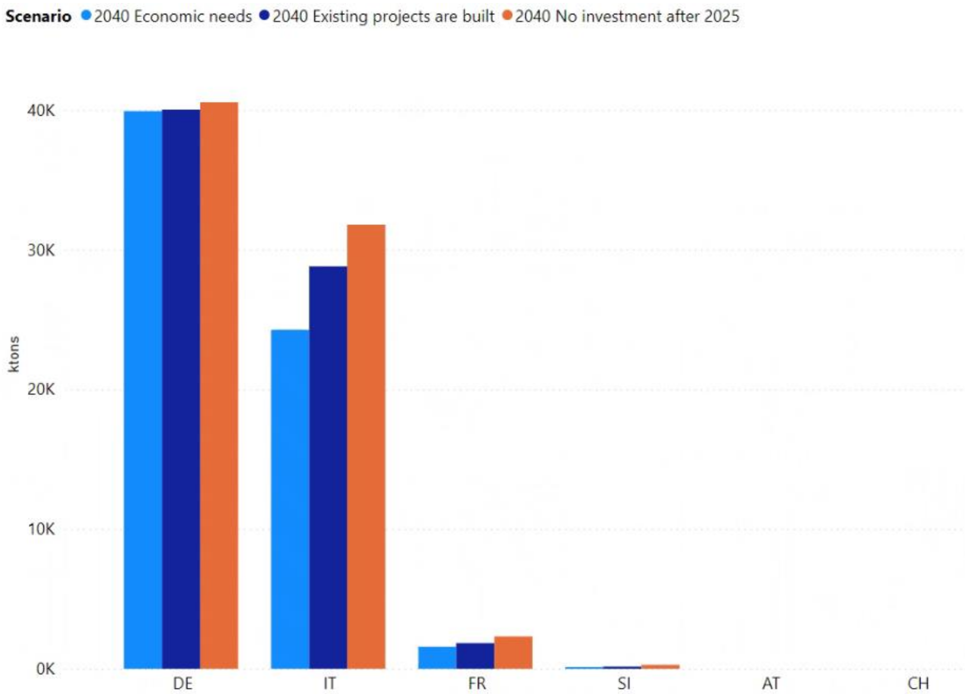

Figure 217 - CO_2 emissions in the CCS region for 2040 scenarios with different capacity increases (i.e., grid with no investment after 2025, SEW grid 2040 and portfolio grid 2040)

In both cases, a CO_2 emission reduction occurs in the region. In the case of IoSN 2030, the reduction of CO_2 emissions is 4 Mt. In the case of IoSN 2040, this reduction is 10 Mt. The rather low values are due to the system already emitting very little CO_2. However, the positive effects are due to CO_2-free technologies. Therefore, although the replacement of fossil fuels in the region is low, additional energy is exported for pan-European benefit.

Market integration in the region

Price difference values greater than a few euros between different market areas demonstrate poor market integration and hint at the need to invest in additional interconnections. As reported in the Report of the Commission Expert Group on electricity interconnection targets[3] 'A well-integrated energy market is considered a fundamental prerequisite to achieving the EU energy and climate objectives in a cost-effective way. Interconnectors are therefore a vital physical component of Europe's energy transition and offer capacity for energy trade'.

Currently, the northern Italian border is one of the most congested in Europe due to the high market price differential between Italy and neighbouring markets. Performed analyses confirm that market integration is the main driver for grid development in the region.

The figure below presents the average hourly price differences across borders in the region under the 2030 scenarios if the transmission grid would not evolve beyond 2025. In this figure, the bars highlight the average values for each country in all 2030 scenarios.

The average price differences between countries are significantly high, with nearly all the values being >10 €/MWh. The highest price differences are found for borders involving the Italian peninsula, which is one of the most isolated systems in Europe due to its geographical characteristics.

In particular, Italy sees very high price differences with neighbouring countries on its northern boundary (AT, CH, DE, SI), with the maximum value corresponding to the IT-FR border (average price difference: >10€/MWh). Also, the border between IT and North Africa presents a remarkable price difference of >10€/MWh.

[3] https://ec.europa.eu/energy/sites/ener/files/documents/report_of_the_commission_expert_group_on_electricity_interconnection_targets.pdf

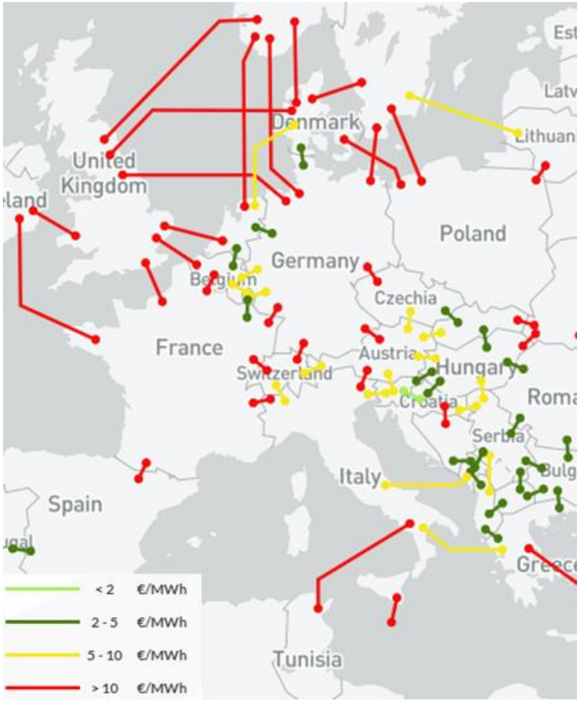

Figure 2822 - Average hourly price differences for national trends (2030 with the 2025 grid)

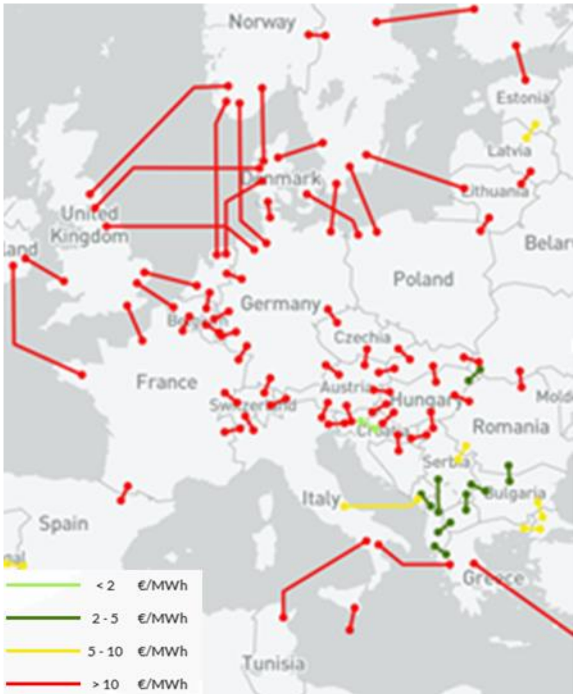

Figure23 29 - Average hourly price differences for national trends (2040 with the 2025 grid)

The development of the common electricity market and the full integration of peripheral areas by removing present and future bottlenecks are required to achieve the IEM and necessary to improve the competitiveness of countries. Hence, the foreseen price spreads in the region if the grid does not evolve beyond 2025 highlight the presence of barriers to power flows, which can lead to inefficiency and scarce competitiveness in countries where the cost of energy is higher.

The need to improve market integration in the region can be mostly addressed in the medium term by confirmed planned projects of TYNDP 2022. However, according to additional analyses and the expert views of TSOs of the region, these projects are not completely sufficient to satisfy a complete market integration in the long-term scenarios.

Planned interconnections on the northern Italian boundary, links with North Africa and the Balkans, and links between the mainland and major islands (e.g., Corsica, Sardinia and Sicily) are of primary importance to integrating the markets of peripheral areas and/or different regions. For instance, the Corsican power plants are less efficient and more expensive than the Italian plants, whereas interconnections with North Africa and the Balkans will foster the integration of the pan-European market.

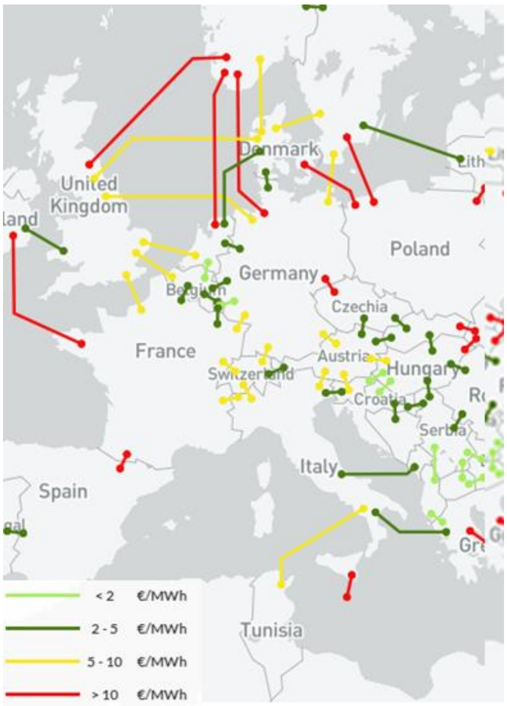

Figure24 30 - Average hourly price differences for national trends (2030 SEW grid)

Figure25 31 - Average hourly price differences for national trends (2040 SEW grid)

The results of the 2040 scenarios in the figures below present the average hourly price differences across borders in the region under the 2040 scenarios if the transmission grid would not evolve beyond 2025. In these figures, the bars highlight the average values for each country under all 2040 scenarios.

The average price differences between countries are significantly high, with nearly all the values being >25–30 €/MWh. Once again, the highest price differences are found for borders involving the Italian peninsula, which is one of the most isolated systems in Europe due to its geographical characteristics.

In particular, Italy sees very high price differences (range: 10–50 €/MWh) with neighbouring countries on its northern boundary (AT, CH, SI, FR), with the maximum value being for the IT-FR border (average price difference: ~50 €/MWh). Also, the border between IT and North Africa presents a remarkable marginal cost difference.

Figure26 32 - Average hourly price differences for national trends (2030 with existing projects built)

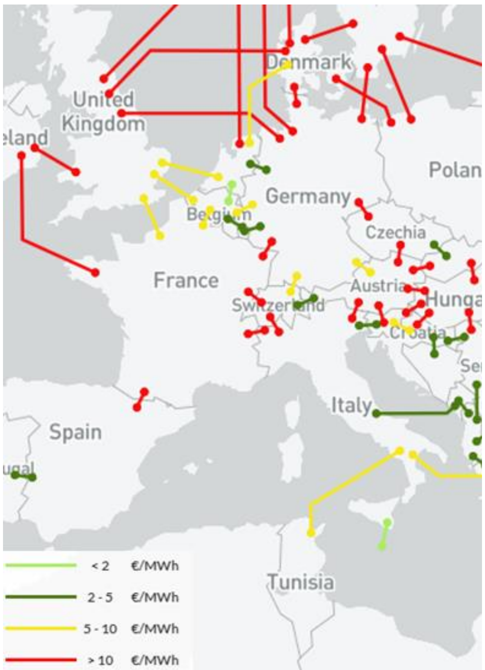

Figure27 33 - Average hourly price differences for national trends (2040 with existing projects built)

The figure below shows the average annual marginal costs under the 2030 and 2040 scenarios if the transmission grid would not evolve beyond 2025.

Under the long-term 2030 scenarios, the region is characterised by notable price differences since the average price could reach over 55€/MWh in 2030 and 69 €/MWh in 2040. These values provide a general overview of the costs of energy production in the countries of the region. In 2030 scenarios, FR and DE present the lower prices, whilst SI and IT present the highest prices.

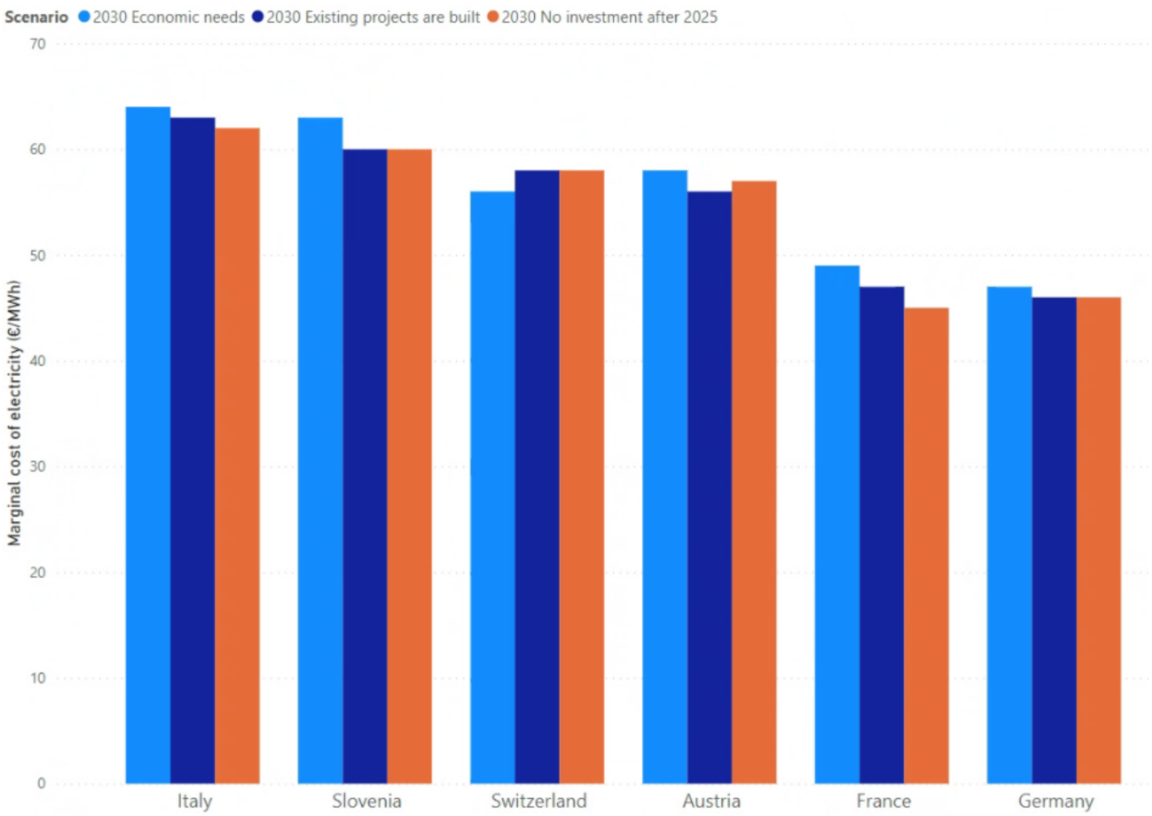

Figure 284 - Yearly average marginal costs in the CCS region for 2030 scenarios with identified capacity increases (i.e., grid with no investment after 2025, the SEW-based needs grid 2030 and portfolio grid 2030)

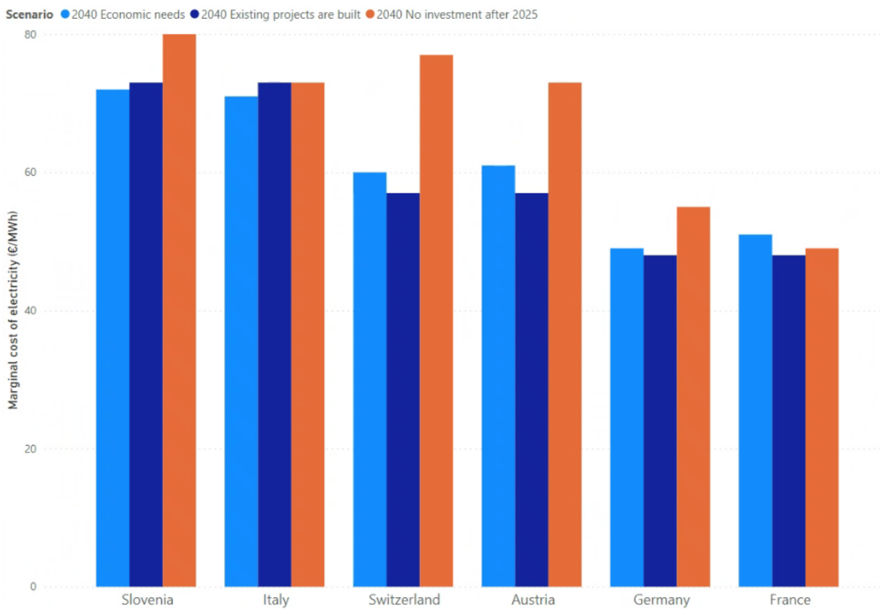

Figure 295 - Yearly average marginal costs in the CCS region for 2040 scenarios with identified capacity increases (i.e., grid with no investment after 2025, the SEW-based needs grid 2040 and portfolio grid 2040)

Interconnection ratio

The European Council (EC) was established on 15 and 16 March 2002 with the objective of reaching a minimum interconnection ratio of 10% of the installed generation capacity in every Member State[4]. In the EC's view, the EU energy policy goals and the 2020 and 2030 energy and climate targets will not be achievable without a fully interconnected European electricity grid that has more cross-border interconnections, storage potential and smart grids to manage demand and ensure a secure energy supply in a system with higher shares of variable renewable energy. In this respect, the gradual construction of pan-European electricity highways will also be crucial.

In October 2014, the EC called for the rapid implementation of all measures required to meet the target of achieving an interconnection level of at least 10% of the installed electricity production capacity of all Member States by 2020.

Concerning the RG CCS at present, only IT is still unable to meet this target due to its geographical configuration (surrounded by sea, with the Alps on the northern border) implying higher complexity with the realisation of new interconnections. In 2020, despite the realisation of new interconnections between Montenegro and AT, IT is still expected to not fulfil the 10% objective (see the figure below). On the other hand, some countries already meet and greatly exceed the target interconnection values (e.g., Slovenia, with 84% in 2017).

For the evolution of interconnection ratios in the region over the long-term (up to 2040) according to the new criteria established by the European Commission Expert Group on electricity interconnection targets, further details are provided in the Pan-European system needs report (link).

Looking forward, the EC established a higher level of interconnectivity between the Member States of at least 15% by 2030.

As a result, many EU countries have a remarkable need to further develop their transmission infrastructure to reach this interconnection target. In many cases, such as that of Italy, it has been estimated[5] that the interconnection target of 2030 will not be reached by considering only the currently planned projects in TYNDP. In this regard, the investigation of new transmission projects is essential for countries that lack adequate transmission capacity.

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[4] *The COM (2001) 775 establishes that 'all Member States should achieve a level of electricity interconnection equivalent to at least 10% of their installed generation capacity'. This goal was confirmed at the European Council of March 2002 in Barcelona and chosen as an indicator in the EU Regulation 347/2013 (annex IV 2.a). The interconnection ratio is obtained as the sum of importing GTCs/total installed generation capacity.*

[5] *See TYNDP2020*

4 REGIONAL STUDIES (OPTIONAL)

4.1 Controllable devices and curative measures

Currently, temporary transmission bottlenecks are created with the increased use of RESs, whilst a reduction in the availability of conventional power plants has also reduced conventional redispatch measures (e.g., the use of controllable devices such as high-voltage direct current (HVDC) or phase shift transformers (PST) to bypass congested areas or the implementation of dynamic line rating (DLR) and developed concepts for the system-wide use of curative congestion management). To help TSOs solve congestion, a storage solution can be offered as a course of action approved by national regulators to alleviate congestion. The substations where these devices will be installed have been selected to achieve an optimal impact on these congestions. Considering such technologies, a few solutions proposed by TSOs are presented in this chapter:

- The new planned and implemented controllable devices (e.g., Gridbooster) offer significantly faster reaction times for grid events that would lead to congestion. Considering 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 use of the aforementioned devices may enable the higher utilisation of the grid. Within the German research project InnoSys 2030, the potential of these approaches was highlighted, concepts for curative measures were developed and a roadmap for implementation was published. The first Gridbooster pilot system in Germany—located in Audorf/Süd and Ottenhofen—should begin operation in 2023. Furthermore, the other German pilot systems (i.e., in Kupferzell of Baden-Württemberg) have been planned for 2025. Gridboosters are used to test the innovative concept for higher utilisation of the transmission grid.
- Depending on the weather conditions (high sunshine, strong winds), local wind and solar power production can peak at times and be too abundant to be transported by the electricity grid, resulting in surplus electricity being lost. In its role as an innovator and major player in the energy transition, RTE is responding to this problem with the RINGO electricity storage experiment, which was approved by the Commission de Régulation de l'Energie (CRE). The project consists of three innovations that will together enable renewable energies to be fed into the network:
  - Automatons developed by RTE, which capture digital network data in real time. They allow remote and autonomous control of what is occurring on high-voltage lines;
  - Supplier storage batteries connected to the grid, which will make it possible to store surplus renewable energy;
  - Power electronics, i.e., large electronic chips that convert stored energy into electricity injected into the network for consumers.

RTE then remotely and automatically controls all the batteries connected to its network simultaneously, as well as the converters that transform the energy stored in the batteries into electricity suitable for the network.
The aim is to adapt the storage/unstorage times according to the electricity load on the network. With this intelligent system, RTE guarantees the efficient use of renewable electricity produced in France.
The experimentation phase will start with three different sites: Bellac (10MW), Ventavol (10MW) and Vingeanne (12MW). The experimental framework provides for strict neutrality in the functioning of the electricity market. Thus, the three sites are synchronised: when one or two sites are under load, the other(s) must discharge by an equivalent volume to avoid any impact on the national supply-demand balance.
This project is foreseen to be commissioned in June 2022.

- In the Swiss transmission grid:
  - Several decades ago, diagonally regulated transformers that can regulate both the active and the reactive power were installed.
  - Recently, four quadrant transformers that can regulate voltage (e.g., the reactive power) and the phase shift (e.g., the active power) independently are being installed (they are already installed in the substations at Beznau, Lavorgo and Romanel and will be installed in the substations at Mettlen (two units) and Lachmatt) as the aforementioned diagonally regulated transformers are progressively being put out of operation.

- In Slovenia, ELES recently completed project SINCRO.GRID and is currently developing a new smart grid project GreenSwitch aiming at installation of different technologies:
  - Battery energy storage system to the transmission grid;
  - Installation of DLR on transmission grid (project SUMO);
  - Installation of power electronics devices and controllable devices such as STATCOM, SSSC, VSR, MSCDN, etc.

- In Italy, Terna recently conducted a series of low capital intensity interventions (called 'capital light') based on innovative technological solutions and the optimisation of operating procedures. These ‘capital light’ solutions can be classified into three macro-categories:
  - Strengthening of the defence system through the use of renewable production units with the logic of automatic remote tripping.
  - Installation of dynamic thermal rating systems on a 400/220/150 kV network to maximise the energy flows whilst considering the real-time conditions of the assets.
  - Limitation removal optimising energy flows.

The implementation of these solutions has improved the management of bottleneck constraints amid increasing RES integration.

4.2 Analysis of data in the TYNDP 2020 and TYNDP 2022

To demonstrate the challenges faced by power systems of the CCS region in future time horizons, additional regional studies have been carried out. The focus is on the influence that potential changes in CO_2 prices (as defined by each RG CCS member) may have on the overall results obtained for the 2030 NT scenarios conducted at the ENTSO-E level.

This analysis focuses on the NT 2030 scenario evolution between TYNDP 2020 and TYNDP 2022. The main objective is to compare assumption changes (installed capacities for the 2030 horizon in the CCS region, CO_2 cost, etc.), the impact of the merit order switch on the generation of different categories, and the market node balances. The figures below illustrate the following:

- A comparison of the installed generation capacities in NT 2030 from TYNDP 2020 and TYNDP 2022 (Figure 36).
- A comparison of the thermal generation, balance and CO_2 emissions from TYNDPs under the scenarios NT 2030 in TYNDP 2020 and TYNDP 2022 (Figure below).

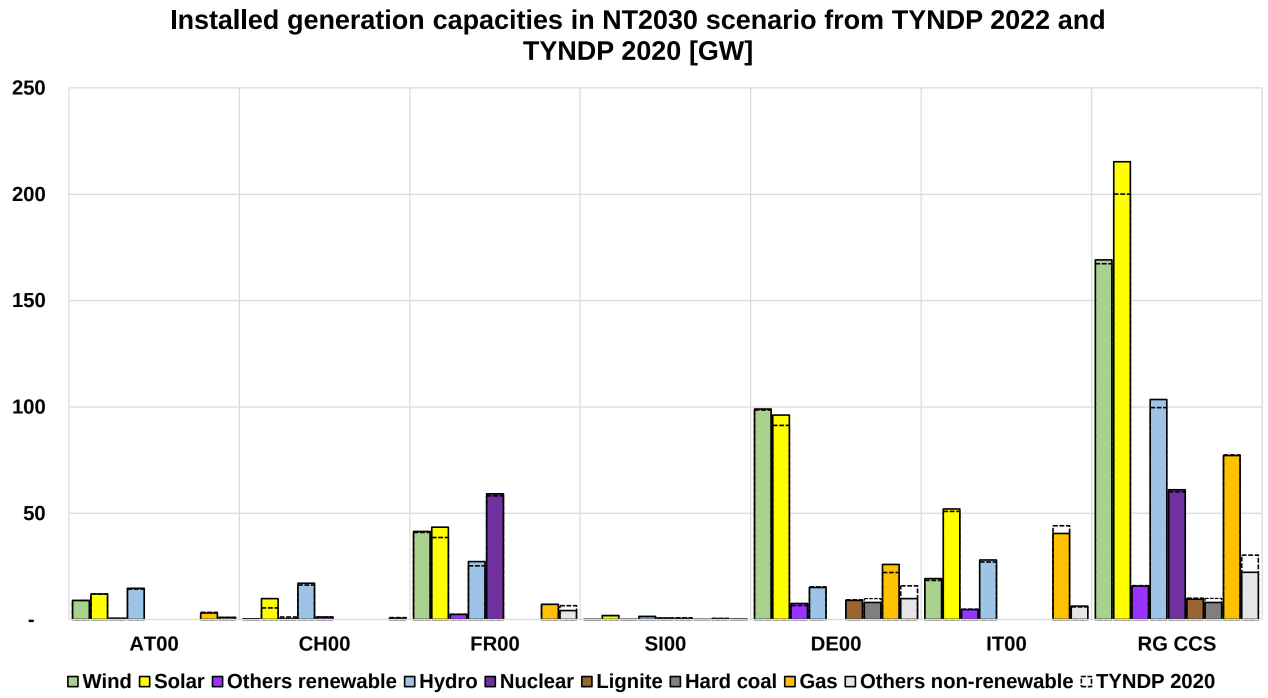

Figure 36 -30 Comparison of installed generation capacities under the NT 2030 scenario from TYNDP 2020 and TYNDP 2022

It can be observed how the new scenario generally foresees more RES sources and less thermal generation (see Figure below), which highlights the following:

- Less CO_2 emissions in the overall CCS region.
- A change in the import/export balance of some countries (e.g., Italy and Germany).

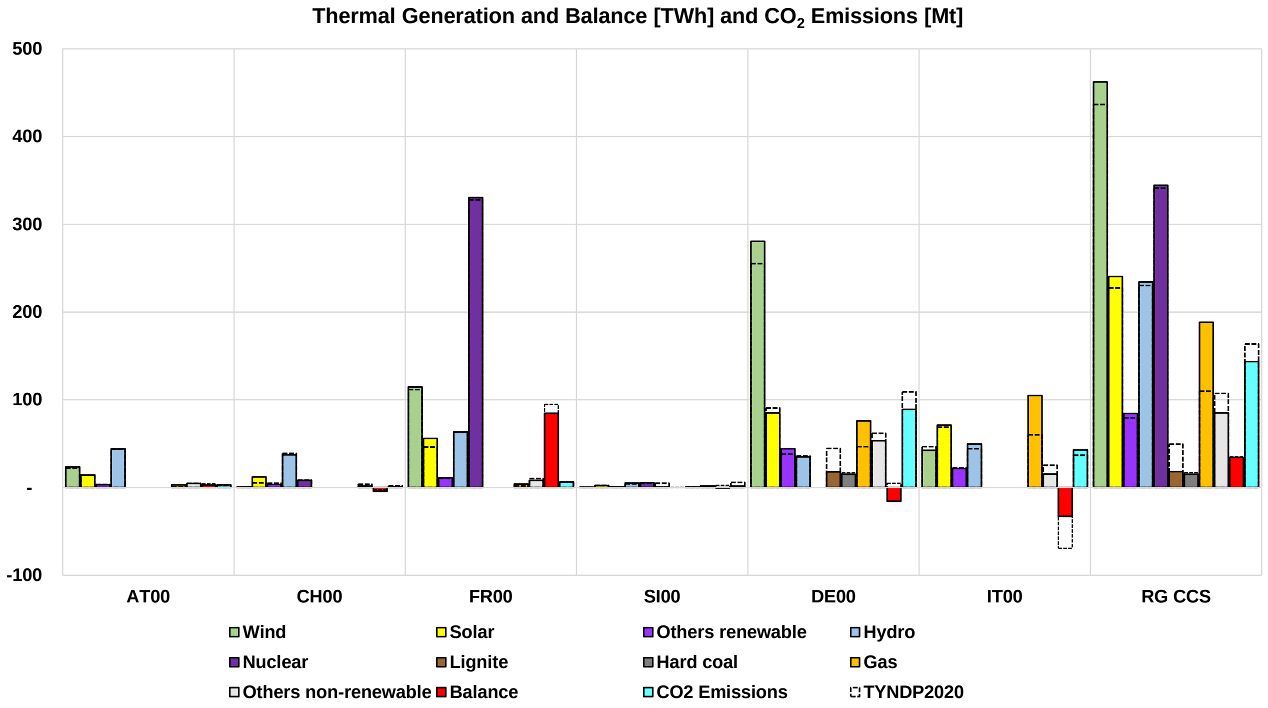

Figure 3137 - Thermal generation, balance and CO_2 emissions under scenario NT 2030 in TYNDP 2020 and TYNDP 2022

4.3 Gas and CO_2 price sensitivity analysis

This sensitivity was conducted for scenario NT2030 from TYNDP 2022. The CO_2 price under scenario NT2030 (70 €/tonne) was changed to the price based on recent trends (90 €/tonne), whilst the gas fuel cost was also increased from 6,77 to 22,22 €/net GJ.

The simulations were performed to demonstrate how the balances and cross-border flows in the CCS region could be affected by changing the CO_2 and gas prices.

The figure below presents the difference in annual energy production of the fossil technology groups showing the greatest changes. The region will become a stronger importer of electrical energy than it currently is.

The largest increases in the balance were observed in all IT bidding zones and DE. The savings originate from a classic fuel switch from coal (mainly lignite) to gas.

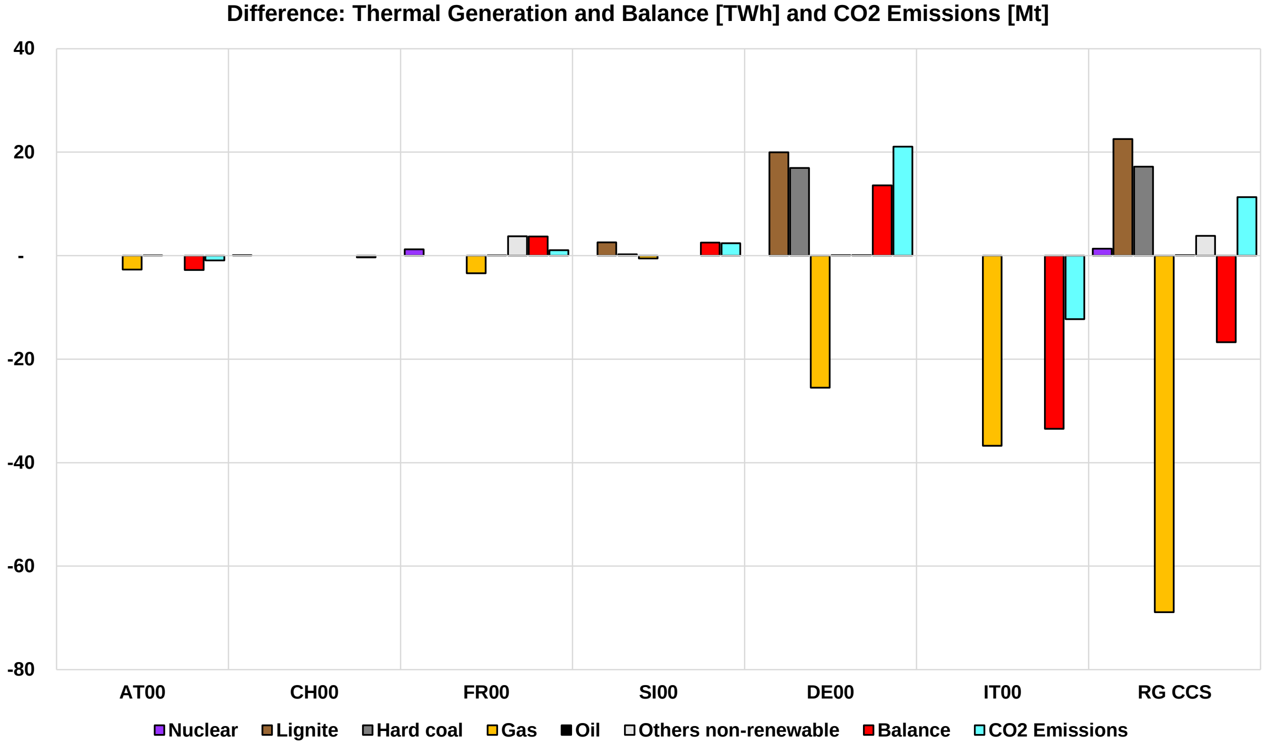

Figure 38 -32 Thermal generation, balance and CO_2 emissions differences – price sensitivity case – reference case

The figure below presents the sum and direction of all market flows between the bidding areas and the balance sheets. The increased need for imports in the region leads to increased export from Germany, Austria, Slovenia and France to Italy. As a result, the need for transport in both import and export directions between the bidding zones in the region increases. The transmission grid in the region must also meet this challenge.

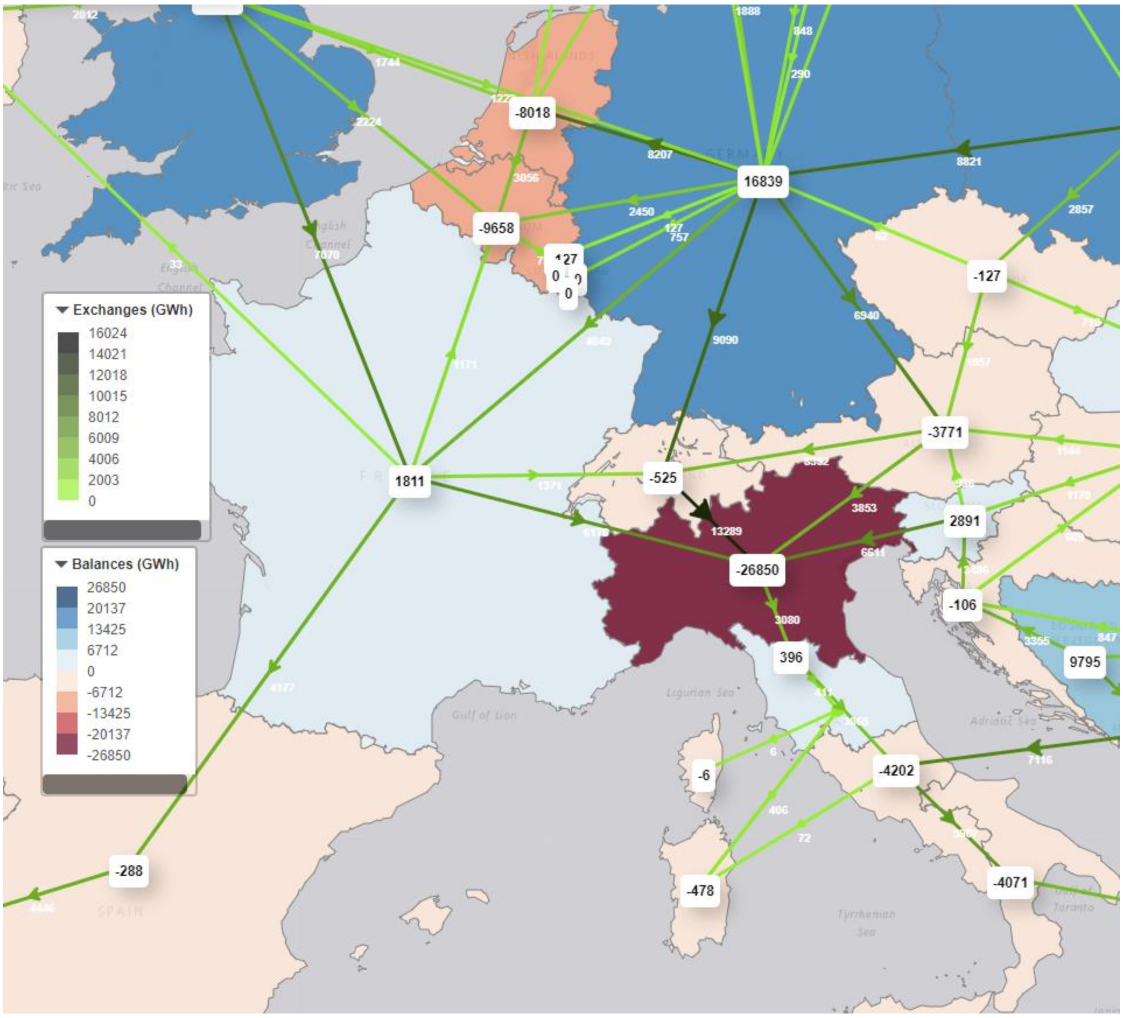

Figure 39 -33 Market flows and bidding zone balance differences - price sensitivity case - reference case one tool, climate year 2009

The sensitivity shows the fundamental influence of CO_2 price on the behaviour of the power plants—and thus the transport demand in the region. From a market perspective, no load coverage problems are to be expected at a higher CO_2 price. This assumes that the additional NTCs planned until 2025 are also available to the market due to the assumed grid expansion.

This sensitivity also indicates different additional transport needs in the region and demonstrates the importance of robustly planned infrastructure. For sustainable grid planning, it is important to analyse a wide range of CO_2 prices.

5 FUTURE CHALLENGES IN THE REGION

The European Study Teams have carried out simulations of all three 2040 and 2030 scenarios with the expected grid of 2025. Even if these simulations were somewhat artificial (e.g., in the real world, the market and grid develop in close interaction with each other), the study revealed expected needs that the power system will have to face if the grid does not evolve beyond 2025. These needs include the following:

- Insufficient integration of renewables (high amounts of curtailed energy) and high CO_2 emissions.
- High price differences between market areas.
- High need for flexibility.
- Bottlenecks between and within market areas.

In addition to the aforementioned problems, operational security issues are present in the areas where the network is less meshed (i.e., the eastern part of the northern Italian border, as well as the internal Italian grid—especially involving the main islands and the Adriatic backbone).

Such needs suggest that all the projects planned until 2025 are of high importance. However, they cannot face all the challenges foreseen in the upcoming years. More detailed identified needs can mostly be addressed through investment in transmission infrastructures in the medium-term time horizon due to the confirmed planned projects of TYNDP 2020.

Identified future capacity needs on the cross-border profiles in the CCS region could be covered by future transmission projects (included in the TYNDP 2022 CBA assessment process) or could remain a need in future grid development.

The outcomes of the IoSN investigations validated the necessity of the confirmed TYNDP 2020 projects to meet market integration needs, increase the sustainably of the transmission system by integrating more RES generation, and improve the SoS.

Additionally, based on the analysis of the 2040 scenarios, a few additional projects covering the upcoming years until 2040 could be developed for inclusion in the present and/or future TYNDPs. For example, it could be interesting to investigate new projects on Italy's eastern and northern borders.

Projects on the northern Italian boundary are key to evaluating the possibility to implement new strategic north-to-south corridors through the Alps. Such corridors would enable the connection and energy exchanges between available load and generation capacities located in the North Sea region with those in the Mediterranean Sea area. Moreover, they would connect the flexibility potential in the Alps region.

Furthermore, the observed results present only cross-border transmission capacity increases because the simulator only investigated borders between countries. However, projects and reinforcements internal to the countries are also vital to the grid's consistent development. The internal investments are a matter of further analysis in the scope of National Development Plans.
For example, in Italy, another more detailed analysis is computed to highlight network needs. Target capacity analysis is useful to identify the optimal development of the grid both on cross-border and internal sections to 2030 taking into consideration different scenarios.

5.1 Task force region-wide studies

In addition to the aforementioned reasons, besides the elaboration of TYNDP, the TSOs of the region are involved in their national grid planning. Moreover, they also perform multilateral studies with their neighbouring TSOs. Each of these multilateral studies includes the following activities:

- Preparation of a grid model, including necessary adaptations and the solving of format issues.
- Definition of scenarios.
- Elaboration of planning principles.

These activities are time-consuming and there is a risk of inconsistency in scenarios and network models. To increase the TSOs' overall efficiency and mitigate inconsistencies, the Task Force region-wide studies were created. The Task Force region-wide studies are led by Christophe Dunand (Swissgrid). It aims to agree on standards to make the sundry bi- or multilateral grid studies conducted (besides TYNDP) more efficient. The Task Force has three pillars, which are listed as follows:

- Grid model: Creation and merging of a detailed common network model that can readily be used by all members.
- Scenarios: Scenarios considering the most detailed, up-to-date, and realistic data/information regarding a certain region.
- Planning principles: Define 'best practices' for certain methods and assumptions, particularly for regulatory frameworks (e.g., the 70% rule, etc.).

6 APPENDICES

Links to national development plans in the CCS region

Country	TSO	National development plan
Austria	APG	www.apg.at/en/Stromnetz /Netzentwicklungsplan
Austria	VUEN	www.vuen.at
France	RTE	https://assets.rte-france.com/prod/public/2020-07/Sch%C3%A9ma%20d%C3%A9cennal%20de%20d%C3%A9veloppement%20de%20r%C3%A9seau%202019%20-%20Synth%C3%A8se%20%E2%80%93%20English%20version.pdf
Germany	Amprion	www.netzentwicklungsplan.de
Germany	TenneT TSO	www.netzentwicklungsplan.de
Germany	TransnetBW	www.netzentwicklungsplan.de
Italy	Terna	http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx
Slovenia	ELES	https://www.eles.si/Portals/EN/Document/ELES_Development_plan_2021-2030-r.pdf
Switzerland	Swissgrid	https://www.swissgrid.ch/swissgrid/de/home/grid/strategic_grid_2025.html

List of TYNDP 2022 projects in the CCS region

Project ID	Project Name	Promoter
26	Reschenpass Interconnector Project	APG; TERNA
28	Italy-Montenegro	CGES; TERNA
29	Italy-Tunisia	TERNA; STEG
33	Central Northern Italy	TERNA
47	Westtirol - Vöhringen	AMPRION; APG
127	Central Southern Italy	TERNA
130	HVDC SuedOstLink Wolmirstedt to Area Isar	50Hertz, TenneT-DE
132	HVDC Line A-North	Amprion

150	Italy-Slovenia	TERNA; ELES
174	Greenconnector	Worldenergy SA
186	East of Austria	APG
187	St. Peter (AT) - Pleinting (DE)	APG; TENNET-DE
210	Wurmlach (AT) - Somplago (IT) interconnection	Alpe Adria Energia Srl
228	Muhlbach - Eichstetten	RTE; TransnetBW
231	Beznau - Tiengen	Swissgrid; Amprion
235	HVDC Brunsbüttel/Wilster to Großgartach/Grafenrheinfeld	TenneT-DE; TransnetBW
244	Vigy - Uchtelfangen area	Amprion;RTE
250	Merchant line: Castasegna (CH) - Mese (IT)	Mera srl (a 100% subsidiary of Repower AG)
253	Upstream reinforcement in France to increase FR-CH capacity	RTE
254	Ultranet	Amprion; TransnetBW
263	Lake Constance East	Swissgrid; VUEN; Amprion; TransnetBW
283	TuNur	TuNur Limited
299	SACOI3	Terna; EDF
312	St. Peter - Tauern (AT internal)	APG
313	Isar/Altheim/Ottenhofen (DE) - St. Peter (AT)	TenneT-DE; APG
323	Dekani (SI) - Zaule (IT) interconnection	Adria Link Srl, E3 d.o.o., HSE d.o.o.
324	Redipuglia (IT) - Vrtojba (SI) interconnection	Adria Link Srl, E3 d.o.o., HSE d.o.o.
325	Upgrade Obersielach (AT) - Podlog (SI)	APG; ELES
333	PST Foretaille	Swissgrid
338	Adriatic HVDC Link	TERNA

339	Tyrrhenian Link	TERNA
375	Lienz (AT) - Veneto region (IT) 220 kV	TERNA; APG
1034	HVCD corridor from Northern Germany to Western Germany	Amprion; TenneT-DE
1052	Lienz (AT) – Obersielach (AT)	APG
1054	Westtirol (AT) - Zell/Ziller (AT)	APG
1058	HVDC Interconnector DE-CH	TransnetBW; Swissgrid
1059	Southern Italy	Terna
1096	Beznau - Mettlen	Swissgrid
1102	Mettlen - Ulrichen	Swissgrid
1103	Bickigen - Chippis	Swissgrid
1109	Basilicata-Campania reinforcements	Terna
1110	Sicily-Calabria	Terna
1112	GRITA2	Terna-IPTO
1085	Malta-Italy Cable Link No.2	Interconnect Malta Ltd
40	Belgium-Luxembourg-Germany: Long-term perspective	Elia; Creos; Amprion
225	2nd interconnector Belgium - Germany	Elia; Amprion
328	Interconnector DE-LUX	Elia; Amprion
1104	Niederstedem - Roost	Creos; Amprion

Regional projects in the CCS region

Country	Project name	Investment from	Investment to	Expected commissioning year	Description	Main drivers	Included in RegIP 2020?
FR	Sud Aveyron	-	-	2023	New substation on the 400-kV Gaudière-Rueyres line for local RES integration.	RES integration	Yes

FR	Eguzon-Marmagne 400kV	Eguzon	Marmagne	>2030	Reconductoring existing 400-kV OHL (maintenance).	Mainte nance, RES integra tion and market integra tion	Yes
FR	Long-term perspective 'Façade Atlantique'	-	-	>2030	Upgrade of the north-south 400-kV corridor between Nouvelle Aquitaine and the Loire valley is under study.	RES integra tion and market integra tion	Yes
FR	Long-term perspective 'Rhône – Bourgogne'	-	-	>2030	Upgrade of the north-south 400-kV corridors between Lorraine and Alsace and Franche-Comté, between Champagne-Ardenne and Bourgogne and in the Rhone valley.	RES integra tion and market integra tion	No
FR	Long-term perspective 'Rhône – Bourgogne'	-	-	>2030	Upgrade of the 400-kV east-west corridors between Languedoc and the Rhone valley and in the West of Provence.	RES integra tion and market integra tion	No
FR	Long-term perspective 'Rhône – Bourgogne'	-	-	>2030	Under study.	RES integra tion and market integra tion	No
FR	Long-term perspective 'Normandie – bassin parisien'	-	-	>2030	Upgrade of the north-south 400-kV corridor between Normandy and the Paris basin is under study.	RES integra tion	No
FR	Long-term perspective 'Massif central – Centre'	-	-	>2030	Upgrade of the north-south 400-kV corridors in the Massif central-Centre is under study.	RES integra tion and market integra tion	Yes
IT		Restructuring of the Sorrento Peninsula Network (IT)		2030	New 380-/220-/150-kV substation is planned for the East Vesuvius area (near Naples) connected in and out to the existing 380- and 220-kV lines 'Montecorvino-S. Sofia' and 'Nola-S. Valentino'. Related to this project, some reinforcements and restructuring of the existing 150-kV network have been programmed in the area of the Sorrento Peninsula.	SoS	Yes
IT		S.Teresa (IT)	Buddusò (IT)	2026	New 150-kV line connecting the substation of S.Teresa, Tempio and Buddusò, allowing the realisation of a new 150-kV backbone in Sardinia.	RES integra tion, SoS	Yes

IT		Treviso (IT)		2030	New 380-/132-kV substations in the Treviso area, connected in and out to the existing 380-kV line 'Sandrigo - Cordignano'.	SoS	Yes
IT		Porto Ferraio (Elba Island) (IT)	Colmata (IT)	2025	New 40-km 132-kV connection via subsea cable between the existing substations of Porto Ferraio and Colmata.	SoS	Yes
IT		Turin (IT)		2030	Restructuring of the 220-kV network in the urban area of Turin. Some new 220-kV cables, some new 220-/132-kV substations and some reinforcements of existing assets are planned.	SoS	Yes
IT		Brennero (IT)		2023	New 132-kV substation with a 110-/132-kV PST.	Market integration	Yes
IT		Dolo (IT)	Camin (IT)	2025	New 15-km double-circuit 400-kV underground cable between existing Dolo and Camin 400-kV substations, to be built in parallel with the existing line.	SoS	Yes
IT		Media Valle Piave Razionalization (IT)		2028	Restructuring of the existing 220- and 132-kV network in the Media Valle del Piave with the realisation of a new 220-/132-kV substation. The substation will be connected by two short links to the existing Soverzene-Lienz 220-kV line.	SoS, RES integration	Yes
IT		Ciminna area (IT)		2025	For the realisation of 400-kV grid reinforcement, a voltage upgrade of the existing Ciminna substation up to 400 kV is planned.	RES integration, SoS	Yes
IT		Assoro (IT)		2030	For the realisation of 400-kV grid reinforcement, a new 400-/150-kV substation is planned for Assoro.	RES integration, SoS	Yes
IT		Chiaramonte Gulfi (IT)	Ciminna (IT)	2026	Realisation of a new 400-kV line: 'Chiaramonte Gulfi - new station of Assoro- Ciminna'.	RES integration, SoS	Yes
IT		Sorgente 2 (IT)		2030	New 400-/150-kV substation in the Sorgente area will be temporally connected in and out to the existing 400-kV 'Paternò - Sorgente' line and to the local 220-kV and 150-kV network.	RES integration, SoS	Yes
IT		Assoro (IT)	Villafranca (IT)	2030	Realisation of a new 400-kV line: 'Assoro-Sorgente2-Villafranca'.	RES integration, SoS	Yes
IT		Paternò (IT)	Priolo (IT)	2023	Realisation of new 400-kV line: 'Paternò-Pantano-Priolo'.	RES integration, SoS	Yes

IT		Milan (IT)	-	2028	Restructuring of the 220-kV network in the urban area of Milan. Some new 220-kV cables (33 km), a new 220-kV substation (Musocco) and some reinforcements of existing assets (35 km) are planned.	SoS	Yes
IT		Naples (IT)	-	2028	Restructuring of the 220-kV network in the urban area of Naples. Some new 220-kV cables and some reinforcements of existing assets are planned. Total length: 36 km.	SoS	Yes
SI		Ravne (SI)	Ravne (SI)	2027	Construction of a new 220-/110-kV substation Ravne with a new double 220-kV OHL substation at Ravne-Zagrad (length: ~4 km), which will be included in the existing interconnection of 220-kV OHL 220 kV Podlog (SI)-Obersielach (AT). Expected commissioning in 2027.	Flicker, high load growth	Yes
SI	New compensation devices at the 400-kV voltage level in the scope of the SINCRO.GRID project	Beričevo (SI), Divača (SI),	Cirkovce (SI)	2022	Installation of new compensation devices on 400-kV voltage level: • SVC/STATCOM (150 Mvar) in SS Beričevo. • VSR (150 Mvar) and MSC (100 Mvar) in SS Divača. • VSR (150 Mvar) in SS Cirkovce.	RES integration, SoS	Yes
CH	Obfelden - Samstagern	Obfelden (CH)	Samstagern (CH)	2028	Reinforcement of the grid and voltage increase to 220 kV between Obfelden and Samstagern. New 220-kV substations in Thalwil and Waldegg.	Improvement of the SoS of the Zurich area	Yes
CH	Flumenthal - Froloo	Flumenthal (CH)	Froloo (CH)	2036	220-kV line between Flumenthal and Froloo	Improvement of the SoS of the Basel area	Yes
AT	Refurbishment of a 220-kV line	St. Peter am Hart (AT)	Ernsthofen (AT)	2021	Reconstruction of old 220-kV line on the same route with a modern bundle of two conductors.	SoS	Yes
AT	St. Peter am Hart - Ernsthofen						

AT	Reitdorf - Weißenbach	Pongau (AT)	Weißenbach (AT)	2023	Refurbishment of old 220-kV line on same route.	SoS	Yes
AT	Weißenbach - Hessenberg	Weißenbach (AT)	Hessenberg (AT)	2025	Refurbishment of old 220-kV line on same route.	SoS	Yes
DE	P38-M27a+M27b +M27c	Pulgar (DE)	Vieselbach (DE)		Construction of new 380-kV double-circuit OHL in the existing Pulgar - Vieselbach corridor (104 km). Detailed information is given in Germany's Grid Development Plan.	RES integra tion, SoS	Yes
DE	P84-M367	Hamburg/Nord (DE)	Hamburg/Ost (DE)		Reinforcement of existing 380-kV OHL: Hamburg/Nord - Hamburg/Ost. Detailed information is given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	P84-M368mod	Hamburg/Ost (DE)	Ämter Büchen/Breitenfeld e/Schwarzenbek-Land (DE)		New 380-kV OHL in the existing corridor: Krümmel - Hamburg/Ost. Detailed information is given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	P22-M80	Elsfleht/West (DE)	Ganderkesee (DE)		New 380-kV OHL in the existing corridor for RES integration between Elsfleth/West, Niedervieland and Ganderkesee.	RES integra tion	Yes
DE	P23-M20	Dollern (DE)	Alfstedt (DE)		New 380-kV OHL in the existing corridor in Northern Lower Saxony for RES integration.	RES integra tion	Yes
DE	P23-M20	Alfstedt (DE)	Elsfleth/West (DE)		New 380-kV line: Alfstedt - Elsfleth/West (in the existing corridor for RES integration).	RES integra tion	Yes
DE	P20-M69	Emden (DE)	Halbemond (DE)		New 380-kV line: Emden - Halbemond (for RES integration). Contruction of new substation in Halbemond.	RES integra tion	Yes
DE	P22-M92	Conneforde (DE)	Unterweser (DE)		New 380-kV OHL in the existing corridor for RES integration in Lower Saxony.	RES integra tion	Yes
DE	P124-M209a	Wolmirstedt (DE)	Klostermansfeld (DE)		New 380-kV OHL in the existing corridor for RES integration between Wolmirstedt - Klostermansfeld.	RES integra tion	Yes
DE	P124-M209b	Klostermannsfeld (DE)	Schraplau/Obhause n – Lauchstädt (DE)		New 380-kV OHL in an existing corridor: Klostermannsfeld - Schraplau/Obhausen - Lauchstädt. Detailed information given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	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 integra tion, SoS	Yes

DE	P407	Several			Vertical measures in the Amprion zone.	RES integration, SoS	Yes
DE	P26-M76	Büttel (DE)	Wilster/West (DE)		New 380-kV line in the existing corridor in Schleswig - Holstein for RES integration—especially on- and off-shore wind.	RES integration	Yes
DE	P26-M432	Brunsbüttel (DE)	Büttel (DE)		New 380-kV line: Brunsbüttel - Büttel in the existing corridor for RES integration.	RES integration	Yes
DE	P26-M89	Wilster/West (DE)	Stade/West (DE)		New 380-kV line: Wilster/West - Stade/West in the existing corridor for RES integration.	RES integration	Yes
DE		Junction Mehrum (DE)	Mehrum (DE)		New 380-kV line junction in Mehrum (Wahle - Grohnde – Mehrum), including a 380-/220-kV transformer in Mehrum.	RES integration	Yes
DE	P118-M207	Borken (DE)	Mecklar (DE)		New 380-kV line: Borken - Mecklar in the existing corridor for RES integration.	RES integration	Yes
DE	P133-M253	Borken (DE)	Gießen (DE)		New 380-kV line: Borken - Gießen in the existing corridor for RES integration.	RES integration	Yes
DE	P151-M353	Borken (DE)	Twistetal (DE)		New 380-kV line: Borken - Twistetal in the existing corridor for RES integration.	RES integration	Yes
DE	P159-M62	Bürstadt (DE)	BASF (DE)		New line and extension of the existing line to a 400-kV double-circuit OHL in Bürstadt – BASF, including the extension of existing substations.	RES integration, SoS	Yes
DE	50HzT-003	Neuenhagen (DE)	Vierraden (DE)		Project involving a new 380-kV double-circuit OHL for Neuenhagen - Vierraden – Bertikow, with a 125-km length as a prerequisite for the planned upgrading of the existing 220-kV double-circuit interconnection Krajnik (PL) – Vierraden (DE Hertz Transmission). Detailed information is given in Germany's Grid Development Plan.	RES integration, SoS	Yes
DE	50HzT-007	Neuenhagen (DE)	Wustermark (DE)		Construction of a new 380-kV double-circuit OHL between the substations at Wustermark and Neuenhagen (75 km length). Support of RES and conventional generation integration, maintenance of SoS and support of market	RES integration, SoS	Yes

					development. Detailed information is given in Germany's Grid Development Plan.		
DE	50HzT-P36	Pasewalk (DE)	Bertikow (DE)		Construction of new 380-kV double-circuit OHLs in the north-eastern part of the 50HzT control area and decommissioning of existing old 220-kV double-circuit OHLs, incl. the 380-kV OHL for Bertikow - Pasewalk (30 km). Support of RES and conventional generation integration in North Germany, maintenance of SoS and support of market development. Detailed information is given in Germany's Grid Development Plan.	RES integra tion, SoS	Yes
DE	P39-M29a+M29b	Röhrsdorf (DE)	Remptendorf (DE)		Construction of new double-circuit 380 kV OHL in the existing Röhrsdorf - Weida - Remptendorf corridor (103 km).	SoS	Yes
DE	P37-M25a+b	Vieselbach (DE)	Mecklar (DE)		New double-circuit OHL 380-kV line in the existing OHL corridor. Detailed information is given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	P211-M434	Gießen/Nord (DE)	Karben (DE)		New 380-kV line: Gießen/Nord - Karben in the existing corridor for RES integration.	RES integra tion	Yes
DE	P150-M352a+M352b	Schraplau/Obhausen (DE)	Wolkramshausen (DE)		New 380-kV OHL in the existing corridor between Schraplau/Obhausen and Wolkramshausen. Detailed information is given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	P180-M406	Marzahn (DE)	Teufelsbruch (DE)		AC grid reinforcement between Marzahn and Teufelsbruch (380-kV cable in Berlin). Detailed information is given in Germany's Grid Development Plan.	SoS	Yes
DE	P215-M454, M579, M586	Güstrow (DE)	Search area communities Sanitz/Dettmannsdorf (DE)		New 380-kV OHL in the existing corridor between Güstrow - Bentwisch - search area communities Sanitz/Gnewitz/Dettmannsdorf/town Marlow. M586+M579: cable connection in Papendorf. Detailed information given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	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	RES integra tion	Yes

					transformer in search area communities Sanitz/Dettmannsdorf. Detailed information is given in Germany's Grid Development Plan.		
DE	P216-M455, M523	Güstrow (DE)	Pasewalk (DE)		New 380-kV OHL in the existing corridor of Güstrow – Siedenbrünzow – Iven/Krusenfelde/Krien/Spantekow /Werder/ Bartow – Pasewalk/Nord – Pasewalk. Detailed information is given in Germany's Grid Development Plan.	RES integration	Yes
DE	P150-M463	Wolkramshausen (DE)	Vieselbach (DE)		New 380-kV OHL in the existing corridor of Wolkramshausen - Ebeleben - Vieselbach. Detailed information is given in Germany's Grid Development Plan.	SoS	Yes
DE	P310-M485	Bürstadt (DE)	Kühmoos (DE)		An additional 380-kV OHL will be installed on existing power poles.	RES integration, SoS	Yes
DE	TTG-P33-M24a	Wahle (DE)	Border Saxony/Anhalt - Lower Saxony (DE)		New 380-kV OHL in the existing corridor of Wahle - Hattorf - Helmstedt/Ost - Border Saxony/Anhalt - Lower Saxony. Detailed information is given in Germany's Grid Development Plan.	RES integration	Yes
DE	50HzT-P33-M24a2	Wolmirstedt (DE)	Border Saxony/Anhalt - Lower Saxony (DE)		New 380-kV OHL in the existing corridor of Wolmirstedt - Border Saxony/Anhalt - Lower Saxony. Detailed information is given in Germany's Grid Development Plan.	RES integration	Yes
DE	P33-M24b	Wolmirstedt (DE)	Gleidingen/Hallendorf (DE)		New 380-kV OHL in the existing corridor of Wolmirstedt - Helmstedt - Gleidingen/Hallendorf. Detailed information is given in Germany's Grid Development Plan.	RES integration	Yes
DE	P222-M461	Oberbachern (DE)	Ottenhofen (DE)		Upgrade of the existing 380-kV line. Detailed information is given in Germany's Grid Development Plan.	RES integration, SoS	Yes
DE	P72-M49, M50	Kreis Segeberg (DE)	Siems (DE)		New 380-kV line at Kreis Segeberg - Siems in the existing corridor for RES integration.	RES integration	Yes
DE	P72-M351	Lübeck (DE)	Göhl (DE)		New 380-kV line at Lübeck - Göhl for RES integration. Contruction of new substation in Göhl.	RES integration	Yes

DE	P53-M54, M350	Raitersaich (DE)	Altheim (DE)		New 380-kV line at Raitersaich - Altheim in the existing corridor for RES integration.	RES integration	Yes
DE	M46	Redwitz (DE)	Schwandorf (DE)		New 380-kV line at Redwitz - Schwandorf in the existing corridor for RES integration.	RES integration	Yes
DE	50HzT-P34-M22a+M22b+M22c	Güstrow (DE)	Wolmirstedt (DE)		New 380-kV OHL in the existing corridor for Güstrow - Parchim/Süd - Perleberg - Stendal/West - Wolmirstedt. Detailed information is given in Germany's Grid Development Plan.	RES integration	Yes
DE	P113-M212, M202a, M203	Krümmel (DE)	Wahle (DE)		Including ad-hoc Maßnahme Serienkompensation Stadorf-Wahle.	RES integration	Yes
DE	P135-M255	Bechterdissen	Ovenstädt		Reinforcement of existing 380-kV line between Bechterdissen and Ovenstädt.	RES integration	Yes
DE	P161-M91	Großkrotzenburg (DE)	Urberach (DE)		Reinforcement of existing 380-kV line between Großkrotzenburg and Urberach.	RES integration	Yes
DE	P175	Wilhelmshaven 2 (DE)	Fedderwarden (DE)		New 380-kV line at Wilhelmshaven 2 - Fedderwarden for RES integration.	RES integration	Yes
DE	P200	Point Blatzheim (DE)	Oberzier (DE)		Reinforcement of existing 380-kV line between Point Blatzheim and Oberzier.	RES integration	Yes
DE	P228	Landesbergen (DE)	Mehrum/Nord (DE)		New 380-kV line at Kreis Segeberg - Siems in the existing corridor for RES integration.	RES integration	Yes
DE	P314				Phase-shifting transformers in the Saarland.	RES integration	Yes
DE	P315	Hanekenfähr (DE)	Gronau (DE)		Reinforcement of existing/ new 380-kV lines between Hanekenfähr and Gronau.	RES integration	Yes
DE	P327				Ad-hoc phase-shifting transformers in the Ruhr region.	RES integration	Yes
DE	P345-M556	Hamburg/Ost (DE)			Four phase-shifting transformers in substation Hamburg/Ost.	RES integration	Yes

DE	P346	Hanekenfähr (DE)			Ad-hoc phase-shifting transformers in Hanekenfähr.	RES integra tion	Yes
DE	P347	Oberzier (DE)			Ad-hoc phase-shifting transformers in Oberzier.	RES integra tion	Yes
DE	P348	Krempermarsch (former: Wilster/West) (DE)			New phase-shifting transformers in Wilster/West.	RES integra tion	Yes
DE	P349	Würgau			New phase-shifting transformers in in Würgau.	RES integra tion	Yes
DE	P353	Twistetal			New phase-shifting transformers in Twistetal.	RES integra tion	Yes
DE	P357-M566	Güstrow (DE)			Four phase-shifting transformers in substation Güstrow	RES integra tion	Yes
DE	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 integra tion	Yes
DE	P359-M571+M582 b	Stendal/West (DE)	Wolmirstedt (DE)		New 380-kV OHL in the existing corridor of Stendal/West - Wolmirstedt. Detailed information is given in Germany's Grid Development Plan.	RES integra tion	Yes
DE	P360-M464+M464 b+M595a-q+M605a-c+M685a-g+M686+M 695a-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, 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)			Installation of reactive power compensation (eg. MSCDN, STATCOM, ...) in the 50Hz 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 integra tion, SoS	Yes

DE	P365-M383	Audorf/Süd	Ottenhofen (DE)		100-MW grid booster at substations in Audorf/Süd and Ottenhofen.	RES integra tion	Yes
DE	P400	Grid of TenneT (DE)			Construction of several reactive power compensation units in the grid of TenneT (DE).	RES integra tion	Yes
DE	P403-M603	Hattingen (DE)	Linde (DE)		Reinforcement of the existing OHL between Hattingen and Linde.	RES integra tion	Yes
DE	P410-M624	Enniger			Phase-shifting transformers in Enniger.	RES integra tion	Yes
DE	P412				Several reactive power compensation systems in the area of Amprion GmbH.	RES integra tion	Yes
DE	P450-M678+M786	Güstrow (DE)	Stendal/West (DE)		Reinforcement of the existing 380-kV OHL (M678: Putlitz/Süd – Putlitz – Perleberg – Stendal/West; M786: Güstrow – Siedenbrünzow – Putlitz/Süd).	RES integra tion	Yes
DE	P451-M681	Graustein (DE)	Bärwalde (DE)		Reinforcement of the existing 380-kV OHL for Graustein - Bärwalde.	RES integra tion	Yes
DE	P450-M683	Ragow (DE)	Streumen (DE)		Reinforcement of existing 380-kV OHL for Ragow - Streumen.	RES integra tion	Yes
DE	P460-M687				Grid reinforcements in the Büscherhof region.	RES integra tion	Yes
DE	P462-M689				Grid reinforcements in the Aachen region.	RES integra tion	Yes
DE	P463-M690				Grid reinforcements in the western Rhein region.	RES integra tion	Yes
DE	P119-M90, M535	Conneforde (DE)	Samtgemeinde Sottrum (DE)		New 380-kV line for Conneforde - Sottrum in the existing corridor for RES integration.	RES integra tion	Yes
DE	P43	Mecklar (DE)	Bergrheinfeld/West (DE)		New 380-kV line for Mecklar - Bergrheinfeld/West for RES integration.	RES integra tion	Yes
DE	P24	Dollern (DE)	Landesbergen (DE)		New 380-kV line for Dollern - Landesbergen in the existing corridor for RES integration.	RES integra tion	Yes

DE	P21	Conneforde (DE)	Cloppenburg (DE)		New 380-kV line for Conneforde - Landkreis Cloppenburg in the existing corridor for RES integration.	RES integration	Yes
DE	P21	Cloppenburg (DE)	Merzen (DE)		New 380-kV line for Landkreis Cloppenburg - Merzen for RES integration.	RES integration	Yes
DE	TTG-006	Wahle (DE)	Mecklar (DE)		New 380-kV line for Wahle - Mecklar for RES integration.	RES integration	No
DE	AMP/TTG 007	Dörpen/West (DE)	Niederrhein (DE)		New 380-kV line for Dörpen/West - Niederrhein for RES integration.	RES integration	No
DE	AMP/TTG 009	Ganderkesee (DE)	Wehrendorf (DE)		New 380-kV line for Ganderkesee - Wehrendorf for RES integration.	RES integration	No
DE	TTG-P25	Husum/Nord (DE)	Klixbühl/Süd (DE)		West coast line Heide/West - Klixbühl for RES integration.	RES integration	No
DE	DC 20	Klein Rogahn/Stralendorf/Warsow/ Holthusen/Schossin(DE)	Isar (DC)		New HVDC cable for Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin – Isar for RES integration.	RES integration	No
DE	DC 31	Hemmingstedt/Lieth/Lohe-Rickelshof/ Wöhrden (DE)	Klein Rogahn/Stralendorf/ Warsow/ Holthusen/Schossin (DE)		New HVDC-cable for Hemmingstedt/Lieth/Lohe-Rickelshof/ Wöhrden (DE) - Klein Rogahn/Stralendorf/ Warsow/ Holthusen/Schossin for RES integration.	RES integration	No
DE	P212	Landesbergen (DE)	Borken (DE)		New 380-kV line for Landesbergen-Borken in the existing corridor for RES integration.	RES integration	No
DE	P227	Lübeck/West (DE)	Krümmel (DE)		New 380-kV line for Lübeck/West - Krümmel for RES integration.	RES integration	No
DE	P500	Sombron	Urberach (DE)		New 380-kV line for Somborn-Aschaffenburg-Urberach for RES integration.	RES integration	No
DE	TNG-P47-M31, M32, M33, M34, M31TR1	Weinheim (DE)	Daxlanden (DE)		Upgrade of existing 380-kV lines in the area from Weinheim to Daxlanden. Additionally, a new phase-shifting transformer in Weinheim to the distribution grid is necessary.	RES integration	Yes
DE	AMP-P47-M60	Urberach (DE)	Weinheim (DE)		Upgrade of the existing 380-kV lines in the Frankfurt-Karlsruhe region.	RES integration	Yes
DE	TNG-P48-M38a, M39	Grafenrheinfeld (DE)	Großgartach (DE)		Additional 380-kV circuit between Point Rittershausen and Kupferzell, incl. the enhancement of a substation in Kupferzell. Reinforcements in the existing corridor between Kupferzell and Großgartach.	RES integration	Yes

DE	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 integra tion	Yes
DE	TNG-P50-M366SA1	Pulverdingen(DE)			Extension of substation Pulverdingen.	RES integra tion	Yes
DE	TNG-P70	Birkenfeld (DE)	Ötisheim (DE)		New 380-kV OHL for Birkenfeld-Ötisheim (Mast 115A), incl. new 380-kV GIS-substation in Birkenfeld.	SoS	Yes
DE	TNG-P90	Grid of TransnetBW			Construction of several reactive power compensation systems in the area of TransnetBW GmbH.	RES integra tion	Yes
DE	TNG-P350-M561	Pulverdingen(DE)			New phase-shifting transformer in Pulverdingen.	RES integra tion	Yes
DE	P51-M37	Großgartach (DE)	Endersbach (DE)		Grid reinforcements in the existing corridor between Großgartach and Endersbach. Enhancement of the substations at Endersbach and Großgartach is required.	SoS	Yes
DE	P302-M511	Höpfingen (DE)	Hüffenhardt (DE)		Additional 380-kV line between Höpfingen and Hüffenhardt, incl. grid reinforcements in the corresponding substations.	RES integra tion	Yes
DE	P206-M417	Herbertingen/Area of Constance/Beuren (DE)	Gurtweil/Tiengen (DE)		Increase of transmission capacity in the Hochrhine region via the replacement of existing 220-kV infrastructure.	SoS	Yes
DE	P428-M700	Kühmoos			Upgrade of the 380-kV substation at Kühmoos in Southern Germany.	RES integra tion	Yes
DE	P430-M646	Kupferzell			250-MW grid booster in substation Kupferzell.	RES integra tion	Yes
DE	P421-M702	Trossingen			Connection of existing 380-kV line for Engstlatt-Gurtweil-Villingen to the substation in Trossingen. Enhancement of the substation in Trossingen and other connected lines is required.	SoS	No
DE	P223-M462a	Güstrow (DE)	Krümmel (DE)		New 380-kV OHL in the existing corridor for Güstrow – Wessin – Görries – Gemeinden Klein Rogahn/Stralendorf/Warsow/Holthusen/Schossin – Gemeinden Talkau/Elmenhorst/Kankelau/Fuhlenhagen – Krümmel. Detailed information given in Germany’s Grid Development Plan.	RES integra tion	No

DE	P252-M534a	Marzahn (DE)	Wuhlheide (DE)		New 380-kV OHL in the existing corridor of Marzahn – Wuhlheide. Detailed information is given in Germany's Grid Development Plan.	SoS	No
DE	P528-M750	Lauchstädt (DE)	Pulgar (DE)		New 380-kV OHL in the existing corridor of Lauchstädt – Leuna/Merseburg/Weißenfels – Pulgar. Detailed information given in Germany's Grid Development Plan.	SoS	No
DE	P402	Westerkappeln (DE)	Gersteinwerk (DE)		380-kV HL OHL in the new corridor between Westerkappeln and Gersteinwerk.	RES integration	No
DE	P408	Eiberg (DE)	Emscherbruch (DE)		380-kV HL OHL in the existing corridor from Eiberg to Emscherbruch.	RES integration	No
DE	P464	Saarland (DE)	Sarwellingen (DE)		New 380-/110-kV transformers.	SoS	No
DE	P501	Gersteinwerk (DE)	Mengede (DE)		380-kV HL OHL in the existing corridor from Gersteinwerk to Mengede.	RES integration	No
DE	P502	Walsum (DE)	Beeck (DE)		380-kV HL OHL in the existing corridor from Walsum to Beeck.	RES integration	No
DE	P504	Sechtem (DE)	Weißenthurm (DE)		New 380-kV line reinforcement from Sechtem to Weißenthurm.	RES integration	No
DE	P531-M531a/M531b	Thyrow (DE)	Reuter (DE)		New 380-kV OHL in the existing corridor of 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.	SoS	No

Acknowledgements

ENTSO-E would like to thank all the experts involved in the Ten-Year Network Development Plan 2022 for their commitment and enthusiasm in building this unique coordinated pan-European plan. In particular, ENTSO-E would like to thank the following experts who contributed to this report.

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