TOGETHER FOR 100% RENEWABLE EUROPE

Future-Proofing Central Eastern European Grids for Tomorrow's Energy System

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Contents

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Executive Summary

This inspiration paper presents a critical analysis and strategic recommendations for transforming the electricity grid infrastructure in Central and Eastern Europe (CEE), a vital step towards a sustainable, renewable energy future. It calls for action from TSOs, DSOs, and governments in CEE to lead this transformative change, paving the way towards an interconnected, resilient, secure, affordable, and sustainable energy future fully powered by renewable energy sources like wind and solar.

There are notable examples within the region that demonstrate the feasibility and benefits of integrating renewable energy into the grid. These success stories provide a solid foundation for broader implementation and serve as a catalyst to scale up and enhance renewable energy integration across the region. However, existing grid bottlenecks, including ageing infrastructure, underinvestment, low demand side flexibility, and delayed digitalization significantly hinder this integration.

By addressing these challenges through elevated political will, fostered strategic planning, improved regulatory frameworks, transparency and stakeholder dialogue, enhanced regional collaboration, decentralisation, and empowered citizens and local actors, the CEE region can not only achieve its climate and energy targets but also position itself as a leader in the European renewable energy transition. Efficient use of EU funds, fully embracing demand-side flexibility, and the integration of advanced technologies are pivotal for modernising the grid infrastructure.

This paper aims to inspire a comprehensive, actionable roadmap for CEE countries to harness the full potential of renewable energy, while adopting a socially inclusive and just approach to energy transition. By acting on the key recommendations, CEE countries will actively shape their future energy systems to be modern, efficient, secure, and people-centred, ensuring each step contributes to the well-being of their citizens and transforms their energy infrastructure to meet current and future needs.

1. Introduction

Europe is rapidly integrating renewable energy sources, such as wind and solar, into electricity grids aiming to reap benefits[1] including lower energy bills and improvements in energy security. Yet, countries in Central Eastern Europe (CEE)[2] notably lag behind, as they often block renewable energy projects through regulatory barriers, fail to address technical bottlenecks that would enable greater integration of renewable power, and continue to heavily rely on fossil fuels such as coal, fossil gas, and oil.

For the CEE countries to fully harness the potential and benefits of renewable energy, addressing the critical bottlenecks in electricity infrastructure has become imperative. This is especially critical in the CEE region due to its ageing and chronically underinvested infrastructure in electricity generation, transmission, and distribution.[3] The outdated infrastructure not only results in power losses and frequent low-capacity operation of generation units, but also exhibits a significant lack of flexibility. Although the challenges vary from country to country the region's pressing need for modernisation presents an opportunity to simultaneously tackle multiple challenges at once: investing in optimal balance of physical and digital assets to integrate growing volumes of renewable generation, electric vehicles (EVs), batteries and increasing electrification demands from industry and citizens.

The entire EU faces similar challenges with ageing infrastructure at both transmission and distribution levels. The EU Action Plan for Grids[4], which emphasises removing bottlenecks and promoting best practices in planning, permitting, and regulation, offers a significant guidance for CEE to become a champion in integrating future-proof solutions and accelerate grid modernisation for the benefit of citizens. Additionally, technical support is available to facilitate financing grid projects and implementing existing regulations.

Grid modernisation is key to reach the required speed and scale of renewable energy growth[5] and transition to a fully renewable, integrated[6], flexible[7], and a secure energy system. Yet, it is crucial to acknowledge that electricity grids, outdated as they may be[8], require improvements in any case, regardless of necessities due to solar and wind energy growth. Nonetheless, such necessary upgrades will also benefit scaling up of solar and wind energy, thus supporting the broader goals of the energy transition.

This paper aims to provide an analysis of the current challenges for electricity grids in the CEE countries by identifying the key obstacles and opportunities. As energy infrastructure is a complex and often technical topic, the purpose of this paper is not to dilute its complexity, but by examining technological, economic, and policy-related challenges, to present a clear and inspiring perspective on how to overcome them and fully harness the potential of the new energy system[9].

1 "How much money are European consumers saving thanks to renewables?," International Energy Agency (IEA), https://www.iea.org/reports/renewable-energy-market-update-june-2023/how-much-money-are-european-consumers-saving-thanks-to-renewables
2 In this Paper we understand CEE as Bulgaria, Czechia, Hungary, Poland, Romania and Slovakia
3 "The energy transition in Central and Eastern Europe: The business case for higher ambition", Corporate Leaders Group, 2019, https://www.corporateleadersgroup.com/system/files/documents/cee-energy-transition-report.pdf
4 Grids, the missing link - An EU Action Plan for Grids (November 2023), https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023DC0757
5 Paris Agreement Compatible Energy Scenario, CAN Europe, https://www.pac-scenarios.eu/pac-scenario/scenario-development.html?L=0#Chapter2:EnergySupply
6 EU strategy on energy system integration, https://energy.ec.europa.eu/topics/energy-systems-integration/eu-strategy-energy-system-integration_en
7 Energy System of Tomorrow, CAN Europe, February 2023, https://caneurope.org/content/uploads/2023/02/ELECTRICITY-MARKET-DESIGN-BRIEFING-ENERGY-SYSTEM-OF-TOMORROW-6.pdf
8 https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions
9 Energy System of Tomorrow, CAN Europe, February 2023, https://caneurope.org/content/uploads/2023/02/ELECTRICITY-MARKET-DESIGN-BRIEFING-ENERGY-SYSTEM-OF-TOMORROW-6.pdf

a) Ambition needs to be elevated

CEE Member States have so far shown limited ambition and political will with regards to climate action and energy transition. The “technological delay” and “different starting point” argument is often used to justify the lack of climate agenda. Across the CEE, the potential wider economic and social benefits that such a transition could offer are not sufficiently taken into consideration. For example, the opportunities that would come from growing clean technology value chains, and related innovation, including from grid technologies, may be missed unless countries show more initiative[10]. Additionally, there is a prevailing belief that the contribution of the EU to the emission reduction, and individual Member States, is relatively minor on the global stage, at least in comparison to the world’s largest emitters like the US and China. The “historic responsibility of the western economies” is not embraced. Same goes for the integrated EU energy market. Politically, each CEE country perceives itself as a “lonely island” with a predominant need of being energy sovereign, or becoming energy independent[11] (from others).

For a successful European energy transition, it’s crucial that all EU member states collectively progress, each contributing towards the EU’s renewable energy goal of 42.5% by 2030, aspiring to reach 45%.[12] This collective effort transcends mere target achievement, it is about building a shared vision for a resilient and energy-secure Europe through increased integration. This includes a pivotal role for imports from other EU countries and cross-border cooperation, especially in offshore projects. In the CEE region, this means enhanced regional collaboration, including cross-border interconnections and electricity trade, which is vital for distributing growing volumes of renewable-based electricity, balancing power systems, ensuring security of supply, mitigating price volatility, providing market flexibility, and optimising the use of existing grids.

According to the draft revised NECPs (National Energy and Climate Plans) submitted to the European Commission by September 2023, the CEE Member States’ are not on track[13] to deliver their respective contributions, especially those countries[14], which still have not transposed the RED Directive from 2018[15].

According to the European Commission’s assessment of the draft updated NECPs[16] published on 18 December 2023, submitted contributions by Member States to the EU 2030 renewable energy target fall short of the benchmarks set by the EU legislation[17]: Czechia’s draft revised NECP proposes a 30% target for 2030, which is lower than the 33% stipulated by the Governance Regulation. This shortfall is more pronounced in countries such as Romania, with a 34% target versus the required 41%[18], Hungary at 29% compared to 34%[19], and Slovakia at 23%, significantly lower than the required 35%[20]. Overall, future energy projections prepared by CEE member states do not anticipate significant reduction in final energy demand, and they fail to fully consider the potential and benefits[21] of energy savings.

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10 EC proposed Net Zero Industry Act is currently under discussion, which foresees EU manufacturing capacity for strategic clean technologies like solar, wind power, batteries, grid technologies to approach at least 40% of domestic deployment needs by 2030.

11 Each national energy mix must be built in a way that would potentially be able to cover the country’s energy needs fully.

12 The revised Renewable Energy Directive EU/2023/2413 raised the EU’s binding renewable target for 2030 to a minimum of 42.5%, up from the previous 32% target, with the aspiration to reach 45%. According to the updated Paris-Agreement compatible scenario, Europe must meet at least 50% of its final energy consumption from renewable sources by 2030 and 100% by 2040, https://www.pac-scenarios.eu/pac-scenario/scenario-development.html?L=0#Executivesummary

13 Time to step up national climate action, CAN Europe, October 2023, https://caneurope.org/content/uploads/2023/10/NECPs_Assessment-Report_October2023.pdf

14 https://ceenergynews.com/eu-affairs/latvia-poland-hungary-and-croatia-among-the-countries-listed-in-the-eu-package-of-infringement-decisions/

15 https://ember-climate.org/data/data-tools/global-renewable-power-target-tracker-2030/

16 https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

17 Annex II of the Regulation (EU) 2018/1999, part of the Governance Regulation of the Energy Union and Climate Action

18 https://commission.europa.eu/system/files/2023-12/Factsheet_Commissions_assessment_NECP_Romania_2023.pdf

19 https://commission.europa.eu/system/files/2023-12/Factsheet_Commissions_assessment_NECP_Hungary_2023.pdf

20 https://commission.europa.eu/system/files/2023-12/Factsheet_Commissions_assessment_NECP_Slovakia_2023.pdf

21 Paris Pact Payoff: Speeding up the green transition for socio-economic co-benefits, CAN Europe, January 2024, https://caneurope.org/content/uploads/2024/01/CAN-Europe-co-benefits-of-climate-action-REPORT.pdf

As a general direction, the EU should halve its energy demand by 2040 to stay in line with Paris Agreement objectives.[22] Against this direction of travel CEE Members States projections for final energy demands show no significant reduction between now and 2040 (for example the scenario included in the Energy Policy of Poland until 2040[23] or in the draft Hungarian NECP[24]), and put a lot of focus on false solutions for decarbonisation. This approach seems to originate from the traditional, but increasingly outdated perception that the energy system must be centralised with a key role assigned to state owned utilities as well as a fixed/outdated understanding of energy security and security of supply as such. When there is limited trust in decentralisation as a solution to both decarbonisation and energy security, actors such as citizens, SMEs, energy communities, companies, but also cities or villages have limited possibilities to become active energy market participants and reap financial benefits[25] (with some examples of corporate Power Purchase Agreements and prosumers).

b) Renewable momentum growing

After the Russian invasion of Ukraine, and the energy price crisis that followed, CEE citizens' perceptions of energy security and consumption changed. Many have felt the burden of higher energy costs and more are recognising that the deployment of renewable energy and the phasing out of fossil fuels is the best solution to this issue.[26]

Governments are already under growing pressure to facilitate renewable energy deployment. Good examples of progress are emerging. If existing good practices within the region are scaled alongside adopting EU best practices, the tide can be turned.

22 According to civil society's Paris Agreement Compatible (PAC) Energy Scenario, the final energy demand halves between 2015 and 2050, https://caneurope.org/content/uploads/2020/06/PAC_scenario_technical_summary_29jun20.pdf
23 https://www.gov.pl/web/klimat/polityka-energetyczna-polski , Appendix 2.
24 https://commission.europa.eu/publications/hungary-draft-updated-necp-2021-2030_en
25 CEE can lower electricity prices by a third by 2030 with ambitious wind and solar deployment, EMBER, May 2023 https://ember-climate.org/press-releases/cee-can-lower-electricity-prices-by-a-third-by-2030-with-ambitious-wind-and-solar-deployment/
26 According to a poll conducted in Poland in March 2023 (https://naradaoenergii.pl/polska-po-zimie-raport-z-badania/), an overwhelming majority wants the energy transition to speed up (and perceives grid modernisation that would enable RES absorption as the very first priority in this context). There is an appeal for "green energy", increasingly recognised by the public as not only affordable and secure. The EU Barometer of June 2023 reveals that 65% of the Hungarian citizens believe that we should accelerate the use of renewable energy sources, increase energy efficiency, and speed up the transition to a green economy as a response to the energy price spikes and restrictions on gas supply due to the actions of Russia (in comparison to 58% for the EU as a whole). When asked about the national governments being active on tackling climate change, 70% of Slovaks, 69% of Romanians, and 73% of Bulgarians say that their governments are not doing enough (67% for the EU overall).

Renewables momentum is building in the CEE region

In **Poland**, thanks to the state support mechanisms (subsidies program "Mój Prąd" / "My power"; initially net-metering, currently net-billing), the number of prosumers has grown (within years 2019-2023) to 1.3 Million with the overall capacity of 9.6 MW installed in micro-installations (as for May 2023).[27]

In comparison, it has been for many years **Czechia** whose citizens were rather reluctant and sceptical with their limited enthusiasm for renewable energy. This attitude originated from the changes in the renewable energy support mechanisms introduced by the Czech government in 2008 followed by the biggest solar boom in 2009-2010 that mainly the biggest companies and business actors took advantage of, and not regular citizens. In 2022 however, the Czech government started to update the national energy legislation with the aim to enable prosumers to form energy communities and cooperatives. The law that implements energy sharing and energy communities into the Czech national legislation was passed by the Czech Parliament at the very end of 2023. Energy sharing should be therefore possible from mid-2024.

Romania, similar to many other countries, has relied heavily on conventional hydropower as its primary source of renewable energy. As a result, national policymakers and decision-makers have not felt a pressing urgency to expand the diversity of renewable energy sources in their energy mix. However, in spring 2023, Romania's Ministry of Energy launched a EUR 500 million subsidy scheme[28], following the success of previous smaller schemes, to help public institutions and organisations install renewable energy facilities for self-consumption and become prosumers. According to the Romanian Minister of Energy the number of prosumers is expected to reach over 230,000 by the end of 2025 and over 350,000 by 2030. In Romania, the slow pace of grid modernisation will represent the main challenge for the electrification process and implicit renewable energy roll out in the following years. Recently, the higher-than-expected increase in prosumers[29] highlighted the strong need for investments in the grid and the limits of the regulatory framework[30]. Moreover, one of the main barriers to untapping the potential of the Romanian offshore wind energy resources resides in the power grid[31]. The grid-related aspects must allow building the offshore grid and bringing the energy onshore, as well as evacuating the energy from Romania's South-East.

In Bulgaria the PV power, which saw major capacity additions through 2023, has tripled compared to October 2022 and maintains a 12% share of overall generation (as in October 2023). In October 2023[32] an amendment of the Renewable Sources Law regulated (among others) the establishment and operation of the citizen energy communities. For the first time in the Bulgaria law energy communities are mentioned and the assessment on barriers and potential of energy communities is underway.

In 2022, **Hungary** blocked development of any small PV prosumers installations across the country, arguing that the distribution network can no longer accommodate prosumers. There are over 200,000 households with solar panels across the country which will be able to continue (as announced in September 2023 by Energy Affairs Minister Csaba Lantos) operating on a basis of a balance-based settlement (consumers can take out energy from the grid in winter for what they delivered into grid during sunny months). The government has also recently promised to lift the ban on solar energy in the coming months.

27 Not only in the electricity sector but also in the heating sector there are positive developments to be noted. In 2022, Poland and Slovakia were - next to Belgium - countries with the biggest growth of the heat pump market (doubling within a year); in Poland they represented ⅓ of all new heating systems (over 200.000 heat pumps were sold in Poland in 2022). EU-funded subsidy programs for households were also very popular in Slovakia; however, in 2022, only approximately 13,000 heat pumps were sold there, whereas in Czechia, with twice the population, sales were at 60,000. (https://www.euractiv.com/section/politics/news/slovakias-gap-in-heat-pump-subsidies-could-lose-a-year-of-progress/) Central Eastern European countries are also becoming a centre of where the European heat pumps are manufactured.

28 https://balkangreenenergynews.com/romania-allocates-eur-500-million-to-help-public-institutions-become-prosumers/

29 Estimated at 1.1 GW installed capacity in August 2023 and expected to reach 2 GW until March 2024

30 https://www.enpg.ro/wp-content/uploads/2023/10/OP-ED-EPG-Prosumatori-si-Sistemul-de-distributie-1.pdf

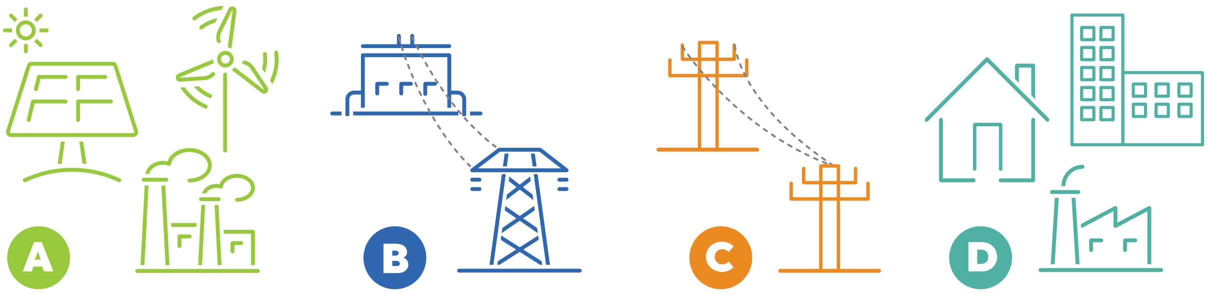
31 https://www.enpg.ro/wp-content/uploads/2023/01/EPG_Report_Offshore_wind-the-enabler-of-Romanias-decarbonisation.pdf

32 https://balkangreenenergynews.com/bulgaria-adopts-changes-to-energy-from-renewable-sources-act/

c) New paradigm for grids

The energy system of tomorrow will fully optimise high renewables generation through balancing supply and demand in a more efficient manner, allowing citizens to control their energy production and consumption, and monitor it far more actively. At the moment, a new approach to design and plan for energy infrastructure is spreading in Europe, steering away from an increasingly outdated one-way, centralised energy system, with a top-down perspective to embrace an interactive, two-way energy system. Here, electricity infrastructure becomes a centre-piece. Traditional power systems were designed for consistent and predictable power generation from fossil fuels, so they lack the necessary flexibility to accommodate the dynamic nature of solar and wind energy. To address this, grids need to evolve from their current state, where dispatchable sources are controlled centrally with minimal consumer interaction, to more decentralised systems where an increasing number of actors and devices actively participate and interact with the power system. This transition involves not just physical infrastructure upgrades but also a shift in how grids are planned and managed.[33]

How electricity grids work



Large-scale generation
Electricity is generated in power plants - such as wind and solar farms, thermal and hydro units. Large-scale generators are typically connected directly to the transmission grid, other generators such as small solar PV units are connected to the distribution grid.

Transmission
The skeleton of the electricity grid - high-voltage lines that connect main substations, carrying electricity between key generation and demand centers. This also includes cross-border connections between neighboring countries.

Distribution
Medium and low-voltage lines and transformer stations. The distribution network carries electricity from transmission grid nodes to end users.

Consumption
End uesr of electricity such as households, factories, office or public administration buildings.

Source: Ember

A set of overarching assumptions for building this new system is essential to implement change in an as cost-optimal manner as possible. This includes a high level of renewables-based electrification across all sectors, sector coupling with renewables, and energy system integration – all helping to make a far more efficient system, and also contributing to energy demand reduction.

Electricity grids can be developed in two ways: upgrading present infrastructure by making it smarter, digital and more efficient or by building new grids. Striking a balance between the two requires a careful assessment of the role of the distribution grid, transmission grid, and interconnections, informed by a wider perspective of how the energy system, and the different sectors, will be electrified. This assessment needs to be conducted carefully in order to avoid overexpansion, which would mean sunk costs, using unnecessary land space, higher biodiversity impacts, and the increased likelihood of local opposition.

In the CEE region, all these interconnected shifts in infrastructure design, with a view to 2030 energy and climate targets, can now be integrated into the development of strategic documents and models, as a new type of planning that goes beyond the energy sector alone. It is a great opportunity for countries of the region to become frontrunners of this change.

33 Electricity Grids and Secure Energy Transitions, IEA, November 2023
https://iea.blob.core.windows.net/assets/ea2ff609-8180-4312-8de9-494bcf21696d/ElectricityGridsandSecureEnergyTransitions.pdf

2. Critical Challenges & State of Play in CEE region

While the challenge of electricity grids not supporting the energy transition is a topic of discussion across Europe, in the CEE the grid related problems are particularly evident, even if the regions is still in the early stages of RES roll out (the wider CEE region only accounts for 7% and 12% of EU wind and solar capacity, respectively[34]). This is far below the EU average, given the CEE covers 20% of both its population and territory, as well as 17% of electricity demand.[35]

Those bottlenecks come mainly from chronic underinvestment and ageing infrastructure, and need to be tackled regardless of future power mixes of individual countries.

34 https://ember-climate.org/data/data-tools/data-explorer/
35 In it together_ the road to a cleaner, cheaper CEE power system, Ember, May 2023 https://ember-climate.org/insights/research/in-it-together-cee-power-system/#supporting-material

In general grid related problems can be grouped into the following four categories:

Grid Connection declines	Technical, economic, structural, and political barriers causing renewable project developers to face declines from grid operators, leading to increased project times and costs. In extreme cases it makes it impossible to grow the renewables capacity in a given country.
Grid congestion and curtailment	The mismatch between the geographical placement of power generation and demand, and a shortage of grid capacity leads to increased costs for power plant owners, grid operators and final consumers, either because of electricity curtailment or the need for redispatching (changing the cost-optimal schedule of power generation).
Reliability and local congestion	The changing pattern of electricity generation (e.g. solar peaks at noon) and consumption (e.g. very high loads from EV chargers) cause more strain on distribution grid elements such as transformers or lines, leading to reliability issues and increased maintenance costs.
Technical grid losses	Transmitting power over physical lines is always related to losses that depend on several factors, such as temperature profiles, line lengths, the technical parameters of utilised cables and the age structure of the grid components. In the EU, the average technical grid losses account for 7%[36] of the total electricity generation, but elsewhere, this can be as low as 3-4% (Austria or Finland), or as high as exceeding 10% (Western Balkans)[37]. In some countries these losses are near the EU average (Hungary, Poland, Czechia), in others, data limitations make assessment a challenge (Bulgaria, Romania).

It's important to understand that these issues can appear on all grid levels - from interconnections, through transmission, down to distribution. However, because most solar capacity is connected to the distribution grid, that is where the majority of connection declines would appear. Grid congestion across the country would typically be related to transmission bottlenecks or a lack of interconnections, if a country cannot trade the surplus of its electricity with neighbours. Reliability issues are most common on distribution level, especially if a significant part of the grid is based on overhead lines versus underground cables. Finally, technical grid losses concern all grid levels, and especially the distribution level.

a) Current Landscape in CEE

Several examples show that the lack of grid capacity in the CEE region is becoming a severe bottleneck for renewable energy growth, with the connection declines becoming a key issue for new RES projects and causing lost RES potential.

While data on grid connection queues and declines is difficult to find, latest reports indicate the shocking scale of the problem.

- In Romania, over 50 GW of renewables projects are waiting for grid connection[38], in Bulgaria 40 GW[39] - roughly 3 times more than the country's current installed electrical capacity across all technologies. Bulgarian energy company "Energo-pro" is increasingly turning down connection requests in the North-Eastern region, particularly attractive for renewables, because the available grid capacity has already been met. Another company - "Electrohold", states that current and planned generation capacity will exceed transformer

36 https://iea.blob.core.windows.net/assets/afebed83-db6b-4e38-8fe7-4ed4f506a742/ElectricityGridsandSecureEnergyTransitions.pdf
37 https://www.ceer.eu/documents/104400/-/-/fd4178b4-ed00-6d06-5f4b-8b87d630b060
38 https://windeurope.org/newsroom/press-releases/no-energy-transition-without-expanded-electricity-grid/
39 https://www.capital.bg/biznes/energetika/2023/09/22/4526900_nad_40_000_mw_sa_zaiavenite_novi_vei_a_kapacitetut_na/

capacity in 5 out of 10 subregions in the western part of the country. It is likely that out of the 40 GW of renewables projects applying for connection in Bulgaria, only around a quarter with preliminary grid connection contracts will be deployed.

- In Poland, the issue is even larger - according to the Regulatory Office, in 2022 grid operators declined the connection for 51 GW[40] of new installed capacity, mainly wind and solar projects. This is a 2.5 times increase in declined capacity compared to 2021, indicating that the situation is getting worse year on year.
- In Hungary, from 2022, prosumer solar installations are not allowed to be connected to the grid anymore, putting a stop to the country's booming industry[41]. This temporary regulation is still in force, but the moratorium on solar panels was expected to be lifted by the end of December 2024.[42]

Preliminary information about electricity curtailment is showing similar negative trends. While the capacity of variable renewables in CEE countries is not high compared to Western European neighbours, there have already been instances of CEE grid operators requesting wind or solar energy producers to reduce generation.

- In April 2023, the Czech Transmission System Operator (ČEPS) turned off around 400 MW of solar capacity[43], or about one-sixth of the country's total PV capacity, in order to ensure proper balancing of the power system.
- In Poland, curtailment events started happening in 2022, with a 400-800 MW[44] reduction of wind generation happening in December. In September 2023, Poland noticed a 8 GW surplus of electricity production, which was partially managed by emergency exports, but still required a 1-2 GW forced reduction in solar generation.

With the Polish and Czech power systems still reliant on inflexible coal power plants and ageing grid infrastructure, these curtailment events will likely be increasing in frequency in the coming years.

When it comes to data and transparency, there is no standard or regular reporting on grid congestion issues such as connection queues or curtailment which limits the ability to monitor severity and track improvements. The absence of accessible reporting on grid development plans in terms of expansion or upgrading/ modernising existing infrastructure complicates tracking and creates supply chain issues as manufacturers of grid components have no long-term visibility.

Also, with oversight of development plans of national transmission and distribution systems largely limited to financial implications, it is difficult to assess whether planned developments will be sufficient to deliver and support the energy transition and energy targets, as well as the net-zero EU economy. For example, assessment of system needs for interconnectors, undertaken biennially by ENTSO-E, provides a good example of how such oversight could contribute to monitoring and improvements. It allows various stakeholders to understand whether planned new interconnections provide such sufficient capacity and the key borders where additional projects are required. Providing national regulatory authorities with a net-zero mandate could enable them to carry out similar assessments of the adequacy of grid development plans for national transmission and distribution systems.

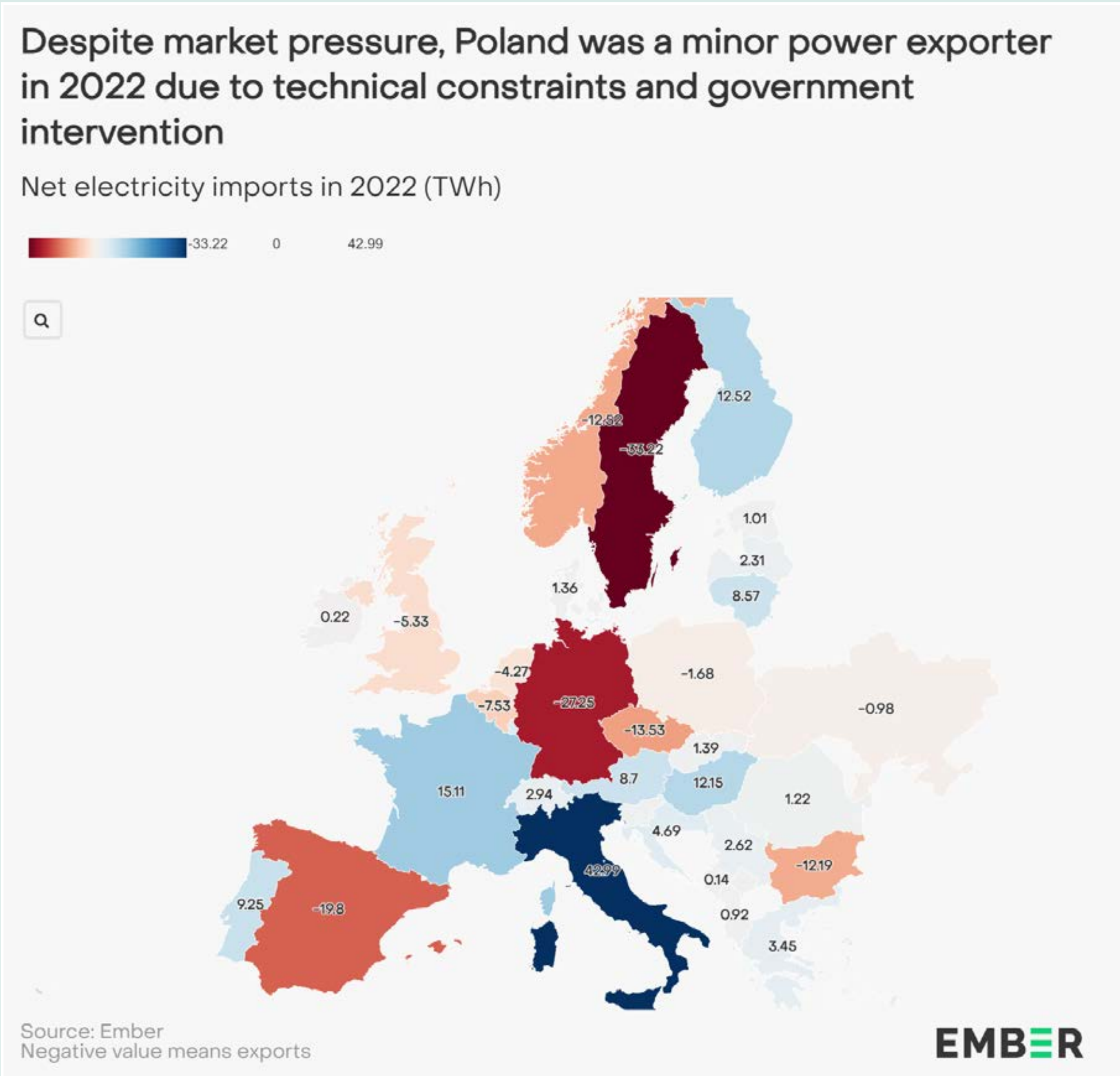
The EU Grid Action plan introduces some improvements on this front: EU DSO Entity mapping the existence and characteristics of distribution development plans and call to TSOs and Member States to ensure that sufficient electricity transmission projects are designed, planned for and developed to fulfil the identified 2030, 2040 and 2050 infrastructure needs of the EU. The Commission also plans to include grid-related actions in the iterative process with Member States on their National Energy and Climate Plans.

40 https://www.ure.gov.pl/download/9/13743/Sprawozdanie2022.pdf
41 https://balkangreenenergynews.com/hungarys-power-grid-cant-fit-any-more-photovoltaic-capacity/
42 With the new government decree of 1st January 2024, the possibility of grid connection of small household power plants was restored in certain areas that had been closed since 1 November 2022.
43 https://www.pv-magazine.com/2023/04/19/grid-issues-plague-solars-comeback-in-czechia/
44 https://energia.rp.pl/oze/art37678111-wiatraki-wyprodukowaly-za-duzo-pradu-nadwyzki-trafily-do-niemiec-i-na-slowacje

Interconnectivity in the CEE

At the moment, interconnections within the wider CEE region constitute a meagre 13% of the EU's internal interconnection capacity despite their importance to reduce power prices by improving the integration of wind and solar, lowering energy curtailment and increasing system flexibility.[45] EU rules require grid operators to make a 70% minimum amount of capacity on interconnectors available for electricity trading with neighbours by the end of 2025. Among 6 CEE Member States, only some have a linear trajectory set to reach this target within national planning (Romania, Poland, Hungary).

In some cases, technical obstacles or government interventions make cross-border trade impossible, as described by ACER[46] in the report evaluating cross-zonal capacities in 2022, for Poland: *"Polish allocation constraints have considerably limited cross-zonal exchanges with Poland for the majority of hours of the analysed period. In most cases, this limitation completely precludes* ***any electrical export from Poland to its neighbouring countries****. This has played a significant role in the European day-ahead electricity market, by effectively decoupling the Polish bidding zone from the rest of the Core hubs for a sizeable share of hours."*



45 https://ember-climate.org/press-releases/cee-can-lower-electricity-prices-by-a-third-by-2030-with-ambitious-wind-and-solar-deployment/

46 https://www.acer.europa.eu/Publications/2023_MMR_MACZT.pdf

b) CEE specific root causes

There are several reasons contributing to grid problems in the CEE region:

Reason	Issue	Description
Technical	**Ageing infrastructure**	About a third of Europe's low voltage grid is over 40 years old[47], by 2030 it will be up to 55%. CEE countries have historic legacy, as majority of the infrastructure was built in the communist era. - Taking Romania as a clear example, a large share of the power distribution network started to develop in the 1960s and '70s, and while some of the grids have been modernised since, there still are parts that have been in service for over 50 years and are in dire need of renewal. - In Poland, around a third of medium and low voltage lines are 40 years old[48], for transmission lines this exceeds 40%. Regardless of the energy transition, grids need to be modernised to sustain current reliability levels.
	Changing demand and generation profiles	The increased adoption of electric vehicles or heat pumps changes electricity demand patterns, leading to higher demand peaks than originally anticipated and overloading grid components such as low to medium voltage transformer stations. Similarly, the growing number of solar installations leads to generation peaks at noon, causing local voltage levels to exceed thresholds. As a result, PV inverters might turn off automatically, leading to curtailment. This problem applies to all EU.
	Low flexibility of power systems and baseload oriented approach	Some types of power plants, such as coal or nuclear units, cannot be ramped up and down quickly, their utilisation is therefore kept above a minimum level, e.g. 40%. This means that, even if renewables could be satisfying all the electricity demand, they might be curtailed to make room for baseload units that are unable to ramp down. This is especially problematic in CEE countries that have higher coal dependence than elsewhere in Europe, namely in Poland, Czechia and Bulgaria.
	Delayed digitalisation	Power system flexibility could be increased on the demand side, if consumers were incentivized to e.g. increase their demand during solar generation peaks or decrease it during periods of low wind through tools like dynamic tariffs. However, these can only be implemented using smart electricity metres, and only around half of EU countries are on track with their deployment[49], with countries like Czechia, Bulgaria, Hungary, Poland and among the laggards with rollout rates below 20%.
	Delayed switching from overhead to underground lines	Grid reliability, as well as grid expansions possibilities, are strongly tied to the type of lines used on distribution level. For example, in Poland only around a third of low and medium voltage lines run underground with the rest being overhead[50], making the grid more prone to the more frequent extreme weather events[51], freezing or overheating, as well as making grid expansion more costly, socially difficult and with a higher impact on bird species.

47 https://www.eurelectric.org/connecting-the-dots
48 https://www.euki.de/en/euki-publications/distribution-grids/
49 https://acer.europa.eu/Publications/2023_MMR_Energy_Retail_Consumer_Protection.pdf
50 https://www.euki.de/en/euki-publications/distribution-grids/
51 https://www.iea.org/reports/climate-resilience-for-energy-security

Economic	**Underinvestment**	While investments in grids are rising, they are far below required levels due several reasons such as a lack of political will and reliance on scarce public funding. Currently distribution system operators (DSOs) in EU27+UK countries spend EUR 25 billion yearly[52], far below the EUR 34-39 billion needed by 2030[53]. A modelling study for Poland[54] shows that distribution grid investments need to increase from the historical average of EUR 1.4 billion per year to EUR 2.7 billion per year towards 2030 - almost doubling. EU Funds available (regional (ERDF), cohesion funds (CF) and the Recovery and Resilience Facility (RRF) including its REPowerEU component and the Modernisation Fund are not used sufficiently to support grids.
	Lack of incentives for operators	Grid investments are often financed by strictly regulated grid charges (tariffs), subject to political pressure due to the impact on household cost of living. These tariffs are renegotiated by the utilities and regulators on a quarterly or annual basis, providing no certainty regarding long-term investment budgets. As a result, grid operators might face difficulties in financing costly multiannual projects such as grid expansion or smart metres rollout. On the other hand, because of the tariff regulation and limited market competition, investments in quality of service will likely not reflect on a grid operator's revenues, nor lead to customer acquisition, so DSOs are not incentivised to take care of the customer satisfaction.
Structural	**Lack of market unbundling**	In some CEE countries such as Poland or Czechia, Distribution System Operators are still integrated with incumbent fossil fuel electricity producers due to the incomplete market unbundling. This introduces a clear conflict of interest, with private renewable energy producers potentially receiving unequal treatment[55] in terms of grid connection procedures and related investments. It can also offer a financial lifeline to coal based generation, because in a vertically integrated financial entity, revenues from distribution can be used to fill losses from inefficient coal generation.
	State ownership and monopolies	Grid operators are typically state owned, with limited competition and a lack of oversight. In Estonia, Latvia, Lithuania, Slovakia, Croatia and Slovenia one DSO covers 80% or more of electricity distribution[56]. In Poland, Czechia, Hungary, Bulgaria and Romania 3 largest DSOs distribute 60% or more of all electricity. State-ownership dominates in Czechia, Slovakia, Poland, Lithuania, Latvia, Estonia, Croatia and Slovenia. This limits access to private funding for grid investments, and contributes to the lack of incentives - as in all monopoly markets, there is no immediate reason to increase the quality of service.
Social	**Delayed introduction of demand flexibility and storage**	While investments are the key lever for tackling some of the grid bottlenecks, issues such as curtailment or local congestion could be tackled to some extent through more demand flexibility - consumers reducing or increasing their demand in response to the power system's needs. The Clean Energy Package introduced demand-side flexibility provisions already in 2019, but these have still not been introduced in many EU Member States[57]. Mechanisms such as demand-side response remain either unregulated[58], discriminated in capacity markets[59], or dispatched much below their potential due to issues such as a lack of financial incentives[60].
	Lack of incentives for consumers	For demand flexibility and storage to be effective, consumers need to be remunerated for shifting their consumption patterns. This is not always the case due to regulatory or market design issues, lack of awareness and education about the power system, as well as delays in smart metering, grid digitalisation and the introduction of dynamic tariffs (for example Poland introduced Clean Energy Package provisions to national law only in 2023). Systems are not ready for consumers becoming more active in managing their consumption, and citizens are not empowered to do so. At the same time solutions to protect vulnerable households, who do not have means to respond to price signals, need to be implemented alongside (e.g. block tariffs, proper tracking of energy poverty, compensations).

52 https://cdn.eurelectric.org/media/6551/extended-full-report_decarbonisation-speedways-h-87D5403D.pdf
53 https://cdn.eurelectric.org/media/6551/extended-full-report_decarbonisation-speedways-h-87D5403D.pdf
54 https://instrat.pl/en/energy-security/
55 https://www.worldbank.org/en/country/poland/publication/poland-cem
56 https://cdn.eurelectric.org/media/5089/dso-facts-and-figures-11122020-compressed-2020-030-0721-01-e-h-6BF237D8.pdf
57 https://caneurope.org/content/uploads/2023/11/10.11.23_CAN-Europe-expectations-towards-EMD-trilogues-1.pdf
58 https://smarten.eu/wp-content/uploads/2022/03/The_implementation_of_the_Electricity_Market_Design_2022_DIGITAL.pdf
59 https://www.clientearth.org/media/yp3j45d5/assessment-of-the-polish-act-on-the-capacity-market-ce-en.pdf
60 https://netztransparenz.tennet.eu/fileadmin/user_upload/Company/News/Dutch/2021/Unlocking_industrial_Demand_Side_Response.pdf

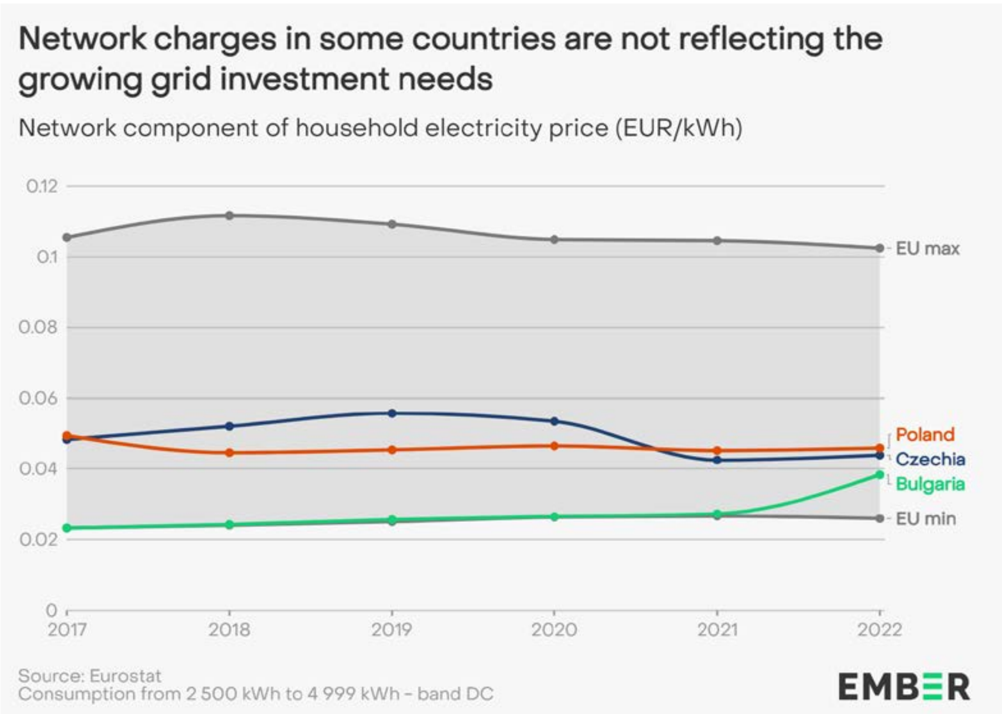
3. Economic and Social Implications

a) Grid charges vs investment needs

Some of the conflicts of interest stemming from ownership structures mentioned above are clearly visible in consumer costs - the bills we pay. The ageing infrastructure requires urgent investments, but grid charges[61] - a component of consumer tariffs that is supposed to finance those investments, have not necessarily been increasing. This is mostly a result of political pressure to keep costs of living down, but it is also leading to chronic grid underinvestment.

In Poland and Czechia, two CEE countries facing severe grid congestion and curtailment issues, network charges[62] have surprisingly decreased by 9% and 7% respectively over the past five years. Concurrently, total electricity bills have risen modestly by 11% and 16%, respectively. Despite these increases being below the inflation rate due to price caps, the decreasing proportion of grid costs in household bills is contradictory to the urgent need for accelerated grid investments. In Poland, for example, grid investments have significantly declined, almost halving between 2018 and 2021[63], and 2022 data shows[64] that these investments are still not at historically expected levels.

On the other side of the spectrum is Bulgaria - with network charges increasing and aiming to increase annual grid investments 10-fold between 2022 and 2030 according to the Bulgarian TSO's plan[65], while Czechia plans[66] to decrease grid investments by 25% between 2023 and 2030. This might indicate that Bulgaria's plan to increase solar capacity almost 7 times between 2022 and 2030, from 1.2 GW to above 8 GW[67], will be supported by on-the-ground implementation, contrary to Czechia's NECP commitment of an almost 5-fold increase from 2.3 GW of solar in 2022 to 10.6 GW[68] in 2030. That is an empty promise if grid bottlenecks are not resolved immediately through a more adequate grid investment plan.



61 Globally majority of the grid charge (60%) goes to DSO, but TSOs cost can be also covered within - depending on the national context and regulations.
62 https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_204_c__custom_8508051/default/table?lang=en
63 https://instrat.pl/wp-content/uploads/2021/12/Instrat-Missing-element.pdf
64 https://raport.pse.pl/wplyw-na-gospodarke-i-rynek/rozwoj-systemu-przesylowego
65 https://www.eso.bg/doc/?transmission
66 https://www.ceps.cz/cs/rozvoj-ps
67 https://www.me.government.bg/uploads/manager/source/NRRP/%D0%B2%D0%B8%D0%B7%D0%B8%D1%8F_2023-2053_1.pdf
68 https://commission.europa.eu/system/files/2023-10/Czech%20Draft%20Updated%20NECP%202021%202030_en.pdf

b) Leveraging EU Funds

The European Commission estimates that EUR 584 billion investments for electricity grids are necessary by 2030 to reach the REPowerEU objectives[69]. EU Grid Action Plan recognises a potential funding gap from national sources (and for cross-border energy networks) due to reduction of CEF Energy[70] (Clean Energy Facility-Energy 2021-27) and proposes reinforced visibility of EU funding opportunities, with special emphasis on smart grids and modernisation of distribution grids. This need was highlighted by the industry, as per the chart below:

Summary of the funds available for DSOs

	FUNDS	CYCLE	BUDGET	EXPECTED DSO's BENEFITS
Innovation	Horizon Europe	2021-2027	€95,5 Bn	0.7% of the total fund
	Horizon Fund	2020-2030	€20 Bn	Not assessed yet
Cohesion & Collection	CEF (Energy)	2021-2027	€5,35 Bn	4% dedicated to smart-grids
	CF & ERDF	2021-2027	€240 Bn	0.3% of the total budget
Loans and Guarantees	EIB	2021-2027	€448 Bn	3.3% of the total fund
	Invest EU	2021-2027	€26,2 Bn	3% for electricity networks
Climate	LIFE	2021-2027	€5,45 Bn	0.7% of the buget
	Modernisation Fund	2021-2030	€14 Bn	25% of the budget
Recovery	Resilience and Recovery Fund	2021-2026	€723.8	Between €5.1 bn and €6.8bn

Source: Eurelectric, Guide on EU Financing and Funding Instruments for DSO projects

Currently EU Funds are largely underutilised for grids and this can have consequences for the new (2028-2035) Multiannual Financial Framework (MFF) planning. The Cohesion Fund, ERDF, RRF or the Modernisation Fund are eligible for this purpose. The Recovery and Resilience Plans allocated around EUR 13 billion to grids so far across EU Member States[71].

The **Modernisation Fund**[72] stands as a pivotal resource for CEE countries as they are major beneficiaries (highest allocation is granted to Poland, Czechia and Romania). It supports investments in energy efficiency, renewable energy, energy networks, and just transition in carbon-dependent regions. This fund is instrumental in modernising energy systems and reducing greenhouse gas emissions in line with EU climate goals. Its absorption is still limited as countries are focused on using resources from the Recovery and Resilience Facility (RRF) and EU Cohesion Funds, but its importance will grow over the coming years because the simple and flexible application process offers fairly easy access to funding for the beneficiary Member States.

69 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022SC0230
70 For the 2021-2027 period, the energy budget of CEF equals €5.84 billion. More information: https://cinea.ec.europa.eu/news-events/news/connecting-europe-facility-2021-2027-adopted-2021-07-20_en
71 Some RRF chapters are still being approved (e.g.for Poland) so this estimation may be subject to change.
72 https://modernisationfund.eu/

In the spotlight: Modernization Fund - Bulgaria
Bulgaria started submitting projects to the Modernisation Fund later than other countries (only in 2023) and all the approved projects are related to grid modernisation and installing smart metering devices. Overall EUR 197 million was allocated in the first disbursement for four projects (3 deploying smart metre infrastructure, 1 with highest allocation of EUR 128 million for automation, digitalisation and development for the electricity network.)

In the spotlight: Modernization Fund in Czechia
Since the start of the operation of the Fund in 2021 until March 2023, Czechia has secured the largest amount of disbursed financial resources (over 35% of all the released funds) via 35 projects, and not a single one is related to grids. New programme called "Elegrid" in the total amount of CZK 20 billion (approx. EUR 811 million) is being prepared to be submitted.[73] This programme should support modernization of the electricity grid, and makes part of the redesign of the national Modernization Fund strategy for Czechia, which is yet to be finally approved.

In the spotlight: Romanian DSOs harnessing the Modernization Fund
By December 2023 Romania managed to have disbursements approved in value of EUR 0.6 bn for the distribution system scheme (EUR 0.1 bn in May 2022[74] and 0.5 bn in December 2023[75]). The entire scheme up to 2030 prepared by the state consists of EUR 1.1 billion. Calls for project proposals (next formal step after project approval by the EIB) organised for the first EUR 100 million of the multi-annual support scheme for expansion and modernization of distribution networks, launched in October 2022[76], show a big appetite for investments. The deadline for the non-competitive call for projects is 30 June 2024, however, until 20 of December 2023[77] 73 projects were submitted, with a total value of the non-reimbursable support of EUR 1.2 bn, already exceeding the total value of the scheme. Out of these, 17 projects were approved worth EUR 175 million in non-reimbursable funds. This highlights an increased appetite of DOSs in using non-reimbursable support. This proactive engagement of Romanian DSOs in leveraging funds from the Modernization Fund exemplifies a praiseworthy approach.

With an allocation of €5.8 billion for the energy sector, the **Connecting Europe Facility (CEF) Programme**[78] is a significant source of funding, but it is important to note that distribution networks are not eligible under this Fund. It focuses on enhancing energy, transport, and digital infrastructures. Notably, the program includes a new section dedicated to cross-border projects for renewable energy[79] emphasising the importance of transnational collaboration in the energy transition. CEF supports **Projects of Common Interest (PCIs)**[80] which are crucial for the development of EU energy infrastructure. These projects play a vital role in interconnecting energy systems across borders, enhancing energy security, and integrating renewable energy sources.

73 Based on strategic documents shared with relevant stakeholders in the Modernisation Fund Platform (organised by the Ministry of the Environment).
74 https://modernisationfund.eu/wp-content/uploads/2022/06/COMMISSION-DECISION-of-23.05.2022-on-disbursement-of-revenues-of-the-Modernisation-Fund-under-Directive-2003_87_EC-of-the-European-Parliament-and-of-the-Council-annex.pdf
75 https://modernisationfund.eu/wp-content/uploads/2023/12/COMMISSION-DECISION-of-14.12.2023-on-disbursement-of-revenues-of-the-Modernisation-Fund-under-Directive-2003-87-EC-of-the-European-Parliament-and-of-the-Council-annex.pdf
76 https://energie.gov.ro/lansare-procedura-necompetitiva-sprijinirea-investitiilor-pentru-extinderea-si-modernizarea-retelei-de-distributie-a-energiei-electrice/
77 https://energie.gov.ro/wp-content/uploads/2023/12/Situatie-actuala-programe-cheie-Fondul-de-Modernizare-Program-Cheie-3_20.12.2023.xlsx
78 https://eur-lex.europa.eu/eli/reg/2021/1153/oj
79 https://cinea.ec.europa.eu/programmes/connecting-europe-facility/energy-infrastructure-connecting-europe-facility-0/cross-border-renewable-energy-projects-cef-energy-new/call-cross-border-renewable-energy-cb-res-projects-application-process-cb-res-status_en
80 https://energy.ec.europa.eu/topics/infrastructure/projects-common-interest_en

The REPowerEU chapters[81], integrated into the Recovery and Resilience Facility (RRF) and Plans (RRPs), provide a framework and financial support for measures accelerate the green transition by, among others, diversifying energy supplies, increasing the uptake of renewables, improving energy efficiency performance, scaling-up energy storage capacities. Grids are eligible.

In the spotlight: National Recovery and Resilience Plan (NRRP) of Bulgaria
Bulgaria's National Recovery and Resilience Plan[82] includes a €312m investment for the digital transformation of the Electricity System Operator[83]. The aim is to achieve complete modernization of the Bulgarian power system planning, control and maintenance activities by deploying cutting-edge digital tools and methods that provide the required manoeuvrability, security and low-latency of the power system. By 2026, the investment should enable the electricity system operator to unlock grid connection for 4.5GW additional renewable energy and increase cross-border capacity by 1.2 GW through optimised use of existing assets.

In the spotlight: RRF for transmission network in Hungary
Two major programmes funded by the European Union and the Government of Hungary under the Instrument for Recovery and Resilience (RRF) are 1) the extension of the Kerepesi substation and 2) transmission network upgrade.

The extension of substations will partly serve to strengthen the security of supply of the capital. However, the development of the distribution system in rural areas is crucial. The problematic grid points and the grid elements that need to be upgraded depend on the future demand from consumers and solar power generation, which cannot be accurately predicted at this stage. In order to serve the energy transition, it is also essential to prepare the infrastructure, which, according to preliminary estimates, will require tens of thousands of network upgrades.

In the spotlight: RRF in Czechia supporting the "Energy Data Hub"
RRF funding will support the creation of the "Energy Data Hub" which is a joint project of 3 Czech DSO's and 1 TSO. The Energy Data Hub should play a significant role in the energy sharing, energy storage and flexibility aggregation - to ensure the functioning of these activities from a technical point of view. The total amount of contribution from RRF is approx. EUR 32,4 million.[84] On top of that, additional investment support to reinforce network capacity is expected from the RRF (currently being updated).

Other EU Funds

In the spotlight: Cohesion Funds in Czechia enabling the smart metres rollout
Various sources of funding are already available in the Czech Republic in connection with increasing the capacity of the electricity grid and demand side flexibility. Except for the abovementioned RRF, the rollout of smart metres which should lead to the development of smart grids is financed from the EU Cohesion Fund[85] in the total amount of CZK 3 billion (approx. EUR 121.6 million) for the period 2021-2027.

81 https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en#:~:text=The%20Recovery%20and%20Resilience%20Facility%20(RRF)%20is%20a%20temporary%20instrument,on%20behalf%20of%20the%20EU).
82 https://nextgeneration.bg/14
83 https://www.eso.bg/doc?ctem
84 Part of the National Recovery and Resilience Plan, section REPower EU - component 7.2. "Support for decentralisation and digitalisation of the energy sector" (currently being updated), available at: https://www.planobnovycr.cz/ke-stazeni
85 https://www.agentura-api.org/cs/podporovane-aktivity-optak/energeticka-infrastruktura-optak/energeticka-infrastruktura-smart-grids-amm-vyzva-i/

In the spotlight: Combining various EU funds for energy transition in Poland

The investment needs for Poland's energy transition are enormous. The modernisation of transmission and distribution grids remains one of the biggest challenges, which can cost over EUR 110 billion (PLN 500 billion) until 2040 (according to the governmental analyses Scenario no.3 NECP/EPP2040[86], p. 28) or EUR 28 billion (PLN 130 billion) solely for distribution grids until 2030 (draft REPowerEU chapter[87]).

At the same time, Poland is the largest beneficiary of EU funds, and at least EUR 66 billion from the European Structural and Investment Funds (ESIF), the National Recovery and Resilience Plan (RRP), and the Modernisation Fund (MF) has already been dedicated to support climate action in this decade. Altogether, nearly EUR 10.5 billion of EU funds is currently earmarked for grid investments in Poland and for energy storage, but ⅔ of it in loans which full absorption will be challenging. The current EU funds allocation covers 9% of the investment needs in grids (transmission and distribution), as indicated in the Energy Policy of Poland until 2040 (EPP2040). Other significant contributions can come from the Polish EU ETS revenues (e.g. in 2023, estimated revenues can reach nearly EUR 5.5 billion).

Examples of EU-funded investments in energy grids planned in Poland:

- In ESIF, investments in grids are planned in the "FEnIKS" programme (European Funds for Infrastructure, Climate, Environment). EUR 1.12 billion from the European Regional Development Fund should support transmission and distribution networks. This investment should result in deploying 221 new digital management systems for smart grids and 250 MWh of energy storage. It is not specified how many kilometres of the new or modernised grids are expected due to this intervention.
- In RRP, energy grid investments have been scaled up, and corresponding reforms strengthened during the Plan's revision, complementing it with the REPowerEU chapter. Now, EUR 8.69 billion is earmarked for grids and storage, including:
  - EUR 600 million (grants) for transmission networks (320 km of 400 kV grid and 50 km of 220 kV grid, five new stations, three new ICT systems, and a new data management system: Central Energy Market Information System (CSIRE)).
  - EUR 972 million (grants) for distribution networks in rural areas (880 km of grid and additional infrastructure)
  - EUR 6879 million (loans) for distribution and transmission networks from the Energy Support Fund (no details, not clear if the Fund will only support electricity networks)
  - EUR 235 million for energy storage, of which EUR 200 million (grant) for large-scale battery system BESS of 0.9 GWh and EUR 35 million (loan) for the modernisation of a pumped hydroelectric energy storage facility.

- In the Modernisation Fund, Poland has, to date, agreed with the European Investment Bank on three investment schemes related to modernising the energy system worth altogether EUR 666 million. The first, Smart energy infrastructure[88] (worth EUR 222 million), aims to install 3.8 million smart energy metres in 2022-2025. The second, the Development of the power grid for future electric car charging stations[89] (also worth EUR 222 million) aims at building or renovating 4 thousand kilometres of distribution grids and 800 substations to connect 12 thousand electric car charging stations. The third, Support for the use of storage and other devices for network stabilisation[90] (worth EUR 222.22 million), is a financing scheme for DSOs that would allow the installation of energy storage and other devices stabilising the distribution network at the local level.

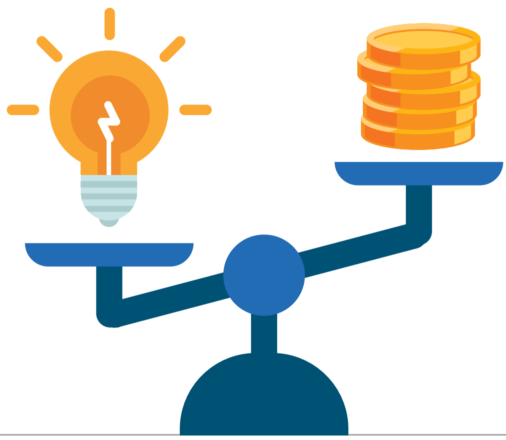
86 https://www.gov.pl/web/klimat/prekonsultacje-w-zkresie-aktualizacji-dokumentow-strategicznych-kpeikpep2040
87 https://www.funduszeeuropejskie.gov.pl/media/120486/Zalacznik_nr_Projekt_rozdzialu_REPowerEU.pdf
88 https://modernisationfund.eu/wp-content/uploads/2021/07/04-AA-010690-PICONFIRM-2021-06-07-MF-2021-1-PL-0-003-.pdf
89 https://modernisationfund.eu/wp-content/uploads/2021/07/06-AA-010693-PICONFIRM-2021-06-07-MF-2021-1-PL-0-006-.pdf
90 https://modernisationfund.eu/wp-content/uploads/2021/12/MF-2021-2-PL-0-001-Support-for-the-use-of-storage-and-other-devices-for-network-stabilisation-%E2%80%93-a-scheme-for-DSOs.pdf

c) Impact on energy poverty

Lack of a clear link in policymaking between energy transition, electricity grids, and energy poverty has severe consequences (with increasing numbers of Europeans becoming energy poor[91]). Despite strong evidence on the associated social costs of energy poverty on the ground, these have been scarcely recognised and addressed in policy and financial schemes in the CEE region. The efforts have focused mainly on shallow retrofit measures and energy price gap support. As a result, key energy transition measures introduced by the governments, including grid modernisation, related technologies and access to more decentralised renewable energy sources, are disconnected from current efforts to address energy poverty and are not tailored to the needs of people experiencing this condition. The region is also one that needs to undergo dual transition, energy and heating transition - with big effort required to introduce renewable district heating[92].

Energy poverty in CEE is a multi-faced problem characterised by energy access, dependency on solid fuels for space heating like forest biomass in Bulgaria and Romania, and hard coal in Poland for individual heating. It also encompasses challenges in affording energy bills, investing in efficiency improvements, and accessing structural support for transitioning to cleaner energy sources. A key problem is also the lack of statistical data and proper definitions that would enable the identification of the energy poor, and people at risk of becoming energy poor, and propose adequate solutions. The EU only recently introduced a definition for energy poverty via the new Energy Efficiency Directive[93], focusing on providing basic levels and decent standards of living and health[94].

CEE countries have particularly high levels of energy poverty due to low incomes, high energy needs stemming from energy-inefficient housing, and limited access to diversified energy supply, as well as disposable income for investments in energy efficiency or renewable energy technologies. Another important characteristic of the CEE region is the prevalence of energy poverty among rural households, many living in single family, large, energy inefficient, dispatched houses with a high dependence on solid fuels for heating. In this context, energy poverty is less associated with mere access to energy and the electricity grid. Instead, it is closely tied to the lack of the energy system design and planning and spatial planning, including of the distribution grid. These shortcomings hinder the development of smart and mini grids, as well as the integration of renewable energy sources.



91 The latest figures show that approximately 40 million Europeans across all Member States representing 9,3 % of the Union population were unable to keep their home adequately warm in 2022. That is a sharp increase since 2021 when 6,9 % of the population were in the same situation

92 https://beyondfossilfuels.org/wp-content/uploads/2022/03/Efficient_district_heating_CEE_countries.pdf

93 According to the EED, Art 2(52), 'energy poverty' means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001&qid=1695186598766

94 In comparison, regulation on energy poverty in Bulgaria includes no criteria for identifying people that live in energy poverty which is a key barrier for advancing intervention measures; on the other hand the energy poverty definition in Romania is strongly linked to the concept of vulnerable consumers (on EU level is enshrined in Electricity Market Design Regulation).

In the spotlight: Energy poverty in Bulgaria

It is estimated that Bulgaria presents the most grim situation in terms of energy poverty in the EU with 22.5% of the population not being able to heat their homes sufficiently.[95] Residential buildings, especially single family homes but also multi-apartment buildings, rely heavily on solid fuels for space heating, especially biomass, which is expected to further increase in the current energy crisis, and is making the country suffer from air pollution.

Regarding the current support measures in place, only 290,000 people receive heating allowance, mainly in the form of firewood, while approximately 40% of the population or around 2,8 million people can be classified as living in energy poverty. Long-term structural solutions for the residential sector, particularly in energy efficiency, and in heating substitutions, have been lagging and have mostly concentrated in shallow energy retrofits for approximately 2200 multi-apartment residential buildings in the last 15 years. Specific support measures to tackle the underlining energy poverty drivers, along with affordability of energy prices, have been lagging behind.

Energy access in Bulgaria is estimated to be close to 100%. High energy prices, including electricity, is a major barrier for people living in energy poverty. The modernisation and rethinking of the electricity grid can serve as a crucial enabler for cost reduction and affordability as well as for decentralised RES integration.

In the spotlight: Energy poverty in Romania

The percentage of the population that cannot heat their homes sufficiently is slightly lower in Romania compared to other CEE countries, reaching 15.2% in 2022[96], while almost 14% of households are in debt on energy bills. At the same time, after paying their energy bills (electricity and heating) 13% of families in Romania fall below the poverty line, 11.7% of families under-consume energy below the level needed for a comfortable living and for 45.3% of families in Romania energy bills are too heavy a burden on the family budget[97].

Another important layer to energy poverty in Romania is the high dependency on solid fuels for heating, the highest in the EU - more than 3 million households use firewood for space heating (which represents 90% of the renewable energy sources used for heating). Firewood may be referred to as the ‘fuel of the poor’: the lower the income, the higher the share of solid fuel use. At the same time, in Romania firewood use is mainly associated with single family households in rural areas, often in poorly insulated houses and inefficient burning stoves. At the same time, similarly to Bulgaria, energy access and grid connection are at high levels in Romania, above 98%. Therefore, more structural aspects behind energy poverty, including affordability and diversification or energy source, need to be tackled.

The recently submitted REPower EU chapter to the Recovery Plan includes some new measures for prosumers, energy communities and new investment framework for energy efficient single family homes, however, a dedicated policy document is still missing. So far, past and existing measures/policies related to energy efficiency in those areas have been developed independently, with common reference to energy poverty.

95 Eurostat 2023, https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES01/default/table?lang=en
96 Ibidem
97 https://www.democracycenter.ro/application/files/7916/2686/2125/Energy_poverty_buildings_-_report.pdf

It is crucial to keep in mind the multidimensional socio-economic character of energy poverty in order to be able to engage in systemic solutions and move away from only providing temporary 'stop-gap' remedies (income and price relief). Structural protection measures that advance the transition of energy poor households to renewable energy systems, electrification and to a more efficient energy use at the household and community level are needed (such as providing targeted support that would enable the consumers to insulate leaky houses and purchase necessary equipment to save energy and become active consumers to generate, store and sell self-generated electricity). This approach is also encouraged in the recent EC Recommendations (EU) 2023/2407 on Energy poverty[98].

Supporting grid modernisation and addressing the bottlenecks, along with connected technologies (e.g. smart grids, off-grid renewables) can bring considerable benefits, on one hand as a result of optimising energy bills and, on the other hand, as an enabler for more renewable energy connections. As such, although needing high upfront investments, grid modernization and especially investment in smart grids, will lead to high cost savings in the longer term as the grid would function more efficiently and with less disturbances. Even more importantly, smart grids enable the integration of more renewable energy based consumer side offers, the creation of mini-grids and energy communities, critical for the decarbonisation of the buildings stock and addressing energy poverty.

98 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302407

4. Inspiring Solutions to Build Upon

The distribution grid of the future will interlink households, offices, public buildings and industry with decentralised photovoltaics, battery storage, and heat pumps, aided by the upgrading and expansion of the existing grid and non-infrastructure solutions. For this transformation to take place, DSOs have to be incentivised to develop the necessary tools to bring about a transparent, digitalised, and decentralised grid, which optimises local generation and consumption. Moreover, DSOs and TSOs have to cooperate more with other stakeholders and by sharing real-time grid data, plan the future energy system together, and share sources for flexibility to ensure congestion at the transmission level can be solved by resources at the distribution level. Below we present some inspiring case studies from all over EU.

In the spotlight: Netherlands - a platform to address grid congestion for operators

In the Netherlands, to manage grid congestion at specific areas, a GOPACS platform aims to manage energy flows. At its heart is an algorithm, which combines buy and sell orders.

In case of grid congestion, it is registered into the platform, and a message is sent out, allowing local market parties to place an order to buy electricity on the platform. The proposed reduction of electricity production from the congested area is combined with a sell order from a market party outside of the area, so grid balance nationally is maintained. The platform ensures that an order does not cause problems elsewhere in the electricity grid for the involved network operators. The involved network operators will pay a price difference between the orders, matched on the trading platform. This flexible bidding resolves the congestion situation. Capacity-limiting contracts mean that a market party can submit a flexibility offer to reduce their power against an agreed compensation.

Accessed by the Dutch network operators who can detect where and when they expect congestion to take place, GOPACS is a platform that helps them jointly coordinate flexible power in the electricity network. As energy markets are changing rapidly, using data, innovation, and transparency help address identified challenges.[99] A market party generates additional income, and the operators address system needs, as a win-win situation.

In the spotlight: Cable pooling and storage facilities in Poland

On August 17, 2023, the Renewable Energy Sources Law was amended to introduce the possibility of shared connection (cable pooling) for various RES installations for the grid below 1 kV. This allows installations whose total installed capacity exceeds the connection capacity to be connected with the appropriate infrastructure/equipment and introduces the Cable Pooling Agreement (CPA), which defines the rules of cooperation for shared use. This will allow the approval of connection when sharing a connection, for complementary RES installations (using, for example, wind, solar and biogas), cooperating with energy storage facilities, which until now have been treated in law as generation sources (!). Last year (among other reasons) connection refusals were issued for more than 7,000 RES applications with a total capacity of more than 50 GW. This amendment should allow that around 5GW of renewable energy could be connected to the grid.

In the Wielkopolska region, EDP Renewables launched a hybrid photovoltaic farm of 45 MW capacity in Konary. This innovative installation uses the same connection as the existing Pawłowo wind farm (so-called cable pooling), which increases their efficiency and eliminates the need to invest in new networks. This is a groundbreaking project in Poland and most likely the first undertaking of this type in Central and Eastern Europe[100].

In the spotlight: Virtual prosumers in Poland

A minimum of 10% of the capacity from newly built wind farms should be allocated to virtual prosumers (also known as energy sharing), according to an RES law amendment in 2022. This will affect the development of energy cooperatives and clusters and also change the organisation of local smart grids using energy storage. It will also pose new challenges to DSOs and the way they are billed and will stimulate the development of the grid and also PPAs.

99 https://en.gopacs.eu/ and https://vimeo.com/794493085 as well as https://www.smart-energy.com/industry-insights/improving-congestion-management-on-the-dutch-grid/
100 https://www.green-news.pl/3666-konary-wielkopolska-edp-renewables-cable-pooling-fotowoltaika-wiatraki

Advancing sector coupling with renewables promotes energy system integration for a more efficient energy system, where energy demand is reduced[101]. Sector coupling means renewables-based electrification for heat, transport and industry. As CEE electrifies with renewables, sector coupling is about assuming a horizontal approach, where this electricity helps in decarbonising the rest of the sectors of the economy.

In the spotlight: Electrification of road transport[102]

In Austria, buyers of electric vehicles receive an incentive for using only renewable electricity to charge their cars. In 2023, the EV subsidy was the same rate as the year before. The Austrian government has also provided subsidies for EV charging stations.[103] Several EU member countries like Croatia, Netherlands, Ireland, and Italy are also adopting policies and strengthening support for the introduction of zero-emission heavy transport in national plans. Related targets are introduced for electric buses and trucks, as steps towards unleashing the potential for sector coupling.

At transmission level, power system flexibility must fully help integrate variable renewable energy, so the demand matches the supply at all times, and to encourage efficient expansion. Demand-side flexibility, efficiency and **cable pooling**[104] enhance the capacity of the grid and optimise existing infrastructure. The incorporation of short-duration, long-duration, and seasonal storages into grid planning will give system operators the ability to provide renewable energy consistently, even through the Dunkelflaute[105]. Demand-side flexibility and storage should be adequately captured in transmission-level planning, and the system operators (TSOs) should be aligned or incentivised to operate grids according to a shifting paradigm. Network development plans and strategies should reflect the climate neutrality target and intermediate targets, such as 2030 renewable ambition. This has crucial implications for grid planning.

Cross-border cooperation and solidarity will underpin overcoming grid challenges in the CEE region. Interconnections between countries are a means to stabilise grids, enhance security of supply, reduce the role of fossil gas peaking plants in the short term, and storage needs in the long-term. At the moment, interconnections within the wider CEE region[106] constitute only 13% of the EU's internal interconnection capacity. Ember modelling shows[107] that additional interconnection capacity in the region further reduces power prices and improves the integration of wind and solar by lowering energy curtailment. Several projects of trans-national energy collaboration are already underway or proposed[108]:

- 500-1000 MW LitPol link co-developed by Poland and Lithuania
- A shared Bulgaria-Romania energy island with up to 3 GW of offshore wind capacity[109]
- 'Black-Sea Corridor' shared grid expansion project[110]
- Energy island concept between Poland, Sweden and Lithuania[111], following the many examples being developed in Western Europe such as the Bornholm Energy Island on the Baltic Sea.

101 See EU Strategy for Energy System Integration: https://energy.ec.europa.eu/topics/energy-systems-integration/eu-strategy-energy-system-integration_en
102 https://www.iea.org/reports/global-ev-outlook-2023
103 https://www.wissenergy.com/news/austrian-electric-vehicle-incentives/
104 Multiple generation units on a single grid connection
105 A period of time in which little or no energy can be generated with wind and solar power,
106 Estonia, Latvia, Lithuania, Poland, Czechia, Slovakia, Hungary, Slovenia, Croatia, Romania and Bulgaria
107 https://ember-climate.org/insights/research/in-it-together-cee-power-system/#supporting-material
108 https://ember-climate.org/insights/research/in-it-together-cee-power-system/#supporting-material
109 https://www.enpg.ro/wp-content/uploads/2023/01/EPG-Report_Offshore-wind-the-enabler-of-Romanias-decarbonisation_.pdf
110 https://tyndp2022-project-platform.azurewebsites.net/projectsheets/transmission/138
111 https://www.ea-energianalyse.dk/wp-content/uploads/2020/02/1811_rap.pdf

In the spotlight: International connections planned in Romania

The expansion of several international connections between Romania and Hungary is also included in the long-term plans up to 2030. For example, the extension of the 400-kilovolt transmission line between Békéscsaba and Nadab in Romania, also with the construction of a second system, the construction of a second 400-kilovolt transmission line between Sándorfalva and Subotica by 2028, and the construction of a 400-kilovolt transmission line between Józsa and Oradea by 2030.[112]

Transparency, the availability of open data, and data interoperability are helpful for enhancing stakeholder engagement in grid planning across different levels. When stakeholders have access and visibility of grid capacity, and related data, it fosters trust and bolsters investor confidence, for the uptake of new projects. Transparency in planning, particularly good use of the latest available methodologies to determine future grid development and also builds public trust. Adopting and applying open data principles is about making information accessible to spur innovation in the sector, and for improving interoperability among different providers[113].

In the spotlight: Czech "GRID CAPACITY MAP"

The role of the DSO's in the EU energy transition is indispensable. Therefore it is pleasing to know that some of them are trying to be more transparent about the grid capacity and connection procedures. This is the case of Czech DSO called EG.D[114] who in the beginning of 2023 launched its online "grid capacity map"[115]. The map allows customers to see if they can install photovoltaic panels at a specific location. In this way customers will have indicative information about connection options before they can proceed with their project. Hopefully, all other Czech DSO's will follow EG.D's example. Nevertheless, the obligation of the DSO to transparently inform customers about the grid capacity is part of the amendment to the Czech Energy Act (passed by the Czech Parliament at the very end of 2023).[116]

In the spotlight: The sectoral agreement between the regulator and distribution system operators in Poland (initiated by the Regulator)

The initiative is called "A charter for the effective transformation of the Polish distribution system"[117]. The signatories are the President of the Energy Regulatory Office and the five largest distribution system operators (DSOs) in Poland. The charter is open for additional network companies to join. The result will mainly be the operators' development plans. They should reflect the investment needs identified in the charter. The Charter creates a stable regulatory environment for energy companies in a multi-year time horizon in the field of network investments (modernization and development of the network). In addition, the card will result in further work aimed at implementing network flexibility services and its digitization, as well as new functional and legal solutions aimed at making the most optimal use of the current network potential. In the above-mentioned moderate scenario, the necessary funds are PLN 130 billion by 2030. As part of these activities, connecting RES is a priority.

112 See the full list on p.161 https://commission.europa.eu/publications/romania-draft-updated-necp-2021-2030_en
113 https://es.catapult.org.uk/case-study/interoperability-in-the-energy-sector/#:~:text=Consumer%20interoperability%E2%80%93%20provisions%20exist%20for,to%2C%20driven%20by%20market%20forces
114 https://www.egd.cz/
115 https://geoportal.egd.cz/itc/default.aspx?ck=1&SID=&serverconf=prip2&br35info=1
116 More information about the bill can be found here: https://www.psp.cz/sqw/sbirka.sqw?O=9&T=487
117 https://www.ure.gov.pl/pl/urzad/informacje-ogolne/aktualnosci/10630,Rynek-energii-elektrycznej-historyczne-porozumienie-sektorowe-regulatora-i-opera.html

Digitalisation represents a significant transformation of energy systems management, moving towards more dynamism and decentralisation. Digital solutions enable real-time monitoring and control of energy flows, ensuring that the grid remains stable and efficient with the increased variability and decentralisation brought by DERs (EVs, small-scale renewable energy installations like solar panels and wind turbines, and electric heat pumps) and new market players such as aggregators and prosumers.[118]

Smart metres help understand how households, light commercial and industrial consumers consume electricity. From a technical perspective, smart metres improve the visibility of loads at the low-voltage level within the distribution grid. At the markets, dynamic pricing and time-of-use tariffs can be introduced. Sub-meters track individual electricity usage, also electric heating or EV charging. Assisted by mobile applications, consumers can be notified, for example, of a shift in electricity price to plan when to heat and cool homes, turn large appliances on, and charge electric vehicles. Consumers do not necessarily have to track market signals or prices, as such devices can also be automated, to lower their bills. Price signals will help decide what portion of consumption should be flexible. As service providers, operators incentivise this behaviour, and in return, they are better able to monitor grid performance.[119] In the future, we may see even more innovative approaches that reward demand side flexibility.[120]

In the spotlight: 17 million new metres for Polish citizens by 2028
Due to change in national legislation, the already installed monitoring smart meters will be replaced with new generation devices (17 million new remote reading electricity metres (ROCs) to be installed by the end of 2028). The new metres will allow electricity suppliers to remotely read energy consumption without the customer's participation, and will enable consumers to control their current consumption (once demand side flexibility systems will be in place). It is assumed that this will give a boost to good habits and save 10% of energy. In 2025, the new metering is expected to cover 25% of consumers.

In the spotlight: Investment into Digital Transformation of the Electricity System Operator in Bulgaria
Bulgaria's National Recovery and Resilience Plan[121] includes a EUR 312m investment for the digital transformation of the Electricity System Operator - Bulgaria's sole transmission system operator. The investment to be implemented until 2026, will fund comprehensive modernisation of planning and operational processes. It aims to prepare the ground for increasing penetration of renewable sources and distributed generation and increase the flexibility of the operational management and monitoring of the electricity system. The objectives to allow the integration of at least 4.5GW of new wind and solar capacity by 2026 (in addition to 1.8GW in 2020); and to increase use of cross-border transmission capacity by least 1.2GW (in addition to 1.4GW in 2020)[122].

118 IEA 2023. https://iea.blob.core.windows.net/assets/ea2ff609-8180-4312-8de9-494bcf21696d/ElectricityGridsandSecureEnergyTransitions.pdf
119 Ibid.
120 "Shaping Tomorrow's Resilient and Renewable Energy System: It Starts at Home", CAN Europe, July 2023, https://caneurope.org/demand-side-flexibility-blog/
121 https://nextgeneration.bg/14
122 ESO.BG - Електроенергиен Системен Оператор https://www.eso.bg/doc?ctem

5. Call to Action & Key Recommendations

It is time for TSOs, DSOs, and national governments in the CEE region to engage in concerted action and collaboration, driving the transformation of electricity grid infrastructure to accelerate the renewable energy transition. CEE countries have the chance to change the current trajectory and become leaders. The involvement of all stakeholders, from policymakers to system operators, is crucial in realising the vision of an interconnected, resilient, secure, affordable, and sustainable energy system for the region.

By taking action on these key recommendations, with a focus on the social dimensions, means more than advancing grid technologies and renewable capacities. It encompasses integrating solutions to energy poverty, ensuring equitable energy access, supporting the growth of energy communities, and providing targeted support to those most in need. By adopting a socially inclusive and just approach to energy transition, CEE countries will actively shape their future energy systems fit for tomorrow, ensuring that each measure contributes to the prosperity of their citizens while paving the way for a resilient, secure, and affordable energy future.

National governments, Regulators (NRAs), TSOs, and DSOs should engage and embrace a new energy paradigm that fosters the development of an energy system capable of meeting the needs of a modern, efficient, people-centred, and fully renewable energy landscape. This requires action under following ten key areas:

1. Foster Political Vision and Strategic Planning

- Assure horizontal and integrated planning of transmission and distribution grids, with 2030 climate and energy targets as objectives integrated with a long term vision towards 2050;
- Ensure coordination and cooperation including improved data exchange between DSOs and TSOs to advance demand side flexibility on the distribution side, to integrate flexibility into their National Scenarios and Network Development Plans;
- Revise and update all the strategic plans and documents related to grids (especially National Energy and Climate Plans (NECPs)),to ensure that renewables-based electrification and required grid capacity/quality are addressed;
- Increase regional collaboration, especially among CEE Member States to share grid capital investment on interconnection capacity across multiple governments, and prepare a plan to reach EU interconnection targets;
- Actively engage at EU level to share challenges and adopt best practices for planning, regulation, stakeholder engagement and effective grid management.

2. Improve the Regulatory and Operational Environment

- Ensure the national regulatory bodies are well-equipped with adequate resources (budget and staff) to respond to the challenges of changing regulatory environments and provide good regulations;
- Encourage national regulatory authorities to support the development of regulatory frameworks for system operators that incentivise the modernisation of grids and the integration of renewable energy sources;
- CEE Members States should use the revision of Energy Market Design implementation to re-think the tariff composition, to assure financial resources are matching needs, both for the capital expenditure (CAPEX) and operational expenditure (OPEX).

3. Improve Transparency and Data Accessibility

- Network operators (TSOs and DSOs) to address data gaps and provide complete grid capacity mapping and make them publicly available to enable informed decision-making and innovation (in view of preparation of the pan-European overview, proposed within EU Grid Action Plan).

4. Revise Ownership Structures

- Make sure the decoupling of the generation and distribution assets is accomplished, according to EU rules, and decoupled from incumbent utilities so that they do not block grid connections for competition (mainly renewables).

5. **Leverage EU Funds**
   - Use all the opportunities to allocate EU Fund under current MFF (2021-2027) to support grids investments;
   - Prepare comprehensive strategy having in mind new MFF 2028-34 on how to utilise the EU Funds for grids investments, including Modernisation Fund;
   - Conduct economic and social studies to assess the benefits of upgraded grids, such as reducing losses from curtailment and enabling a more resilient system;
   - Ensure that financial instruments, subsidies, and support mechanisms are accessible to energy-poor households and are structured to encourage investments in energy efficiency and sustainable renewable heating solutions.

6. **Engage in cross-sectoral dialogue and enable sector coupling**
   - Establish cross-sectoral platforms for dialogue that will support the adoption of new technologies and collaborative approaches;
   - Advance sector coupling principles, as the use of electricity cross-sectorally beyond the power sector, with supportive policies, pilots, and experiments.

7. **Embrace flexibility as a cost optimisation and system stability measure**
   - Embrace demand-side flexibility, by implementing fast the new reformed Energy Design provisions (flexibility needs assessment and national objectives) and put forward measures to allow consumers to adapt their energy use patterns, benefiting both the grid and themselves. Build awareness campaigns to engage consumers in energy demand management;
   - Accelerate the rollout and integration of enabling technologies such as smart metres (serving both grid monitoring and consumer empowerment);
   - Enhance TSO–DSO cooperation for active system management and realise the coordinated use of distributed flexibility; dynamic pricing to be promoted, locational tariffs to be considered.

8. **Build systemic link between energy transition (incl. grids) and addressing energy poverty**
   - Develop comprehensive energy transition strategies and policies that link grid modernisation, decentralisation, and acceleration of renewable energy deployment directly to measures that alleviate energy poverty, ensuring these policies are inclusive and address the multifaceted nature of the issue;
   - Move beyond short-term fixes that only provide temporary financial relief, and instead, design and implement long-term structural solutions that enable energy poor households to become active consumers and benefit from renewable energy systems and more efficient energy use.

9. **Make Renewable Heating Solutions Accessible for All**
   - Prioritise the installation of sustainable renewable heating solutions (e.g. renewable energy based-heat pumps, solar thermal and district heating networks using renewable sources) making them accessible, efficient and affordable for all.

10. **Ensure access to grids for local actors and energy services**
    - Small and local actors, such as energy communities, active consumers and SMEs who are not able to participate in competitive procedures should be granted access to the grid under dedicated terms, to advance the decentralisation. Same applies to flexibility services, such as demand side response and storage.

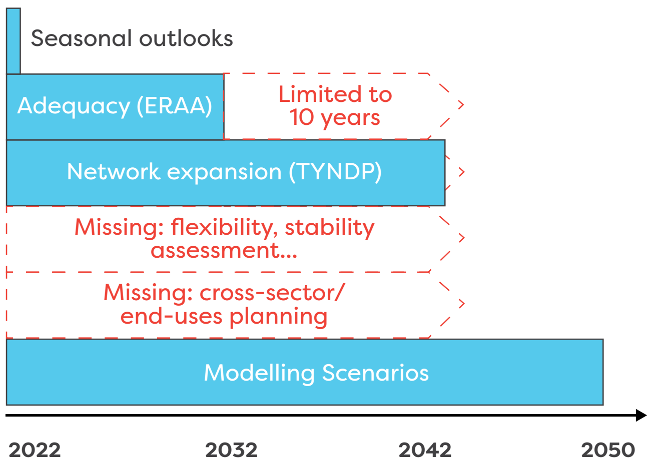
Annex 1: Grid Planning

Europe's power system is currently planned through separate processes, despite the inherent interrelationship between various components of the power system. Each planning process has its particular focus area, specific planning horizon and responsible entity, with national energy and climate targets typically constituting a unifying driver. These are broadly summarised below:

- Interconnection, national transmission grids and distribution grids are planned by system operators. These plans typically have a planning horizon of about ten years, although some countries have extended this up to 2045.
  - Grid plans for the transmission network are typically published every two years with a ten-year planning horizon, in line with Directive (EU) 2019/944 for the electricity market. Its cyclical nature is intended to enable evolving circumstances to be integrated within the network plans, and the ten-year scope is considered the minimum to provide adequate time for investment.
  - Through the Ten-Year Network Development Plan (TYNDP), regional cooperation is facilitated for planning of cross-border infrastructure. ENTSO-E undertakes its own assessment of cross-border infrastructure needs with an outlook to 2040.
- Resource adequacy assessment looking at power generation with a typical ten or fifteen year outlook. This is coordinated at EU level through the EERA.
- The upcoming revision to the Electricity Market Directive is expected to require governments to undertake regular assessment of flexibility needs.

These separate processes make it difficult to identify solutions that represent the highest system efficiency, thereby keeping costs down, particularly for technologies that facilitate benefits across the entire power system such as grids.

Limitations to current power system planning studies



Source: Eurelectric - A Market fit for Net Zero power system, https://www.eurelectric.org/publications/a-market-fit-for-net-zero-power-system-full-study

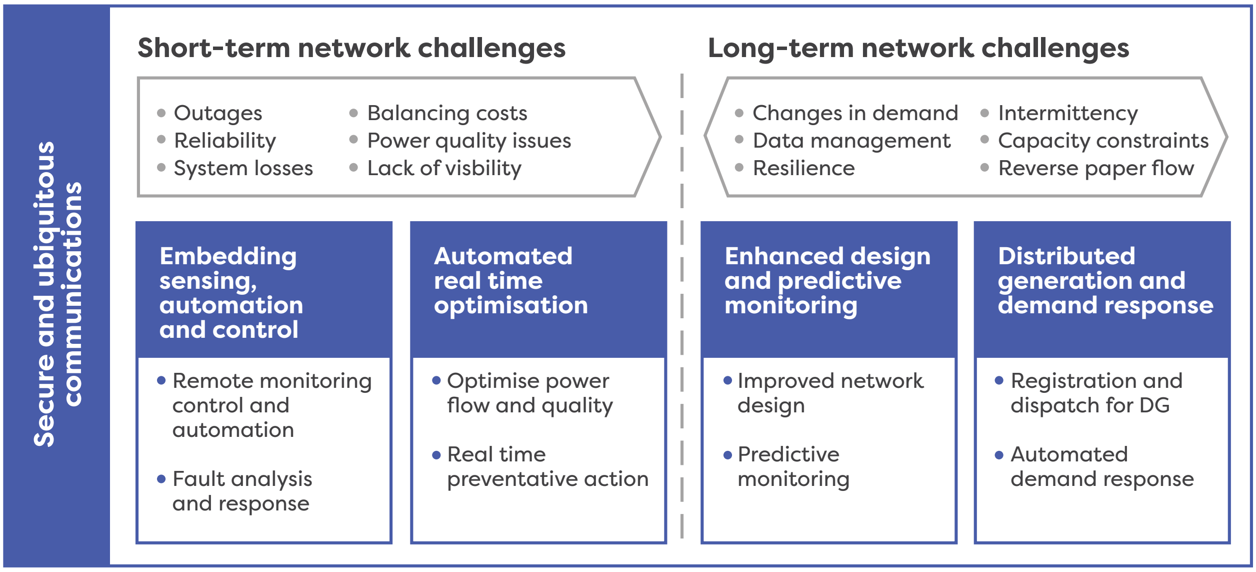
The grid planning process undertaken by TSOs and DSOs (for transmission and distribution systems, respectively) is complex, combining the objectives of maximising efficiency, ensuring security of supply and supporting decarbonisation while keeping costs low. In addition to identifying necessary grid investments, long-term grid plans also serve as a vital compass for multiple stakeholders, such as long-term signals to renewable investors and manufacturers of grid components. The current planning framework of the power system has already been recognised as insufficient[123] to deliver on the Green Deal and net-zero commitments, and grid planning processes have been specifically highlighted as lacking.[124]

123 https://cdn.eurelectric.org/media/6448/market-design-flagship-final-h-0706B927.pdf?_gl=1*1ug8dgk*_ga*MjExNDQwMjYyMS4xNjYyNTUzNTE2*_ga_CB82F90MQ6*MTY5Nzk3MTA2MS4xMS4xLjE2OTc5NzE4NDguNTMuMC4w

124 https://climate-advisory-board.europa.eu/reports-and-publications/towards-a-decarbonised-and-climate-resilient-eu-energy-infrastructure-recommendations-on-an-energy-system-wide-cost-benefit-analysis/advice-on-a-harmonised-eu.pdf/@@display-file/file

Annex 2: Digitalisation of grids

Digital solutions to tackle short- and long-term grid challenges



Note: DG = distributed generation
Sources: IEA analysis based on 3DEN, Unlocking Smart Grid Opportunities in Emerging Markets and Developing Economics (2023), World Economic Forum, Accelerating Smart Grid Investments (2010)

Annex 3: Glossary

This glossary provides key concepts that assist in understanding the emergent role of the grids in the transition towards a future energy system in the CEE.

demand-side flexibility

Demand-side flexibility means that a portion of demand in the system is reduced, increased or shifted, within a specific time duration. Demand-side flexibility, of adapting consumption and production patterns based on external signals assists in reducing demand especially, if grid capacity is limited. It also contributes to minimising grid extensions, new transmission lines or large-scale power generation. Examples of this are when charging points for electric vehicles assist in matching grid needs, or can assume various forms, also as electrified heat and transport.

digitalisation

The digital transformation of the energy grids allows for data collection, smart control and optimisation, by users, service providers and system operators. It also raises the necessity to anticipate cybersecurity issues and address data privacy. It intertwines with electrification, decarbonisation and decentralisation.

distribution system operators, DSOs

The role of distribution system operators, DSOs, becomes more pronounced in the future energy system. DSOs will receive more attention as they will act as an interface between multiple prosumers, especially as power flows through low- and medium voltage grids, enabling the management of a more flexible energy system, with the transmission system operators (TSOs), as national level actors who are in charge of network development plans. To achieve this, DSOs will have to work for distribution development plans, ensure grid hosting capacity, and acquire necessary skills and funding to upgrade their grids.

electricity market design

Electricity Market Design is a set of rules, common for the whole EU, on how the electricity trade is organised, what the price setting mechanisms are, and how electricity is being distributed, also cross-border. The rules are enshrined in Treaties, EU Energy Packages and detailed rules such as network codes and guidelines. The market design is composed of different marketplaces, which operate under different timescales (short-term, long-term, balancing). The idea is that all EU countries follow similar rules, under an integrated EU energy market. Thanks to a regulatory process driven by European Union institutions, most countries now have a very similar sequence of electricity markets. Some of these markets have already evolved from national markets into European markets, while others remain national or regional.

Current revision of the EU legislation - Electricity Market Regulation and Directive revision - is focused on addressing the fossil fuel crisis impacts - the price volatility and exposure to pierce hikes of the vulnerable Consumers. To address the first, the legislation proposes state support for long-term wholesale contracts, so the price setting is less impacted by the changes in short-term markets (hedging). Increasing protection for consumers, but also empowering them to control their bills is expressed via engaging them in the demand flexibility (dynamic pricing, energy sharing, better contractual information) and introduction of schemes for the most vulnerable (ban on disconnection, energy price crisis conditions).

Key objectives:

- Lowering the influence of gas and coal on price setting
- Enhancing system flexibility and rewarding Demand Side Response (DSR) and storage
- Support for the integration of RES into the grid
- Customer protection from volatile energy prices impacts

energy sharing
As a fundamental, underlying principle, energy sharing allows maximising especially self-producing prosumers to become a part of the energy system. Energy sharing increases engagement, ownership, and also helps shift the focus in energy system planning to a more local level from the wider system-level. Energy sharing is a key enabler in advancing progress towards a more interactive energy system of the future.

energy system integration
Energy system integration is closely linked to another concept, namely sector coupling, in advancing an integrated view towards a renewables-based energy system where all sectors are linked with one another. The future, integrated, renewables-based energy system enables energy flows between users and producers, and is about the optimisation of the energy system, to avoid wasting resources and money. An integrated view helps avoid efficiency gains made independently in each sector or in siloes.

As outlined in the EU strategy on energy system integration, set in 2020 already raises attention to the interplay of renewable district heating and renewable electricity, as supplementary sources of supplying energy, in an integrated manner. Examples of energy system integration are how electric vehicles use power, serve for transport, and even act as batteries, as storage for the energy system, as they charge and discharge power in buildings.

Harnessing various existing and emerging technologies, processes and business models, such as ICT and digitalisation, smart grids and meters and flexibility markets.

flexibility
Flexibility is a principle that symbolises how the energy system is changing. A flexible enough power system enables variable renewable energy to be fully integrated through various means. EVs are a flexibility option, more flexible buildings use heat pumps, while flexible heat connects heat and power networks by harnessing the complexity in distributed thermal flexibility. At markets, flexible price-based solutions mean new market signals e.g. as more flexible tariffs for residential, commercial or industrial users, as incentives to motivate them.

grid capacity
Grid capacity refers to the maximum amount of electricity that can be transmitted through the power grid at a moment in time. Additionally, for a grid to stay in balance, the amount of electricity fed into the electricity grid must always match the amount of electricity consumed.

grid edge
Grid edge, as an umbrella term, refers to distributed hardware, software and business innovations in close proximity to the end user. Attention to the grid edge is about the rise of distributed energy resources, shifting and decentralising power generation and delivery. So-called grid edge solutions are at the heart of evolving electricity markets, their new-look design, and a far more transactive electric grid. As known in the field of innovation, innovation and disruption often play out ‘at the edge’, to the benefit of their users.

interconnections
Interconnections help transmit variable renewable electricity from areas of production to areas of consumption, for avoiding grid congestion and minimising curtailment. Expansion of interconnection capacity calls points to more cross-national and sub-regional collaboration. Enhanced interconnections support the phase out of gas peaking plants currently providing flexibility, and in the renewables-based energy future, can reduce long-term storage needs between countries.

interoperability
Interoperability includes how district heating and power systems begin to "talk" to one another, how heat from summer to winter can be stored - for instance with excess heat from data centres. Interoperability mechanisms are necessary for connecting flexible assets: smart buildings, supermarkets, wastewater treatment plants, power-to-X plants, and the like to the grids and markets. Data interoperability is an element of interoperability, to ease the sharing and portability of data between different systems.

prosumerism
Prosumers, as producer-consumers, generate their own power, and a prosumer-centric market design means that customers who are willing can become active market participants, and also reap the benefits from energy savings/renewables-based generation. Also referred to as consumer-centric market design, this idea is not new for the EU, as it has already been introduced by the Clean Energy Package in 2019.

sector coupling
Sector coupling means an approach where renewables-based electricity from the power sector enables the use of renewables also for heating, cooling, transport, and even industry, to assist the energy transition, minimising the amount of fossil energy required in other sectors.

storage
A range of energy storage options exists, across shorter and longer timespans, which can also be differentiated between different types. A focus on battery storage is usually in focus, but there are also other options, such as pumped hydro storage, flywheel, each with different characteristics. In future energy planning, underlying scenarios, and subsequent policies, more has to be made of the recognition of short-, long-term and seasonal storage options, as an element of a more flexible energy system.

transmission system operators (TSOs)
Transmission system operators will need to ensure that in their Grid Development plans, and their underlying scenarios, renewables-based electrification is recognised, as a strong driver, in line with climate targets. A changing energy landscape has to be reflected in the assessments of relevant projects, national and pan-European scenarios, into which the TSOs are contributing to, assessing specific needs. Like DSOs, the TSOs may need new capacities to acknowledge these needs, and collaborate with them, and other national TSOs at cross-border projects. They may also aim to adopt best innovative practices for nature conservation.

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