Polish Electricity Association

Polish Energy Transition Path

Warsaw, October 2022

PKEE
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The report was prepared by PKEE in cooperation with Ernst & Young Consulting.

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Building a better working world

Letter from the President of the Management Board of PKEE

Ladies and Gentlemen,

we are now at a turning point for the European energy sector. Many experts say that we are facing the biggest energy crisis since the 1970s. It is the joint effort of entire energy sector, Members States and EU institutions that will determine the time and the terms on which the European Union will recover from this crisis. I am convinced that Poland can use the ongoing crisis to build a strong, independent, environmentally friendly and solidary energy sector.

We were the first to warn of the threat posed by reliance on energy resources from Russia. For years, we have been explaining to our Western partners that Russia is an aggressive and undemocratic state that treats the energy sector as a tool of expansion and political pressure. Today, our partners from the European Commission and governments of the so-called "Old Union" openly admit that we were right.

The report "Polish Energy Transition Path" prepared by the Polish electricity sector allows to understand how we came to such conclusions and where we are now in terms of the energy sector development and coming out of the energy crisis. The evolution of the Polish electricity sector that has been consistently carried out since 1989, when Poland regained economic sovereignty, is of great importance here.

Care for the natural environment, a stable climate, clean air and healthy water for future generations - our children and grandchildren - have been guiding the Polish electricity sector for years. Therefore, we are consistently striving to achieve an ambitious goal by 2050: to produce completely clean, green energy that will be affordable to individuals and industrial customers.

With this report, we would like to show you our achievements in this field and present plans for the coming years. Plans that thousands of Polish power engineers implement in their daily work.

Wojciech Dąbrowski

President of the Management Board
Polish Electricity Association

Executive summary

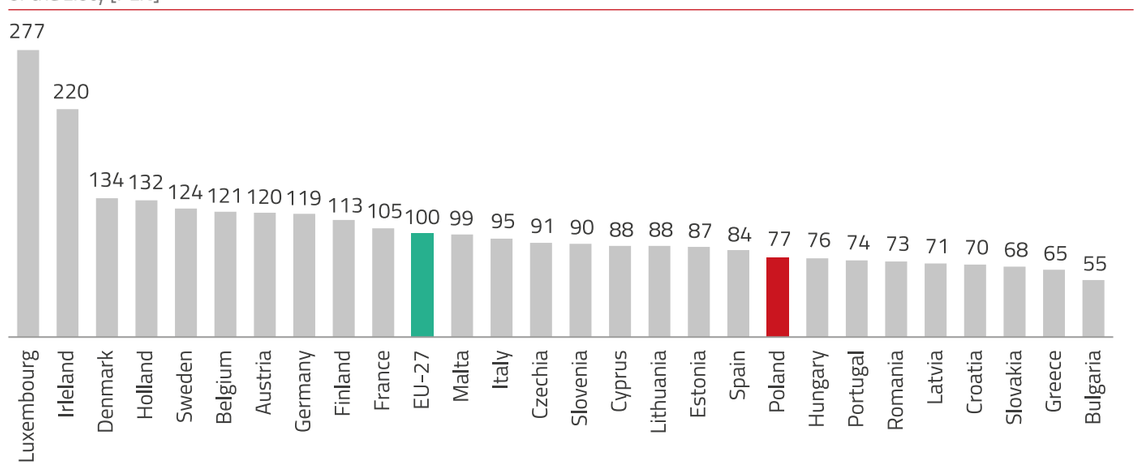
Reducing greenhouse gas (GHG) emissions and the negative impact humans have on the environment are at the heart of climate policy at global and European Union (EU) levels. The implementation of an ambitious climate policy places the EU in the role of a world leader in climate protection, with the long-term goal of achieving climate neutrality by 2050. Poland, which is a Member State of the EU since 2004, is also committed to achieving these climate goals.

Poland is also actively involved in global initiatives in the field of climate policy by being a party to the United Nations Framework Convention on Climate Change (UNFCCC) since 1994 and the Kyoto Protocol since 2002, and ratifying the Doha Amendment and Paris Agreement.

The energy sector in Poland, due to historical and geopolitical conditions, was dominated by fossil fuels – hard coal and lignite. Nevertheless, the share of energy generated from low- and zero-emission sources is increasing gradually and consistently, and therefore the carbon intensity of energy production in Poland is steadily decreasing.

Due to geopolitical conditions until 1990, the Polish economy developed at a much slower rate than the economies of Western Europe. Achieving economic development close to the EU average will result in an increase in electricity consumption despite energy savings resulting mainly from the implementation of measures to improve energy efficiency.

Fig. 1 | GDP per capita in Poland and EU countries GDP per capita (EU27 = 100) in 2021 according to the purchasing power parity of the zloty [PLN]



Source: Own study based on data from EUROSTAT

As the history and experience of developed countries show, climate and environmental measures require very high investment and involve significant costs. Aid funds only partially compensate the sector's expenses, which are much higher than the average in the EU countries. In order to effectively implement the assumed transformation, the energy sector must also take into account a number of micro- and macroeconomic conditions in its activities.

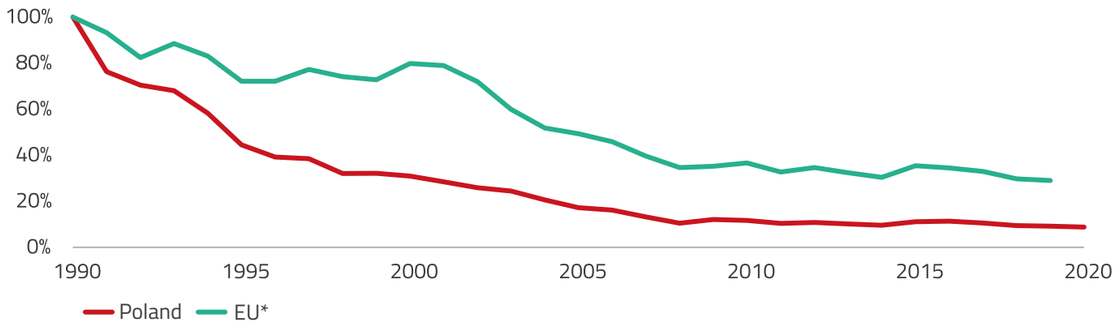
The first binding targets for reducing greenhouse gas (GHG) emissions were set in the Kyoto Protocol. Poland overachieved its target by reducing GHG emissions by 6% in 2012 compared to 1988 levels, in which the energy sector had a significant

share. As targets for the following years could not be agreed at the global level, subsequent binding targets were established at the EU level for 2020 as part of the 20-20-20 package.

Poland has met EU targets for 2020, reducing the total GHG emissions by more than 20% relative to 1990 levels, and in the non-ETS sector achieving emissions of approx. 201.8 mln tonnes of $CO_{2\,eq.}$ relative to the target of 205.2 mln tonnes of $CO_{2\,eq.}$ and reaching approx. 16.1% share of RES (renewable energy sources) in final energy consumption in relation to the 15% target and reaching the value of primary energy consumption at 96.5 Mtoe and final energy at 71 Mtoe, similar to the assumed 96.4 Mtoe of primary energy and 71.6 Mtoe of final energy[1].

The reduction of GHG emissions was possible despite the significant economic growth and the achievement of over ten times higher GDP in 2020 than in 1990[2]. Poland reduced unit GHG emissions by over 90% relative to the value of Poland's GDP from 1990 to 2020. These values were achieved thanks to changes in the energy mix, shifting it towards renewable and low-carbon sources.

Fig. 2 | Change in the GHG emissivity of the gross domestic product



*World Bank data for the EU take into account the UK and are available until 2019

Source: Own study based on data from EUROSTAT and World Bank

Further path to climate neutrality

The 2030 climate goals were set by the European Council in 2014:

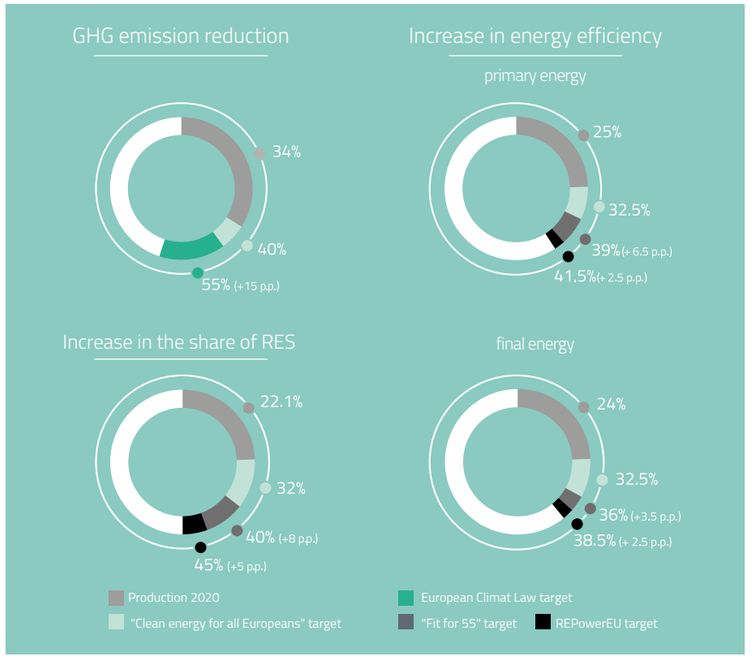
- a 40% reduction in GHG relative to 1990 levels,
- a 32% share of RES-based production in final energy consumption,
- a 32.5% improvement in energy efficiency[3].

The implementation regulations package was published in 2016, and the legislative process was completed in mid-2019. To increase the share of national initiatives in achieving these goals, National Energy and Climate Plans (NECPs) were introduced, developed by individual countries and agreed at the EU level. The first NECPs were developed and have already been submitted to the European Commission. The reconciliation process has not ended because the growing negative phenomena resulting from climate change led to the acceleration of actions aimed at reducing GHG emissions at the EU level. At the end of 2019, the EU adopted a political goal of achieving climate neutrality in 2050 as part of the European Green Deal. For its implementation in the years until 2030, a regulatory package "Fit for 55" was developed, supporting the implementation of an increased GHG emission reduction target in 2030 from 40% to 55% relative to 1990 levels. Legislative work on these regulations is still ongoing, but European Climate Law was adopted in 2021[4] – with a binding goal of achieving climate neutrality by 2050.

1 Based on data from EUROSTAT.
2 Based on data from the World Bank.
3 Relative to the PRIMES 2007 baseline projection.
4 Regulation of the European Parliament and of the Council (EU) 2021/1119 of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (European Climate Law).

Due to Russia's invasion of Ukraine and disruptions in the global fuel market, the second goal of the EU climate policy – the rapid reduction of the reliance of EU countries on the import of energy resources – is gaining importance. To accelerate actions under this target, the EU announced a new plan – REPowerEU, which proposes even higher targets for improving energy efficiency and energy consumption from RES than the "Fit for 55" package and includes additional measures to support Europe's energy independence.

Fig. 3 | Summary of goals resulting from EU regulations until 2030



Source: Own study based on data from EUROSTAT and information and documents of the European Commission pertaining to the "Clean Energy for All Europeans", "Fit for 55", and REPowerEU.

In the long-term perspective, the energy transition and counteracting climate change in Poland are carried out on the basis of strategic documents such as Energy Policy of Poland until 2040 (PEP2040) and the NECP. Both documents require significant revision, because they were created before the planned increase in reduction targets and acceleration of efficiency measures included in the "Fit for 55" package and REPowerEU. According to current documents, Poland will reduce the share of fossil fuels in its energy mix and invest in low-emission energy sources, such as offshore wind farms or nuclear energy. By 2049, Poland intends to shift away from coal mining, which will be pose significant challenge for the entire energy sector and will require socio-economic changes in the main mining regions in Poland[5].

The peak of hard coal extraction in Poland at the end of the 1980s occurred 30-50 years later than in countries such as France, the UK or Germany. These countries are only now shutting down their mining operations completely, which illustrates the scale of time that Poland needs to implement changes in the economy as part of transitioning away from coal. The transformation in the mining sector is particularly difficult, as it is concentrated in a few small regions, with Górny Śląsk producing more than 80% of hard coal. Poland is trying to carry out reforms in the mining industry in an evolutionary manner, while maintaining social protection and creating new jobs. This requires the transformation to be spread over many years.

5 Based on the Śląskie Agreement on the Transition of the Hard Coal Mining Sector and Selected Transition Processes in the Śląskie Voivodeship.

This requires the transformation to be spread over many years.

Poland's strategic plans are also reflected in the strategies of the largest Polish energy groups, which assume a significant increase in the share of renewable energy sources and the implementation of network investments supporting this process in the coming years. According to the government program, the acceleration of investment processes is to be achieved, among other things, through structural changes in the energy sector, including the spin-off of coal assets and their concentration in the National Energy Security Agency (Pol. *Narodowa Agencja Bezpieczeństwa Energetycznego*, NABE) and further consolidation of fuel and energy companies. Structural changes in energy groups are to increase the competitiveness of the Polish energy sector on European markets and increase the investment potential for the energy transition.

Implementation problems of the transformation

In order to avoid sector barriers to economic growth, it is necessary to maintain a stable supply of electricity in the required quantities and at acceptable prices. An important factor lies in social aspects resulting from the level of electricity prices for the poorest households.

The transition of the Polish energy sector takes place in difficult conditions. Apart from historical hardship, in recent years the emerging problems related to destabilization on the EUA markets[6], fuel, and electricity markets are of significant importance. A smooth and quick implementation of the climate transformation requires a comprehensive approach to ongoing changes, which also means addressing problems of energy poverty and the need to reconstruct the economies of entire regions.

Due to significant increases in fuel and energy prices from 2019, which are compounded this year by the Russia's war in Ukraine, the number of households at risk of energy poverty is growing. On top of that, the number of enterprises at risk of limitation or suspension of production, or even bankruptcy, is growing in the entire economy. Intervention and protective measures are necessary. For several weeks now, such actions have been taken by individual Member States and the EU as a whole.

The first market shock in EUA prices occurred in 2018-2019, when EUA prices rose from approx. 7 EUR/EUA to over 20 EUR/EUA. In the years that followed, the EUA price (except for the initial period of the COVID-19 pandemic) grew dynamically, reaching even over 90 EUR/EUA. In the last two quarters of 2021, the prices of energy commodities on the global markets of natural gas and hard coal increased several times compared to the prices observed at the beginning of 2021[7] as a result of the accumulation of several events: increased demand for electricity, especially in China and India, adverse weather phenomena including droughts in several countries, cold winter in the EU, floods affecting coal production, and political conditions such as a ban on Chinese coal imports to Australia.

In 2022, in particular since the outbreak of war in Ukraine (at the end of February 2022), there has been another spike in natural gas prices due to uncertainty about the capacity to obtain gas in Europe (resulting from sanctions and limiting the volume of gas supplied from Russia via Nord Stream 1). The war in Ukraine also caused instability on the domestic hard coal market – the average annual coal price in 2022 may significantly exceed 5 EUR/GJ. In turn, cheap imports from Russia must be replaced by imports from countries that sell coal based on the ARA price index (conventional coal price in the ports of Amsterdam, Rotterdam and Antwerp). Global coal prices were gradually rising already in 2021 as a result of the recovery in global demand, but after Russia's attack on Ukraine, they increased by leaps and bounds, about threefold. They have been fluctuating between 12 and 15 EUR/GJ for several months now.

Meanwhile, almost all competitive energy markets operate according to the marginal cost pricing model, i.e. the price is determined by the costs of the unit closing the energy balance in a given trading period. Nowadays, when changing production technology with a widespread rollout of units with low to no variable cost, it is fairly easy to use the market to make a very high, unjustified profit (windfall profit), especially in periods of unusually high prices of EUA and raw energy materials.

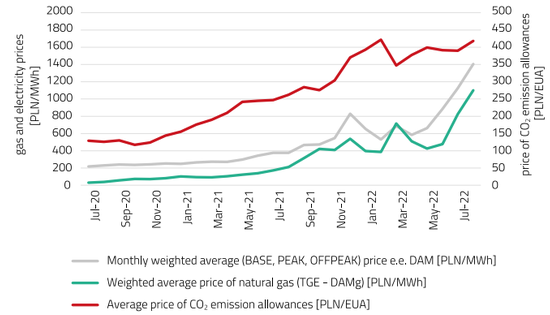
The destabilization of energy commodity markets has led to unprecedentedly high electricity prices on the wholesale market (mainly due to extremely high prices of natural gas), reaching up 383 EUR/MWh[8]. The persistence of such high prices would have catastrophic consequences for the energy market in the EU and end-users, and consequently would lead to an economic downturn.

6 1 EUA is equal to 1 t CO_{2eq}.

7 According to quotes and indices from ICE Dutch TTF Natural Gas Future, Coal (API2) CIF ARA (ARGUS-McCloskey) Futures.

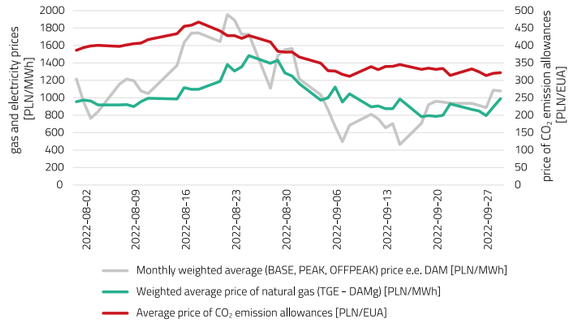
8 Based on data from TGE; weighted average transaction rate for delivery Base_Y-2023 as at 30 August, 2022.

Fig. 4 | Increase in the prices of natural gas and CO_2 emission allowances and the resulting electricity prices from July 2020 to August 2022



Source: Own study based on data from TGE and ICE

Fig. 5 | Increase in the prices of natural gas and CO_2 emission allowances and the resulting electricity prices in August and September 2022



To mitigate the effects of extremely high energy prices in 2022 and in forward contracts for 2023, on 6 October 2022, Council Regulation 2022/1854 on an emergency intervention to address high energy prices was published[9] (hereinafter referred to as the "Regulation"). The solutions adopted in the Council Regulation include intervention in the energy market and the activities of its participants, unprecedented in the history of the EU. It is based on instruments redirecting surplus profits to protective measures for end-users (establishing a cap on the market revenues obtained from electricity generation using inframarginal technologies[10] or a mandatory solidarity contribution from surplus profits in the oil, gas, coal and refinery sectors). Efforts to reduce electricity consumption during peak hours are also essential.

Poland is actively involved in developing intervention solutions at the EU level, while simultaneously implementing a number of solutions at the national level. In September, the system regulation was amended, specifying the method of calculating offer prices on the balancing market. The introduction of this regulation will significantly lower clearing prices on the balancing market, which will directly reduce the level of market prices in other market segments.

Further effective transformation of the energy sector requires the use of all available resources to stabilize electricity prices as soon as possible. In the conditions of economic recession and growing energy poverty, there is a risk that the energy transition may be slower or even stops altogether. Excessive reduction in the margins of enterprises from the energy sector to implement protective measures may slow down the pace of transformation due to the reduction of investment funds. It is also important to recognize potential liquidity problems of enterprises from the energy sector which may occur as a result of the necessity to pay very high collateral on commodity energy exchanges due to high energy prices. The best practice when implementing intervention measures is to introduce regulations for a specified period with the possibility of quick adjustments.

Main challenges facing Poland and PKEE's supporting members in achieving the planned goals

The energy transition in Poland will require ambitious changes in the entire value chain, from electricity generation, through the market, transmission and distribution, and end-user consumption. The implementation of these tasks will require significant investments in many sectors of the economy.

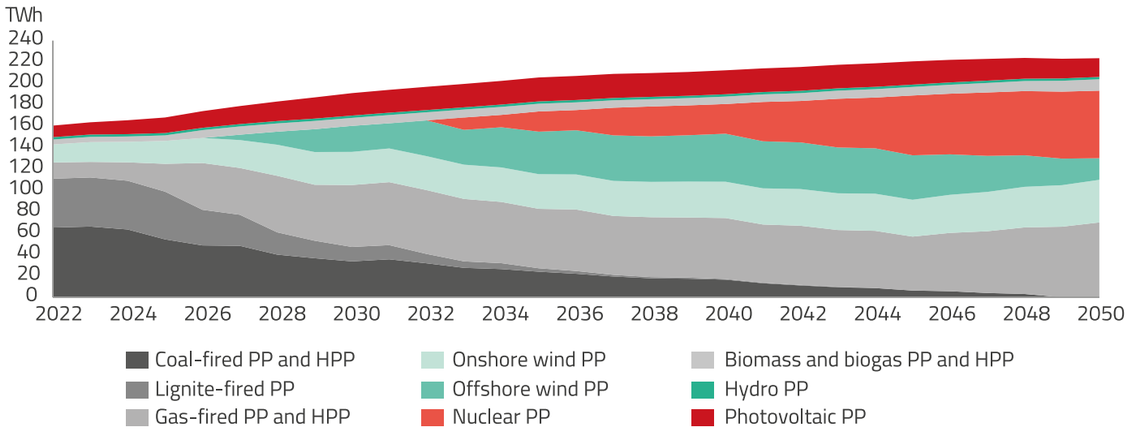
In terms of electricity and district heat generation, a shift away from fossil fuels will require investments in low-carbon energy sources and energy storage supporting the balancing of supply and demand. In addition,

9 https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=uriserv%3AOJ.LI.2022.261.01.0001.01.POL&toc=OJ%3AL%3A2022%3A261I%3ATOC

10 According to the content of the Regulation; those using wind, solar, geothermal, hydroenergy from power plants without reservoirs, biomass, waste, nuclear and lignite, crude petroleum products, peat.

it will also be important to develop natural gas storage facilities, which will secure the supplies of raw material for new power plants fired with this fuel. The generation sector will also have to meet the growing demand for electricity resulting from the electrification of district heating, the use of electric cars or the production of decarbonized gases such as hydrogen. The consequence of these measures will be a complete change in the structure of electricity generation in the coming years.

Fig. 6 | Forecast of electricity production for Poland's baseline demand[11] until 2050



Source: Own study based on the assumptions of the PEP2040 update

Distributed generation and the emergence of significant new generation capacities in the north of Poland, i.e. offshore wind farms, will require investments in transmission and distribution networks to accommodate two-way energy flow.

Energy recipients will be able to support the generation sector by making investments in energy efficiency improvement, demand management and periodic reduction of energy consumption, supporting energy balancing and by acting as prosumers.

Financing the energy transition

According to PEP2040, the value of investment outlays in the production, transmission and distribution of electricity and district heat until 2030 was estimated at 53 bn EUR. Additionally, taking into account the changing market environment, including the rising ambitions of the EU and Poland in terms of the pace of energy transition, these outlays may increase significantly. The estimated costs of the energy transition in the field of electricity, district heating and the necessary protective measures by 2030 may increase to as much as 135 bn EUR[12].

Given the scale of challenges, investments related to the energy transition cannot be implemented only with the use of funds from energy groups and potential investors; they also require support from national and EU funds. Along with its ambitious climate policy goals, the EU allocated funds in its 2021-2027 budget for supporting the energy transition and created mechanisms using funds from the EU emissions trading system (EU ETS). However, support from EU funds will not make it possible to cover the entire investment gap. Therefore, in order to cover the expenditure it will be necessary to, inter alia, search for additional sources of funding at both national and EU levels.

11 Electricity demand without electricity production for hydrogen production. Due to the significant increase in the volume of hydrogen after 2045, the production of electricity from OWFs and PV for the purposes of basic demand decreases while production in gas units using hydrogen (produced from electricity from OWFs and PV) increases. In 2050, it is expected that 30 TWh of electricity will be produced from green hydrogen, the production of which requires additional energy production in RES of about 75 TWh.

12 Own study – assumptions described in more detail in Chapter 7.1.

01
Introduction

1.1 Aims of the report

Conducting a swift energy transition in Poland requires full commitment from all interested parties. Power companies play a crucial role in this process as they are at the forefront of the fuel and energy transition. Transitioning to renewable energy as a main source of power requires a technological reconstruction of the energy sector. Replacement of fossil fuels in transport and district heating with electricity from RES will cause a significant increase in electricity demand.

In recent times, there has been a significant increase in the scale of challenges facing the Polish energy sector. The EU's GHG emission reduction targets for 2030 have been raised from 40% to 55%, which means that the reconstruction of the Polish energy sector must be accelerated. This reconstruction is complicated by the destabilization of the EU emission allowance (EUA), fuel, and electricity markets. From 2021, speculative action has multiplied the results of the European Commission's efforts to keep allowance prices high, which led to a price increase from around 25 EUR/EUA[13] in 2020 to 80-100 EUR/EUA at the turn of 2021 and 2022. Increased demand for natural gas and coal post COVID-19 was met with similar actions on the global market, leading to around a twofold increase in the prices of those resources from July to October 2021. After the Russian invasion of Ukraine and the decrease in the supply of natural gas and coal from Russia prices spiked once again in March 2022. Compared to July 2021, natural gas prices increased more than fourfold, and coal prices almost threefold[14]. These commodity price hikes are affecting energy markets, causing a similar increase. Government action in many countries, including planned freezing or reduction of the prices of natural gas and electricity in, among others, France, Italy, Spain and Germany, as well as at an EU level by implementing a proposed EU Council Regulation 2022/1854 on an emergency intervention to address high energy prices, will most likely lead to a price decrease, but it may take a few years for market prices to stabilize.

The Polish Electricity Association (Pol. *Polski Komitet Energii Elektrycznej*, PKEE), whose supporting members are the largest Polish companies and industry organisations within the energy sector, has developed this report in order to present Poland's achievements in terms of energy transition. Another objective of this report is to familiarize the reader with the scale of challenges facing the Polish energy sector as a result of the implementation of EU and Polish climate and energy policies, and to indicate the impact that the market destabilization will have on the energy transition.

The scope of transformation of Polish energy is much wider and more expensive than in an average EU country. One of the reasons behind it is very specific historical conditions, especially a high proportion of coal in the energy production mix.

1.2 Specific conditions of the Polish energy sector

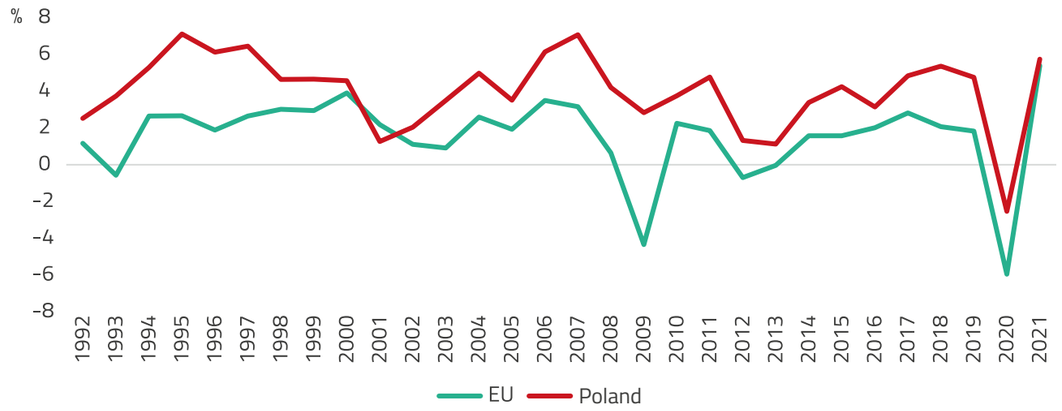
At the end of the 1960s, Poland was still rebuilding its economy after the destruction brought on by World War II. Being in the Soviet sphere of influence and having a limited capacity to cooperate with western countries meant that Poland did not have the conditions for stable, long-term economic growth.

After the geopolitical changes of 1989/1990 and the related economic disruptions they have caused, Poland has had one of the longest periods of economic growth in the world since 1992 – it was the only EU Member State to avoid a recession during the 2008 global financial crisis. Only in 2020, as a result of the COVID-19 pandemic, the Polish economy slowed down significantly, however its recession level was lower than in the whole of the EU. Maintaining a good pace of economic growth for almost two decades

13 1 EUA is equal to 1 t CO_{2eq}.
14 Based on closing indices ARA (ATWMc1) and TTF (TFAc1).

was possible due to, among other things, gradually reaching energy prices that fully cover the material costs of energy. Unfortunately, it had a negative impact on investment financing, and as a result caused a slower pace in the technological reconstruction of the sector.

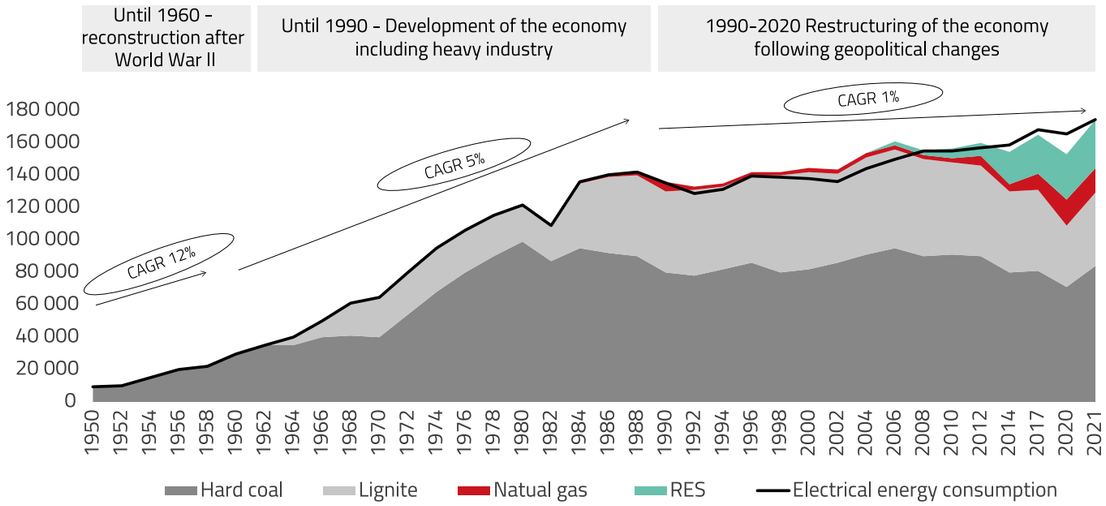
Fig. 1.1 | Polish economic growth compared to the EU (GDP growth) [%]



Source: Own study based on data from EUROSTAT

Despite such hurdles, necessary modernisation required to meet emission standards, improving production efficiency, and lowering network losses were carried out and completed. Improving production efficiency gave rise to a decrease in CO_2 emissions and played a significant role in Poland exceeding the targets set out by the Kyoto Protocol. New technologies were introduced at the turn of the millennium, building combined cycle gas-fired power units with a total capacity of about 800 MW.

Fig. 1.2 | Development of electricity production and consumption in Poland [GWh]



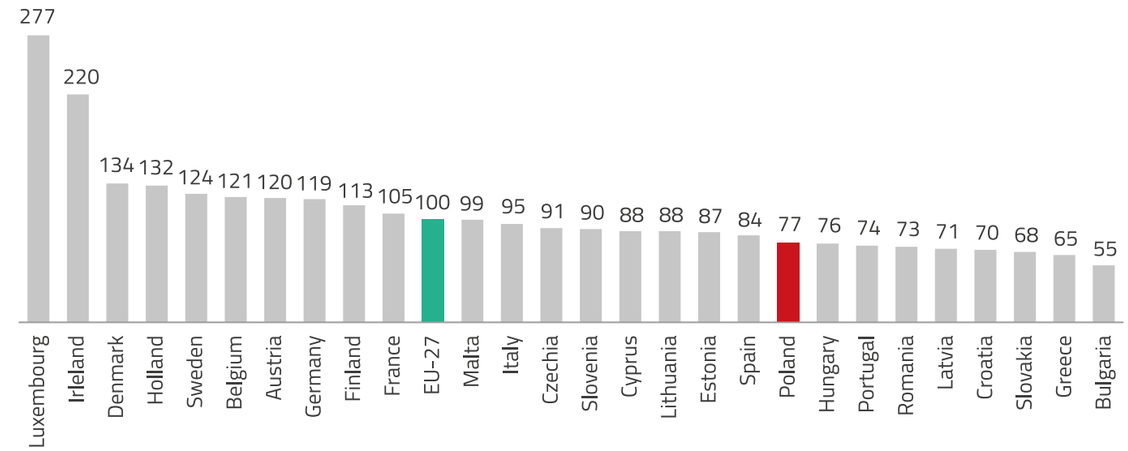
Source: Own study based on data from PSE and ARE

Despite subsequent, large investments in modernisation and development after Poland's accession into the EU in 2004, the historical conditions of the energy sector cause problems to this day in complying with policies and requirements set forth by the EU.

Poland's GDP level is still significantly lower than in Western European countries. In 2020, the GDP per capita in Poland was about 77%[15] of the average value of this indicator across the EU. To achieve a level of economic development at least at the level of the EU average, further rapid economic growth is necessary. The need to abandon imported hydrocarbons, alongside economic growth, will cause a significant increase in electricity consumption despite energy savings resulting mainly from the implementation of measures to improve energy efficiency.

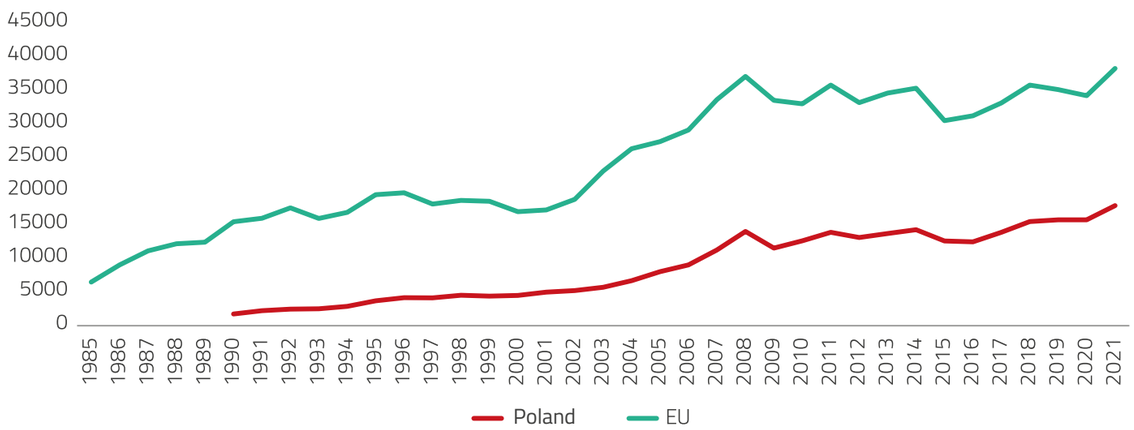
In order to avoid sector barriers to further economic growth, it is necessary to maintain a stable supply of electricity in the required quantities and at acceptable prices.

Fig. 1.3 | GDP per capita in Poland and EU countries GDP per capita (EU27 = 100) in 2021 according to the purchasing power parity of the zloty [PLN]



Source: Own study based on data from EUROSTAT

Fig. 1.4 | GDP per capita in Poland and the EU [USD per capita] at the zloty [PLN] exchange rate



Source: Own study based on data from the World Bank

15 Data from EUROSTAT for 2021 taking into account the purchasing power parity.

The energy sector, despite its small share in GDP (around 4%16), contributes significantly to the economy as a result of the prevalence of energy consumption, and disruptions in energy supply have an enormous impact on the economy. The estimated cost of unsupplied energy in the National Power System (Pol. *Krajowy System Elektroenergetyczny*, KSE) is on average around 6.5 thousand EUR/MWh[17] but can reach up to around 11.7 thousand EUR/MWh[18], and in some sectors the cost can be even greater. These costs can lead to barriers in economic growth, which increases the significance of investment in new production capacity, as well as expansion and modernisation of transmission and distribution networks. For this reason, it is crucial to ensure a stable energy supply at a competitive price in the context of the above average effort, compared to the rest of the EU, that is required to decarbonize the energy sector in Poland.

1.3 PKEE and its role in the transformation of the energy sector

The Polish Electricity Association (PKEE), as an association of the Polish energy sector, has been operating from 1997[19]. Its statutory goal is primarily to propagate knowledge on how the energy sector functions in market economy conditions that follow the rules and procedures of the EU as well as conducting opinion-forming activities for the development strategy of the Polish energy sector and the directions of its restructuring. PKEE, as the leading energy association in Poland, is actively involved in activities and projects which help the Polish energy sector better respond to the challenges of European integration, ensure the security of electricity supply, develop and improve rules that maintain a competitive market, support environmental protection, as well as stimulate the development of modern technologies. PKEE is focused on supporting the development of the Polish energy sector and the country's energy security, while respecting the rules of sustainable development, including environmental and climate protection.

Additionally, PKEE actively supports the energy sector, influencing the formation of rational regulation that allows for development thanks to its expert knowledge, both in Poland as well as in the EU. It is the only organisation that represents the interests of the Polish energy sector in the Union of the Electricity Industry – EURELECTRIC. Seated in Brussels, EURELECTRIC is the largest organisation of the energy sector in Europe. PKEE has been a member of EURELECTRIC since 21 March 2000. Since 2014, PKEE also has its own representatives in Brussels. In Poland, PKEE is an important forum for discussion of the energy industry, it cooperates with public administration bodies and is actively engaged in public consultations on draft legal acts and initiatives that would influence the functioning of the industry.

The companies that support PKEE are some of the largest Polish energy firms: PGE Polska Grupa Energetyczna S.A., TAURON Polska Energia S.A., ENEA S.A. and Energa S.A. as well as three industry organisations: Polish Power Transmission and Distribution Association (PTPiREE, Pol. *Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej*), Polish Power Plants Association (TGPE, Pol. *Towarzystwo Gospodarcze Polskie Elektrownie*) and the Polish CHP Association (PTEZ, Polskie Towarzystwo Elektrociepłowni Zawodowych).

16 Based on data from GUS.

17 the average Value of Lost Load (VoLL) indicator in Poland based on the publication of ACER, Study on the Value of Lost Load of electricity supply in Europe, 6 lipca 2018.

18 The value from the ACER publication is an average value for all sectors of the economy in the entire European Union. According to EY's 2017 study "Analyses for the estimation of the cost of unsupplied energy in the NPS for PGE", this value for the entire Polish economy was 17 740 EUR/MWh. The methodology from the EY report was used by PSE as part of work on the justification for the capacity market, where the value of the unsupplied energy for the upper price range on the balancing market - the result of this study was just over EUR 11 700, which was applied in the Polish regulation.

19 The founding meeting of the PKEE took place on 3 September 1996. The Association was registered in 1997.

PKEE's core business areas are as follows:

EU Regulations

as well as key national regulations in the area of energy – by systematically monitoring and analyzing draft legal acts as well engaging in public affairs activities on the national and EU forum.

Energy security

by conducting activities aimed at creating and maintaining conditions that allow the market to function efficiently, ensuring stable energy supply for the economy and the society while meeting the expectations of consumers, companies in the industry, and government administration.

Energy efficiency

by promoting solutions that improve the energy efficiency of equipment, production units, and networks.

Innovation in the energy sector

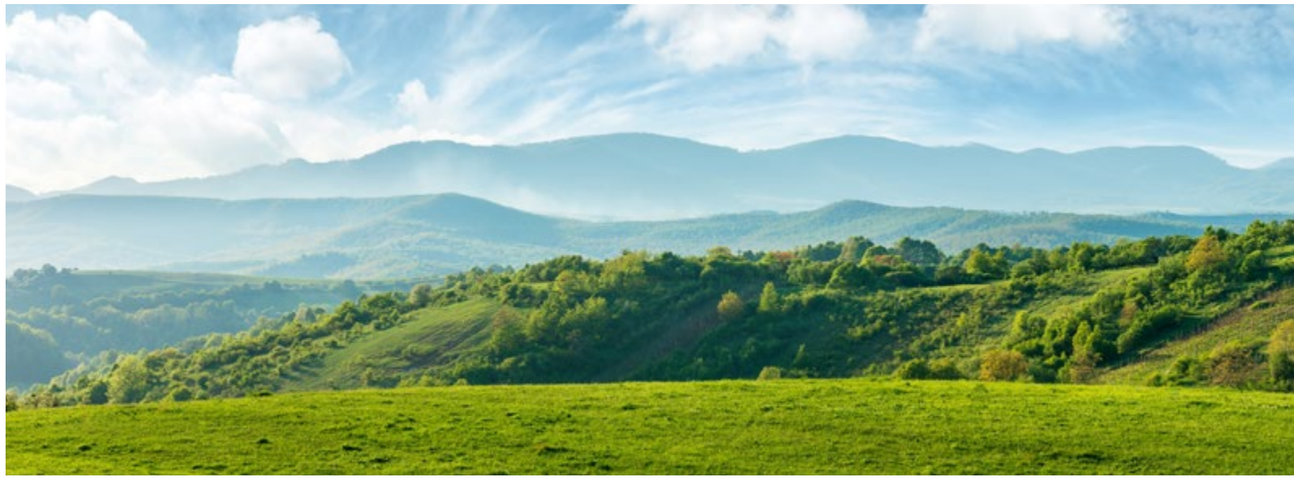
by engaging in analytical and expert work for new solutions such as smart grids, electromobility, energy storage, and utilizing alternate fuels (including hydrogen) in the energy sector.

Investment in RES

by promoting renewable energy solutions and recommending ways to integrate them into the energy system.

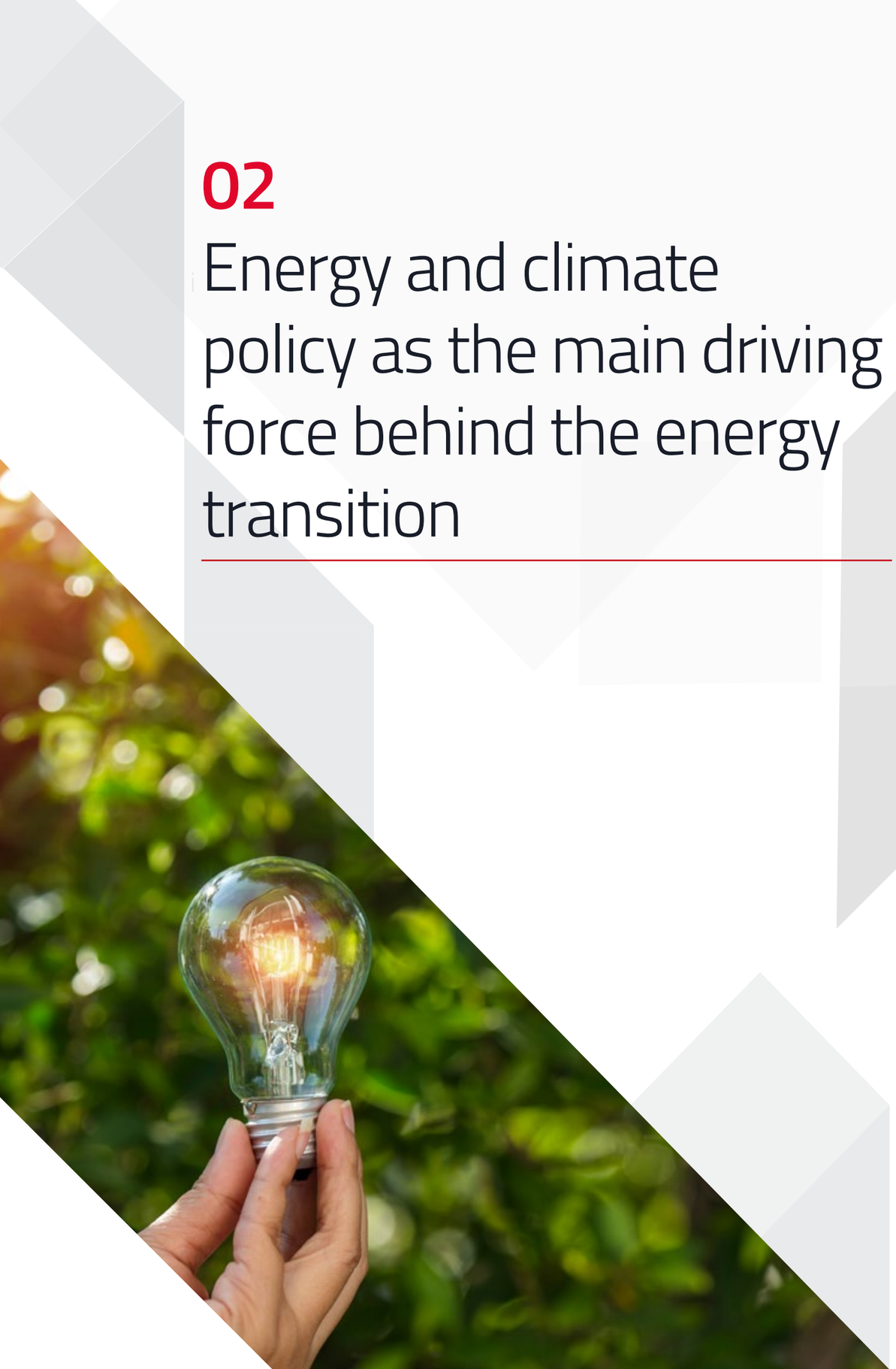
Energy education

by engaging in activities that aim to deepen knowledge and public awareness of key challenges facing the Polish energy sector.



02

Energy and climate policy as the main driving force behind the energy transition



2.1 Policy and global goals

Reducing GHG emissions that are responsible for the phenomenon of global warming is the main goal of the global climate and environmental policy due to the need to reduce the human impact have on the climate.

According to the first report published by the IPCC[20], it is necessary to stabilize the concentration of GHGs in the atmosphere at a level that will guarantee no negative human impact on the climate.

To this end, the UNFCCC was signed in 1992 at a conference in Rio de Janeiro, which setting the main objectives of international cooperation on climate protection. EU became a party to the agreement in 1992, and Poland ratified the UNFCCC in 1994. Initially, the UNFCCC did not contain any binding orders regarding GHG emissions reduction, but over time, in 1997, the first protocol was established, which introduced dimensioned requirements for GHG emissions reduction, also known as the Kyoto Protocol. From that moment, signatories to the UNFCCC were obliged to initiate intensive efforts in the name of protecting the climate.

The Kyoto Protocol imposed a global requirement for GHG emissions reduction by 5% (relative to 1990 levels) between 2008 and 2012 for developed countries. Some countries made a higher commitment, including Poland. The 2012 Doha Amendment extended the validity of the Kyoto Protocol until 2020.

To accelerate efforts that aim to curb climate change, in 2015 at the COP21 summit in Paris, the Paris Agreement[21] was established which obliged all 196 signatories to take further action after 2020 to curb global average temperature increase to 1.5°C relative to preindustrial levels. The Paris Agreement[22] is the first international contract in history which obliges all the world's nations to take action to protect the climate after 2020, and opens a new chapter in global climate policy. The agreement also draws attention to actions resulting from the "Just Transition" concept, outlining the objectives of specific countries in ensuring decent working conditions for people leaving the extractive sectors. Actions that aim to curb GHG emissions will be taken by all parties, while respecting their specificity and socio-economic capabilities.

20 The First Assessment Report, which was the first comprehensive overview of global climate change research, was compiled by the IPCC and published in 1990.

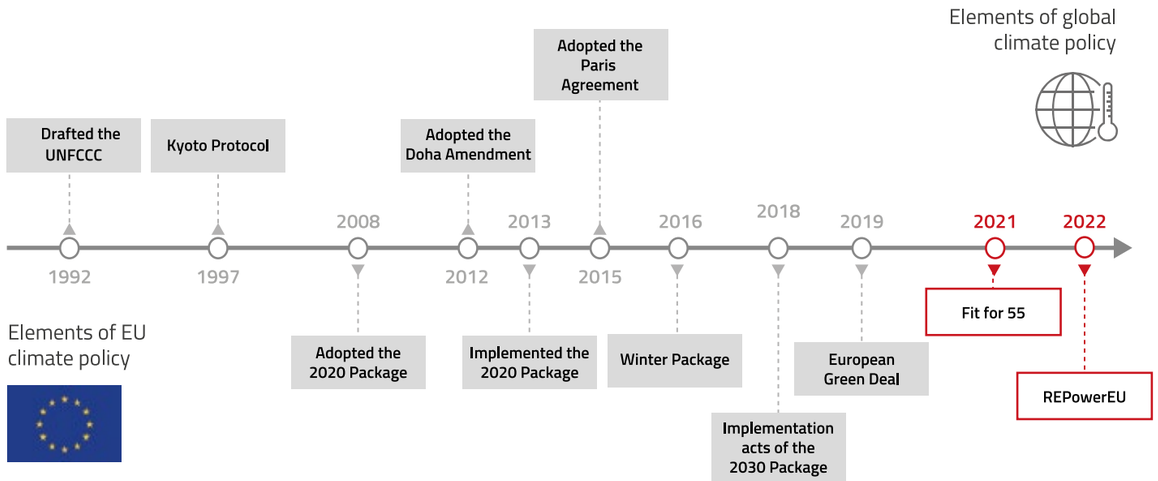
21 To date, the Paris Agreement has been ratified by 180 Parties to the Climate Convention and has already entered into force. Currently, the United States rejects participation in the Agreement, despite earlier ratification in 2016.

22 To date, the Paris Agreement has been ratified by 180 Parties to the Climate Convention and has already entered into force. Currently, the United States rejects participation in the Agreement, despite earlier ratification in 2016.

2.2 EU policies, goals, and regulations

Global resolutions have also had an impact on EU policies. The EU's first climate goals were set in 2007 with a time horizon until 2020. In 2014, the EU established goals for 2030, and the objective of achieving net neutrality by 2050 was established in 2019 in the European Council conclusions and later in 2021 it was added to European Climate Law[23].

Fig. 2.1 | Key elements of climate policy development on the global and EU levels



Source: Own study

2.2.1. EU policies, goals, and regulations until 2020

The climate goals established by the European Council in 2007 were implemented through the regulatory 2019 Climate and Energy Package. At the same time, the European Council adopted several directional measures that aim to increase the security of natural gas and electricity supplies and to reduce EU Member State's reliance on fuel imports, especially natural gas. Unfortunately, the effects of these measures did not produce a significant effect due to the relatively low prices of natural gas and liquid fuels at that time and deeming importing natural gas from Russia as stable.

Table 2.1 | EU climate and energy policy goals until 2020

	GHG reduction	RES	Energy efficiency
Objective:	-20% relative to 1990	20% in final gross energy consumption (binding national targets)	a 20% improvement relative to base scenario forecasts
Including:			
EU ETS	-21% relative to 2005	10% in transport	
Non-ETS	-10% relative to 2005 (national targets from -20% to +20%)		

Source: Own study based on EU regulations

23 Regulation of the European Parliament and of the Council (EU) 2021/1119 of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (European Climate Law).

2.2.2. EU policy, goals, and regulations until 2030

Further climate goals were established for 2030 by the European Council in 2014; they are currently being implemented through the regulatory Climate and Energy Package from 2018-2019, also known as the "Clean Energy for All Europeans" package.

Table 2.2 | EU climate and energy policy goals until 2030

	GHG reduction	RES	Energy efficiency
Objective:	-40% relative to 1990	32% in final gross energy consumption (non-binding national targets)	a 32.5% improvement relative to base scenario forecasts
Including:			
EU ETS:	-43% relative to 2005	14% in transport	
Non-ETS:	-30% relative to 2005 (national targets from -40% to 0%, Poland -7%)		

Source: Own study based on EU regulations

This package introduced new regulations regarding the internal electrical energy market, which aim to accelerate the construction of a common energy market – the Regulation on the internal market for electricity[24] as well as the Directive on common rules for the internal market for electricity[25]. It is important to note that the assumed parallel marketization of energy from renewable energy sources was treated as secondary. A requirement forcing CO_2 emissions below 550 kg CO_2/MWh for generation units taking part in the capacity market was introduced into the Regulation on the internal market for electricity. This practically eliminates coal-fired units from the capacity market starting 2026. In order to replace them, the construction of several, large gas-fired units has begun in Poland.

The 2030 climate targets are in the process of being amended in order to align them with the new path of achieving climate neutrality by 2050, as outlined in the European Climate Law. In 2021, the European Council supported increasing the reduction target from 40% to 55% relative to 1990 levels, which entails an increase in other specific targets. To attain this goal, a new regulatory package was developed, "Fit for 55", concerning reduction and support measures in many areas.

2.2.3. The European Green Deal – Policy, goals, and regulations for the period until 2050

Adopting the targeted goal of climate neutrality by 2050 required a revision of the assumptions of the EU climate and energy policy. In 2019, a package of legislative initiatives of the European Commission (also known as the European Green Deal) was developed and pre-approved. It concerned further development of EU countries, with particular focus on climate and environmental aspects, with the overarching goal of achieving climate neutrality.

The arrangements to increase the GHG reduction target to at least 55% by 2030 are included in the regulation containing the European Climate Law, which was adopted in July 2021. In addition, it included a legal arrangement of the climate neutrality goal in 2050.

24 Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity.

25 Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27 /EU.

Apart from climate goals, the European Green Deal sets goals for restoring biodiversity and the environment, and adjusting the economy to allow for sustainable development. The input that EU Member States have had in accomplishing GHG emission reduction goals, the share of RES in final energy consumption, and energy efficiency improvements is outlined and presented to the European Commission as part of National Energy and Climate Plans.

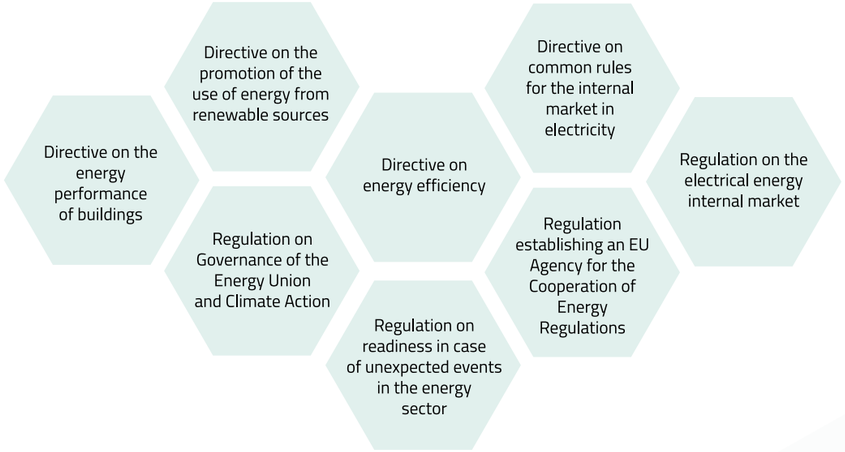
In 2022, the European Commission developed REPowerEU, which was EU's response to the challenges that resulted from the Russian invasion of Ukraine. The plan sets more ambitious goals in terms of utilizing RES and energy efficiency for 2030 than "Fit for 55".

2.2.4. Contents of the recent regulatory packages

"Clean Energy for All Europeans"

One of the main initiatives whose goal is to implement EU objectives pertaining to clean energy provided for in the Paris Agreement is the "Clean Energy for All Europeans" regulatory package. The package is comprised of eight directives and regulations, which were adopted in 2018 and 2019, and it mainly concerns partial objectives for 2030, as well as the functioning of the European electricity market. The "Clean Energy for All Europeans" package also sets a framework for making sustainable decisions and climate action at the EU, national, and local levels, thus contributing to synergies and efficient cooperation in carrying out the plan.

Fig. 2.2 | Directives and regulations of the "Clean Energy for All Europeans" package



Source: Own study based on information on "Clean Energy for All Europeans"

„Fit for 55"

The "Fit for 55" regulatory package was announced in July 2021, and amended in December 2021 with a recast of the Energy Performance of Buildings Directive[26]. It outlines an accelerated energy transition for 2030, which will contribute to the EU's long-term goal under the European Green Deal and implemented under the European Climate Law, and namely climate neutrality in the EU in 2050. Apart from support in accomplishing the goal of GHG emission reductions to 55% in the EU, which was already directly proposed in the European Green Deal, "Fit for 55" outlines more rigorous goals compared to the "Clean Energy for All Europeans" package for 2030. These goals consist in increasing the share of RES in final energy consumption from 32% to 40% as well as increasing energy efficiency at the EU level from 32.5% to 39% in the case of primary energy, and 36% for final energy.

In June 2022, the EU Council adopted negotiating positions concerning legislative changes, among other things, in regards to the EU-ETS mechanism, RES, and energy efficiency, supporting the proposals to raise the targets proposed by the European Commission, including the general targets for improving energy efficiency and the share of RES in final energy consumption. The EU Council also supported the proposition of the European Commission regarding GHG emission reduction in sectors covered by the EU-ETS mechanism by 61% relative to 2005 levels, strengthening the market stability reserve, a one-time reduction in the cap on available emission allowances and increasing the rate of cap reduction by 4.2% per year (also known as the linear reduction factor), and creating a new emissions trading system for the construction and road transport sectors. Additionally, the EU Council's position indicates that in the case of excessive increase in the price of allowances, the mechanism that releases amounts from the reserve will be activated automatically in an intervention mode directly when indicated by price changes.

Fig. 2.3 | Proposals for amending and establishing new directives and regulations prepared as part of the "Fit for 55" package

Source: Own study based on information on the "Fit for 55" package

26 Directive of the European Parliament and of the Council on the energy performance of buildings (recast) (COM/2021/802).

"REPowerEU"

The new geopolitical reality caused by the Russian invasion of Ukraine forced the EU to set new targets in terms of energy security. "REPowerEU" was presented in May 2022, and its main goals are saving energy, diversifying energy supply, and increasing the share of RES in energy production. REPowerEU will also involve actions that aim to change the energy market in order to reduce the number of potential accidents that would require intervention through public funds.

Short-term actions planned under REPowerEU:

- joint purchase of natural gas, LNG and hydrogen under the EU Energy Platform,
- forming new partnerships and cooperating with suppliers of technology and solutions including RES and decarbonized gases,
- rapid development of projects in the field of solar and wind energy combined with the use of hydrogen,
- increase of biomethane production,
- approval of the first pan-European hydrogen project,
- an EU communication to citizens and firms that support gas savings,
- replenishment of gas storage to 80% of capacity by 1 November 2022,
- developing plans to reduce gas demand at the EU level in the event of a disruption in the gas supply.

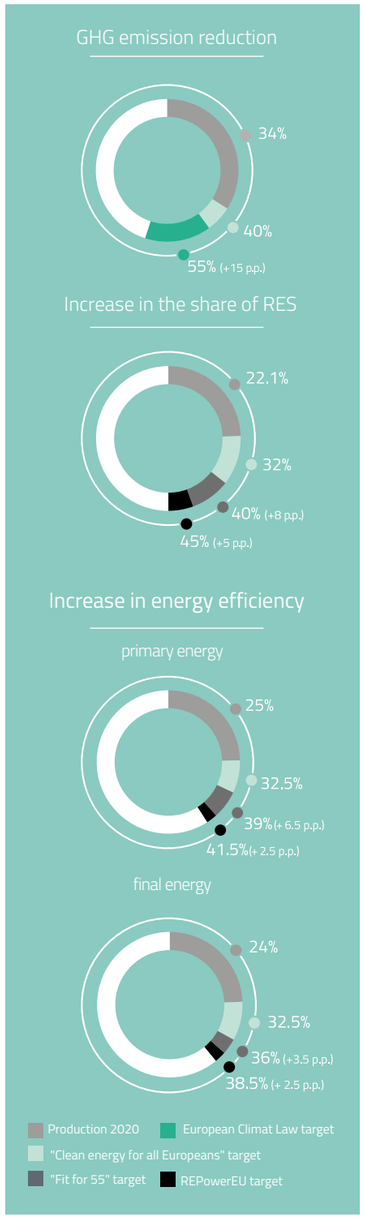
Long-term actions planned under REPowerEU:

- update of the National Recovery and Resilience Plans (NRRPs) taking into consideration the premises of REPowerEU,
- accelerating the decarbonization of industry by utilizing the development fund,
- new regulations streamlining the process of obtaining permits for RES projects,
- investment in an integrated and modern network of gas and electrical infrastructure,
- make the goals included in the "Fit for 55" package more ambitious,
- new EU legislative proposals that will provide industry with access to critical raw materials,
- regulations that are influential towards the improvement of energy efficiency in transport,
- increasing the power of produced electrolysers to 17.5 GW by 2050,
- modern regulatory framework for hydrogen.

REPowerEU modifies the goals included in the "Fit for 55" package, such as increasing the share of RES in energy consumption from 40% to 45% as well as raising energy efficiency at the EU level from 9% to 13% calculated with regards to the new PRIMES 2020 forecast (which translates to an increase from 39% to around 41.5% of the goal in terms of primary energy and from 36% to around 38.5% in terms of final energy with regards to the PRIMES 2007 forecast) by 2030 which contributes to a faster implementation of the premises of the European Green Deal. It also proposes new targets for the development of solar power on top of buildings.

Additional investments results from the implementation of REPowerEU can reach 210 bn EUR, of which 29 bn EUR is to be allocated to investments in power grids, with 113 bn EUR being allocated to investments in RES and hydrogen infrastructure[27].

Fig. 2.4 | Summary of goals resulting from EU regulations until 2030



Source: Own study based on data from EUROSTAT and information and documents of the European Commission pertaining to the "Clean Energy for All Europeans", "Fit for 55", and REPowerEU.

27 Based on information from the European Commission "Financing REPowerEU", May 2022.

EU Taxonomy

The EU Taxonomy is a supporting element of the implementation of the energy and climate policy. It was established through the 2020 regulation[28] and related delegated acts[29]. Its purpose is to facilitate the evaluation of investments in terms of sustainable development and thus channeling funds to investments that meet the criteria in this respect. Qualifying investments for activities specified in the EU Taxonomy will have a significant impact on the financial sector, companies subject to non-financial reporting, and those using the taxonomy voluntarily by clearly illustrating the involvement of enterprises in 6 sustainable development goals:

1. mitigating climate change;
2. adapting to climate change;
3. sustainable use and protection of water and marine resources;
4. transition to a circular economy;
5. preventing and controlling pollution;
6. protection and restoration of biodiversity and ecosystems.

In terms of climate change mitigation, it is, among other things, activities that increase the use of RES, improve energy efficiency, and create infrastructure that supports the decarbonization of energy systems that are included in the activities of the EU Taxonomy. As part of the 2022 supplementary delegated act, selected activities in the field of nuclear energy and natural gas energy production were also qualified for sustainable development activities (the provisions of the supplementary delegated act will enter into force on 1 January 2023).

2.3 National policy and targets

The implementation of national climate policy is determined by Poland's strategic documents. The main strategic document of the energy sector is the Energy Policy of Poland, which is periodically updated to take into account new challenges of the sector in subsequent time horizons.

2.3.1. Energy Policy of Poland until 2040

The current Energy Policy of Poland until 2040 (PEP2040) was adopted on 2 February 2021, thus replacing the Energy Policy of Poland until 2030 adopted in 2009. This document sets strategic directions for the transformation and further development of the energy sector in the 2040 perspective.

Due to the current geopolitical situation, an update of PEP2040 is planned for 2022 aimed at energy sovereignty and acceleration of the energy transition. Currently, only the main assumptions of the PEP2040 update are known, and according to the government's announcements, the document should be published at the turn of 2022 and 2023.

Main assumptions of the development of the energy sector in Poland

According to PEP2040, the goal of developing the energy sector in the 2040 perspective in Poland is maintaining energy security, while ensuring the competitiveness of the economy, energy efficiency, and reducing the environmental impact of the energy sector, all while taking into account the optimal use of own energy resources.

The implementation of the energy transition in Poland is to take place on the basis of 3 main pillars and 8 cross-field specific objectives.

28 Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.

29 Including Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 on technical qualification criteria for major sectors of the economy and Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 on the inclusion of nuclear energy and gas in taxonomy.

Fig. 2.5 | Pillars and specific objectives of PEP2040

1 Just transformation	**2 Zero-emission energy system**	**3 Good air quality**
Development of energy markets		
Development of district heating and cogeneration		
Optimal use of own energy resources	**Development of electrical energy production and network infrastructure**	**Improvement of energy efficiency (as a result of the positive impact of activities aiming to do so)**
Improving energy efficiency (in the context of bottom-up activities)	**Diversification of supplies and expansion of the network infrastructure of natural gas, crude oil and liquid fuesl**	
Implementation of nuclear energy		
Development of renewable energy sources		

Source: Own study based on the Energy Policy of Poland until 2040

As a result of changes in the market environment, especially after the Russian invasion of Ukraine, a plan to revise PEP2040 was announced. A fourth pillar will be added to the existing three pillars – energy sovereignty, which consists in, among others, quickly making Poland independent from fuel imports from the Russian Federation. Activities in the remaining pillars are to be accelerated, supporting Poland's energy sovereignty. The assumptions of the update are described in Chapter 4.1.

2.3.2. Poland's goals until 2030 results from the implementation of the "Clean Energy for All Europeans" package

The directives and regulations of the "Clean Energy for All Europeans" package do not explicitly indicate national contributions to achieve 2030 targets at the EU level. These contributions are determined at the national level and are presented to the European Commission, which ensures compliance of national targets with those set at the EU level.

The preparation and presentation of the National Energy and Climate Plan (NECP) in December 2019 fulfilled the obligation imposed on Poland by the provisions of the Regulation on the governance of the energy union[30]. The NECP presents national measures for the implementation of the EU climate goals, policies, and actions within 5 pillars of the energy union:

1. decarbonisation,
2. energy efficiency,
3. energy security,
4. internal energy market,
5. research, innovation, and competitiveness.

The NECP replaces previously developed sector documents such as the National Energy Efficiency Action Plan (NEEAP) and the National Renewable Energy Action Plan (NREAP) by combining and expanding the scope of these studies and was prepared on the basis of strategic documents, including draft PEP2040.

In accordance with the requirements of the regulation, NECP is to be periodically updated and presented to the European Commission along with an indication of achieved goals.

Poland's contribution to the implementation of the EU's goals from the Energy and Climate Package was proposed in the NECP, which was submitted to the European Commission. The NECP was created earlier than the proposals of the "Fit for 55" package and REPowerEU, thus it does not take into account the increased targets at the EU level.

In terms of sectors covered by the EU ETS, as in the previous period, the target of GHG emissions reduction at the EU and national levels is achieved through market mechanisms. As regards the reduction of GHG emissions from non-ETS sectors (i.e. sectors not covered by the emissions trading system), the target was declared at -7% in 2030 compared to the level in 2005.

In terms of renewable energy sources, Poland has declared that it will achieve a 21-23% share of RES in gross final energy consumption in 2030, with a higher value being possible if additional funds are allocated by the EU for just transition. Both in district heating and power sectors, this share is planned at a higher level of over 28% and around 32%, respectively.

In terms of energy efficiency, the national target has been declared at a 23% reduction in primary energy consumption compared to the PRIMES 2007 forecast, which translates into the target of achieving domestic primary energy consumption at approximately 91.3 Mtoe in 2030. For final energy the target was defined at 21.5% reduction in relation to the final energy consumption compared to the PRIMES 2007 forecast, which translates into the target of achieving domestic final domestic energy consumption at approximately 67 Mtoe in 2030.

30 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

Energy and climate policy as the main driving force behind the energy transition – summary:

Global and European policy in regards to the impact of the energy sector on climate change aims to achieve the ambitious goal of energy neutrality. For the EU, this goal is planned for 2050.

Acceleration of the pace of energy transition assumed in REPowerEU is driven by the need to increase the EU's energy independence.

The ambitious reduction targets of the of the EU climate and energy policy until 2030 constitute a challenge for the Polish economy and will require significant financial outlays.

The legal framework established in Poland for the operation of the energy sector is in line with requirements of international law, EU regulations, and Poland's obligations under signed international agreements.

03

Implementation of climate policy in Poland, including the activities of the Polish energy sector

Despite a large share of energy sources using high-emission fuels for energy production, mainly hard coal and lignite, the Polish energy sector is gradually and consistently increasing its share of energy generated from low- and zero-emission sources, and therefore the carbon intensity of energy production in Poland is steadily decreasing. The reduction of GHG emissions in electricity and heat generation sectors from 1988 to 2020 was 47%, and in the last 10 years 20%[31], overachieving all targets under international obligations. Such a significant reduction in emissions required many changes, including political and economic ones (e.g. departure from centrally planned economy, dismantling monopoly, introducing competition elements) and the modernisation of most coal units to increase energy efficiency and investments in less carbon-intensive technologies (mainly gas-fired CHP plants and RES).

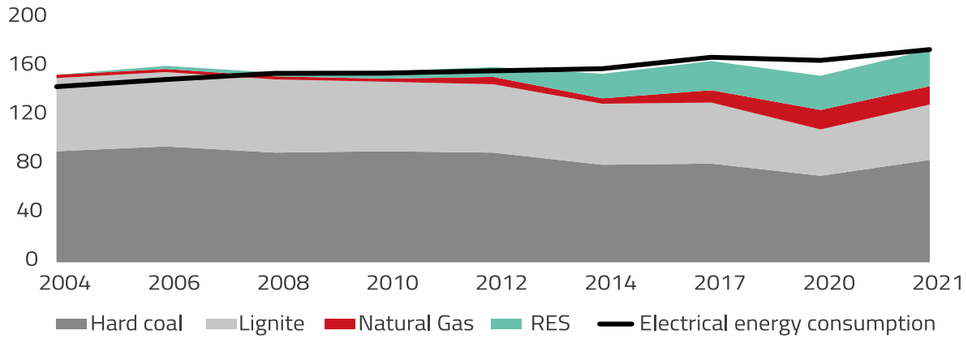
3.1 Transformation of the Polish energy sector

3.1.1. Electricity production from 2005 to the end of 2021

Since 2005, Poland has consistently carried out activities aimed towards RES development that were stimulated by dedicated support systems (green certificates, auction system, FiTs and FiPs, etc.), generating additional revenues for producers and the development of prosumer energy, while enabling a stable increase in the share of RES in electricity generation.

The 2010-2020 decade saw the beginning of intensive development of gas technologies used in both commercial and industrial power industries. The level of electricity production from gas units increased more than 3 times in this period. In the commercial energy sector, the production of electricity from natural gas increased by approximately 66%[32]. The occurrence of the COVID-19 pandemic in 2020 had a significant impact on the level of consumption, and consequently, the level of electricity production. Due to market conditions, the level of production from RES remained relatively constant with a simultaneous decline in electricity production from conventional units.

Fig. 3.1 | Development of electricity production and consumption in Poland [TWh]



Source: Own study based on data from PSE and ARE

31 Based on data from EUROSTAT.
32 Based on data from ARE.

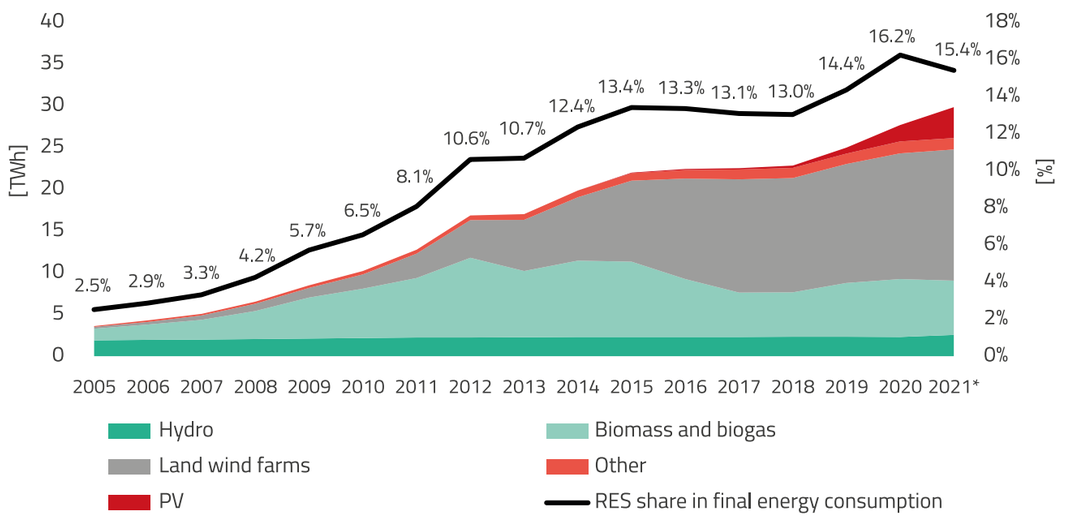
3.1.2. Development of renewable energy sources and low-carbon sources

The introduction of the green certificate scheme led to rapid growth of RES, which exceeded the rate assumed by the National Renewable Energy Action Plan. From the introduction of the system until the end of 2020, the amount of produced energy certified with green certificates amounted to approximately 226 TWh – almost half of which was from wind installations[33].

To enable the development of other, more expensive technologies, an auction-based support system was introduced in 2015, which by the end of 2020 led to the contracting of almost 210 TWh (in contracts for difference for a period of 15 years).

In total, by the end of 2021, the level of electricity production from RES in Poland increased to approximately 30 TWh[34].

Fig. 3.2 | Development of electricity production from RES



* Estimation based on data from ARE - possible correction when new data is published by Eurostat

Source: Own study based on data from EUROSTAT

The consistent development of renewable energy technologies and the impact of the COVID-19 pandemic on total electricity consumption in 2020 contributed to the achievement of the required RES target with a surplus of approximately 1% beyond the target for Poland.

In 2021 and 2022, the photovoltaic (PV) sector in Poland developed very rapidly, in particular in the field of prosumer energy. Between December 2020 and July 2022, the installed capacity of prosumer PV installations increased almost threefold[35] as a result of implementation of dedicated support programs such as "Mój Prąd" (Eng. "My Electricity").

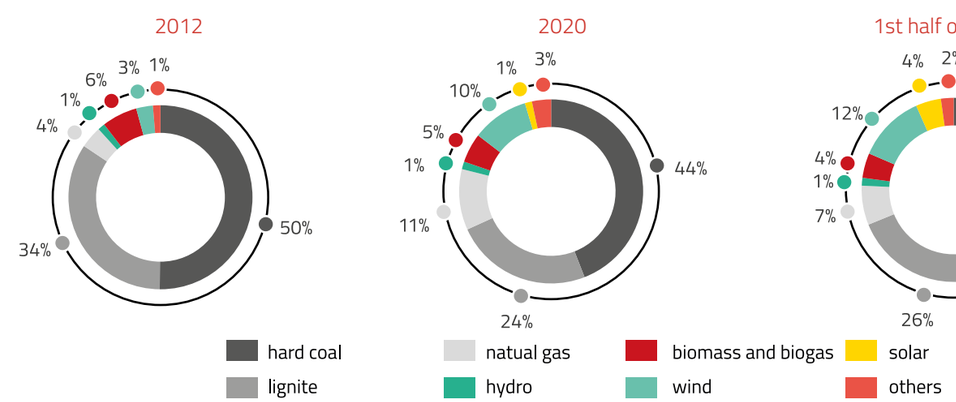
The share of natural gas in electricity production also increased due to, among others, new gas and steam units in the suburb of Żerań in Warsaw with a capacity of almost 500 MWe, in Włocławek with a capacity of over 450 MWe, in Płock with a capacity of almost 600 MWe, and in Stalowa Wola with a capacity of over 450 MWe. Additional gas units are under construction – CCGT Ostrołęka with a capacity of 745 MW, two units at Dolna Odra power plant with a total capacity of 1340 MW, and a gas and steam unit with a net capacity of approx. 560 MW in Grudziądz.

High-efficiency cogeneration utilizing natural gas is intended to act as a transitional solution in the heating sector, which in the short term allows to reduce GHG emissions in relation to the use of solid fuels while contributing to the status of being an efficient heating system, and in the future it may be replaced by decarbonized gaseous fuels, or use carbon capture and storage/carbon capture and utilization technologies (CCS or CCU), implementing the target of climate neutrality. With regard to large heating systems, the construction of high-efficiency gas-fired cogeneration units remains a realistic and accessible solution due to weather conditions, as well as high power and temperature, which precludes, for example, the use of RES on a large scale.

In 2022, due to the limited availability and the rising cost of gas, its use is limited in favour of coal-fired units, and the previously planned pace of investment in new capacities may be limited in order to maintain security of supply.

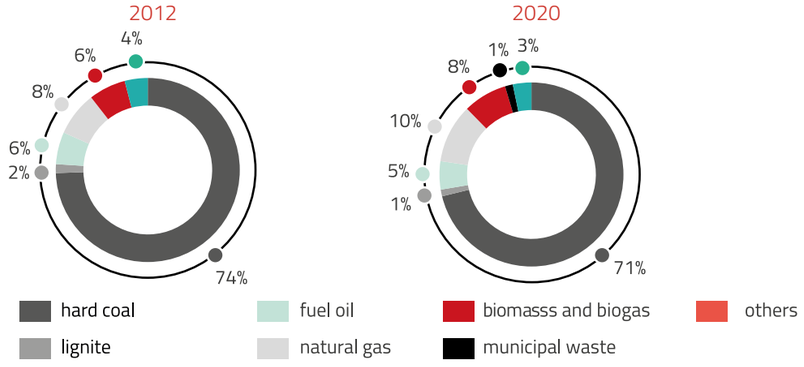
Additionally, the process of shutting down depleted coal-fired units is also observed. An example can be the investment in Adamów, Konin and Pątnów Power Plant Complex (Pol. *Zespół Elektrowni Adamów Konin and Pątnów*, ZE PAK), which started production from another biomass unit with a capacity of 50 MW (the first unit also had a capacity of 50 MW), created as a result of conversion of a coal-fired boiler to a biomass powered one, as well as the modernisation of its condensing turbine to cogeneration.

Fig. 3.3 | Share of energy carriers in electricity production in 2012 and 2020 and the first half of 2022



Source: Own study based on data from ARE and GUS

Fig. 3.4 | Share of energy carriers in the production of district heating in 2012 and 2020



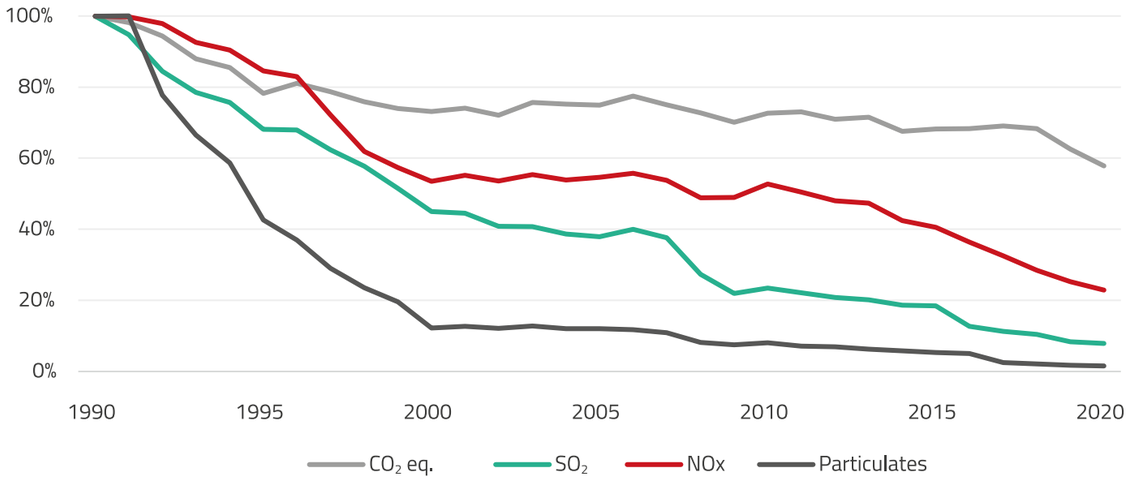
Source: Own study based on data from URE

33 Based on data from URE.
34 Based on data from ARE.
35 Based on data from ARE.

3.1.3. Reduction of GHG emissions and air pollution

After 2000, the modernisation of generation units continued, in particular with regard to further reduction of SO_2 and NOx emissions, this time in order to meet EU emission standards, effective from 1 January 2008. Poland used derogations that delayed the effective date, which allowed the country to spread the costly investments over several additional years. The BAT Conclusions contained another tightening of requirements which entered into force from mid-2021. Polish units benefited from the 2-3 year derogations only in a few cases. Another review of the best technologies and further tightening of emission restrictions are scheduled for the second half of the 2020s. Emission restrictions can also be tightened based on the current BAT Conclusions, which include lower and upper values. Current limits are based on the lower value, but initiatives are in place to recognize the upper values as the minimum.

Fig. 3.5 | Changes in emissions resulting from electricity generation in Poland relative to 1990 levels [%]



Source: Own study based on data from KOBIZE and EUROSTAT

3.2 Achievement of Polish goals resulting from the Climate and Energy Package

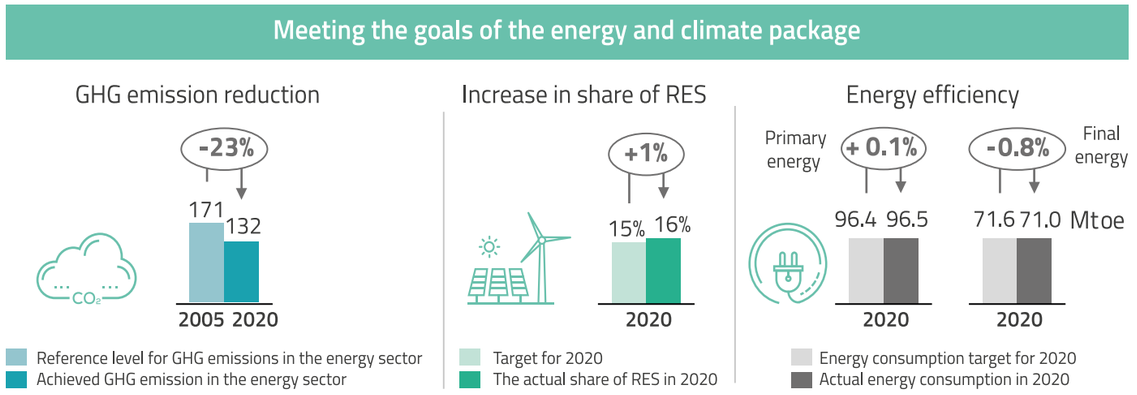
3.2.1. Achievement of Polish goals resulting from the Climate and Energy Package for 2020

The transformation of the electricity sector made it possible to meet the targets set out for Poland in the energy and climate package in terms of reducing GHG emissions, increasing the share of renewable energy sources in final energy consumption and the value of final energy consumption, and in the case of primary energy, the achieved value differed by less than 1% from the assumed target. The RES share target was met with a surplus of over 1%, largely due to generation from onshore wind farms. The goal of reducing GHG emissions was achieved thanks to changes in the energy mix, shifting it towards renewable and low-carbon sources.

The implementation of support programs, mainly White Certificates and improvements in the efficiency of energy production and distribution, including an increase in the use of cogeneration and the modernisation of heating networks, contributed to meeting the goal of increasing energy efficiency.

The achievement of all goals was also influenced by the COVID-19 pandemic, which resulted in lower energy demand.

Fig. 3.6 | Poland fulfilled the 2020 goals resulting from the Energy and Climate Package



Source: Own study based on data from EUROSTAT

3.2.2. Implementation of Polish goals resulting from the Energy and Climate Package for 2030

The activities carried out from 2020 to mid-2022 aimed at meeting the RES target include the implementation of prosumer energy support programs, including the "My Electricity" program, enabling the development of PV installations to the level of over 10 GW by June 2022[36]. Especially in this respect, it is worth noting the enormous progress in the added plant capacity. Additionally, renewable energy projects are also being developed in the field of offshore and onshore wind, supported by an auction-based system and contracts for difference.

The implementation of the 2030 energy efficiency target is supported by an amendment to the Energy Efficiency Act of 2021, which, among other things, (i) extends the number of obligated entities under the energy efficiency certificate system to include the liquid fuels sector, and (ii) simplifies the regulation of the development of market mechanisms for the implementation of energy

36 Based on data from ARE.

efficiency improvement projects (e.g. EPC contracts[37]).

In the sectors covered by the EU-ETS, in order to reduce GHG emissions, in addition to the integration of renewable energy sources, activities to move away from fossil fuels are being accelerated, including the implementation of the provisions of the Social Agreement on the Transition of the Hard Coal Mining Sector and Selected Transition Processes in the Śląskie Voivodeship, which was signed in May 2021.

3.3 Selected "green" projects completed by PGE, TAURON, ENEA, ENERGA

By 2020, PKEE entities have completed many projects that support the transformation of the sector in the areas of electricity and heat generation, as well as power grids. Selected projects with the greatest impact on the energy sector are listed below.

Lotnisko Wind Farm

Lotnisko wind farm consists of 30 Alstom Eco 110 wind turbines with a unit capacity of 3.0 MW, a rotor diameter of 110m, and a height of 90m. The total capacity of the wind farm is 90 MW. As part of the investment, a LV/110 kV transformer station was built, which was connected to GPZ Żarnowiec using a HV cable line with a length of about 40 km.

Investment outlays	Implementation time
83.7 mln EUR	2014 – 2015

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Average annual production of green energy	**187 500 MWh**
CO_2 emissions avoided*	**152 250 tonnes**

* Estimated value determined on the basis of the emission from other sources in KSE

Distinctive aspect

- Lotnisko WF is the first wind farm that provides, on behalf of PSE, regulatory system services (ARNE). The wind farm can affect the voltage of the substation through the regulatory capacity of its wind turbines in the range of passive power.
- 40 km of connections took place largely through the railway track area, which made the investment very demanding.

Other benefits

One of the largest currently operational wind farms in Poland.

Location

37 EPC (Energy Performance Contract) – contract for the improvement of energy efficiency.

Reduction of air pollutant emissions in the center of Gorzów Wielkopolski

The project was carried out by the City of Gorzów Wlkp. and PGE GiEK S.A. The aim of the project was to reduce the emission of air pollutants: PM10 dust and benzoaprene through the modernisation of high-emission coal heat supply systems in the area with exceeded permissible levels of pollution in Gorzów Wlkp.

Investment outlays	Implementation time
16.5 mln EUR	2015 – 2017

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Annual reduction of the amount of coal burned	**16 700 tonnes**
CO_2 emissions avoided*	**17 520 tonnes**

Distinctive aspect

The project was implemented in partnership between the local government and PGE, using NFOŚiGW funds.

Other benefits

Reducing the exposure of the population on the impact of air pollution in the zones in which permissible standards of air quality was exceeded, the liquidation of 2,927 heat sources in residential buildings (coal and waste tiled stoves), and connecting these buildings to the heating system occurred.

Location

Purchase of five wind farms with a total power of 180 MW

For 137 million euros, TAURON purchased five wind farms with a total power of 180 MW. Thanks to the investment, the group almost doubled its installed capacity in wind technology in 2019. Thanks to the takeover of wind farms, TAURON was (in 2019) in second place among Polish energy groups in terms of installed production capacity from onshore wind farms. All farms are connected to a high or medium voltage network.

Investment outlays

137 mln EUR

Implementation time

2019

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Annual production of green energy	**480 000 MWh**
CO_2 emissions avoided	**130 000 tonnes**
Development of new RES	

Distinctive aspect

- The largest acquisition of renewable energy assets in the TAURON Group.
- Increasing the installed capacity in RES, diversification of energy sources in the TAURON Group.

Other benefits

Development of the knowledge and culture of climate responsibility of employees and suppliers through involvement in the project.

Location

VPP – RES and energy storage system integration platform

The aim of the project was to develop a platform that allows you to aggregate the production and regulatory potential of dispersed renewable energy and energy containers as well as selected categories of DSR.
The developed VPP platform will become a tool that will allow you to extend the catalog of currently provided services and allow you to increase the volume of the available power of manufacturing sources.

Investment outlays

Research and development project co-financed by the National Center for Research and Development

Implementation time

2017 – 2020

The benefits achieved from the implementation of the goals of the EU climate and energy policy

- Currently the platform support almost **70 MW** of installed RES power, an increase of approx. **350 MW** is planned by the end of 2023;
- Increasing the economic efficiency of renewable energy sources, increasing the attractiveness of investments and operation.

Distinctive aspect

A platform that allows:

- Centralized and coordinated production management of dispersed renewable energy, energy storage and consumption of selected categories of control receivers,
- Controlling the work of individual elements of renewable energy infrastructure using distributed architecture and artificial intelligence.

Other benefits

- Increasing the availability of renewable energy - remote control, planning of technical procedures in optimal periods.
- Improving the quality of forecasting and planning the production of hydropower, wind and photovoltaic sources.
- More effective adjustment of production profiles to planned contract positions - an increase in the economic efficiency of production, while reducing the resources necessary for technical and commercial service.
- The ease of implementation of subsequent business models giving the possibility of adaptation of services to market challenges

Location

The area of activity of TAURON Ekoenergia S.A.

Construction of an intelligent electricity network in the area of ENEA Operator's activities

The implementation of the project involves the construction of an intelligent electrical network in the area of ENEA Operator Sp. z o.o. by modernising and rebuilding the network, through automation of lines and stations as a result of the use of remote control and power automation, including short-circuit currents. The project also includes the installation of intelligent meters at the electricity consumers.

Investment outlays	Implementation time
55 mln EUR	2017 – 2023

The benefits achieved from the implementation of the goals of the EU climate and energy policy

- development of RES, including prosumer energy, and eliciting rational use of electricity in consumers
- decrease in GHG emissions
- possibility to limit investments in peak system power (including fossil fuels)

Distinctive aspect

As a result of the implementation of Smart Grid projects, new functionality of intelligent power infrastructure will be implemented:

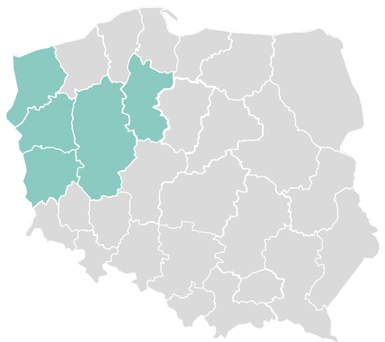
- real time network load monitoring with visualization,
- automatic error identification (together with a repair system)

Other benefits

- SAIDI index decrease – shorter interruptions in electricity supply
- Possibility to reduce network losses
- Increase in connection possibilities resulting directly from the nature of the Smart Grid network. The creation of smart energy grids will help stabilize the supply by using renewable energy and attempting to limit the process of climate change.

Location

Areas of activity of ENEA Operator Sp. z o.o.



Increasing the potential of the ENEA Operator power network to receive energy from renewable energy

The aim of the project is to increase the possibility of connecting sources of renewable energy electricity by building new and reconstructing the existing power network, while maintaining the parameters of energy supplied and minimizing the risk of failure and interruptions in energy supply (significant barriers to the development of renewable energy will be lifted).

Investment outlays	Implementation time
57 mln EUR	2016 – 2023

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Additional ability to connect RES to the network	**422 MW**
CO_2 emissions avoided	**990 504 tonnes**

Distinctive aspect

As a result of the implementation of Smart Grid projects, new functionality of intelligent power infrastructure will be implemented:

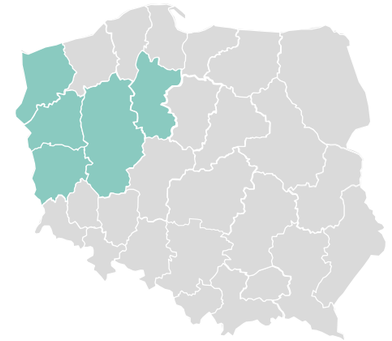
- dynamic reconfiguration of the network to optimize functioning,
- active and passive flow control (including control of distributed sources).

Other benefits

- The conditions for supplying consumers that are in the range of network infrastructure covered by the project will improve.
- Moreover, part of the investment entails the conversion of overhead lines into cable lines, as well as the use of advanced network automation technologies, enabling the reduction of the risk of damage to power infrastructure
- In the face of more and more frequent weather anomalies, these modernisations will significantly affect the reliability of electricity supply, while increasing safety for the health and life of bystanders and the environment.

Location

Areas of activity of ENEA Operator Sp. z o.o.



Construction of a demonstration project for the application of a security automation system in Poland

The aim of the project was to build and conduct research related to the energy storage facility (6 MW) connected to an operating Wind Farm. The project was implemented by Energa OZE S.A. (currently Energa Wytwarzanie) in cooperation with PSE S.A., Japanese NEDO agency and Hitachi & Hitachi Chemical companies.

Investment outlays	Implementation time
Sensitive data	2017 – 2020

The benefits achieved from the implementation of the goals of the EU climate and energy policy

The development of similar hybrid installations in the future will allow for the stabilization of electricity generation in non-controllable RES, which, from the point of view of the power system, may make it possible to resign from investing in conventional generation units whose task is to balance RES production.

Distinctive aspect

Acquiring unique knowledge on the impact of electricity storage connected with RES on the operation of the Polish Power System.

Other benefits

Acquiring unique knowledge on the impact of electricity storage connected with RES on the operation of the Polish Power System and the ability to control the operation of Wind Farms connected to the transmission grid.

Location

Przykona Wind Farm

The construction of a wind farm with a capacity of over 31 MW is an example of an idea for the use of reclaimed post-mining areas (lignite mining, Turkish poviat). The total area of approx. 300 ha of land after the former Adamów lignite mine has the potential to host a large-scale renewable energy installation, using various electricity generation technologies, with different availability and operating characteristics.

Investment outlays	Implementation time
35.5 mln EUR	2019 – 2020

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Average annual production of green energy **75 000 MWh**

Distinctive aspect

Use of land inaccessible to other types of investments, development of post-mining areas related to the regional energy transformation.

Other benefits

The project is a part of a planned RES Center which is to be created on a recultivated area of lignite open pit mine.

Location

3.4 Implementation challenges of the transformation – increase in CO_2 emission allowance and natural gas prices and the related market disruption

The transition of the Polish energy sector takes place in difficult conditions. In addition to the invariable historical burdens, in recent years there have been problems related to the excessive speculative influence on the EUA, fuel, and electricity markets. The EUA market has a system for influencing prices through the Market Stability Reserve (MSR) mechanism, some allowances may be withdrawn from the market at low prices or introduced at high prices. The EU regulations lay down very strict criteria for intervening to reduce EUA prices, which makes the mechanism practically useless in times of rising prices. The fuel market is a global market which makes it very difficult to introduce stabilization measures. Despite the very mature regulations in the area of climate and energy policy and the technical aspects of its operation, emergencies (such as pandemics or war) still show the important role of the Member States and rapid interventions, which are rarely undertaken at the EU level and most often with a long delay.

Almost all competitive energy (and other commodity) markets operate according to the marginal cost pricing model, i.e. the price is determined by the costs of the balance closing unit during the trading period. According to the model, in the short-term energy market (SPOT), these are the variable costs of energy from the unit closing its balance sheet in a given hour or shorter period. In the medium-term market, it should be the operating costs of energy from the unit closing the balance sheet in a given year, at full long-term costs. In practice, the prices on the SPOT market have the greatest impact on energy prices. Nowadays, with an almost complete change in manufacturing technology, with a very wide rollout of units with low or no variable costs, it is fairly easy to use the market to make a very high, unjustified profit (windfall profit).

The experience of the last few years have raised some very serious questions regarding the need to introduce additional regulation in the energy market, or the need for market segmentation. One of the potential answers for the EU market lies in the solutions used in the USA, especially the PJM market area (Pennsylvania, New Jersey, and Maryland). Nevertheless, there are many worldwide examples of solutions to problems resulting from direct competition between technologies with high variable costs and technologies with near-zero variable costs and/or with high subsidies.

CO_2 emission allowances

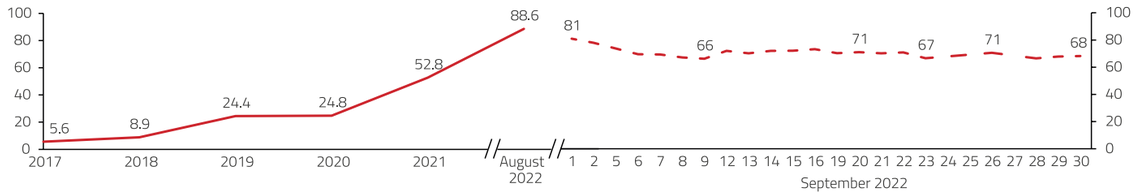
The first market shock in this regard occurred in 2018-2019, when wholesale electricity prices rose by approx. 70% due to an almost threefold increase in prices for CO_2 emission allowances (from approx. 7 EUR/EUA to over 20 EUR/EUA) - mainly as a consequence of activities related to the so-called "Back-loading". The resulting price shock on the energy market prompted the government to intervene by adopting a law which forced retail companies to freeze retail prices in 2019 at the level of 30 June 2018. Despite compensations, this intervention caused market disruption, and PGE and ENERGA reported a financial loss as a direct consequence of enforcing the law. It may also be important that, since 2018, emission allowances are treated as a financial instrument due to the entry into force of the provisions of MiFID II (Markets in Financial Instruments Directive[38]), which recognized CO_2 emission allowances as financial instruments, which significantly increased the input of financial institutions and intensified speculation on the market. Another factor in this respect was the market sentiment as a result of the European Council's decision to adopt the 2050 climate neutrality target.

The high ceiling of prices of CO_2 emission allowances at the level of 25-30 EUR/EUA, which was also achieved in 2019 and remained on the market in the first two months of 2020. Then, as a result of the slowdown in economic activity caused by the outbreak of the COVID-19 pandemic, it fell to around 20 EUR/EUA between March and May 2020, which also resulted in a moderate reduction in wholesale electricity prices. Nevertheless, in the second half of 2020, the increases in CO_2 emission prices returned, reaching the 2019 peaks at the end of the year. In this period, coal-fired power plants (accounting for approx. 70% of total production) were the generation technology driving the price of electricity on the market on the basis of marginal costs, and the main reason for their increase was the increase in the prices of EUA emission allowances. The increase in EUA prices resulted from the implementation of the EU climate policy, the entry into the so-called Phase IV of the EU ETS (under which, among others, the linear reduction factor of the total amount of emissions in circulation was increased from 1.74% to 2.2% annually[39]) and the reduction of the supply of CO_2 emission allowances on the market as a result of the market stabilization mechanism, where a specific pool of CO_2 emission allowances was withdrawn from the market. Apart from the above regulatory factors, the increase in EUA prices resulted also from the higher demand for emission allowances related to the economic rebound after the effects of the pandemic in 2020.

In 2022, the drivers of EUA price growth remained the same as in the second half of 2021, i.e. regulatory actions and the strengthening of demand as a result of the economic rebound after the pandemic, however, they were also strengthened by market actions, most visible after the presentation of the proposal for the "Fit for 55" package.

In the recent period, market activities have had the strongest impact on prices. This is best evidenced by the sharp drop in prices after the information that during the extraordinary meeting of energy ministers on 9 September 2022, ways to curb electricity prices will be discussed. However, as soon as the market received confirmation that EUA intervention would not be considered during the extraordinary meeting, there was an almost 8% surge in the EUA price from 66 to 71 EUR/EUA.

Fig. 3.7 | Historical price of CO_2 emission allowances for the last 5 years, till September 2022 [EUR/EUA]



Source: Own study based on data from KOBIZE and ICE EUA Futures

Energy commodity prices

Another market that generates problems with the implementation of the transformation is the commodity price market - hard coal and especially natural gas.

Historically, over the past 5 years, the price of domestic hard coal[40] for the energy sector (based on the Polish Power Coal Market Index PSCMI) has remained relatively constant, averaging around 2.5-3 EUR/GJ. Growing coal imports from Russia have stabilized hard coal prices at a low level. Until the end of 2020, natural gas prices also remained relatively constant compared to price increases in the years that followed.

In the last two quarters of 2021, the prices of energy commodities in the global markets of natural gas and hard coal increased several times compared to the prices observed at the beginning of 2021[41]. The price increase reflected a sudden surge in electricity demand, especially in China and India, as a result of the dynamic economic rebound after the COVID-19 pandemic, and the constrained supply of energy in part due to adverse weather events. The drought reduced hydroelectric energy production in Brazil, China, Turkey, and the United States, creating a higher demand for natural gas and hard coal, while the cold winter (in the 2020/2021 heating season) in the EU caused an increase in gas demand in this market. Adverse weather events also affected the extraction of fossil fuels, with floods limiting hard coal production in several countries, including China and Indonesia. The supply of coal was also influenced by political conditions, primarily China's ban on coal imports from Australia, which had a direct impact on international coal trade. As a result, China has seen a sharp increase in natural gas imports.

In the fourth quarter of 2021, the prices of CO_2 emission allowances continued to rise and the prices of natural gas increased rapidly due to a further increase in demand as a result of the economic rebound, low stock levels, and restrictions in the supply of Russian gas by

38 Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU (recast).

39 Phase IV of the ETS implements changes in the functioning of the system in order to meet the required GHG reduction in the ETS sectors by 43% relative to 2005 levels in the 2021-2030 perspective. In addition to increasing the linear reduction factor with respect to Phase III, it also strengthens the market stabilization mechanism - from 2019-2023, the amount of allowances placed in the reserve will double to 24% of allowances in circulation, while from 2024 the normal ratio of 12% will be restored.

40 Lignite prices have remained relatively constant in recent years. This is mainly due to the fact that this raw material is not obtained on the market, but is mainly consumed by power plants associated with local mines. For this reason, they are not included in the presented analysis as an impact factor.

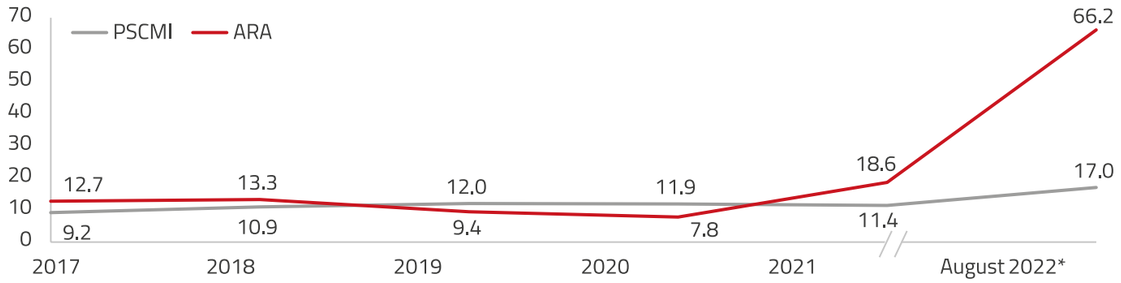
41 According to quotes and indices from ICE Dutch TTF Natural Gas Future, Coal (API2) CIF ARA (ARGUS-McCloskey) Futures.

the Russian Federation[42]. Following the increase in the price of gas, the cost attractiveness of energy production from hard coal increased, which contributed to the rising prices of this raw material, and as a consequence of these phenomena there was a sharp increase in electricity prices (by 74.9% and 75 EUR/MWh[43] between October and December 2021) leading to a price peak in December 2021.

In 2022, in particular since the outbreak of war in Ukraine at the end of February, there has been another spike in natural gas prices due to uncertainty about the capacity to obtain gas in Europe (sanctions and limiting the volume of gas supplied from Russia via Nord Stream 1). It also led to a further increase in demand.

The war in Ukraine also caused instability on the domestic hard coal market – the average annual coal price in 2022 may significantly exceed 5 EUR/GJ. In turn, cheap imports from Russia must be replaced by imports from countries that sell coal based on the ARA price index (conventional coal price in the ports of Amsterdam, Rotterdam and Antwerp). Global coal prices were gradually rising already in 2021 as a result of the recovery in global demand, but after Russia's attack on Ukraine, they increased by leaps and bounds, about threefold. They have been fluctuating between 13 and 15 EUR/GJ for several months now.

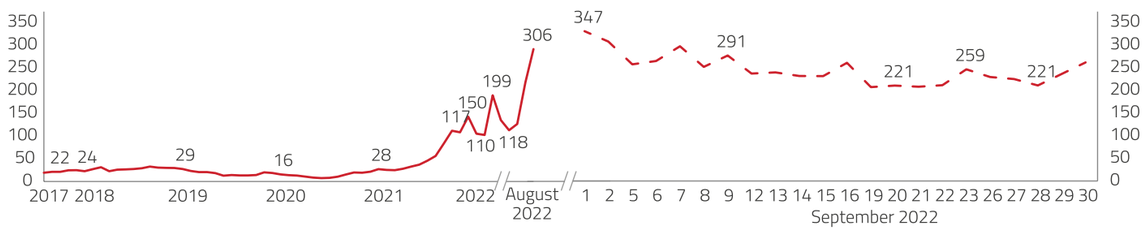
Fig. 3.8 | Historical price of hard coal for the last 5 years and in August 2022 [PLN/GJ]



*The value is projected based on the average price increase from January to July 2022

Source: Own study based on data from PSCMI and the ARA (MTFc1) index

Fig. 3.9 | Historical SPOT price of natural gas in the last five years and until August 2022 - [PLN/GJ]



Source: Own study based on data from TGE - weighted average monthly price of the DAMg

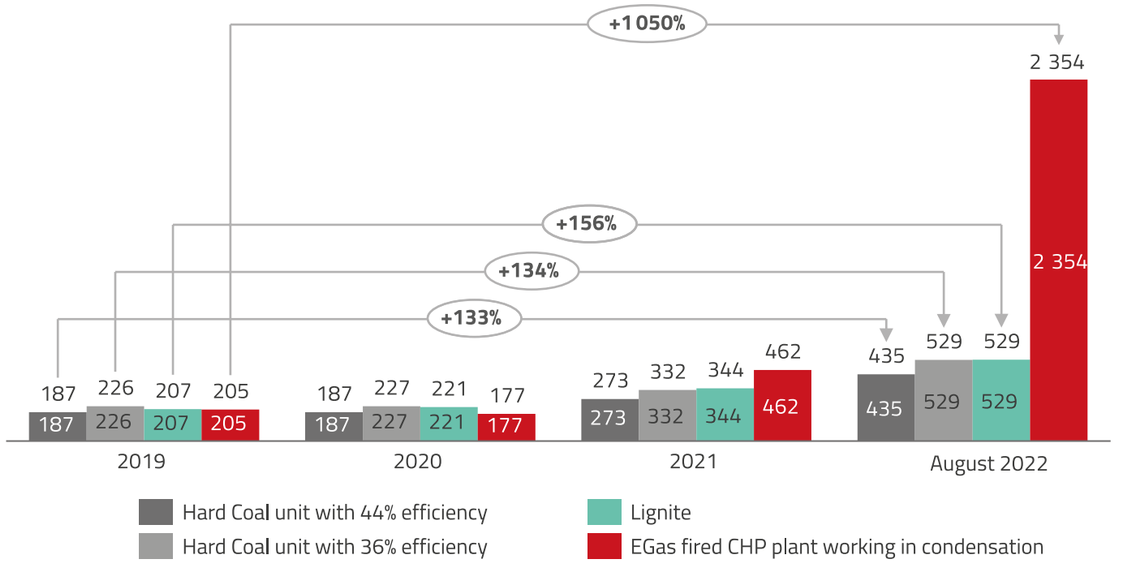
42 The Russian Federation restricted gas exports via pipelines to Europe in 2021 due to high domestic demand, production disruptions and high prices for liquefied natural gas (LNG) exported to Asia. It also deliberately limited natural gas supplies to Europe in order to support its arguments for launching Nord Stream 2 at the political level.

43 According to data from TGE.

Impact of price volatility of CO_2 emission allowances and raw materials on marginal production costs and electricity prices

As a result of the change in the relation of the costs of electricity production from hard coal and natural gas, in 2022 the production of energy from natural gas was, on average, more expensive than from hard coal.

Fig. 3.10 | Increase in short-term marginal costs of conventional units [PLN/MWh]



Source: EY's own study

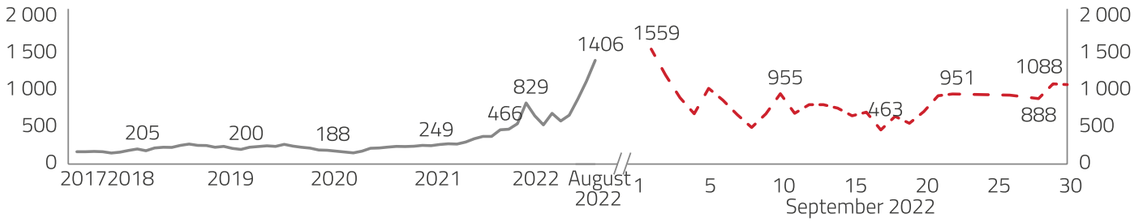
Thus, the growing energy price set on the market is strongly correlated with further increases in natural gas prices, despite the relative stabilization of the prices of CO_2 emission allowances in 2022 and the continued significant dominance of electricity production from hard coal. As a consequence, the price of electricity in Poland increased from 139.5 EUR/MWh in January to 265.5 EUR/MWh at the end of August 2022[44] (an increase of 90.5%).

Some of the increases were justified by rising coal, gas, and EUA prices, but in many markets, including Poland, the impact of speculative actions played a very significant role. After the Polish government took steps and started discussions at the EU level, electricity prices dropped significantly. On about 10 September, the prices on the SPOT market fell about two times compared to the highest price in August, the drops on the futures market were much lower, only around 25%. Another, even deeper decline was recorded on 16 September, after one full day passed from the announcement publishing the draft regulation[45], which presented the mechanisms discussed at the EU summit.

44 Based on data from TGE.

45 Council regulation on an emergency intervention to address high energy prices (COM/2022/473).

Fig. 3.11 | Historical electricity price* on the SPOT wholesale market until September 2022 [PLN/MWh]



* Weighted average (by volume) price of electricity based on TGE data: DAM - Base, Peak and Offpeak

Source: Own study based on data from TGE

To sum up, the dynamically growing and high prices of CO_2 emission allowances significantly burden the costs of electricity generation in Poland, which in the medium and long term may constitute an obstacle for energy companies to generate funds for new investments and, on the other hand, increase electricity costs for end-users. On the other hand, the extremely high prices of natural gas and the resulting unprecedented electricity prices on the wholesale market, if they continue at such levels (the weighted average rate of transactions for the supply of Base_Y-2023 as of 30 August 2022 was 381 EUR/ MWh[46]), may have catastrophic effects not only for the energy market and the ability of end-users to handle such costs, but as a consequence may lead to a wider economic downturn.

It is likely that actions at the EU and national level will partially limit price increases, but it will take several years for gas and coal prices shaped at the global level to stabilize. Unfortunately, there are no indications that for this period decision-makers at the EU level will also decide to intervene or reform the ETS by modifying the Market Stability Reserve mechanism in order to lower the EUA price. Rising electricity and gas prices will lead to an increase in energy poverty, which will force the use of subsidized prices and costly shields for vulnerable customers. Financial resources, instead of being directed towards the transformation, will be directed to more and more expensive consumption.

Fig. 3.12 | Increase in the prices of natural gas and CO_2 emission allowances and the resulting electricity prices from July 2020 to August 2022

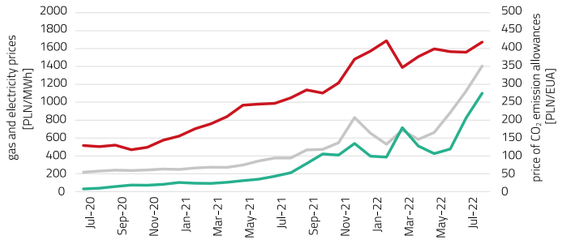
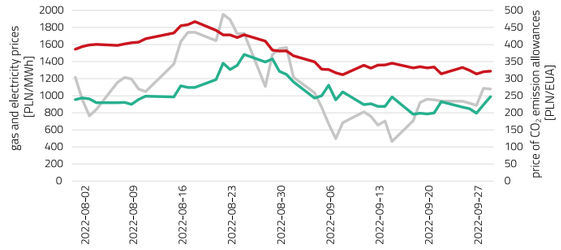


Fig. 3.13 | Increase in the prices of natural gas and CO_2 emission allowances and the resulting electricity prices in August and September 2022



Monthly weighted average (BASE, PEAK, OFFPEAK) price e.e. DAM [PLN/MWh]
Weighted average price of natural gas (TGE-DAMg) [PLN/MWh]
Average price of CO_2 emission allowances [PLN/EUA]

Source: Own study based on data from TGE and ICE

46 Based on data from TGE.

Proposal for EU emergency measures

In the context of the unprecedented disturbances in the electricity market in the third quarter of 2022, as described in the previous sections, EU energy ministers at an extraordinary meeting on 9 September 2022 called upon the European Commission to propose specific solutions to be taken at the EU level for lowering electricity prices. At the same time, some Member States have started implementing or are considering implementing various measures to mitigate the effects of the energy crisis at the national level.

On 6 October 2022, Council Regulation 2022/1854 on an emergency intervention to address high energy prices was published (hereinafter referred to as the "Regulation")[47]. The Regulation introduces an integrated package of interdependent measures aimed at, among other things, mitigating the effects of high electricity prices and protecting consumers, while maintaining the benefits of the internal market and ensuring a level playing field. The Commission is proposing a coordinated and unified EU response to the crisis, while looking for instruments that do not, as far as possible, hinder the implementation of reforms provided for in the REPowerEU plan.

The Regulation includes the following measures:

- Voluntary overall target to reduce gross electricity consumption by 10% (compared to the average gross electricity consumption in the relevant months of the reference period) and a mandatory 5% reduction target in peak hours of electricity consumption. Member States shall define peak hours corresponding to a total of at least 10% of all hours between 1 December 2022 and 31 March 2023, during which they reduce energy demand;
- Introduction of a cap on the market revenues obtained from electricity generation using inframarginal technologies (i.e. using wind, solar, geothermal, hydro power plants without reservoirs, biomass, waste, nuclear and lignite, crude petroleum products, peat).[48] There is some flexibility in the implementation of the price cap to reflect national circumstances and the national measures being implemented. This includes the possibility of setting a higher revenue cap, applying measures that further reduce market revenues, differentiating between technologies, including technologies not listed in the regulation, setting a separate revenue cap for hard coal technology and applying restrictions to market revenues for other entities, including those dealing with electricity trading[49]. All surplus revenue resulting from the application of the market revenue cap should be allocated to protective measures for end-users, pro-efficiency and savings measures, decarbonisation, RES development and compensation for suppliers who have to supply electricity to consumers below cost following state intervention in the field of pricing;
- Possibility of using the surplus of revenues from transmission congestion resulting from the allocation of inter-area transmission capacity to finance funds supporting electricity end-users;
- Committing Member States to remove unjustified administrative and market barriers that hinder renewable power purchase agreements (PPAs). Countries would be asked to take measures to speed up the implementation of such agreements, in particular by small and medium-sized enterprises. Member States should also implement support schemes and guarantees of origin in such a way that they are compatible with renewable power purchase agreements by enterprises;
- Periodic introduction of regulated tariffs for small and medium-sized enterprises;
- Periodic and conditional fixing of electricity prices below the purchase costs of electricity on the wholesale market[50];
- There will be a mandatory solidarity contribution in the oil, gas, coal and refinery sectors in the 2022 or 2023 tax years on surplus profits (above 20% of the average of the last four tax years beginning on or after 1 January 2018), unless Member States have introduced equivalent national measures. Member States may maintain national measures equivalent to the solidarity contribution, provided that they are compatible with the objectives of the Regulation and generate at least comparable revenue. The contribution should be used for the same purposes as surpluses from the cap on the market revenues obtained from electricity generation and for additional

47 https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=uriserv%3AOJ.LI.2022.261.01.0001.01.POL&toc=OJ%3AL%3A2022%3A261I%3ATOC

48 In the day-ahead market, electricity prices depend on the variable cost of the marginal technology, i.e. the last and most expensive bid needed to meet demand (marginal prices). However, the market revenue cap should not apply to technologies where the input fuel costs cause the break-even point to exceed the cap, as this would jeopardize the activity and ultimately the security of supply. This applies, for example, to gas and coal-fired power plants.

49 Provided that those measures are proportionate and non-discriminatory, do not compromise investment signals, cover investment costs, do not distort the functioning of wholesale electricity markets and comply with Union law.

50 This requires that the following conditions are met: (a) the measure covers a limited amount of consumption and maintains an incentive to reduce demand; (b) there is no discrimination between suppliers; (c) suppliers are compensated for deliveries below cost; (d) all suppliers are entitled to bid at the regulated price on the same basis.

investments to be provided under REPowerEU. The rate used to calculate the temporary solidarity contribution shall be at least 33% of the surplus profits. By 31 December 2022, Member States shall adopt and publish measures implementing the mandatory temporary solidarity contribution.

These measures are temporary and exceptional. They will apply from 1 December 2022 to 31 December 2023. The reduction in gross electricity consumption during peak hours shall apply from 1 December 2022 to 31 March 2023. Measures to achieve the reduction in demand and the allocation of surplus revenue under a cap shall apply from 1 December 2022. The mandatory market revenue cap and related national measures apply from 1 December 2022 to 30 June 2023. The Regulation shall enter into force on the day following its publication in the Official Journal of the European Union.

The solutions adopted in the Council Regulation provide for an intervention in the energy market, unprecedented in the history of the EU, with the use of sanctions (establishing a cap on the market revenues obtained from electricity generation using inframarginal technologies, or a mandatory solidarity contribution from surplus profits in the oil, gas, coal and refinery sectors). However, on the other hand, the persistent high level of gas and energy prices has not yet occurred in history and could have disastrous consequences not only for the electricity market, but also for the entire EU economy.

Excessive reduction in the margins of enterprises from the energy sector to implement protective measures may slow down the pace of transformation due to the reduction of investment funds. It is also important to recognize potential liquidity problems of enterprises from the energy sector which may occur as a result of the necessity to pay very high collateral on commodity energy exchanges due to high energy prices. The best practice when implementing intervention measures is to introduce regulations for a specified period with the possibility of quick adjustments.

Poland is actively involved in developing intervention solutions at the EU level, while simultaneously implementing a number of solutions at the national level. In September, the system regulation was amended, specifying the method of calculating offer prices on the balancing market. The introduction of this regulation will significantly lower clearing prices on the balancing market, which will directly reduce the level of market prices in other market segments.

Regulations developed at both EU and national levels are intended to ensure, among other things, the ability to implement protective measures for the most vulnerable end-users.

3.4.1. Impact of the war in Ukraine on the acceleration of the energy transition

Following Russia's aggression against Ukraine, on 11 March 2022, EU leaders adopted the Versailles declaration, which set out directions for reducing the energy dependence of the EU and its Member States on Russia by:

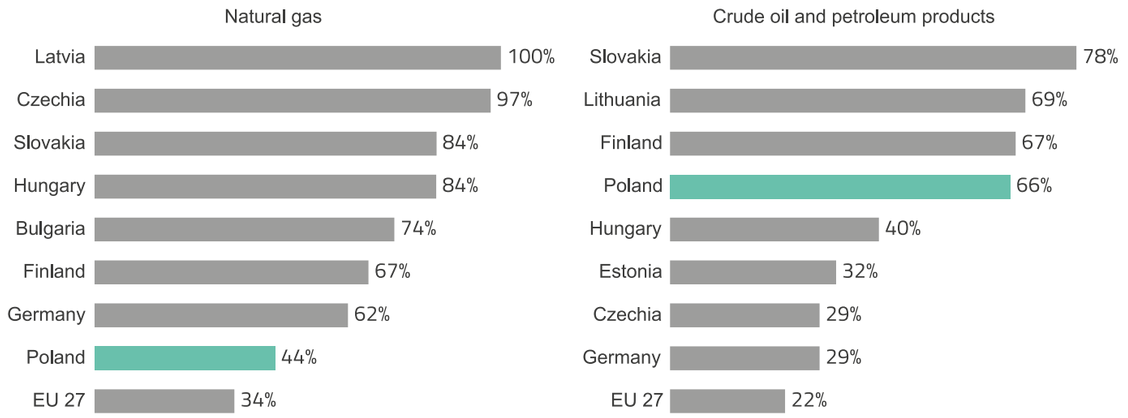
- accelerating independence from fossil fuels,
- diversifying supplies through the use of LNG and biogas,
- further development of the hydrogen market,
- speeding up the development of RES and the production of key components as well as streamlining authorization procedures to accelerate energy projects,
- reinforcing contingency planning for security of supply,
- improving energy efficiency and energy management towards a more circular approach.

The Versailles declaration instructed the European Commission to prepare a REPowerEU plan which will implement the described actions of reducing the energy dependence of the EU and its Member States on Russia.

Need to redirect fossil fuel imports

Dependence on supplies of energy resources from Russia makes it necessary to diversify the directions of supplies not only in Poland, but throughout the EU. This process is additionally accelerated by further sanctions imposed by the EU. Since the beginning of the war to July 2022, the EU adopted seven packages of sanctions against Russia, which, among others, cover the energy sector, including a ban on the import of coal and other solid fossil fuels from Russia and a ban on the import of crude oil and refined petroleum products from Russia (with few exceptions).

Fig. 3.14 | Share of natural gas and crude oil imports together with petroleum products in energy consumption (demand + export) in 2020



Source: Eurostat

Natural gas production capacity in Europe is relatively small – only in Norway, the Netherlands, and Denmark gas extraction exceeds energy consumption, and in the entire EU natural gas extraction covers only about one-third of the needs, hence the use of this raw material on the current scale creates a significant dependence of the EU on import.

In addition to gas and oil from Russia, Poland also imported coal. In 2020, coal imports from Russia amounted to almost 9.5 mln tonnes, which accounted for over 10% of domestic consumption. Approx. 4% of coal imported from Russia was coking coal, the remaining part was steam coal[51]. The main recipients of imported coal were entities not dealing with the energy sector (approx. 82%), mostly households, public utility buildings, and agriculture[52].

51 Based on data from EUROSTAT.
52 The Jagiellonian Institute, 2021, Scenario analysis of supply and demand balance of hard coal in Poland until 2040.

Implementation of climate policy in Poland, including the activities of the Polish energy sector – summary:

Poland is consistently carrying out activities that help it move towards energy transition and climate protection, significantly changing the structure of energy generation by reducing the role of coal and introducing new low- and zero-emission technologies.

Over the past several decades, the Polish energy sector has significantly reduced the emission of pollutants into the air. It required many costly modernisations and investments, which proves the sector's commitment to environmental protection.

Poland is actively involved in global and EU efforts to combat global warming, as evidenced by the achievement of a 42% reduction in GHG emissions since 1990 from the energy sector, which has been involved in its implementation since the adoption of the climate protection policy in Poland.

The transition of the Polish energy sector takes place in difficult conditions. In addition to the invariable historical burdens, in recent years there have been problems related to the excessive speculative influence on the EUA, fuel, and electricity markets, especially after Russia's attack on Ukraine. In this context, without further deep reforms of the energy market, it may be difficult to effect the energy transition and the funds allocated for it will be directed elsewhere.

The dynamic development of low-carbon and zero-emission energy sources from 2020 exceeds the pace assumed in strategies, hence it is necessary to update them. In addition, the challenges related to the limited availability of raw materials and dynamic price changes make it necessary to accelerate the reduction of the use of fossil fuels in the Polish energy sector while maintaining energy sovereignty.

04
Further path to climate neutrality

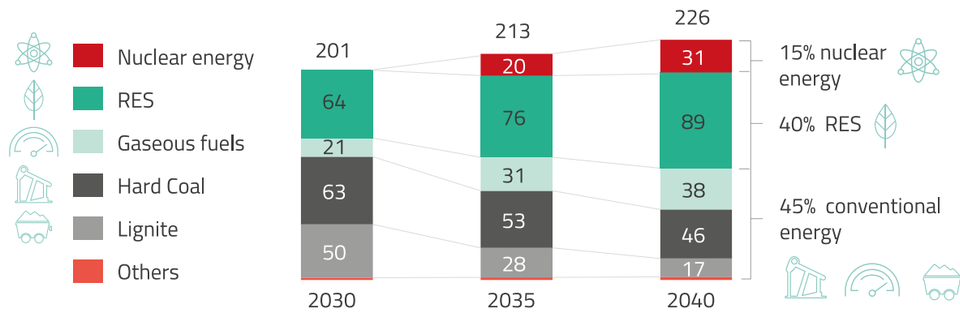
4.1 The need to change the Polish energy mix

According to PEP2040, addressing the challenges resulting from ambitious climate goals will require limiting the use of coal-fired units and replacing them with low-carbon and zero-emission technologies.

In addition, work is underway to prepare for the construction of the first nuclear power plant in Poland, which will reduce Poland's reliance on the use of fossil fuels. According to PEP2040 projections, the first power plant is to be put into operation in 2033, and subsequent units every 2-3 years to reach a capacity of 6-9 GW. Greater diversification of the energy mix is also envisaged by increasing the capacity of natural gas-powered generation sources, mainly in cogeneration and by the development of offshore wind energy.

Despite measures to improve energy efficiency, an increase in demand for electricity is planned, mainly related to the use of electric cars and heat pumps. Peak power demand is expected to increase from 24.5 GW to 31.3 GW and net electricity from 160 TWh to 204 TWh by 2040.

Fig. 4.1 | Forecast of gross energy mix [TWh] of Poland according to PEP2040



Source: Own study based on PEP2040

Once implemented, PEP2040 will contribute to the reduction of NOX and SOX emissions, dust emissions from the energy sector by over 50%, and the reduction of GHG emission intensity in electricity generation by over 50%.

Assumptions for revision of PEP2040 resulting from changes in the market environment

Limited supply and increases in energy commodity prices, as well as increasingly more ambitious targets in the EU climate policy within REPowerEU are forcing PEP2040 to be updated. Additionally, many of the premises outlined in the current PEP2040 are now being implemented at a pace that exceeds the targets set by the document.

In terms of solar energy generation, the rate of change significantly exceeds the rate assumed in PEP2040. Installed PV capacity in 2022 exceeded 10 GW[53], where according to PEP2040 such a high level should only be achieved after 2030.

In terms of offshore wind farms, PEP2040 assumes that a capacity of 5.9 GW can be achieved by 2030, and in this regard has received support in the form of contracts for difference (these are installations that will become operational already in 2026-2028), a location permits (PSzW, Pol. *Pozwolenie na wznoszenie Sztucznych Wysp*) have been approved for over 7 GW of power.

53 Based on data from ARE.

In terms of onshore wind farms, their development is slower than assumed in PEP2040, according to which 2020 the total capacity could reach around 9.5 GW, whereas the current installed capacity as at the beginning of the second half of 2022 is only around 7.4 GW[54].

In terms of the use of lignite, the rate at which it is phased out is faster than assumed in PEP2040. The launch of new open pit mines, including the Złoczew open pit mine, was abandoned. In addition, the shutting down of coal-fired power plants is being accelerated, including ZE PAK (Pol. *Zespół Elektrowni Adamów Konin and Pątnów*). The coal units in Pątnów are to remain in operation until 2024, however the coal-fired power installation in Konin is being replaced by biomass plants.

The Russian aggression against Ukraine also forced a reduction in the use of fuels imported from Russia and other countries subject to sanctions in Poland, and the whole of the EU, and thus significantly impacted the assumptions made in PEP2040, forcing them to be updated. In March 2022, the Polish government adopted the assumptions of the PEP2040 update.

Key changes proposed in the PEP2040 update:

1 Increased technological diversity and expansion of power capacity based on domestic sources

- Taking action to cover the demand for electricity with technologically diverse domestic sources in order to maintain a high degree of energy independence.

2 Further development of renewable energy sources

- By 2040, around 50% of electricity production is expected to come from RES, relative to the previously planned level of 40% in 2040.

Apart from developing sources reliant on atmospheric conditions, the development of energy from water, biomass, biogas and geothermal sources is also planned.

- According to the Development Plan for meeting the current and future electricity demand for 2023-2032 prepared by PSE, the production level in RES will exceed 100 TWh by 2030, which will account for over 50% of electricity demand.

3 Improving energy efficiency

- Work in this regard will focus on reducing energy demand through intensification of activities in the area of process efficiency in industry as well as thermal modernisation and renovation of buildings, which will help protect households from energy poverty.

4 Further diversification of supply chains and providing alternatives to hydrocarbons

- Continued work aimed at diversifying natural gas and crude oil supply, aimed at achieving independence from supplies from the Russian Federation and other countries subject to economic sanctions, this includes the construction of a Floating Storage Regasification Unit (FSRU) in the Gulf of Gdańsk, as well as the use of biocomponents in liquid fuels, biomethane, hydrogen, low-carbon synthetic fuels, or electricity in transport.

5 Adapting investment decisions into natural gas generation capacity to the availability of the fuel

- Due to the change in geopolitics and unpredictability on the gas market, investment plants for new gas units that are not yet at the stage of implementation will be verified in terms of production profitability, and the pace of changes will be adjusted to the availability of natural gas. At the same time, opportunities to use alternative energy sources that are viable replacements for natural gas in heating will be sought out.

6 Use of coal-fired units

- In the event of a threat to energy security, the use of existing coal-fired units using coal from domestic deposits may increase. Ensuring the continuity of energy supply will be supported by keeping coal-fired units operational. In order to optimize the use of domestic resources, efforts to develop clean coal technologies will also be intensified.

7 Implementation of nuclear energy

- Work related to the implementation of nuclear energy based on large nuclear reactors (with a capacity of over 1,000 MW) will be continued. At the same time, solutions for small modular reactors (SMRs) will be developed, supporting energy security at the local level.
- SMR technologies can contribute to the gradual decarbonization of generating units and reduction of emissions, while mitigating the risks associated with large-scale nuclear power plants in terms of maintaining schedules and investment expenditures.

8 Development of grids and energy storage

- Grid development and energy storage will be supported by automation mechanisms, ensuring a high level of cybersecurity. In the field of energy storage, development of pumped storage hydropower plants (PSPs), prosumer storage facilities, and hydrogen solutions will be intensified.

9 Negotiating changes in EU regulations

- Poland's negotiating efforts will focus on reforming EU climate policy mechanism, so that it is possible to carry out the transformation, while taking into account the temporary use of conventional generation capacities without excessively burdening it with the costs of the climate policy. Additionally, it is of utmost importance to ensure the financial means for the development of new, low-carbon technologies and for integrating them into the system. This multi-directional approach will strengthen the flexibility and security of the system's operation.

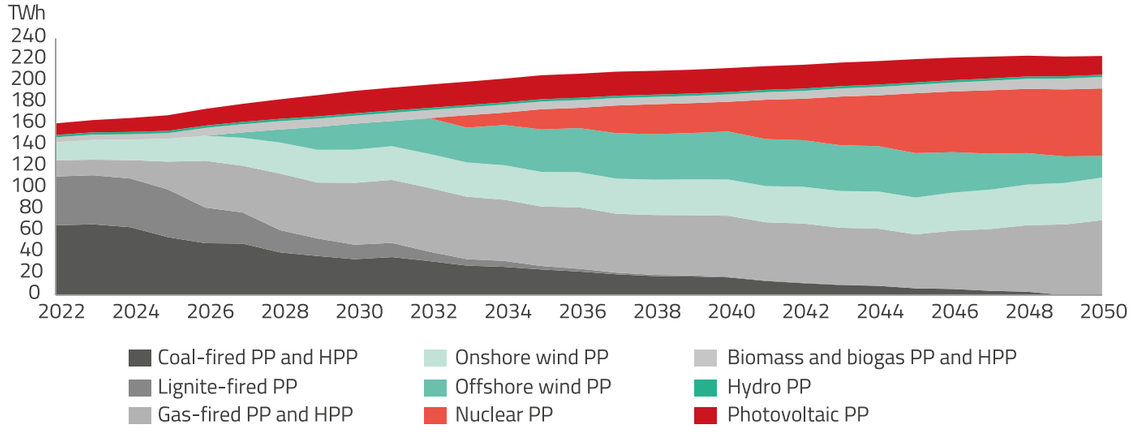
Implementing the proposed changes may result in a significant change in Poland's energy generation in the 2050 horizon. The increase in the use of hydrogen in terms of achieving climate neutrality in 2050 will have a particularly significant impact on the energy production structure.

Table 4.1 | Projected increase in electricity demand for hydrogen production

	2030	2035	2040	2045	2050
Demand for green hydrogen production [TWh]	0	5	22	33	75
Power for producing hydrogen through OWFs [MW]	0	1000	3600	6500	15000
Power for producing hydrogen through PV [MW]	0	1000	3600	6500	15000

Source: Own study based on data from PRSP 2022-2032

Fig. 4.3 | Forecast of electricity production Poland's baseline demand[55] until 2050



Source: Own study based on the assumptions of the PEP2040 update

Due to the significant increase in the volume of hydrogen after 2045, the production of electricity from OWFs and PV for the purposes of basic demand decreases while production in gas units using hydrogen (produced from electricity from OWFs and PV) increases. In 2050, it is expected that 30 TWh of electricity will be produced from green hydrogen.

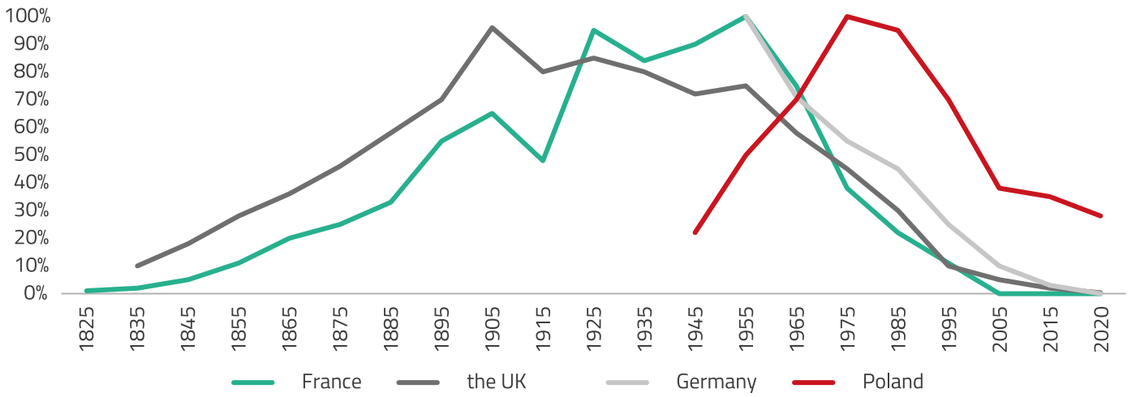
54 Based on data from ARE.

55 Electricity demand without electricity production for hydrogen production.

4.2 Moving away from the dominant role of coal

The transformation of the energy sector towards a low-carbon economy in Poland is directly correlated with the reduction of coal consumption. The peak of hard coal extraction in Poland occurred 30-50 years later than in countries such as France, the UK or Germany. These countries have shut down their mining operations altogether only in recent years, which illustrates the scale of time that Poland needs to effect changes in the mining sector.

Fig. 4.4 | Coal use in Germany, the UK, France, and Poland [%]



Source: Own study based on data from WISE-Europe and UNdata

Due to the war in Ukraine and the limitations in gas availability, the use of coal in Europe is increasing. Germany has the largest share in this growth[56]. In July 2022, German authorities established a reserve which will allow to replace gas with other sources. Within this reserve, there was over 10.5 GW capacity, of which almost 2 GW were lignite-fired units, and almost 7 GW in units using hard coal. Across the EU, coal consumption in the first half of 2022 rose by approx. 10% compared to the same period last year.

Moving away from coal forces a deep transformation in mining regions. Due to the concentration of over 80% of extraction in a small area of Górny Śląsk[57], an evolutionary transformation with the creation of new jobs and the use of social protection (due to the concentration of the transformation impact on one area) is required.

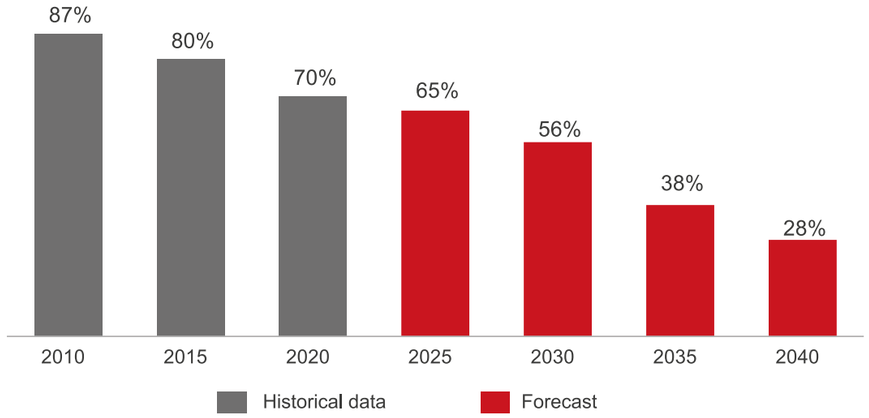
Issues relating to just transition are described in more detail in Chapter 6. Just transition as the only effective and long-term solution for transformation of the energy sector.

Social issues raised in the Paris Agreement and the idea of just transition also became the basis for calls that aim to create a special protective fund ("Just Transition Fund"), which is expected to amount to over 19 bn EUR, of which 8.45 bn EUR has been allocated under the current EU budget perspective for 2021-2027 and additionally increased by 10.87 bn EUR through the NextGenerationEU recovery instrument. Moreover, the social issues raised in the Paris Agreement formed the basis for creating Just Transition Mechanism. Nevertheless, the energy sector must, as part of its transformation, take into account the conditions required to restructure the coal mining industry, its needs, and the necessity of change of industry.

The shift away from coal also involves changes in the manufacturing sector. At the end of June 2022, the installed capacity in units using hard coal and lignite amounted to over 23 GW and almost 9 GW, respectively, which in total accounts for over 55% of total installed capacity in Poland. These power plants had an approx. 69% share in the total energy production in the first half of 2022[58]. The 100 MW coal-fired unit currently under construction in Puławy, which is scheduled to be commissioned 2022, will probably be the last coal-fired unit to be built in Poland. According to the currency Energy Policy, electricity production with the use of hard coal and lignite is to be cut by almost half by 2040 compared to 2010.

56 Based on information from IEA, Coal Market Update – July 2022.
57 Net hard coal extraction in Poland in 2021 according to ARP data.
58 Based on data from ARE for June 2022 .

Fig. 4.5 | Forecast of the share of electricity production from coal in the total gross electricity production in Poland



Source: Own study based on PEP2040 and ARE

Forecasts prepared under PEP2040 and NECP will be updated through amendments to these documents, taking into account current conditions of the sector, which will change the mentioned forecasts. The current amendment is likely to slow down the pace of shifting away from coal in the 2030 perspective, and it will increase the pace from 2030 to 2040. Coal units will increasingly shift to a back-up peak operation system. However, due to the destabilization of the gas market, it cannot be ruled out that the share of coal will increase in the coming years, until around 2030, or even a little later – until nuclear power is incorporated into the Polish power system.

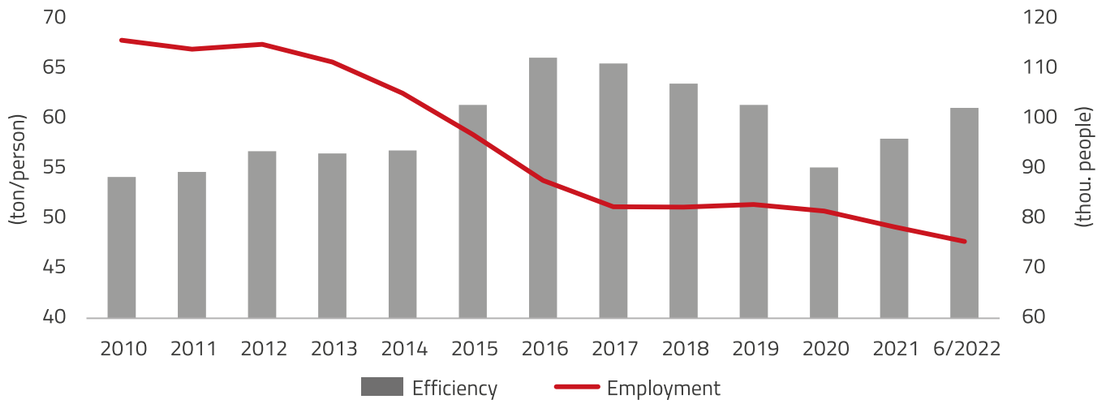
4.2.1. Impact of the energy transition on the mining sector

Rapid changes in the fuel and technological structure of electricity generation entail significant changes in coal mining and in many sectors and sub-sectors related to coal energy and mining.

The fact that 82%[59] of hard coal extraction on a national scale is concentrated in Górny Śląsk is the main challenge for the energy transition of the mining sector in Poland. A distinctive feature of people employed in the mining sector is that they have highly specialized skills, which makes it difficult to use their skills in other sectors, especially in the case of those employed in the hard coal mining sector. The estimated costs of protective measures in the mining sector amount to 30-40 bn EUR, of which around 25 bn EUR will be dedicated for the mining sector related to electricity and heat[60].

59 Net hard coal extraction in Poland in 2021 according to ARP data.
60 Own estimation based on just transition plans.

Fig. 4.6 | Average annual employment in the hard coal mining sector (thousand people) and productivity (ton/person) over the last 12 years



Source: Own study based on data from ARP

4.2.2. Structural changes in the energy sector

In order to enable the emergence of new branches of the energy industry related to offshore wind energy, nuclear energy, the production and use of hydrogen, energy storage technologies, and other innovative solutions, it is necessary to introduce structural changes to allocate significant investment outlays in development areas while maintaining competitiveness and energy security.

Building large multi-energy companies

The consolidation of the energy sector in 2007 and the creation of 4 vertically integrated energy groups were carried out as part of the preparation of the electricity sector for effective competition on the EU energy market. The entities created are still much smaller than other European energy companies. Due to the further integration of electrical energy market in the EU, it is necessary to maintain the competitiveness of the Polish energy sector on the European markets, while increasing investment opportunities for further energy transition. Achieving these goals requires further consolidation and structural changes in the energy sector in Poland. Such processes have already begun, e.g. PKN ORLEN is building a multi-energy group. In turn, the concentration of coal energy in the National Energy Security Agency (NABE) will ensure greater operational and investment flexibility for energy groups.

PKN ORLEN has already completed two consolidation processes (one merger with ENERGA S.A. in 2020 and another merger with the LOTOS Group in mid-2022) to create a large multi-energy entity, and it is at an advanced stage of work on the merger with the PGNiG Group (PKN ORLEN and PGNiG have agreed and signed a merger plan which will take place through the transfer of PGNiG's assets to PKN ORLEN), as a result of which it will be possible to match the potential of European competitors. It is assumed that the new multi-energy group will have greater investment potentialand will be more involved in investments in low-carbon and zero-emission energy than in the case of the operation of separate energy entities.

Fig. 4.7 | Consolidation of the ORLEN, ENERGA, LOTOS, and PGNiG groups

1 The acquisition of the ENERGA Group by the ORLEN Group took place in 2020.

2 The acquisition of the LOTOS Group took place in August 2022. To this end, PKN ORLEN and LOTOS have been obliged by the European Commission to implement the so-called remedial measures to prevent any negative effects of the proposed concentration on competition in relevant markets.

3 The acquisition of the PGNiG Group by the ORLEN Group is planned at the turn of October and November 2022.

Source: Own study based on press releases

The merger of PKN ORLEN with the LOTOS group and PGNiG will make it possible to increase energy security in Poland and in Central and Eastern Europe. Shifting away from liquid fuels, which made European countries dependent on imports, requires significant technological changes, reorganisation of work, the creation of new production plants, and the allocation of significant expenditure on R&D, which will be possible thanks to the creation of one multi-energy concern.

4.2.3. NABE as a new formula for the operation of the energy sector in Poland

The energy transition in Poland must be carried out while maintaining energy security and be adapted to the current power generation structure.

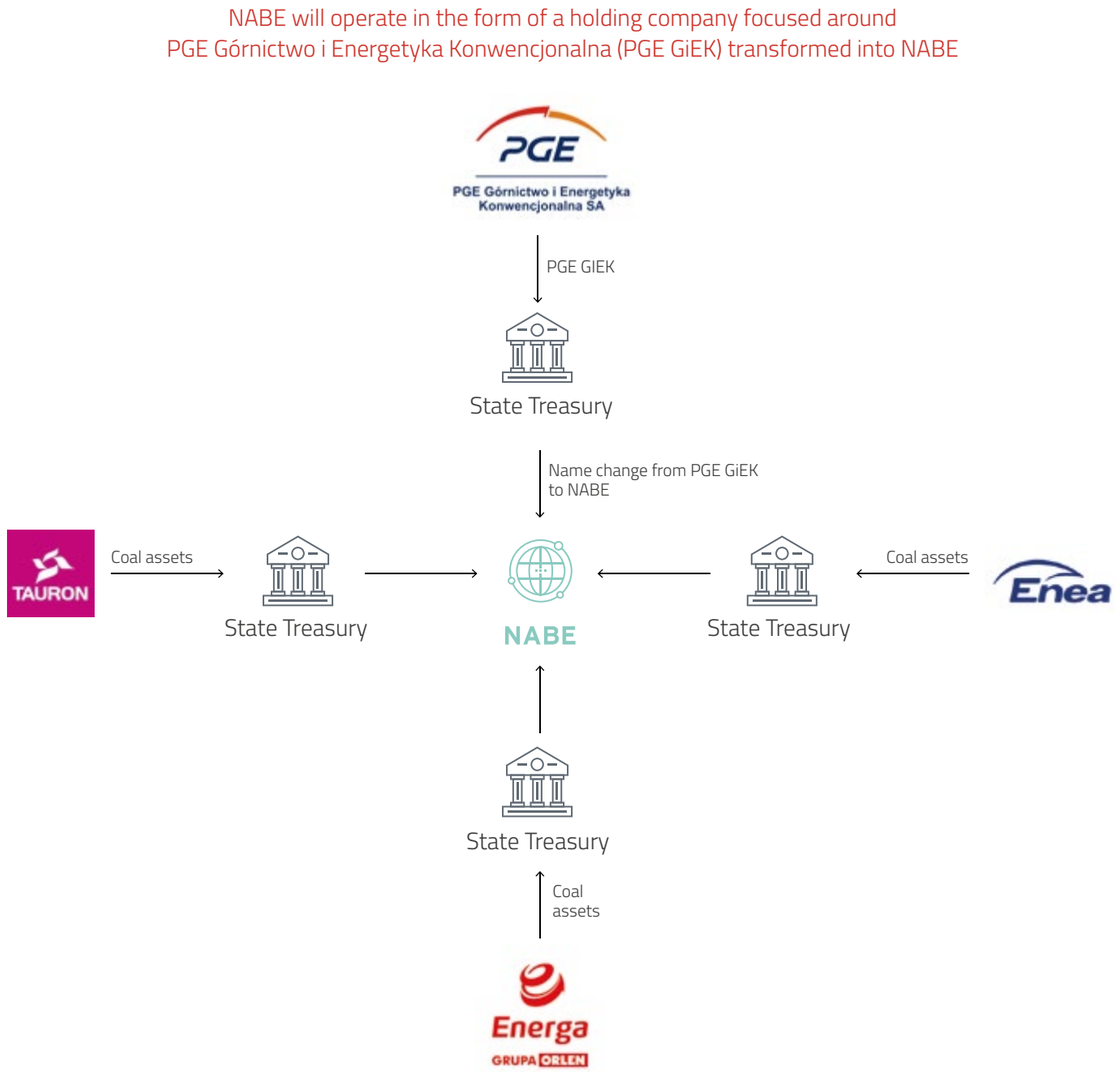
Despite projected increases in RES capacity according to PEP2040, as well as the planned development of nuclear energy, coal-fired units will still be necessary to ensure Poland's energy security until 2040.

In view of the need to use existing coal-fired units in the medium term, the Ministry of State Assets (Pol. *Ministerstwo Aktywów Państwowych*, MAP) has prepared a project to transform the energy sector in Poland by separating coal-based power generation assets from state-owned companies. This project assumes the creation of the National Energy Security Agency (NABE), which will concentrate coal assets in the electrical energy sector and will be fully controlled by the State Treasury. NABE is to contain over 70 coal-fired units that are currently owned by PGE Polska Grupa Energetyczna S.A., ENEA S.A., TAURON Polska Energia S.A., and ENERGA S.A. (which is currently owned by PKN ORLEN S.A.). Coal assets are to be purchased by PGE Górnictwo i Energetyka Konwencjonalna S.A. (PGE GiEK), which will then be transformed into NABE. According to the approved schedule, NABE will be functional in 2022.

There are no planned investments in building new coal-based power sources within NABE. NABE is to focus its work on the maintenance and management of existing coal assets, enabling Polish energy companies to accelerate investments in low-carbon and zero-emission energy sources as well as transmission and distribution infrastructure, relieving them of the burden on financial markets related to the possession of a coal portfolio and facilitating the acquisition of the necessary capital on the financial markets.

NABE's operations will be based fully on market principles, competing with other entities on the energy market and using support mechanism such as the Capacity Market (Pol. *Rynek Mocy*). Power units grouped under NABE will be centrally managed by Polskie Sieci Elektroenergetyczne S.A., which will enable the continuation of the operation of the National Power System on the same terms.

Fig. 4.8 | Transfer of coal assets to form NABE



Source: Transformation of the electricity sector in Poland, Separation of generation coal assets from state-owned companies

4.3 Strategies of PKEE's supporting members

The entities affiliated with PKEE plan further work in regards to the transformation of the Polish energy sector, which are reflected in the long-term strategies of companies that will allow them to adapt their core business to the changing surroundings and regulatory requirements.

Selected strategic goals of PGE group

Based on the document: *Strategia PGE Polska Grupa Energetyczna S.A.*

Actions that help achieve climate neutrality	Actions that help implement innovative technologies/products	Actions that help develop network infrastructure
Development of RES through construction of onshore and offshore wind farms, extensive development of photovoltaic installations, as well as cooperation with clients in the field of prosumer installations.	Increasing the Group's energy storage capacity. By 2030, at least 800 MW are planned in energy storage, which will contribute to increasing the flexibility of production from distributed sources and greater reliability of the DSO network.	Modernisation of backhaul networks in order to improve energy quality, reliability of supplies and increase the connection capacity for RES. Additionally, elements of the smart grid will be developed.
No new investments in the use of hard coal (mining and electricity generation). The currently exploited coal assets are ultimately to be transferred to NABE.		
Temporary use of natural gas, and in the long run, "green gases" such as green hydrogen and biogas.		

Selected strategic goals of TAURON group

Based on the document: *Strategia Grupy TAURON na lata 2022-2030 z perspektywą do 2050 r.*

Actions that help achieve climate neutrality	Actions that help implement innovative technologies/products	Actions that help develop network infrastructure
Increasing RES capacity by over 500% by 2030 enabling to reach the installed capacity of: ■ 1.1 GW in onshore wind farms ■ 1.4 GW in PV farm ■ 1.0 GW in offshore wind farms, as part of cooperation with strategic partners, as well as own development.	Supporting the management of RES infrastructure.	Conducting investments aimed at ensuring the stability of electricity supplies and implementing projects related to the modernisation and expansion of the grid infrastructure, which will allow the connection of new consumers and renewable sources, including the implementation of 100% smart meters by 2030.
	Developing and implementing new technologies that support the „green transformation" of heating.	
	Implementing technologies that enable the establishment of a significant position in the hydrogen economy.	
The implementation of the points above will allow to reduce the emissivity of electricity production from approx. 750 kg CO_2/MWh in 2021 to approx. 160 kg CO_2/MWh in 2030.	Achieving readiness for the construction of a modern nuclear energy source generating electricity and heat in high-efficiency cogeneration.	In terms of network infrastructure, as part of heating system, investments will be undertaken to: ■ connect new clients (which will contribute to reducing so-called „low-emission"), ■ ensure high reliability and quality of heat supply and minimize losses in heat transmission.
In the field of heating – replacing by 2030 existing generation sources, fired with coal, with low- and zero-emission units.	Carrying out digital transformation in the TAURON Group.	
	Intelligent solutions for clients.	

Selected strategic goals of ENEA group

Based on the document: *Strategia Rozwoju Grupy Kapitałowej ENEA do 2030 roku z perspektywą 2040 roku*

Actions that help achieve climate neutrality	Actions that help implement innovative technologies/products	Actions that help develop network infrastructure
Development of renewable energy sources through acquisitions, building own projects, and with the participation of business partners.	Development of new product and service packages, such as energy storage, which will be key to ensuring RES stability and energy security.	Transforming its network infrastructure into a Smart Grid.
Separation of assets related to electricity generation from conventional coal units to NABE from the Group's structures.	Management of elements left over from used RES installations and energy storage, as well as combustion by-products from the industrial sector.	Adaptation of the distribution network to changes caused by the dynamic increase in the number and power of distributed sources, in particular by rebuilding the passive (unidirectional) network into an active (bidirectional) network.
Using gas as a transition fuel to ensure energy security. Based on the already existing infrastructure, conventional low-emission sources will stabilize developing renewable energy sources.		

Selected strategic goals of ENERGA group

Based on the documents: *Strategiczny Plan Rozwoju Grupy Energa na lata 2021-2030 oraz Wieloletni Plan Inwestycji Strategicznych Grupy Energa*

Actions that help achieve climate neutrality	Actions that help implement innovative technologies/products	Actions that help develop network infrastructure
Development of renewable energy sources (PV, off- and onshore wind farms) - By 2030, the Group expects to achieve approx. 1.1 GWe of installed capacity in onshore RES and participation in OWF projects with a capacity of approx. 1.3 GWe.	Improving the quality of customer service through investments such as increasing the share of Advanced Metering Infrastructure (AMI) installed at customers to 100% in 2026 or the development of IT tools.	Reconstruction and expansion of the distribution network in order to improve the reliability of electricity supply, connecting electricity sources, increasing network flows, and connecting customers.
The activities carried out are to contribute to the reduction of CO_2/MWh emissions by 33% in 2030 compared to 2019.	Carrying out a thorough program of digitalization and cost reduction.	Participation in the implementation of new capacities in gas installations and modernisation of cogeneration installations.

Offshore Wind Farm

The OWF project is implemented in two phases: Baltica 2 and Baltica 3, consisting of the construction and commissioning of an offshore wind farm with its connection to the National Power System. The largest offshore wind farm in the Polish part of the Baltic Sea is a joint investment between PGE and Ørsted, for the implementation of which 181 wind turbines located on an area of 582 km^2 will be used.

Investment outlays

7.4 bn EUR

Implementation time

2023 – 2027

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Total capacity	**2544 MW**
Avoided CO_2 emissions	**8 013 600 tonnes**

Distinctive aspect

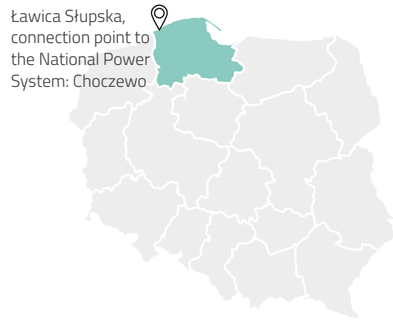
The use of a 275 kV export cable for the first time in the world in an OWF investment and the use of a modern type of "TP less monopile" foundation.

Other benefits

Maximizing the "local content" indicator aimed at engaging Polish entities in the supply and installation of OWF components, increasing Poland's independence from importing energy and raw materials necessary for energy production, and supplying 4 million households with electricity.

Location

Ławica Słupska, connection point to the National Power System: Choczewo



Commercial Hybrid Electricity Storage

A project aimed at connecting the existing 716 MW Żarnowiec pumped storage power plant (PSP) with a Battery Electricity Storage facility with power of at least 200 MW and a capacity of over 820 MWh. The resulting innovative hybrid installation, with a capacity of over 4.6 GWh, will correspond to the capacity of the largest conventional power units in Poland. The implementation of the project depends on obtaining external financing sources.

Investment outlays	Implementation time
Over 210 mln EUR	2024 – 2026

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Reduction in SO_x emissions	**700 tonnes**
Avoided CO_2 emissions*	**1 mln tonnes**

*value after 10 years of operation

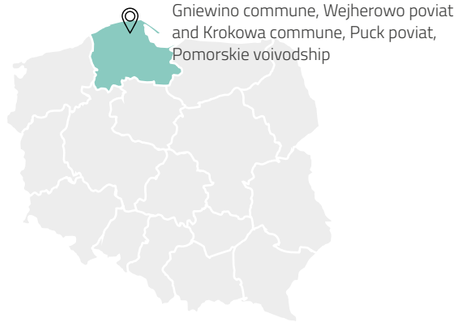
Distinctive aspect

Innovative hybrid installation combining mechanical and electrochemical storage technologies, allowing for the provision of a full catalog of system services.

Other benefits

Increasing the flexibility of the National Power System and improving energy security, especially in the north of the country, and supporting the stabilization of the electricity connection under construction between Poland and Lithuania called "Harmony Link", which improves the energy security of the Baltic States.

Location



Gniewino commune, Wejherowo poviat and Krokowa commune, Puck poviat, Pomorskie voivodship

Construction of the PV Mysłowice solar farm (phase I)

The 37 MW solar farm (with the prospect of expansion) will produce electricity using solar radiation. The supporting structure is placed directly on the ground of the combustion waste landfill in Mysłowice, on an area of approx. 50 ha.

Investment outlays	Implementation time
25.5 mln EUR	2022 – 2023

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Annual production of green energy	**39 000 MWh**
CO_2 emissions avoided	**30 000 tonnes**

Distinctive aspect

Construction of installations on economically unused areas belonging to the TAURON Group - restoration of economic functions. The PV Mysłowice project is part of a wider program of building PV installations in post-industrial areas.

In 2020, the first wind farm began operation (5 MWp capacity) under the program built in the same place where the Jaworzno I Power Plant used to be located.

Other benefits

- Development of knowledge and a culture of climate responsibility, in employees and suppliers through involvement in the project.
- Joint building of competences related to the implementation of renewable energy sources - the farm in Jaworzno was built by a consortium of TAURON Serwis and TAURON Nowe Technologie, which won the tender for the implementation of this project.

Location

Mysłowice

Distributed energy model 2.0 - self-balancing areas of the power grid

The aim of the project is to build and test a pilot installation, microgrids including local energy sources (mainly those producing electricity from RES) and the consumers of this energy gathered around them. Additionally, there are energy storage facilities being built in order to ensure the stability of energy supply for consumers within the microgrid.

Investment outlays

Research and development project co-financed by the NCBR

Implementation time

2017 – 2022

The benefits achieved from the implementation of the goals of the EU climate and energy policy

- Increase in the number of dispersed sources using renewable energy, as well as reducing CO_2 emissions during the operation of the microgrid;
- Investigation of an innovative way of managing renewable energy sources that allows them to be used in an new way and allows for the increase in the attractiveness of these technologies.

Distinctive aspect

- The system allows switching to island mode from synchronous mode and back.
- Control of production sources such as photovoltaics, wind turbines with a vertical axis of rotation, and gas engines, so that they cooperate with energy storage facilities and work within the microgrid as one device.

Other benefits

Developing the knowledge and culture of climate responsibility of employees and suppliers through involvement in the project.

Location

Construction of a biomass cogeneration unit

The project includes the construction of a completely new unit using the existing infrastructure, which will constitute the production base for the district heating system of the city of Białystok. It will guarantee the supply of heat to residents, as well as reduce the generation of heat in coal units at the premises of the Białystok Heat and Power Plant and the Zachód Heat Plant.

Investment outlays

Sensitive data

Implementation time

2020 – 2028

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Annual production of green energy **423 809 MWh**

Distinctive aspect

Equipping the unit with a heat recovery system and a heat pump, which will improve the efficiency of source generation.

Other benefits

Ensuring long-term, stable operation of the new unit allows for the necessary investments to extend the life of the remaining sources installed at the Białystok Heat and Power Plant in the horizon of 2050.

Location

The program of building hybrid energy generation sources

The project consists in the development of hybrid renewable energy installations (mix of generating energy sources: wind, photovoltaics, energy storage, hydrogen) until 2030. Thanks to hybrid systems, it will be possible to increase the availability of generation sources while being independent of weather conditions.

Investment outlays

Sensitive data

Implementation time

2021 – 2030

The benefits achieved from the implementation of the goals of the EU climate and energy policy

- Increase in the share of renewable energy sources in the national energy mix.
- Reduction in GHG emissions
- Striving to achieve climate neutrality.

Distinctive aspect

Improving the stability of the power system operation.

Other benefits

Sustainable transformation of the energy sector.

Location

The whole territory of Poland

Gryf solar farm

The construction of a 20 MW solar power plant is an example of an idea for additional development of land already used for electricity generation. The development of PV in Poland is a key element in the development of this type of renewable energy in the ORLEN Group.

Investment outlays	Implementation time
2 mln EUR	2021 – 2022

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Total capacity	**20 MW**
Annual production of green energy	**20 000 MWh**

Distinctive aspect

Development of renewable energy installations with different availability, reducing their impact on the balancing of electricity fed into the grid.

Other benefits

The new installation is being built (its completion is scheduled for December 2022) in the areas adjacent to the operating Przykona Wind Farm. This will allow for a synergy effect in terms of construction costs of the necessary infrastructure, including connection infrastructure, and the effective use of owned land.

Location

Implementation of ORLEN Group's Hydrogen Strategy by 2030

The strategy of the ORLEN group until 2030 assumes the construction of a sustainable portfolio in various business areas in which hydrogen plays a critical role. The Hydrogen Strategy aims to ensure that the ORLEN Group is a market leader in Central Europe. The strategy assumes action in 4 areas: (I) mobility, (II) refining and petrochemicals, (III) industry and energy, and (IV) research and development.

Investment outlays	Implementation time
1.6 bn EUR	2022 – 2030

The benefits achieved from the implementation of the goals of the EU climate and energy policy

Enabling the transformation of the Polish economy towards zero emissions.

Distinctive aspect

Implementation and development of electrolyser technology.

Other benefits

Creation of a modern infrastructure for the production of hydrogen, which will be an important fuel, among other things, for energy.

Location

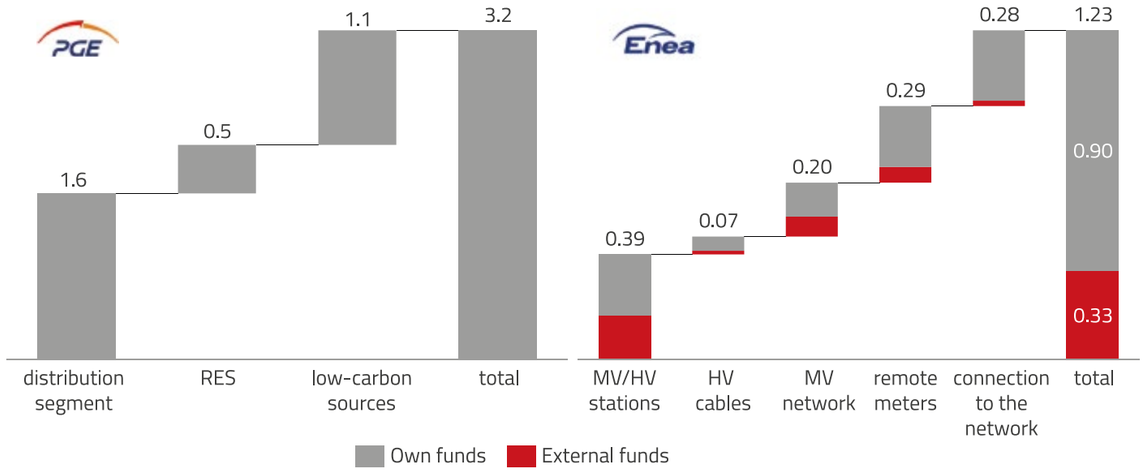
Business activity areas of the ORLEN group

Issue of new shares to finance the energy transition (PGE, ENEA)

In January 2022, PGE and ENEA announced plans to issue new shares to cover short-term investment needs. In the case of PGE, the total value of funds from the new issue reached approx. 0.7 bn EUR, of which approx. 0.5 bn EUR was bought back by the State Treasury. These funds are to be allocated to 3 main goals: investment in the distribution sector, development of renewable energy sources, and development of low-carbon sources.

ENEA obtained over 160 mln EUR from the issue of shares in 2022, of which over 89 mln EUR was bought back by the State Treasury. All these funds are to be allocated to projects supporting the development of the distribution network and improving security of supply.

Fig. 4.9 | Investment projects planned for 2022-2023 financed from the issue of new shares [bn PLN]



Source: press releases of PGE and ENEA

Further path to climate neutrality – summary:

By 2050, changes will be made to the structure of the Polish energy mix, aimed at increasing the share of zero and low-emission technologies, which will involve significant costs. Due to the means of the Polish economy, this process should be carried out gradually and in a sustainable manner.

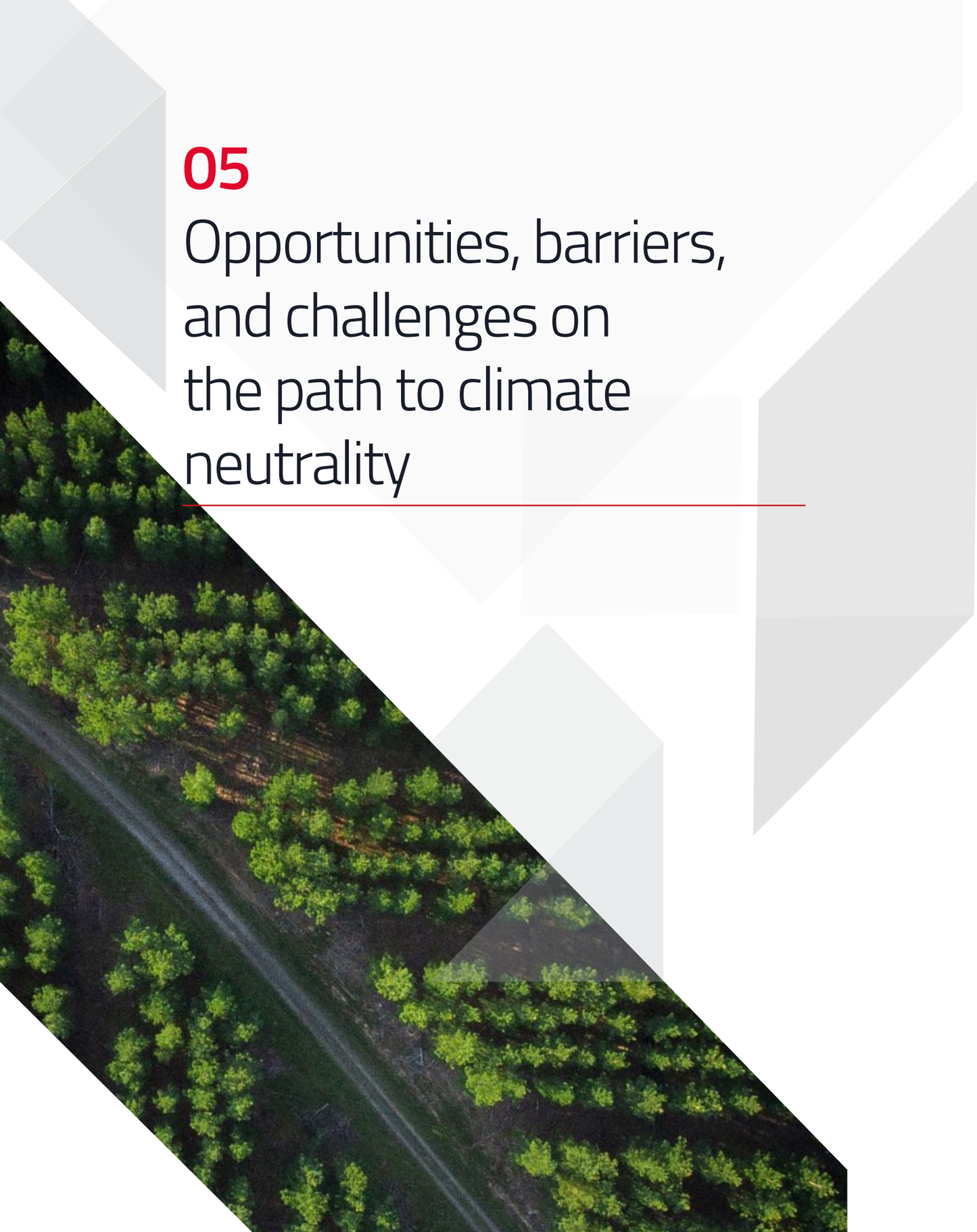
The historical conditions of the Polish energy sector require much more effort to achieve the goals of the global and EU climate policy than in other EU countries.

PEP2040 assumes a gradual decrease in the share of coal in the power generation structure through the construction of new RES and gas sources. It is also assumed that a nuclear program will be implemented, with the first nuclear unit being commissioned in 2033.

The ambitious plans to transform the sector are reflected in the planned and implemented projects and strategies of Polish energy groups.

The challenges of the energy transition and the pursuit of climate neutrality will require structural changes that will enable increased investment outlays in new and developed areas such as offshore wind energy, nuclear energy, energy storage, and hydrogen projects.

05
Opportunities, barriers, and challenges on the path to climate neutrality

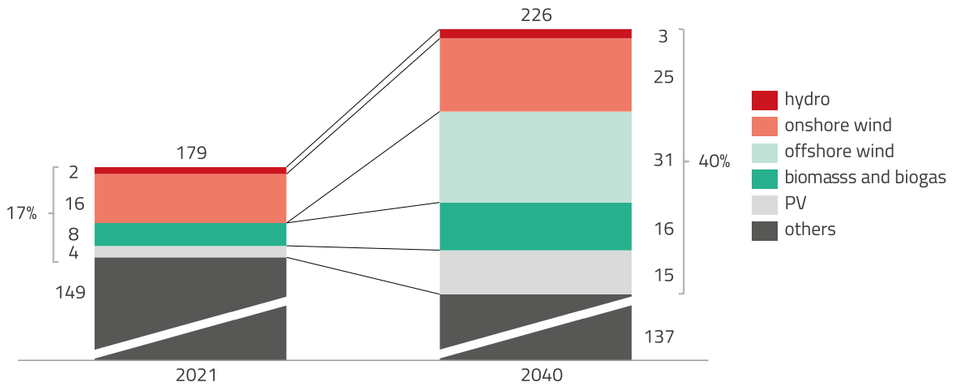


The implementation of an ambitious climate policy poses many new challenges for the energy sector. The transformation must be carried out at every stage of the value chain, from fuels (including the transition to green hydrogen or gas), through electricity generation, transmission and distribution, to its use by end-users. Achieving climate neutrality cannot be completed without mature generation technologies, such as nuclear energy or renewable energy, as well as innovations and the application of many developing technologies, such as energy storage, low-emission transport or the use of decarbonized gases. The pace of changes is significantly influenced by the interconnection of many sub-sectors and the interdependence between the electricity, district heating, and transport sectors. In each of these areas, there are many opportunities to improve efforts to achieve climate neutrality, and many potential barriers and challenges that may slow down or even prevent effective transformation.

5.1 Opportunities, barriers, and challenges in terms of RES development

The development of RES is one of the key aspects of Poland's energy transition, supporting both the achievement of climate goals and the improvement of energy security. PEP2040 assumes a significant increase in RES generation capacity – by 2040, 40% of electricity is to come from RES, which is an increase of over 23 percentage points relative to 2020. In addition, according to the assumptions for the PEP2040 update, the share of RES in electricity production may increase up to 50% by 2040.

Fig. 5.1 | Planned share of electricity production from RES in 2040 in accordance with PEP2040 [TWh]



Source: Own study based on ARE and PEP2040 data

RES investments will continue to be implemented with the use of dedicated support systems and, due to the continuous reduction of the RES technology costs, they may be implemented on the basis of new commercial forms of cooperation, such as PPA (Power Purchase Agreement). PPAs are a form of an energy purchase/sale agreement between an energy producer and an energy customer, most often concluded for many years. These types of agreements may take various forms depending on the technical capabilities and requirements of both parties to the agreement. For energy producers, they can be an alternative to the existing forms of energy sale and guarantee its sale at a specific price, thus improving the bankability of

the investment. For the customer, they provide the opportunity to increase the purchase of energy from renewable sources and to obtain a stable price for many years to come. "Customer" may be an end-user or a company supplying energy to end-users or their group. Polish regulations address the topic of long-term contracts quite superficially, especially for producer-consumer contracts (cPPA – consumer Power Purchase Agreement), in particular in the field of direct power line. Industrial recipients could be connected to electricity producers with a bypass of transmission and distribution networks via direct power lines, but in practice it is not feasible due to, inter alia, the necessity to indicate the impossibility of satisfying the needs of the given customer through the National Power System (which in the case of RES is impossible for industrial recipients because it is necessary to ensure supply certainty, and therefore to combine supplies from the National Power System in addition to direct supplies from the RES).

The growing awareness of energy customers about the impact of electricity generation from fossil fuels on the climate and the environment increases consumer pressure on producers - more and more consumers declare their willingness to buy electricity from renewable energy and products with a negligible carbon footprint. It is especially visible among corporate consumers and large enterprises as a result of implementing strategies in the field of Environment, Social Responsibility, and Governance (ESG), which is why more and more producers decide to contract/produce energy from RES, which also translates into lower production costs of goods. Renewable energy contracting is possible due to guarantees of origin or using PPAs (or both). In total, as a result of financial and non-financial effects, the demand for energy from renewable sources increases significantly, which translates into an increase in investments in such sources.

An important barrier to the increasing use of renewable energy sources is the inability to control production from these sources and inaccurate prediction of long- and short-term production. The greater the share of RES in the electricity production structure, the more difficult it is to balance production with demand. Therefore, parallel to the development of RES, investments in short- and long-term storage will be necessary, which will enable a significant increase in the share of RES. In addition, the development of RES should be supported by stable sources that can quickly meet changes in demand, but which will increase the costs of using RES.

In addition, the dynamic development of distributed generation (PV) and the variable nature of the operation of RES affect significant fluctuations in the operating parameters of distribution networks, which are mostly not adapted to such operation (technical limitations, related primarily to the fact of its construction under conditions of one-way energy flow, cause problems with compliance with the quality parameters of energy and limit the possibility of connecting new sources) and require significant investment outlays in order to adapt them to the new mode of operation.

Offshore wind farms

Electricity production from offshore wind farms (OWFs), due to more favourable wind conditions than on land, may be significantly higher than in the case of onshore wind farms (LWFs – land wind farms) of the same capacity.

The Baltic Sea has a significant potential for OWF construction – according to a study by the European Commission, the potential by 2050 is over 90 GW[61] of which 28 GW is in the Polish part of the Baltic Sea[62]. The realization of this potential will also be strengthened by the joint declaration of the Baltic states (from The Baltic Sea Energy Security Summit, which took place in Copenhagen in August 2022) to strengthen cooperation in energy security and RES development, primarily in the field of OWFs – a target of 19.6 GW of installed capacity in the Baltic Sea was adopted for 2030.

The development of offshore wind energy in the Polish exclusive economic zone of the Baltic Sea is one of the strategic priorities of PEP2040 – the planned increase in the generation capacity of offshore wind farms by 2030 is expected to be around 6 GW, and by 2040 – up to 11 GW. Already now, seven projects with a total capacity of 5.9 GW have been covered by the support planned under the offshore act and further auctions in 2025 and 2027 are planned for contracting an additional 5 GW of capacity to be built in the mid-30s. The intensive development of offshore wind energy may support the energy transition also as a new economic sector generating tens of thousands of new jobs in the entire OWF value chain.

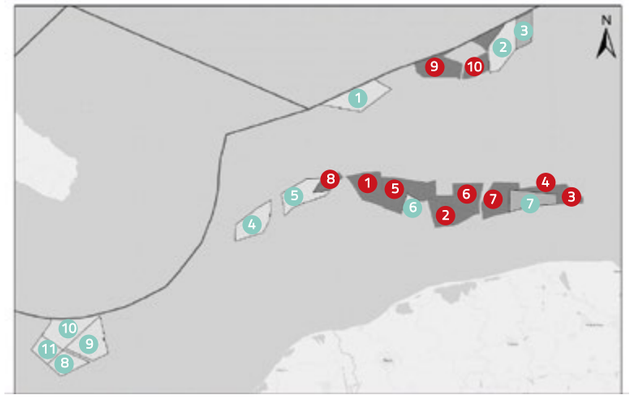
Given that there are currently no OWFs operating in the Polish part of the Baltic Sea and the OWF projects currently implemented by Polish energy companies are at an early stage of development, building competences and human resources will be a key challenge. Currently, many Polish OWF specialists work for foreign energy companies, therefore the potential use of these human resources will involve higher costs.

Additionally, the lengthy process of obtaining administrative permits is a significant challenge in the OWF investment process. This challenge is also reinforced by instability and many changes in regulations resulting from the fact that administrative bodies are also only at the beginning stage of gaining experience in the OWF investment process. This process has the potential to be optimized due to the homogeneous nature of the investment and the possibility of determining the destination of selected maritime areas. It is also important to simplify the paths to respond to changes due to ongoing technological advances in OWFs which may adversely affect the efficiency of the authorization procedure for OWFs.

The acceleration of OWF investments is also supported by the proposed regulatory changes under REPowerEU, according to which investments in renewable energy will be recognized as an overriding public interest, thus facilitating the process of obtaining relevant administrative permits. At the same time, it is necessary to use the development of OWFs as a flywheel for the Polish economy by maximizing the use of the local supply chain and creating new jobs.

In addition, the development of offshore wind energy will require the expansion of transmission grids (due to the location of generation capacities in the north of Poland, it will be necessary to strengthen the transmission grids in the north-south direction) and the construction of direct power output from OWFs. This challenge may turn out to be even greater because new nuclear power generation capacities are also planned in the northern part of the country.

Fig. 5.2 | Location of wind farms in the Polish exclusive economic zone of the Baltic Sea



Phase I of development		Phase II of development (location)
1	Bałtyk II	1 53.E.1
2	Bałtyk 3	2 60.E.3
3	B Wind	3 60.E.4
4	C Wind	4 43.E.1
5	Baltica II	5 44.E.1
6	Baltica 3	6 45.E.1
7	Baltic Power	7 46.E.1
8	Baltic II	8 14.E.1
9	Bałtyk 1	9 14.E.2
10	Baltica 1	10 14.E.3
		11 14.E.4

Source: Own study based on market data

Onshore wind farms

Onshore wind farms are one of the most mature RES technologies, characterized by the lowest average total cost of electricity generation, currently between 57 and 88 EUR/MWh[63]. In 2021, onshore wind farms (LFWs) generated 16.4 TWh[64], and in the years to follow, due to the planned liberalization of the Wind Farm Investment Act, the so-called the "10h" Act (the 2016 Act specifying the minimum distance between a residential building and the onshore wind farm as ten times the height of the facility, which consequently made it practically impossible to build a new LFW), the production level will most likely increase significantly - the estimated potential of new onshore wind farm capacity is 6-10 GW by 2030[65].

Nevertheless, the construction of new units may encounter resistance from local communities due to, among other things, the noise level in the immediate vicinity of the onshore wind farm and

61 European Commission study, November 2020 "An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future".
62 According to the report by WindEurope and PSEW, "The future of local supply chain in the offshore wind sector in the Baltic Sea".
63 Based on the Polish Nuclear Power Program, 2020, taking into account system costs.
64 Based on data from ARE for 2021.
65 Based on press releases from PSEW.

its impact on the local landscape. In 2022, the Council of Ministers adopted a draft amendment to the "10h" Act (the draft is still pending approval by the Polish Sejm), partially alleviating the provisions regarding the distance requirement, giving the municipal authorities the right to decide on the location of the wind farm regardless of the provisions of zoning plans and linking the distance requirement with the area of the projected wind farm impact instead of a rigid provision of ten times the height of the designed wind farm.

Photovoltaics

The dynamic development of photovoltaics was possible due to the implementation of dedicated support systems, limiting the development of new wind projects by the "10h" Act and technological progress directly affecting the efficiency and cost of solar energy generation. According to PEP2040, the installed PV capacity should increase to the level of approx. 16 GW in 2040, while already in 2022 the achieved level of PV capacity exceeds the assumptions of PEP2040 by over 10 years (in May 2022, the installed capacity in PV exceeded 10 GW[66].

According to PEP2040, such capacity should be achieved around 2035).

In the future, further technological development of solar energy may additionally affect the flexibility of working conditions and integration with other surfaces, e.g. roofing, facades or solar panel panes.

One of the solutions to mitigate the technical problem of integrating the unstable operation of distributed sources into distribution grids may be wider support for prosumers and entrepreneurs (consuming a significant amount of energy produced from their own sources) with PV sources, consuming a large part of energy at times when there is no proper sunlight (non-insolation hours), in the construction of energy storage facilities. In many cases, it may be more profitable to build larger storage facilities at main power supply points (GPZs) in MV branches or even in MV LV substations. In this regard, appropriate changes to the regulations should be made.

Biomass and biogas

Biomass and biogas technologies are stable and controllable sources that support the operation of non-controllable RES units. Biomass and biogas can be used in high-efficiency cogeneration systems, and thus replace fossil fuels in the future, especially in the district heating sector.

Such application has been found in the Konin power plant, where since July 2012 a 50 MW biomass unit has been in operation, producing 350,000 MWh of green energy on average annually, and in April 2022 the modernisation of another 50 MW unit was completed, and in this case the goal was to burn biomass, contributing to the production of 300,000 MWh of green energy on average annually. These units are a replaceable heat source for the city of Konin, and thus this heating system meets the efficient criterion as defined in the Polish Energy Law. In addition, the phase-out of coal-fired boilers contributed to avoiding CO_2 emission from 2022 of approximately 650,000 Mg CO_2/year[67].

As for these sources, there are also accessibility limitations. In order to be considered a renewable energy source, biomass must meet the conditions of sustainable biomass specified in the Renewable Energy Directive (RED)[68], which, among other things, affects the possibility of transporting or using biomass with adequate calorific value. Biomass combustion also generates GHG emissions, which are partially offset by carbon sequestration during plant growth period. In some cases of biomass use, it may be necessary to apply solutions reducing GHG emissions, such as carbon capture and storage/carbon capture and utilization technologies (CCS and CCU[69]) to meet EU requirements.

A further reduction in the use of biomass for energy purposes is planned under the "Fit for 55" package proposal. According to the package, the possibilities of supporting and energy use of selected types of biomass are to be limited and the obligation to meet sustainable biomass criteria will be extended to smaller combustion plants, and forest biomass should be used in a cascade manner, i.e. firstly for product manufacturing purposes and only then if it is not possible to reuse and recycle it, it can be used for energy purposes.

In the case of biogas, its use is also related to the location of the availability of raw materials for its production, which is currently limited. Biogas can be produced from, among other things, municipal organic waste, waste from sewage treatment plants or waste from agricultural production. Biogas can be transported through the gas network, but it requires purification and additional treatment to adjust the parameters of the network gas.

66 Based on data from ARE for May 2022.

67 Based on data from ZE PAK.

68 Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).

69 CCS/CCU – Carbon Capture and Storage/Carbon Capture and Utilization - the process of capturing carbon dioxide from exhaust gases and its subsequent storage/utilization.

Hydropower

Hydropower can act as a stable and easily regulated source. Although the potential of the energy sector in Poland is not large, it should be used as much as possible. This requires relatively high expenditure on new and modernised sources.

A vital role is played by pumped storage power plants (PSPs). They act as reservoirs of large amounts of energy, operating on a daily or hourly cycle, they can be a good partner for large PV farms. PSPs have very good operating parameters, which makes it easier to regulate the operation of the entire power system. Further development of this type of solutions is limited due to the unavailability of locations with favourable conditions affecting the construction cost. Currently, only a few locations in Poland with average parameters have been identified. Currently, the Development Plan for meeting the current and future electricity demand for 2023-2032, developed by PSE, envisages the implementation of the PSP Młoty project with a capacity of 750 MW, the construction of which was suspended in the 1980s. The project is in the portfolio of the PGE Capital Group. As for existing plants, in the longer term, it will be necessary to establish a system to maintain existing assets (i.e. after the end of support from FiTs/FiPs), which will have to be modernised over time to maintain the level of installed capacity.

5.2 Opportunities, barriers, and challenges in terms of developing transmission and distribution networks

5.2.1. Opportunities for the development of transmission and distribution networks

The maintenance, modernisation, and development of transmission and distribution infrastructure in the electricity sector are crucial to improve Poland's energy security, from the point of view of increasing the possibilities of cross-border connections and enabling greater penetration of RES in the grid. Currently, there are over 15,000 km of extra high voltage (EHV) transmission networks in Poland (400 kV and 220 kV)[70]. According to PSE's plans, by 2030 more than 3,500 km will be additionally constructed, which is equivalent to an expansion by almost a quarter. Additionally, over 1,600 km of EHV lines and 44 substations are to be built.

The development of cross-border connections will support the operation of the Polish power system and will provide additional opportunities for trade. One of the main cross-border connections supporting the synchronization of the Baltic states is the construction of a 700 MW undersea DC link called "Harmony Link" between Poland and Lithuania, which will be approx. 330 km long, which is expected to be put into operation in 2025. Additionally, there are plans to modernise cross-border connections and build new lines in Poland to support the operation of these connections. PSE's plans for 2021-2030 also indicate two projects for new cross-border connections which were considered promising, with the possibility of implementation in 2031-2040, but their final implementation will depend on economic conditions and the ability to connect generation sources, in particular offshore wind farms. A potential new connection could be established between Poland and Denmark in the form of over 300 km of direct current line. The second connection under consideration is a 400 kV double-circuit line between Poland and Germany, at the level of Zielona Góra. It would be the third connection on this border, and its implementation would also require the installation of phase shifting transformers (PSTs) and the expansion of infrastructure on the Polish side.

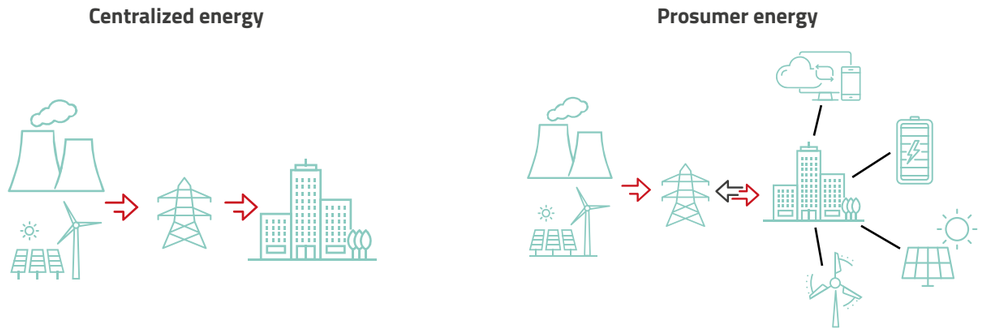
The development of distribution networks has so far been based on a centralized model of energy generation with a one-way flow of energy from sources to distributed recipients. Changing this model requires significant investments in distribution networks whose design must account for fluctuations and change in direction of flows. Development and upgrades are needed, supported by new and innovative solutions such as energy storage, smart two-way meters, and IT solutions.

Distribution companies ensure the reliability of electricity supplies by fulfilling the obligations set forth by the law, which, however, requires constant investments in network infrastructure. In view of the dynamic changes in the energy market, in particular the significant increase in the share of RES in the system, the obligation to meet the schedule of installing remote reading meters on a mass scale, supporting the development of electromobility, the process of cabling

70 PSE data - https://www.pse.pl/dane-systemowe/praca-kse/informacje-ogolne/opis-systemu.

the network, ensuring connectivity and cybersecurity, and in the near future, connecting energy storage facilities, acquiring flexibility services and cooperation with more and more entities which bring together energy market participants, most of the investments of distribution companies should be treated as priority investments which are crucial for the transformation and development of the market. This situation requires additional support at the regulatory and legal level, as well as the provision of external funding dedicated strictly to network investments with the use of aid funds, at a level that enables the achievement of the goals of the energy transition.

Fig. 5.3 | Prosumer and centralized energy models



Source: Own study

An important element of the activities of distribution system operators will be the fulfilment of statutory obligations imposed on DSOs that came with the amendment to the Polish Energy Law of 2021, and namely the obligation to install smart meters for 80% of customers by the end of 2028 and 100% of customers by 2030, which translates into over 18 million new meters. This will significantly accelerate the transformation of the distribution grid into a smart grid. In addition, full metering of MV/LV stations is planned through the installation of over 250 thousand balancing meters in these stations until 2025.

In addition, distribution companies continue activities related to the development of the network necessary for connecting new customers, RES producers, energy storage, and electromobility development. The digitization and automation of networks and services (smart grids), increasing network flexibility and supporting the transformation of the energy market (market participants' activity, development of new products and services) are constantly deepened. The reliability of energy supplies is also being gradually improved through, inter alia, increasing the share of cable lines - it is expected that the share of cable lines in MV lines will reach approx. 42% by 2030.

The process of installing smart meters is related to the creation of Energy Market Information Operator pursuant to the above-mentioned amendment to the Polish Energy Law (this function will be performed by PSE S.A.), which, through the Central Energy Market Information System, will significantly reconstruct the processes on the retail electricity market.

The challenges in the field of grid investments have been taken into account by PSE (it is planned to allocate approx. 3 bn EUR for the development of transmission networks) and distribution companies (approximately half of the investment outlays of PGE, TAURON, ENEA, and ENERGA for the coming years are to be allocated to the development of the energy distribution area) in strategic documents.

5.2.2. Barriers and challenges in terms of transmission and distribution networks

In the area of transmission networks, due to the historical conditions of the development of these networks and the concentration of generation sources in the south of Poland, the challenge will be to connect new units, in particular OWFs and nuclear power plants, which are planned to be situated in the north of the country. By 2030, it is planned to install almost 6 GW of generation capacity through OWFs and 1-1.6 GW through nuclear power plants by 2033. The key condition for the operation of the Polish power system will be the expansion of the grid in the north of the country.

There is a risk in cross-border exchange in Poland – the regulation of unplanned energy flows. There may be energy flows on cross-border interconnections not resulting from planned commercial operations, but from physical phenomena. In order to optimize the operation of the grid, it is necessary to improve the methods of sharing transmission capacity between countries and to use phase shifting transformers that enable partial flow regulation.

Distribution network challenges arise from:

- meeting statutory obligations of DSOs, which in accordance with the Polish Energy Law, are responsible for: network traffic in the power distribution system, current and long-term security of the system's operation, utilization, maintenance, repairs and necessary expansion of the distribution network, including connections with other power systems. An important element is also the implementation of tasks aimed at improving the reliability of electricity supply and continuity of power supply as well as improving the process of connecting to the distribution network in order to meet the requirements for quality regulation introduced by the President of the Energy Regulatory Office (Pol. *Urząd Regulacji Energetyki*, URE). In this regard, it is necessary, for example, to make investments to increase the degree of insulation of medium voltage overhead lines and to replace overhead lines with cable lines,
- development of distributed generation, including prosumer facilities, the vast majority of which is connected to distribution networks. As a result, supporting investments are necessary to enable the transformation of passive networks with one-way energy flow into active networks enabling two-way energy flow. Such a system of operation also poses an additional challenge in terms of balancing production and demand, and requires investments in smart metering and IT solutions. These changes related to the implementation of grid flexibility services are necessary to ensure the further development of distributed energy.

Taking into account the investment needs of distribution network operators, it is necessary to work out a model for financing the development of distribution networks.

The investment costs of the five largest distribution companies until 2030 only in the field of the so-called "necessary investments" are estimated for approx. 130 bn EUR, which covers investments that result from formal and legal requirements (current and prepared for implementation), including connection measures for electricity consumers and producers (in particular RES). Necessary investments increased by additional investments resulting from the implementation of all PEP2040 objectives require approx. 35% more outlays. Currently, the supporting measures in this regard amount to around 1.5 bn EUR and they could only partially support the implementation of planned investments.

The rapid development of RES also affects the disproportion between the available connection capacity and the connection conditions issued. According to the PSE report, as at the end of May 2022, taking into account the connection capacity also on the basis of the issued connection conditions to the 110 kV grid throughout Poland, the available connection capacity is 1830 MW in 2022 and it is predicted to be the same in 2027. Investments supporting the provision of new connection capacities, implemented in the coming years, are expected to support areas where there is a shortage of connection capacities and where the network may be overloaded. The connection capacity in the transmission system is available only in central and south-

eastern Poland. There is a lack of available connection capacities in the north and west of the country and, taking into account the issued connection conditions at the 110 kV grid level, the available connection capacities may be significantly exceeded, in particular in Pomorskie, Lubuskie, and Łużyce. During the first half of 2022, the available capacities for sources with a voltage above 1 kV connected to a network with a rated voltage of 110 kV decreased by over 2 GW. The greatest restrictions are in the north of Poland, on the premises of ENERGA-OPERATOR S.A. - in this area, new RES generation capacities are developed the most.

Since 2019, the number of refusals to connect generation facilities to distribution networks has also been growing. Most of the refusals are due to the limited technical capabilities of the network in the planned connection points, also taking into account the previous connection conditions (blocking capacity by investors who received but fail to meet the conditions).

5.3 Opportunities, barriers, and challenges arising from introducing nuclear energy to the Polish energy mix

5.3.1. Opportunities arising from introducing nuclear energy to the Polish energy mix

Incorporating nuclear power into the Polish energy mix will increase the country's energy security, enable the construction of new, zero-emission energy sources, and diversify the structure of primary energy carrier generation and supply directions, while contributing to the development of a completely new sector of the economy and the creation of new jobs.

In addition to large-scale nuclear energy, there is also growing interest in SMRs (small modular reactors), including among several representatives of energy-intensive industries. SMRs are seen as the potential for zero-emission, stable energy, which is especially important for energy-intensive industrial actors. In addition, SMRs will also be considered at the national level (after the revision of PEP2040).

5.3.2. Barriers and challenges arising from introducing nuclear energy to the Polish energy mix

The potential implementation of nuclear energy entails many risks that may limit the effectiveness of the project and its profitability. Many nuclear power plant projects in the world do not meet the assumed schedules, budgets are exceeded, therefore it is important to properly plan the project and its ownership structure. It is also important to build an appropriate scientific and technical base and train staff, maintain a political consensus around the construction of the nuclear power plant and keep high public confidence in nuclear energy.

The use of SMRs in Poland will require, among others, legislative changes so that the regulations are adapted to the specifics of SMRs and their licensing process including the possibility of supplying heat for grid or industrial purposes. Another challenge is the scarcity of functioning units of this kind in the world. Nevertheless, the characteristics of SMRs may address the risks associated with the construction of large nuclear reactors in terms of schedule (due to the modularity of the construction of the SMR) and budget overruns (due to the lower required capital expenditure and potential serial production of the reactors).

5.4 Opportunities, barriers, and challenges in terms of district heating

District heating plays an important role in the heating sector in Poland, supplying nearly 300 PJ of heat to recipients in 2020, of which 65% is produced with the use of cogeneration[71]. District heat covers around a quarter of heat demand for space heating and hot water in households in Poland[72]. PAs in the electricity sector, hard coal is the primary energy source, providing approx. 68%[73] of heat in the entire district heat sector. Therefore, in order to achieve climate neutrality, significant changes are also required in the district heating sector. Currently the most commonly used source of renewable energy is biomass, which accounts for almost 10% of total heat production, with the remaining sources representing less than 1% of the entire mix.

The directions of changes in the district heat sector in Poland are indicated in the draft Strategy for the District Heating Sector until 2030 with the 2040 perspective presented in May 2022 and are consistent with PEP2040.

5.4.1. Opportunities arising from the development of efficient cogeneration and the electrification of district heating

In many cases, the energy transition involves the so-called "electrification", i.e. replacing fuel with electricity, due to the availability of zero-emission energy sources. As a result, the connection between the heating and energy sectors will increase in the coming years.

There is a noticeable increase in electricity demand due to the electrification of district heating and an increase in the number of heat pumps currently which mainly address the needs of individual recipients. In the longer term, as temperatures in summer rise, the demand for electricity in summer for cooling and air conditioning may also increase further, which can help optimize the operation of polygeneration units.

At the same time, the district heating sector may provide regulatory support for the power system by consuming or storing surplus electricity production in heat (e.g. during favourable weather conditions) in power-to-heat solutions using heat pumps or electrode boilers and heat storage.

The increase in the connection between heating and electricity also results from the increase in cogeneration capacity (the current demand for heat indicates that it is possible to double the production of electricity in high-efficiency cogeneration, compared to current production at about 30 TWh).

The production of electricity and heat through high-efficiency cogeneration is the most effective way of converting primary energy - it translates into almost 40% savings in fuel use, and thus reduces CO_2 emissions and pollution.

Cogeneration may additionally support the use of locally available resources such as biogas, biomass or municipal waste, which can also be used as fuel for cogeneration (as long as they are not recycled), provided that future regulations do not block the use of waste for energy purposes. In order to optimize the use of local energy resources, it is necessary to analyze local conditions, therefore local

71 Based on data from URE.
72 Based on data from Eurostat for 2020.
73 Based on data from ARE.

governments and energy communities will play an important role in cogeneration development.

The development of cogeneration is also supported by a financial mechanism in the form of support systems for high-efficiency cogeneration units. Producers may receive a subsidy on the price of electricity obtained as a result of an auction, premium or call - depending on the capacity and condition of the generating unit. Support for high-efficiency cogeneration fits into the assumptions of PEP2040 and its continuation is planned.

The use of high-efficiency cogeneration fuelled by natural gas is planned as an interim solution. In the long term, it is to be replaced by hydrogen or other decarbonized gases, which is reflected, for example, in the EU taxonomy, where installations using natural gas should also be adapted to the use of decarbonized gases.

5.4.2. Barriers and challenges arising from the development of district heating

On the one hand, EU regulations create opportunities to increase links between the heating sector and the electricity sector; on the other hand, they impose important requirements that will be difficult to be met by the district heating sector in Poland. The current requirements for efficient heating systems according to the Energy Efficiency Directive[74], assume that 75% of heat will come from cogeneration or 50% from RES, or waste heat, or a combination of these sources with cogeneration. However, these requirements are not met in many heating systems in Poland, in particular in small systems, most of which are based on solid fuel boilers – mainly hard coal. This means the need to replace a large number of sources along with the change of fuel used. In Poland, only about 20% of enterprises meet the condition of an energy-efficient heating system.

Fig. 5.4 | Layout of efficient district heating systems

A heating system that meets the criterion of an energy-efficient district heating system

A heating system that does not meet the criterion of an energy-efficient district heating system

Source: IGCP, 2020, Report on heating

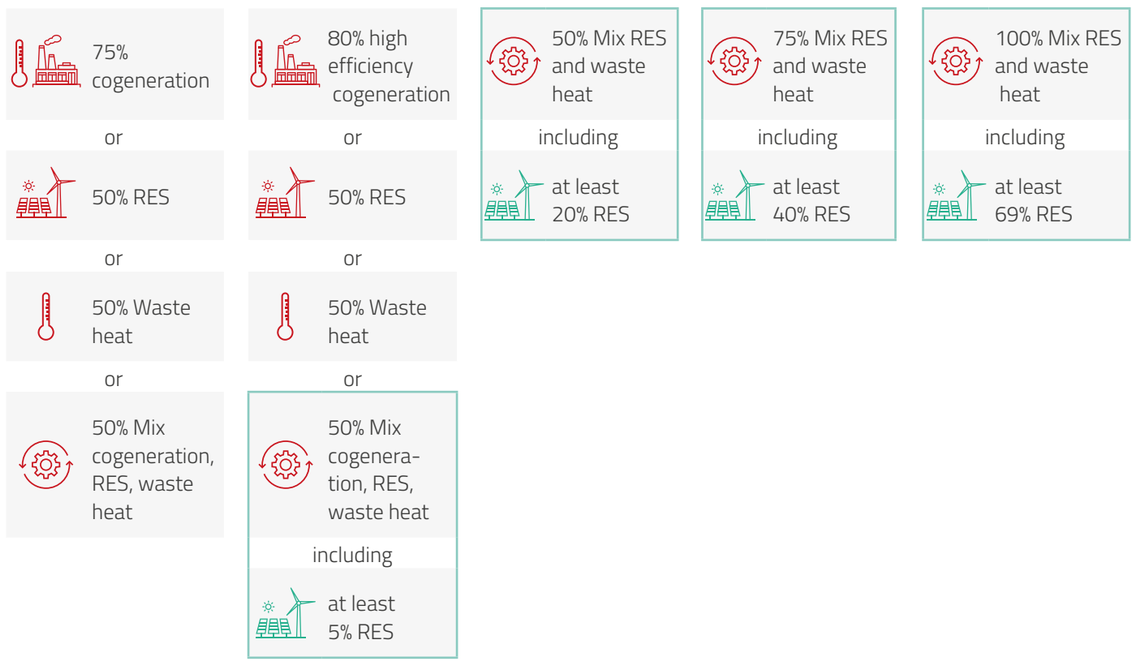
The planned changes in the "Fit for 55" package further tighten the requirements with regard to recognizing a given heating system as energy-efficient. These requirements would be applied after 2025 and in subsequent periods until 2050.

According to the current proposal of the European Commission, from 2026 cogeneration will have to meet high-efficiency conditions so that, based on an appropriate, required share of heat produced by CHP, it would be possible to obtain or maintain the status of an efficient heating system. The use of cogeneration will not contribute to obtaining/maintaining the status of an efficient heating system from 2035, leaving only the requirements for renewable energy and waste heat. Systems that do not obtain the status of an efficient heating system will not obtain support from public funds (EU or national). Additionally, it is planned to make it mandatory to develop a plan and measures to improve the efficiency and increase the share of RES in heating systems that do not meet the criteria of an efficient heating system.

The limitation of the implementation of RES (except biomass and biogas) and waste heat in heating systems is the network operating temperature, which is significantly higher than required by the effective operation of low-temperature sources. Lowering the operating temperature of district heating networks will require investments on the part of recipients in order to be able to adjust the internal installations of the district heat recipients to the use of heat at a lower temperature.

74 Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

Fig. 5.5 | Requirements for an efficient heating system according to the "Fit for 55" project (proposition by the European Commission)



Source: Own study based on proposals to recast the Energy Efficiency Directive "Fit for 55"

As part of the planned revision of the Energy Efficiency Directive from the "Fit for 55"[75] package, changes are also planned in the definition of high-efficiency cogeneration so that it also takes into account the level of CO_2 emissions per unit of energy. This rate is to be 270 gCO_2/kWh (it would apply to units using fossil fuels), which would exclude coal-fired units from this definition, as their emission factor per unit of energy in fuel was approximately 337 gCO_2/kWh[76] for combined heat and power plants and heating plants. This requirement may further exclude older natural gas cogeneration units. In addition, any modernisations limiting cogeneration emissions should be completed by the end of 2025 to be able to maintain the status of an efficient heating system in the period 2026-2034.

In addition, the tightening of the requirements for the use of biomass indicated in the proposed amendment to the Renewable Energy Directive (RED) from the "Fit for 55"[77] package, including limiting the possibility of using forest biomass and requiring the use of these criteria also for installations with lower capacity, will hinder the development of RES and meeting the targets within the district heating sector, where the share of RES and waste heat should increase by 2.1% annually. This is important due to the direction of development so far, where biomass was the basic source of RES in district heating, and other renewable energy sources and waste heat had a marginal share in total district heating production (less than 1%[78]).

In the proposed revision of the Energy Performance of Buildings Directive (EPBD) from the "Fit for 55"[79] package, it is additionally proposed to tighten the requirements for new buildings. According to the proposal, new public buildings from 2027 and all other new buildings from 2030 will have to comply with the zero-emission status, which means that in addition to reducing the demand for final energy, 100% of energy will have to be supplied from RES or waste heat as part of efficient heating systems. Meeting this requirement will be particularly difficult in large district heating systems, which at present mainly use cogeneration based on fossil fuels and result in restrictions on connecting new customers due to the failure to meet the requirements for an efficient heating system (offering heat only from RES or waste heat).

The EU Medium Combustion Plant (MCP) Directive[80] and the Industrial Emissions Directive (IED)[81] also impose significant emission requirements for existing and new heat sources.

The MCP Directive, addressed to sources with a thermal energy of 1 to 50 MW, requires the limitation and monitoring of emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x) and particulates into the atmosphere. The requirements differ for new and existing units and may vary depending on the source power range, fuel used, and technology. For units with a capacity of 5 MW and below, the requirements should be implemented by 2030, and for units between 5 and 50 MW by 2025. This calls for significant investment outlays for fume extraction systems, which, especially in older coal-fired sources, may be unprofitable, or alternatively, the replacement of heat sources with low-emission ones. Even stricter requirements are imposed under the IED Directive on large combustion plants, including those from the energy sector with a capacity of 50 MW and above – these are required to adapt to the BAT Conclusions within four years of their publication. After the judgment of the Court of Justice of the EU invalidating the 2017 BAT Conclusions, the European Commission issued new conclusions in November 2021. In addition, a draft amendment to the IED was presented in April 2022, which plans to significantly tighten the emission requirements and further limit the applicability of derogations.

75 Directive of the European Parliament and of the Council on energy efficiency (recast) (COM/2021/558).

76 Based on data from KOBIZE for 2019.

77 Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 (COM/2021/557).

78 Based on data from URE for 2020.

79 Directive of the European Parliament and of the Council on the energy performance of buildings (recast) (COM/2021/802).

80 Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants.

81 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (recast).

5.5 Opportunities, barriers, and challenges arising from the development of energy storage, electromobility, and hydrogen projects

5.5.1. Opportunities arising from the development of energy storage, electromobility, and hydrogen projects

Energy storage facilities

Increasing the share of weather-dependent energy sources in the Polish energy mix causes additional challenges in the field of energy balancing. Mechanical energy, chemical/electrochemical energy, electric or heat energy storage, or the use of power-to-gas technology can support the energy sector in balancing energy demand and supply and in maintaining the grid operating parameters at a stable level.

Reservoir hydroelectric power plants and PSPs are so far the largest source serving as energy storage in Poland, supporting the balancing of the National Power System (KSE). Their power in 2021 reached 1.5 GW, and PSP efficiency is about 70%. The feasibility of building such warehouses and the necessary investment outlays depend on the location conditions which are very limited in Poland. The storage potential can also be increased by damming water in run-of-river power plants, but this requires the favour of environmentalists and regulatory changes.

An opportunity for the development of short-term storage systems lies in developing electrochemical storage facilities where energy losses are relatively small, and the efficiency usually exceeds 90%. PGE plans to build the largest warehouse of this type in Europe at *ESP Żarnowiec* (Eng. PSP Żarnowiec). A battery storage facility with a total power of over 200 MW and a capacity of over 820 MWh will support the technical and commercial balancing of electricity and the integration of renewable energy sources located in the north of Poland (including planned offshore wind farms) with the power system.

Support for this type of solutions is available, among others, in the Capacity Market, which, in addition to generation sources, also supports energy storage and demand reduction (DSR) solutions.

Additional flexibility of the power system operation can be provided by system services such as energy storage, demand side management (DSM), and demand side response (DSR). Combining energy storage and generation services from distributed sources and demand management services is possible within the concept of virtual power plants, which, through ICT technologies, group many units and services within one system, enabling flexible resource management.

The use of heat storage can also support the operation of the power system. The use of power-to-heat technology in conjunction with heat storage can help in the consumption of surplus electricity production occurring in particularly favourable weather conditions and at night valleys. In addition, heat storage can help optimize the operation of CHP units.

In the case of the natural gas sector, energy storage ensures security of supply and thus enables the stable operation of such units. In the short term, the construction of new natural gas storage facilities may decrease Poland's energy reliance and security, and in the long term – additionally enable the storage of decarbonized gases or hydrogen, increasing the balance potential of the entire energy system.

Green hydrogen/gas technologies, produced using electricity from wind, PV (photovoltaic) and possibly nuclear sources, allow to store large amounts of energy. Green gases can be stored and then used to produce electricity and heat at times when there is no wind or sun. Hydrogen issues are discussed in more detail in the section entitled Hydrogen projects.

Electromobility

The transport sector is responsible for almost one third of total final energy consumption in Poland. Currently, mainly liquid fuels are used in transport, which contribute to GHG emissions, and due to the lack of available resources in Poland, make the sector dependent on fuel imports. The electrification of transport may help make this sector independent of fuel imports, and as the electricity sector is decarbonized it will contribute to a reduction in GHG emissions.

Regulatory changes at the EU level open up opportunities for the development of electromobility. According to the proposal adopted by the European Parliament on 8 June 2022 to amend the regulation setting CO_2 emission standards for new passenger cars and for new light commercial vehicles[82], emission standards will be tightened. The existing standards for 2030

82 Regulation of the European Parliament and of the Council amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition.

assumed the reduction of emissions of new passenger cars by an average of 37.5% relative to the 2021 limits and 31% for new light commercial vehicles. These standards are to be tightened to 55% and 50%, respectively. In addition, from 2035, all new passenger cars and light commercial vehicles must be zero-emission – a 100% reduction in CO_2 emissions.

There is potential for electric cars in the future to also act as energy storage under certain circumstances within the vehicle-to-grid (V2G) concept. Owners of electric car fleet could be providers of services supporting the operation of power grids, both consuming surplus energy and putting energy into the grid as part of V2G. In order to develop this type of services, IT technologies and dedicated systems must be developed.

Hydrogen projects

The use of hydrogen may help move away from fossil fuels and thus increase the energy independence of Poland and Europe, hence the use of hydrogen is an element of the energy transition strategy at the EU and national level. The use of hydrogen in the energy sector in Poland is only at the stage of research and development, which will indicate the directions and technical and economic possibilities of using this fuel within the entire power system.

Within the electricity sector, hydrogen can act as a storehouse for energy generated from low- and zero-emission facilities. In addition, it can help stabilize the operation of the grid with a significant input of RES.

In the heating industry, hydrogen can be used in cogeneration plants and thus can replace the use of natural gas, which is treated as a transition fuel. The use of hydrogen will be important, especially in large heating systems, where it is difficult to integrate RES to a degree that meets the needs of such systems.

The development of hydrogen solutions is supported by the Polish Hydrogen Strategy for 2030 with an Outlook until 2040. Developed in 2021, the strategy sets 6 main goals:

- implementation of hydrogen technologies in the power and heating sector,
- use of hydrogen as an alternative fuel for transport,
- supporting the decarbonization of industry,
- hydrogen production in new installations,
- efficient and safe hydrogen transmission, distribution and storage,
- creating a stable regulatory environment.

According to this strategy, Poland is to develop 6 GW of electrolyser capacity by 2024 with an annual production of at least 1 mln tonnes of hydrogen using RES and 40 GW of capacity by 2030 with an annual production of 10 mln tonnes of hydrogen from RES. The main areas of hydrogen use will be industry and transport. Hydrogen is to be used, among other things, in cogeneration systems in heat and power plants, including those using fuel cells. There are plans to expand PV farms with electrolyser installations and create 5 hydrogen valleys by 2030. These are centers for implementing hydrogen solutions along the entire value chain – from production to use.

Polish energy groups are involved in research and development projects and pilot investments in the area of hydrogen, which support the implementation of the Polish Hydrogen Strategy. PKN ORLEN, ENEA, TAURON, the Faraday Research and Development Center of the ENERGA Group are among the signatories of the sectoral agreement for the development of the hydrogen economy in Poland, the objectives of which include the development of elements of the value chain in the field of hydrogen use in Poland, research and development work, and pilot investments in the field of hydrogen use.

The Orlen Group has developed the ORLEN Group Hydrogen Strategy 2030, which assumes the Group's involvement both as a supplier and recipient of hydrogen within the European Hydrogen Transmission Network. By 2030, the Orlen Group is to build hydrogen production installations using low- and zero-emission sources with a capacity of over 0.5 GW, and low-carbon and zero-emission hydrogen is expected to account for approx. 50% of the Group's total hydrogen production. In addition to the use of hydrogen in transport, it is also planned to use hydrogen in heating and electricity generation from 2030, and all new gas and steam installations will be adapted to the co-firing of hydrogen.

The ENEA Group is involved in the creation of the Wielkopolska Hydrogen Valley and the H2eBuffer research project. The latter aims at building a prototype of a buffer installation enabling energy storage and stabilization of the power grid operation.

The TAURON Group plans to implement a project in cooperation with the Father Sebastian Kneipp Scientific and Research Institute – Sebastianeum Silesiacum in Kamień Śląski, the purpose of which is to generate electricity from a fuel cell installation. Hydrogen is to be produced in an electrolyser plant, and waste heat from the entire process is to be used for heating purposes, reducing energy waste throughout the process.

The Energa Group manages the Faraday Research and Development Center, which is involved in the research project involving a two-way hydrogen production installation using an electrotechnical cell, which, in addition to producing hydrogen, enables the generation of electricity.

The ZE PAK Group is carrying out a project for the production of hydrogen (approx. 21 tonnes of hydrogen per day) for fuel cells – the first electrolyser will be put into operation in the third quarter of 2022 and the total capacity of the electrolysers is to be 50 MW. In addition, ZE PAK is developing its own electrolyser (with a capacity of more than 0.5 MW), which is expected to be commissioned in the first quarter of 2023. ZE PAK also uses modern mobile hydrogen storage facilities with the use of 4th generation cylinders (with a capacity of up to 1,250 kg).

5.5.2. Barriers and challenges arising from the development of energy storage, electromobility, and hydrogen projects

Energy storage facilities

Due to the high energy costs resulting from the use of electricity storage compared to the costs of energy generation from conventional units, energy storage has not played a significant role in the Polish electricity sector so far. The economic profitability of energy storage depends on the difference in energy costs when power is charged into and discharged from a storage facility, which may occur due to differences in energy demand over the daily cycle - reduced energy demand in the night valley and high demand in the morning and evening peak or imbalance in energy supply and demand resulting from the dependence of energy production on weather conditions and the inaccuracy of their forecast.

An additional limitation in the use of energy storage is the generation of energy losses, which causes deterioration of the efficiency of energy conversion throughout the energy transition cycle, regardless of the type of storage. The addition of storage processes thus contributes to an increase in primary energy demand with a constant demand for final energy.

The highest efficiency of electricity storage in solutions used in the energy sector on a larger scale in the world can be observed in chemical and electrochemical warehouses, where the efficiency rate reaches over 90%. An example of such storage facilities are lithium-ion batteries, which are used, among others, in electric cars, home installations or in package solutions supporting the balancing of energy from RES. However, due to the high demand for the production of electric cars and the limited availability of raw materials for the production of this type of warehouses, they are characterized by relatively high investment expenditures compared to the capacity of warehouses, which result in high operating costs.

In the case of warehouses using compressed gases (e.g. air) or power-to-gas solutions (including hydrogen), the efficiency achieved is significantly lower, down to 70%. It is therefore important to optimize the efficiency of the energy storage processes, e.g. when using electrolysis for hydrogen production or storage in the form of compressed gas, the overall efficiency of the process can be increased by collecting and using waste heat. The use of energy recovery imposes additional restrictions on the location of various forms of energy storage and makes its use dependent on the possibility of collecting heat.

Electromobility

In 2020, electric and plug-in hybrid cars barely accounted for barely 2% of newly registered cars, and these cars represented less than 1% of all passenger cars in Poland. A significant increase in the number of electric cars will increase the demand for electricity in the system. It is estimated that by 2050 about one-third of electricity consumption will be allocated to transport, electrification of heating and production of decarbonized gases. Such a significant increase will require increased production capacity and flexible operation of the system.

Until now, one of the main barriers to the development of the electromobility market in Poland are high investment outlays compared to internal combustion vehicles and the limited availability of both charging and parking infrastructure, resulting from restrictions, for example, in the use of underground garages. Due to the pace of development of electromobility in Poland so far, moving away from internal combustion engine vehicles may be a significant challenge.

Additionally, it will be necessary to develop and significantly increase the number of charging stations. The availability of infrastructure is even more important when using electric cars due to a shorter range compared to internal combustion cars.

The charging infrastructure is underdeveloped so far. The goals regarding the construction of generally accessible charging stations provided for in the 2018 Act on Electromobility and Alternative Fuels have not been met in most municipalities. At the end of July 2022, there were only 4,431 such stations in Poland[83].

Hydrogen projects

The costs of producing hydrogen constitute a major barrier to the use of hydrogen from zero-emission sources in Poland. Currently, hydrogen production in Poland is based mainly on steam reforming of hydrocarbons, and the total production is about 1.3 mln tonnes per year. In order for hydrogen to be considered renewable or low-carbon, it must be produced in the electrolysis of water in an electricity-powered plant, from low-carbon energy sources, in the process of biogas or biomethane reforming, or biochemical conversion of biomass, provided that it is sustainable or in plants powered by fossil fuels using CCS/CCU technologies[84].

Hydrogen plants using renewable energy in the electrolysis process exist in Poland only as part of research and development projects. According to the Polish Hydrogen Strategy for 2030 with an Outlook until 2040, in order for hydrogen produced by electrolysis to be competitive, it is necessary to reduce the costs of electricity used in this process to 10-20 EUR/MWh. Such a significant cost reduction can be achieved with a large share of nuclear energy and RES in the generation of electricity.

The main barrier in the hydrogen economy is the supply of large amounts of emission-free energy to produce hydrogen, in which CO_2 is not produced as a by-product.

83 According to data from the Polish Association of Alternative Fuels (Pol. Polskie Stowarzyszenie Paliw Alternatywnych, PSPA).
84 In line with the Hydrogen Strategy for a Climate-Neutral Europe, July 2020.

Opportunities, barriers, and challenges on the path to climate neutrality – summary:

The implementation of new generation technologies, such as offshore wind farms and nuclear energy, will contribute to a change in the energy mix, further decarbonization of electricity generation and the creation of new sectors of the economy and new jobs.

The energy transition in Poland will require significant changes in the entire value chain, from electricity generation to transmission and distribution as well as end-users.

Further development of renewable energy technologies will be the foundation for reducing the degree of emissions from electricity generation in the Polish energy sector.

The electrification of heat and the development of cogeneration units will contribute to the reduction of the emissivity of heat production.

The development of hydrogen economy in Poland will enable the balancing of production from RES through power-to-gas technologies and decarbonization of sectors in which it will be difficult to achieve emissions reduction through other tools.

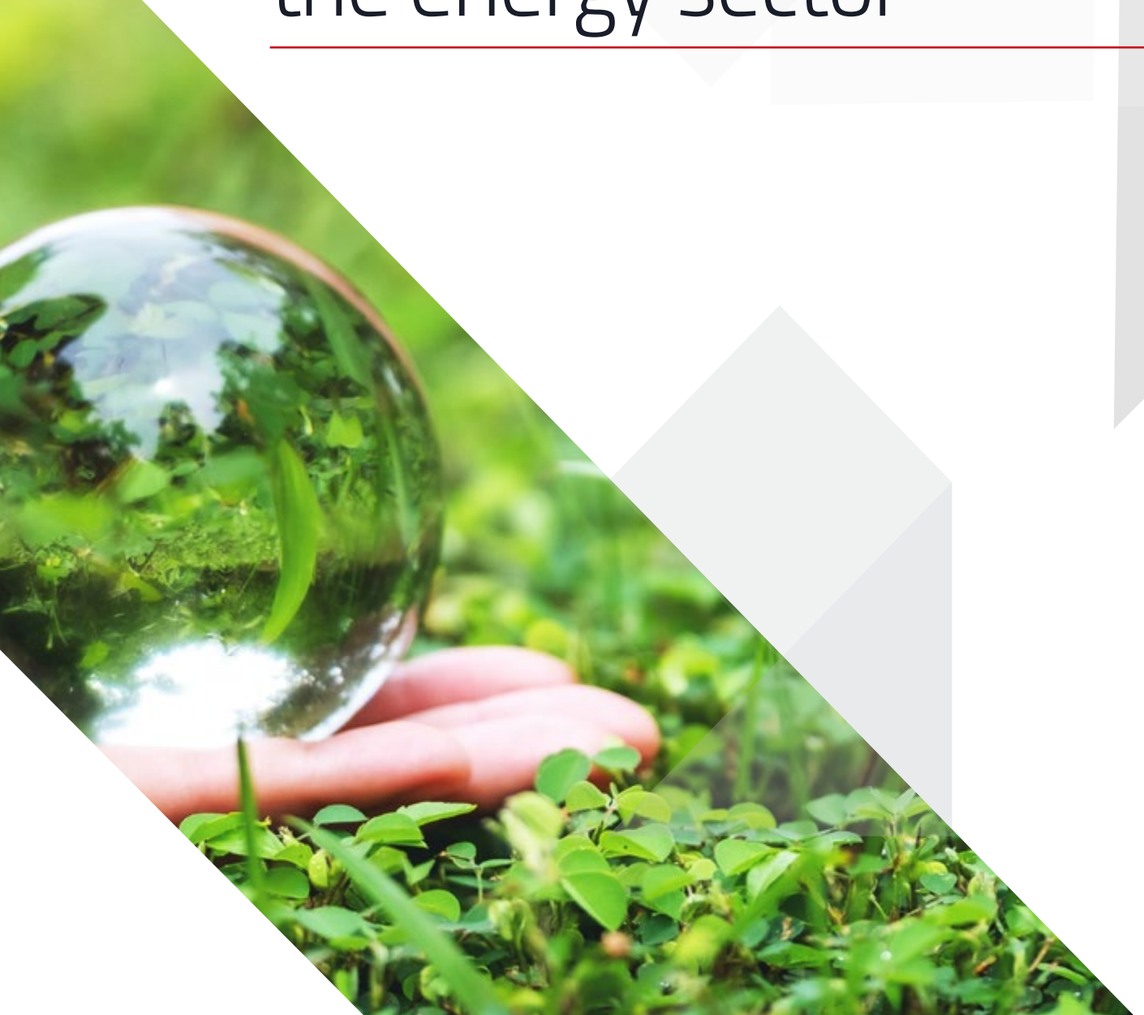
Mastering efficient energy storage will unlock the full potential of wind and solar farms.

In order to enable an increase in the share of RES in electricity generation, which will also contribute to improving energy security by reducing reliance on the import of fossil fuels, it will be necessary to modernise and develop transmission and distribution networks.

The use of energy storage and DSR mechanisms, while increasing the cross-border transmission capacity, will contribute to more flexible coverage of peak energy demand, which in turn may significantly reduce investments in new, peak generation sources.

06

Just transition as the only effective and long-term solution for modernisation of the energy sector



The Polish electricity sector went through a very deep transition during the 1990s. Dissolution of energy monopolies and partial transition towards market based systems coincided with very unstable conditions of recovery from the market collapse after geopolitical changes in 1989/1990. Social tensions were common in that period, however the electricity sector was able to mitigate them relatively quickly because of an evolutionary approach towards changes. Moreover, due to gradual increase of prices to levels covering full costs, the electricity sector supported other sectors of the economy in coming out of the recession. The situation in the mining sector, especially hard coal, was much more difficult, but it should be noted that 38 coal mines were completely shut down by 2005. The unbalanced pace of transformation of the mining sector and insufficient social aid caused severe social tensions, which slowed the transformation process.

Currently the energy sector needs to undergo another deep transition connected with climate protection. This time the electricity sector needs to almost entirely change its generation technology and the mining sector needs to put an end to extraction no later than in the 2040s. Many things will be generating social tension, especially in the regions where coal mines and power plants will be decommissioned. Rising electricity costs are another important issue that will impact the deepening energy poverty. To ensure a smooth transition a comprehensive approach is required. The need to consider social issues is included in the acts and regulations in the EU and globally, however speculations on the EUA, natural gas, and coal markets show that social aspects are not fully considered.

Poland should draw on its own experience from the 1990s and opportunities created at the EU level. In 2017, the EU launched a Coal Regions in Transition platform. Moreover, a Just Transition Mechanism was established to support regions affected or at high risk of being affected by negative socio-economic implications of transition such as Górny Śląsk or regions surrounding the mining and electricity generation sites in Bełchatów and Turów.

Additionally, the need to reduce energy poverty, which negatively impacts the transition process, is being underlined more and more often. Recognizing and addressing specific issues are taking place at the EU and national levels. The need to reduce energy poverty was underlined in the “Fit for 55” package proposal. On the national level, the definition of energy poverty was included in the Polish Energy Law as part of its amendment in 2021.

Environmental and climate protection issues addressed in parallel on the UN agenda influence and increase awareness of consumers. Interest in sustainable development, the emissions of the electricity sector, as well as the carbon footprint of purchased goods rises social pressure to reduce high emission fuels and increase production of energy from renewable sources. This directly influences the electricity generation sector as well as the mining sector including their functioning and how they are perceived by different stakeholders.

6.1 Energy poverty in Poland

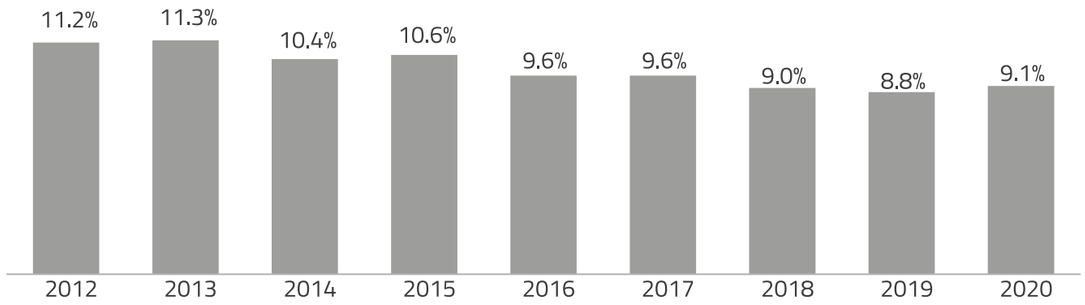
Rising electricity and heat prices increase the risk of more and more people being affected by energy poverty.

Energy poverty includes the inability to fully cover basic energy needs. The definition of energy poverty in Polish law was introduced in the Polish Energy Law in 2021. It covers 3 aspects: the amount of income, energy expenses, and efficiency standards of buildings/flats.

Historically, energy poverty was addressed, among other things, by support for vulnerable consumers of electricity and natural gas. Since 2013, such consumers could apply for an energy benefit provided by municipalities.

Defining the scale of energy poverty on a national level is difficult because of lack of precise indicators in Polish legislation (specific indicators should be prepared for the purpose of dedicated support mechanisms). A common indicator to describe energy poverty is Low Income, High Cost (LIHC). It encompasses both energy spending and overall income. This is one of the main indicators used by The Institute for Structural Research (Pol. *Instytut Badań Strukturalnych*, IBS) to measure energy poverty in Poland for many years.

Fig. 6.1 | Share of energy poor households in Poland between 2012 and 2020



Source: Own study based on data from IBS

The share of energy poor households was close to 10% over the past years, with the trend being on a decline between 2012 and 2020. Nevertheless, the share of energy poor households is expected to rise because of a significant increase in fuel and energy prices since 2021 which were further compounded by the impact of the Russian invasion of Ukraine.

Reduction of energy poverty is supported by energy efficiency and social programs. In response to rising prices many countries in Europe decided to introduce policies and instruments aiming to mitigate the impact of high energy prices on consumers. In Poland, such support is available under the Act of 17 December 2021 on Protective Benefit. The support amounts up to EUR 319 per person and the value is dependent on the income, number of persons living in a household, and the heat source.

Moreover, in 2022 an anti-inflation shield was implemented which temporarily decreases excise duties on the sale of electricity and certain motor fuels to minimum levels required by the EU. It also lifts a tax on the retail sale of motor fuels and reduces VAT for fuels, natural gas, heat, and electricity. Current anti-inflation shield measures in Poland are binding until the end of October 2022 and could be prolonged until the end of the year depending on the political and economic situation.

The implementation of long-term policies along with the ad hoc aid is crucial for reducing energy poverty, which was supported in the "Fit for 55" package proposal. Energy efficiency measures could support vulnerable consumers affected by energy poverty through measures to achieve the goals of the "Fit for 55" package, such as reducing energy consumption of households in this consumer group. The support for vulnerable consumers should also include consultancy on a local, regional, and national level.

Moreover, Poland put in place energy efficiency programs that include an additional income criterion when defining the amount of support. According to the "Clean Air" program, households meeting the income criterion may receive a grant which could reach up to 90% of total costs of modernisation of their heating system.

6.2 Social acceptance of the energy transition in Poland

Social aspects are crucial in the energy transition. Active participation of citizens is required to achieve ambitious climate targets. In Poland, the awareness of the need to effect changes is high. Almost 80% of Poles perceive climate changes as one of the major challenges in modern civilization and almost 75% believe that coal should be phased out of the energy sector and other generation technologies should be developed[85].

However, the cost aspect is still pointed out as the most important factor in transition (51%) followed by environmental and climate benefits (43%).

6.2.1. Influence of ESG on how the climate challenges are perceived

Over the past years, the Environmental, Social, and Governance (ESG) aspects became more and more important for companies and organisations alike. Due to the need for ESG reporting resulting from the implementation of EC directives on non-financial reporting, investors will be able to put pressure on companies, increasing their environmental requirements and contributing to increased investment in RES and other energy transition initiatives while limiting financing opportunities for fossil fuel projects.

Moreover, consumers also pressure companies through their choices, as they pay close attention to environmental impacts such as the carbon footprint of goods and services. Therefore, the implementation of internal assumptions of the ESG strategy can positively impact the image of companies.

The power companies – supporting members of PKEE appreciate the impact of ESG on their future development. The ESG aspects are incorporated into their strategies and operation plans of each company.

85 Based on CBOS research, Energy Transition: expectations and demands, June 2021.

Fig. 6.2 | Selected activities of PGE, ENERGA, ENEA and TAURON in terms of ESG

	PGE	ENERGA	ENEA	TAURON
Are ESG elements included in the strategy?	✓	✓	✓	✓
Are ESG elements included in operational plans?	✓	✓	✓	✓
E Example of an Environmental target	Achieve climate neutrality by 2050 at the latest	Biodiversity policy - systematising the approach	Activities for energy efficiency	Striving to minimize the use of hard coal and achieve climate neutrality by 2050
S Example of a Social target	Just transformation	Building social, civic and consumer, and ecological awareness	Development of cooperation with local communities (city movements and local governments)	Supporting activities for the public wellbeing and effective and transparent dialogue
G Example of a Governance target	ICT security	Development of a climate policy, Identification of physical and regulatory climate change risk	Modern, transparent and ethical Organisational Governance at all levels throughout the ENEA Group	Management of the TAURON Group while maintaining corporate governance and management goals related to ESG
An example of an ESG project	Competence Development Center, which creates opportunities for retraining employees related to lignite, mainly to specialties related to renewable energy	The implementation of ESG goals has been included in the Managerial Goals Charter	The nationwide educational campaign #BałtykDlaPokoleń (*Baltic for Generations*), the aim of which is to draw attention to threats to the Baltic Sea ecosystem from dumped ammunition and chemical weapons for WWII	Investments in renewable energy as part of the implementation of TAURON's Green Return, including in post-industrial areas

Source: Own study based on CSR reports of supporting members of PKEE

6.2.2. Social acceptance in the mining sector

Activities limiting the impact of the mining sector on the environment and human health are developed on wide range of forums at the EU and global level. This topic was broadly addressed in the Paris Agreement, Just Transition initiative, and EU Coal Regions in Transition platform. At the EU level, the activities were further developed within the Just Transition Platform.

"Just Transition" initiative

The "Just Transition" initiative focuses on transformation aspects in the mining sector. The overarching goal of the initiative is to support regions whose economies rely on mining in their transition process towards sustainable economy, create suitable jobs for workers leaving the mining sector and combat climate change.

The purpose of the guidelines which were developed based on the experience of other countries is to guide countries in their transformation by proper definition, implementation, and supervision of transition actions towards a sustainable economy. Although development stages and needs vary from country to country, the initiative identifies actions that should be taken in all countries:

- investments in the low-carbon sectors which offer high employment,
- establishment of related social and health policies,
- social dialogue and trilateral policies,
- education and development in the area of new technologies supporting changes in the industry.

Once implemented, these actions will support transition from high-carbon economy to a sustainable one.

Actions on the EU level

In 2017, Coal Regions in Transition initiative was launched to help EU countries address social issues due to the decline of coal mining. The initiative was further developed in 2020 in the scope of Just Transition Platform operating between 2021 and 2027 and Just Transition Mechanism facilitating access to protective measures.

Coal Regions in Transition Initiative and Just Transition Platform

"Coal Regions in Transition" initiative aims to support regions that are the most carbon-intensive in identifying, developing, and implementing projects that will have a long lasting impact on stimulating economic and technological transformation. The platform facilitates a dialogue between national, regional, and local levels with EU representatives in defining a realistic policy framework and direction of the transformation processes through the development of a long-term strategy speeding up the transition to clean energy sources.

The scope of Coal Regions in Transition initiative was expanded through Just Transition Platform in 2020, which supports just transition through dedicated counselling for regions reliant on fossil fuels and carbon-intensive industries.

Just Transition Mechanism and Territorial Just Transition Plans

Just Transition Mechanism supports regions, industries, and workers most affected by the transition by providing access to dedicated funding, including:

- Just Transition Fund, which mainly supports the activities envisaged in Territorial Just Transition Plans with grants,
- InvestEU programme,
- Public Sector Loan Facility (PSLF) for the public sector to support public infrastructure projects that cannot obtain commercial financing.

These instruments are described in more detail in Chapter 7.2.

Preparation of a Territorial Just Transition Plan in cooperation with the EC is a requirement to receive support from Just Transition Fund. The plan should outline a roadmap for moving away from fossil fuels by 2030 and 2050 and the resulting social, economic, and environmental challenges. The plans should also provide measures that could be financed through Just Transition Fund and the other two pillars of Just Transition Mechanism.

Territorial Just Transition Plans were prepared for the areas shown in Fig. 6.5. The preparation of Territorial Just Transition Plans was supported by PKEE members. TAURON was actively involved in the preparation of the Western Małopolska Territorial Just Transition Plan by joining the team developing this document. PGE actively supported the process that led to the European Commission recognizing in 2022 the Łódzkie Voivodeship as one of the regions supported by the Just Transition Fund.

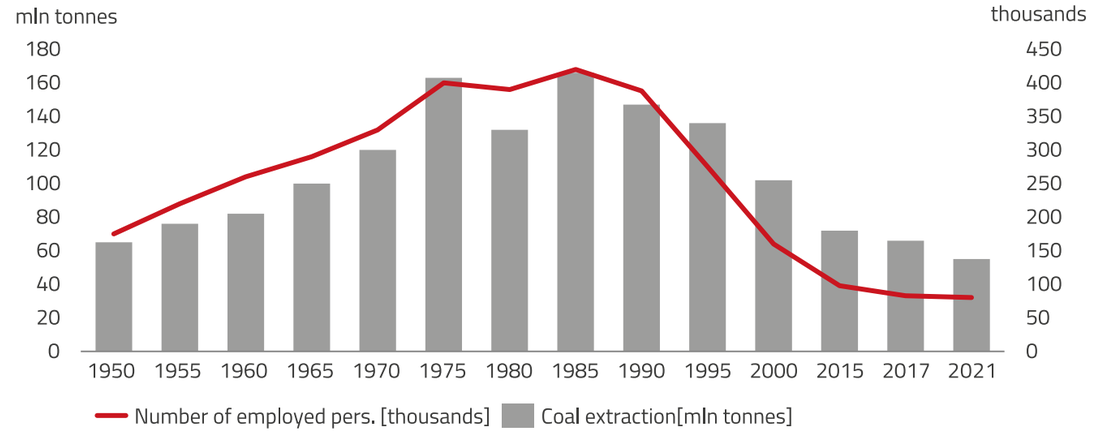
Moreover, the transition actions on national level are outlined in the Recovery and Resilience Plan for Poland (NRRP) which aims to allocate 42.7% of 35.4 bn EUR of the total budget towards climate objectives including just transition projects[86]. The National Just Transition Plan is also in progress; it will describe actions supporting the implementation of NECP and how the funding from Just Transition Mechanism is to be used.

86 On 30 June 2022, the draft of the CSRD as agreed upon by the Council and the EU Parliament was published – the primary objective of the proposed regulations was to ensure transparent and public access to information on ESG for investors, financial institutions, and other stakeholders.

6.2.3. Influence of the transition of the energy sector on the labor market between 2021 and 2050

Despite enormous changes in the sector and a reduction in employment by approx. 80% since 1989, Poland still has a long way to go in transforming the mining sector. According to estimates of the Joint Research Center, over 200,000 people work in mining and directly related industries at the EU level, and more than half of them work in Poland[87]. According to The Institute for Structural Research (Pol. *Instytut Badań Strukturalnych*, IBS), the Polish mining industry may experience a surplus of 14,000 to 36,000 people.

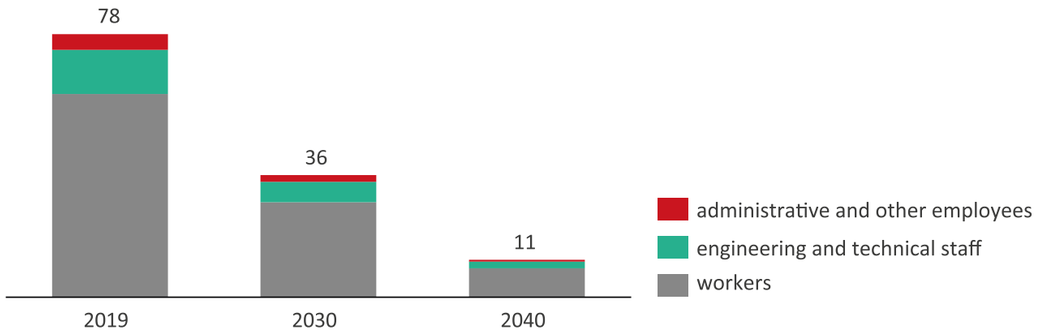
Fig. 6.3 | Employment (in thousand persons) and production (in mln tonnes) of the hard coal mining sector in Poland



Source: Own study based on Eurostat, ARP, and historical data

87 Mandras, G., and Salotti, S. (2021). Indirect jobs in activities related to coal, peat and oil shale: A RHOMOLO-IO analysis on the EU regions. JRC Working Papers on Territorial Modelling and Analysis No. 11/2021, European Commission, Seville, JRC127463.

Fig. 6.4 | Forecast of employment in the hard coal mining sector in Poland until 2040 [in thousand persons]



Source: Own study based on IBS and ARP data

Śląsk is the region most affected by the transition since the employment rate in hard coal mining in the region corresponds to around 90% of the sector's workforce nationwide. Transforming the region and aligning with climate policy will lead to a decrease in coal consumption and mining. In this context, it is necessary to implement appropriate protective programs in which local authorities should play an important role. Their role is to lead an open dialogue with residents, workers, and managers of the coal mines which will define the potential for transition activities and needed protective measures in the region. Only a clear vision of the transition process can lead to implementation of relevant investments.

Programs that will effectively reduce employment in the mining sector without causing major social tensions are needed to respond to the challenges of transformation in the mining sector[88]. Current restructuring programs take into consideration the requalification of employees leaving the sector to work in different branches of the economy. Aside from requalification programs in the mining industry, it is also important to enable workers to improve their skills in order to maintain work safety in the mines and support their technical development, despite staff reductions.

Example of such activities is a Competence Development Center (Pol. *Centrum Rozwoju Kompetencji*, CRK), which was established in 2021 as a result of cooperation between local government of the Łódzkie Voivodeship and PGE. CRK educates and supports workers in the development of their competences in the energy sector, supports the requalification of workers of the conventional energy sector and educates residents in Łódzkie region. Moreover, PGE has established a technology center for RES market which was based on the current companies supporting the conventional energy sector (which will undergo transformation to carry out renewable energy projects involving production, maintenance, and recycling of end-of-life PV and onshore wind farms).

TAURON is also actively involved in just transition projects. A number of actions have been taken to prepare current workforce for requalification, starting a new business or relocating to other divisions of companies in the TAURON Group. Additionally, TAURON takes an active part in The Secretariat's Technical Assistance to Regions in Transition (START) – a program which aims at providing technical support by the EC for projects reported for the Just Transition Fund for the Małopolskie Voivodeship.

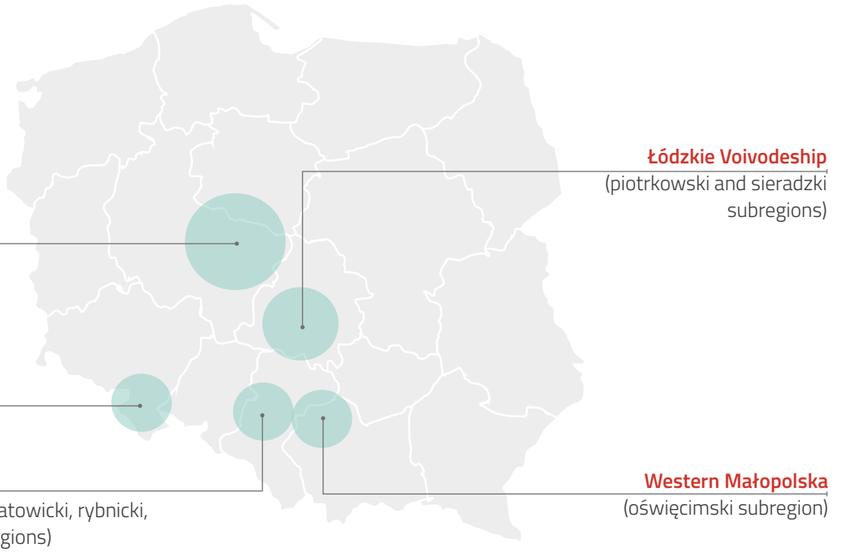
Without implementing initiatives, support mechanisms, and protective measures, the phase out of coal mines in Poland and the demand for workers in the mining sector will significantly increase the poverty of mining families, the long-term increase of unemployment rate, and depopulation of regions. Considering that social tensions can slow down the transformation process, it is necessary to create programs for Górny Śląsk and other coal mining regions including lignite (Łódzkie, Dolnośląskie, and Wielkopolskie) as part of planning of the extensive transformation process.

In case of lignite, the deposits on which the mines operate are nearly depleted, whereas downsizing (despite being deferred over a period of time in many regions) will cause challenges across Poland. Some cities such as Bogatynia or Bełchatów are almost 100% dependent on the operation of their mines and power plants, which will be phased out starting in the 2030s. This is why the transition process in the lignite sector is facing different challenges than in the hard coal sector in Śląsk. Nevertheless, the process should be supported by the implementation of Territorial Just Transition Plans.

88 There are new initiatives, such as the Social Agreement on the Transition of the Hard Coal Mining Sector and Selected Transition Processes in the Śląskie Voivodeship, which was signed in May 2021.

The figure below presents the regions to be supported under Just Transition Fund. Final support from the Just Transition Fund may take place upon approval of the Territorial Just Transition Plan.

Fig. 6.5 | Regions to be covered by support as part of Just Transition Fund



Source: own study based on Partnership Agreement with Poland for the implementation of the 2021-2027 Cohesion Policy

6.3 Necessity for long-term planning of the energy transition

Achieving climate neutrality by 2050 in Poland will require a thorough and dynamic restructuring of the energy system. Investments in the energy sector are time-consuming therefore it is crucial to carry out the transition in the most economically, technically, and socially efficient way while maintaining Poland's energy independence.

Hard coal

The Program for Hard Coal Mining Sector in Poland was adopted in 2018 with an outlook until 2030. The purpose of the Program is to improve the standing of the hard coal mining sector and make effective use of its resources. The implementation of the Program is monitored annually. In 2022, the Program was revised based on the assumptions of the PEP2040 update and the Social Agreement on the Transition of the Hard Coal Mining Sector and Selected Transition Processes in the Śląskie Voivodeship which set the dates of closing of hard coal mines in Poland. Once revised, the Program will achieve an additional just transition target taking by incorporating actions aimed at phasing out the hard coal mining and the public support mechanisms of that process. According to the Program, the closure of hard coal mines in Poland should be completed by 2049. Moreover, The 2030 Górny Śląsk Territorial Just Transition Plan also provides a time schedule for restructuring or closing the hard coal power plants in the region.

Apart from the coal mines in Śląsk or Małopolska, the Bogdanka mine, which is located in Lubelskie Voivodeship, is scheduled for closure in 2049.

Lignite

In 2018, the Program for Lignite Mining Sector in Poland was adopted. The purpose of the Program is to assure the competitiveness of the lignite mining sector in Poland and efficient management of lignite deposits. The Program covers the 2018-2030 time frame including actions in the 2050 horizon and shows the directions of development of the lignite mining sector in Poland and the planned use of currently

mined lignite deposits. By 2044, all of the lignite open pit mines currently in operation are scheduled for closure:

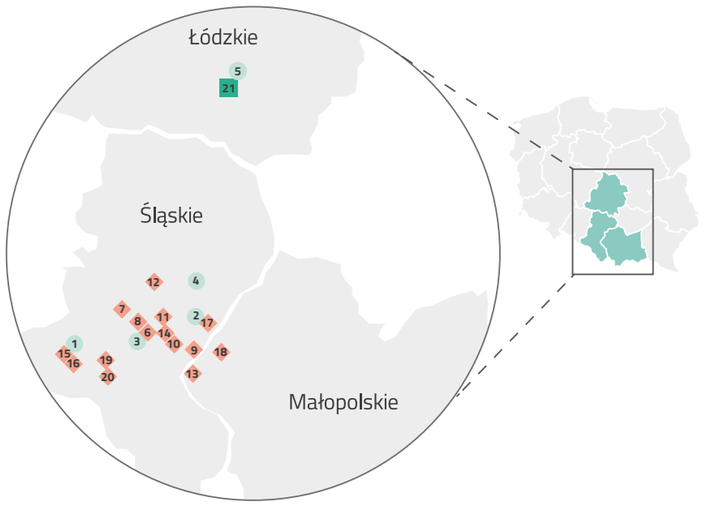
- Konin Lignite Mine – in 2030,
- Bełchatów Lignite Mine – in 2040,
- Turów Lignite Mine – in 2044.

Adamów Lignite Mine was closed in 2021. Although the Program initially pointed out possible investments in new deposits apart from scheduled closures, at the stage of PEP2040 preparation it was decided not to extract coal from new open pits which were so far regarded as promising, such as Złoczew deposit. The likelihood of similar investments is low as the CO_2 emission reduction targets on the EU level are increasing.

Lignite mines are closely linked to energy generation as its main recipients are nearby power plants. Aside the lignite deposits there are power plants and power plant complexes such as Adamów, Konin and Pątnów Power Plant Complex (ZE PAK), Bełchatów Power Plant, and Turów Power Plant. Their operation in the current form is dependent on lignite extraction and closing the open pits forces the plants to be closed or rebuilt with different energy source. ZE PAK may terminate coal-fired energy production as soon as 2025. Adamów Power Plant was closed at the beginning of January 2018. The shutdown of the power plant's generating units was dictated by the decision of the EC acting on the basis of the derogation described in the Directive of 24 November 2010[89] stating that the operation of generating assets at the Adamów Power Plant must be terminated at the beginning of January 2018. In Pątnów, the operation of all coal-fired units is planned until the end of 2024, which is the time until which the assets will receive support from the Capacity Market. In Konin Power Plant, the total power output is 100 MWe (2 x 50 MWe) which uses biomass as the primary fuel and replaces coal-fired units. Putting an end to energy production based on lignite at ZE PAK will also trigger early termination of extraction operations changes in the implementation of the Program for the lignite mining sector in Poland.

Fig. 6.6 | Planned dates for closing or significant restructuring of mines and power plants in Śląskie, Małopolskie, and Łódzkie Voivodeships

Termination/restructuring dates	
Power Plants	
1 - Rybnik	2030
2 - Jaworzno	2030
3 - Łaziska	2030
4 - Łagisza	2035
5 - Bełchatów	2036
Hard coal mines	
6 - Bolesław Śmiały	2028
7 - Sośnica	2029
8 - Halemba i Bielszowice	2034
9 - Piast	2035
10 - Ziemowit	2037
11 - Murcki-Staszic and Wujek	2039
12 - Boberek-Piekary	2040
13 - Brzeszcze	2040
14 - Mysłowice-Wesoła	2041
15 - Rydułtowy	2043
16 - Marcel	2046
17 - Sobieski	2049
18 - Janina	2049
19 - Chwałowice	2049
20 - Jankowice	2049
Lignite mines	
21 - Bełchatów	2036

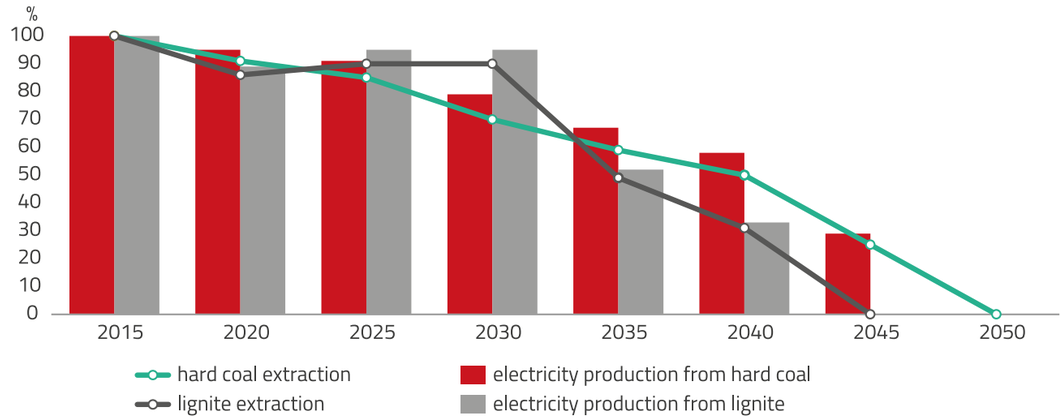


Source: Own study based on The 2030 Górny Śląsk Territorial Just Transition Plan, Łódzkie Voivodeship Territorial Just Transition Plan, and The Social Agreement on the Transition of the Hard Coal Mining Sector and Selected Transition Processes in the Śląskie Voivodeship

89 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (recast)

The coal mining and electricity production provided for in PEP2040 will be updated. Due to the current market situation and abandoning the plans to operate on the Ościsłowo and Złoczew lignite deposits, planned lignite mining can be much lower than expected after 2020. The projected electricity production at ZE PAK and Bełchatów Power Plant can also be lower and coal-fired electricity production may come to an end sooner – around mid-2020s for ZE PAK and mid-2020s for Bełchatów Power Plant.

Fig. 6.7 | Forecast for hard coal, lignite and associated electricity production in Poland until 2040 including the plans for closure of the hard coal and lignite mines until 2050



Source: own study based on PEP2040 and publications of the Ministry of State Assets (MAP)

Just transition as the only effective and long-term solution for modernisation of the energy sector – summary:

Since 2021, there is a noticeable increase in energy prices due to rising prices of fuels and CO_2 emission allowances contributing to a higher share of investments in RES. An additional catalyst for reducing the use of fossil fuels is the growing pressure from different stakeholders resulting from the implementation of the ESG principles.

Rapid increase in electricity prices over the past two years may contribute to the growth of the share of households affected by energy poverty, which accounted for around 9% of all households in 2020.

Phasing out the coal and lignite mining and the corresponding power plants is carried out pursuant to the national sectoral programs, which call for the decommissioning of lignite mines and hard coal mines by 2044 and 2049, respectively.

Energy transition will have a considerable influence on the labour market in the mining regions in Poland, where the mining sector and the conventional energy sector employ approx. 100,000 people.

Energy transition should be realized in such a way as to minimize the negative impact on communities most affected by the changes, especially those at risk of energy poverty and living in the mining regions.

The support for just transition is available through dedicated EU support mechanisms that are part of the Just Transition Mechanism and should be effectively utilized.

07
Costs and financing of the energy transition

7.1 Investment outlays of the energy transition in Poland and investment capabilities of the sector

Achieving the emission reduction targets or the share of renewable energy sources will require further implementation of the country's energy transition and additional investments in the following areas:

- **Conventional energy generation** – in relations to modernisation and replacement investments, upholding the BAT Conclusions and MCP Directive (in case of sources under 50 MW), investments increasing flexibility of generation units for cooperation with non-controllable RES and investments related to the growth of electricity demand,
- **Renewable energy** – in order to continuously increase the share of renewable energy to reach CO_2 emission reduction and RES share targets,
- **Nuclear energy** – in order to introduce zero-emission nuclear power plants to the Polish energy mix from 2033,
- **District heating systems** – in order to increase the share of RES in heat production, increase the share of alternative heat sources using electricity, increase waste heat utilization, build high-efficiency cogeneration units, build heat storages, modernise and further develop heat networks,
- **Transmission and distribution networks** – which must be developed to ensure the crucial security of energy supply, the ability for RES to connect to the network and provide additional services for local initiatives,
- **Energy efficiency** – in terms of electricity and heat generation – by improving the efficiency of existing conventional sources, local boilers, and district heating plants,
- **Protective measures** – through creation of new jobs, requalification of workers and restructuring of mining regions directly connected to electricity generation and industry, as well as supporting households.

Additionally, the Polish economy will need to cover the costs of lost benefits resulting from early mine closures, rehabilitation of former coal mining sites and reduction of activities in energy-related sectors. These costs are difficult to estimate, however considering the scale of activities needed to be implemented in Poland they could be a significant burden for the country especially considering the rapid pace of the transition.

According to PEP2040, investment outlays in electricity generation sector between 2021 and 2030 should reach around 45 bn EUR, followed by around 66 bn EUR in the next period between 2031 and 2040. In the district heating sector, the total investment outlays between 2021 and 2030 are estimated at 8.5 bn EUR, followed by around 5 bn EUR between 2031 and 2040.

Estimation of costs based on the assumptions of the PEP2040 update, possible energy efficiency measures, investment plans of PSE and distribution companies and necessary protective measures suggest that total investment outlays in electricity and heating sectors could exceed 100 bn EUR. Further 25 bn EUR will be required for protective measures in the mining and energy generation sectors. Total costs of achieving climate neutrality by 2050 could exceed 200 bn EUR in electricity generation alone.

Additionally, according to the draft Strategy for the District Heating Sector until 2030 with the 2040 perspective total investment outlays covering heat production and distribution could reach around 16 bn EUR by 2030 and up to 20 bn EUR by 2040 in district heating sector considering the ambitious climate targets set in the "Fit for 55" package. In case of further development of the district heating systems, those costs could be higher.

The costs of protective measures in the mining sector will also need to be covered. According to EY estimation based on the just transition plans, these costs could reach up to 40 bn EUR.

This Chapter focuses on the 2030 perspective since analyses covering longer periods carry a high degree of uncertainty to both the reduction targets and technological development over the next thirty years. Moreover, the financing measures for energy transition using the EU budget are defined only for part of this decade (until 2027).

Most likely there will be a need to update current estimations of costs as a result of the dynamic changes on commodity and metal industry markets as well as real labour costs in the medium term. Factors that could impact the update should be considered not only for forecasts but also during detailed planning of the regulatory measures.

Table 7.1 | Forecasts of energy transition costs from 2021 to 2030 [bn EUR]

	Estimation based on the assumptions of the PEP2040 update, investment plans of PSE and distribution companies, cost estimates for energy efficiency and protective measures		
Investments in electricity generation	~66 bn EUR	including: ~34 bn EUR for RES Including: ~10 bn EUR for CHP and CCGT including: ~12 bn EUR for modernisation of existing units including: ~10 bn EUR for first stages of building the first two nuclear power plant units	EY estimation based on required investment outlays and projected energy generation mix in 2030 (developed based on PEP2040 and draft assumptions for PEP2040 update, required investments in existing generation units and expected costs for nuclear power plants)
Investments in the transmission networks	~7 bn EUR	For modernisation and expansion of transmission networks	Investment outlays by 2030 estimated by EY based on PRSP 2022-2032 assuming linear distribution of costs over defined period
Investments in distribution networks	~18 bn EUR[90]	For modernisation and expansion of distribution networks	Costs by 2030 estimated based on strategies of energy companies (assuming linear distribution of capital costs for strategies with a horizon beyond 2030)
Investments in heat production and distribution	~16 bn EUR[91]	For transition of the district heating networks to meet the "Fit for 55" targets	Costs estimated at the level set by the Strategy for the District Heating Sector until 2030 with the 2040 perspective
	Estimation based on the assumptions of the PEP2040 update, investment plans of PSE and distribution companies, cost estimates for energy efficiency and protective measures		
Energy efficiency investments in the production and distribution of electricity and heat	~ 5 bn EUR	Considering increase in efficiency of electricity and heat generation	Costs estimated based on the energy efficiency sectoral studies and analyses carried out for the preparation of NECP done by EY on behalf of PKEE[92]
Protective measures in the mining end energy generation sectors	~25 bn EUR	For protective measures in the mining sector	Costs estimated based on press releases from the Ministry of Development Funds and Regional Policy with respect to just transition
Total	**~135 bn EUR**		

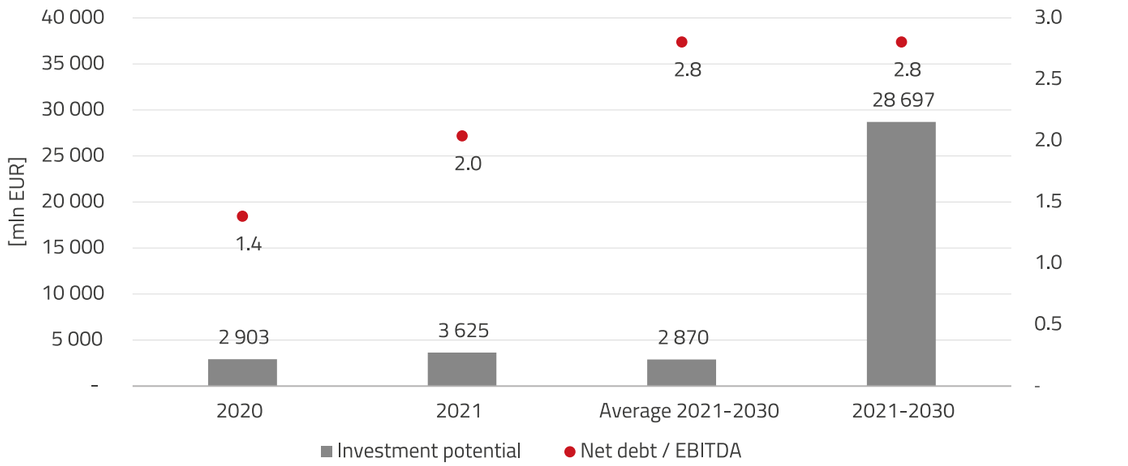
Source: Own study based on PEP2040, assumptions of the PEP2040 update, Strategy for the District Heating Sector until 2030 with the 2040 perspective, strategies of energy companies and studies carried out by EY on behalf of PKEE

Major part of the presented capital costs will need to be covered by national energy companies whose investment potential is significantly reduced as a result of i.a. increasing CO_2 emission costs and high debt.

According to an EY study, the total investment potential of four largest energy groups, i.e. PGE, TAURON, ENEA, and ENERGA – considering safe levels of debt – reaches almost 29 bn EUR in the 2021-2030 period, however this estimate does not include dividend payments throughout the period. In the event of a decision to change the dividend payment policy, this potential could be significantly reduced. Assuming that 18 bn EUR will be spent on distribution networks, the remaining potential (around 10.5 bn EUR) of the energy companies will be allocated to investments in new generation sources most of all RES.

The estimations were based on the current economic situation of the energy companies, their investment plans and related additional cashflows (in terms of expenditure, debt service, and generated funds).

Fig. 7.1 | Estimated investment potential of four Polish energy groups in the 2021-2030 period [mln EUR]*



* net debt/EBITDA – average for 4 energy companies
investment potential – sum for all 4 energy companies

Source: Own study based on the reports of energy companies

90 According to data from PTPiREE concerning the Charter of Effective Transition, the investment costs of the five largest distribution companies until 2030 only in the field of the so-called "necessary investments" are estimated for approx. 30 bn EUR, which covers investments that result from formal and legal requirements (current and prepared for implementation), including connection measures for electricity consumers and producers (in particular RES). Currently, the supporting measures in this regard amount to around 1.5 bn EUR and they could only partially support the implementation of planned investments.

91 According to data from PTEZ concerning the decarbonization of the district heating sector in Poland in the light of the "Fit for 55" package, the total cost of the adaptation of the requirements set out in the draft package could reach up to 50 bn EUR by 2026 for the generation infrastructure, transmission and distribution networks and modernisation of recipient installations.

92 Report "Elaboration of the forecast of final energy demand, RES development and increase of energy efficiency between 2021 and 2030".

Considering that the RES investments are carried out also by private entities and foreign investors, it is expected that the investment potential to enable energy transition will be higher. The estimated share of the investment costs covered by private investors (both national and foreign) in onshore and offshore wind farms and PV totals 10.5 bn EUR (covering around 40% of the required investment costs in this regard).

The 7 bn EUR of investments required in the area of transmission networks will most likely by covered by the PSE Transmission Network Operator, mainly from sources such as quality fee supported by financing from EU budgetary measures.

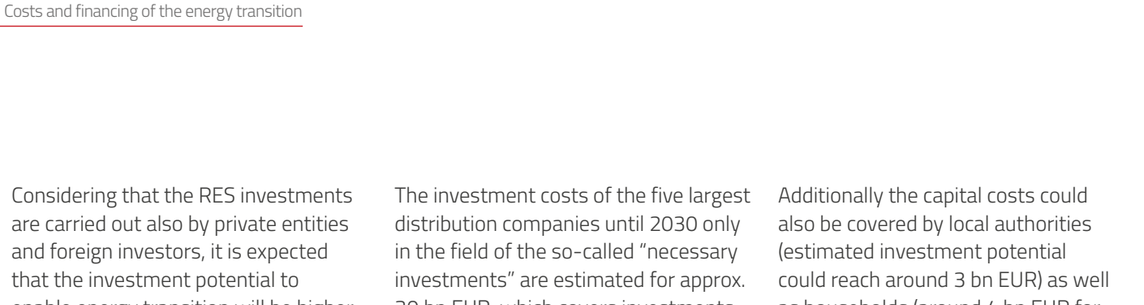
The investment costs of the five largest distribution companies until 2030 only in the field of the so-called "necessary investments" are estimated for approx. 30 bn EUR, which covers investments that result from formal and legal requirements (current and prepared for implementation), including connection measures for electricity consumers and producers (in particular RES). Currently, the supporting measures in this regard amount to around 1.5 bn EUR and they could only partially support the implementation of planned investments.

Moreover, the investment potential of district heating companies – apart from main energy companies – is estimated at around 4 bn EUR for the 2021-2030 period[93].

Additionally the capital costs could also be covered by local authorities (estimated investment potential could reach around 3 bn EUR) as well as households (around 4 bn EUR for development of the prosumer sector – including possible grant component for PV installations[94]).

Considering the investment potential and the sectoral needs in this regard, delivery of the energy transition in Poland according to the CO_2 emission reduction and RES share targets will require significant support from EU funds or additional capital inflows from foreign or national investors. The total gap could reach **around 77 bn EUR** by 2030.

Fig. 7.2 | Estimated investment gap for the energy transition in the 2021-2030 period [bn EUR]



Source: Own study based on PSE analyses and reports of energy companies

93 Estimate based on the historical investment costs of heating companies presented in District Heating in Numbers by URE.

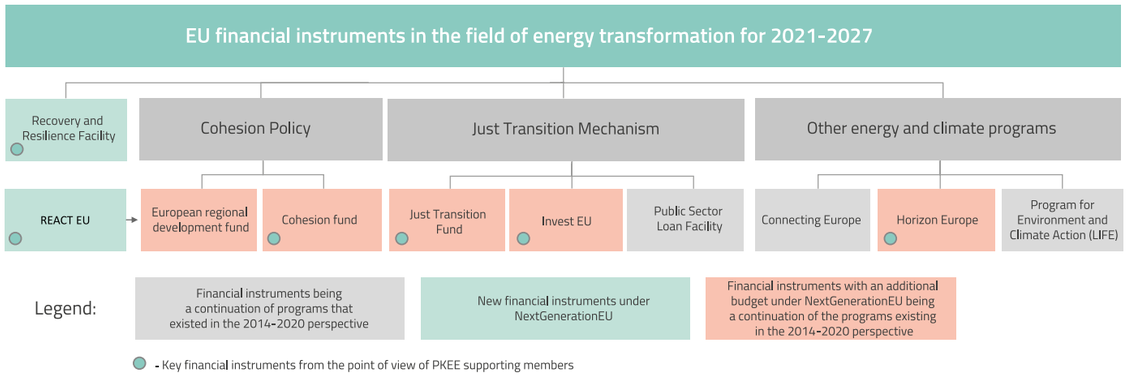
94 In the form of programs such as "My Electricity", as part of which until July 2022 the financing supported over 2.3 GW of micro PV installations reached over 0.4 bn EUR of total paid out grants.

7.2 Financial support for the transition from EU funds and the state budget

The investment gap between the investment capacity of the sector and its needs in terms of transformation and implementation of climate policy should be covered by financial resources available under EU and national funds.

Poland, as one of the largest beneficiaries of EU funds, can also count on significant financial support for the transformation of the economy in the new 2021-2027 perspective, including the implementation of climate policy in the energy sector in the form of the Cohesion Policy (including the Just Transition Fund) and the Modernisation Fund. In addition, as part of stimulation efforts aimed at the economy after the COVID-19 pandemic, Poland will also be able to use the Recovery and Resilience Facility, which, according to the NRRP, would be dedicated almost in half to renewable energy and to increasing energy efficiency. Not all instruments can be used by entities from the commercial energy sector. In many cases, it is not possible to determine the share of the allocation of funds for the commercial energy sector, but due to limitations, including those resulting from the conditions for granting state aid, most of the funds will most likely be used by other entities. Nevertheless, the use of all funds is crucial for an effective transformation of the energy sector.

Fig. 7.3 | EU financial instruments in the field of energy transition for 2021-2027



Source: Own study based on the Multiannual Financial Framework 2021-2027

7.2.1. Funds coming directly from the EU budget

Recovery and Resilience Facility

The Recovery and Resilience Facility is intended to mitigate the impact of the COVID-19 pandemic on the economy and support the green and digital transformations. The funds for this Facility have been provided under the NextGenerationEU recovery plan and amount to over 806.9 bn EUR in the 2020-2026 period for the entire EU. On the basis of the resources allocated to individual Member States, National Recovery and Resilience Plans were prepared. Approximately 35.4 bn EUR of expenditure has been planned under the Polish Plan, with subsidies and loans representing 23.9 bn EUR and 11.5 bn EUR, respectively. 42.7% of the budget under the Polish NRRP could be allocated to support the green transformation – approx. 15.1 bn EUR.

Table 7.2 | Planned support from the Recovery and Resilience Facility from 2021 to 2026

Total budget	Poland's share	Implementation of the goals of the green transformation in Poland
806.9 bn EUR	35.4 bn EUR	15.1 bn EUR

Source: Multiannual Financial Framework 2021-2027 and the National Recovery and Resilience Plan

Cohesion Policy

The Cohesion Policy is one of the main sources of funding in the EU in 2021-2027. It covers areas such as job creation, business competitiveness, sustainable development, and improving the quality of life of citizens. Thus, it also includes elements of the energy transition.

Support from the Cohesion Policy is provided under specific funds and the Just Transition Fund (JTF), which is also part of the Just Transition Mechanism. Additional support through the Cohesion Policy was launched under the REACT-EU instrument, which is part of the NextGenerationEU program, by allocating additional funds to counteract the impact of the COVID-19 pandemic and support digital investment and green transformation. Funds under this instrument are allocated based on the impact of the COVID-19 pandemic on individual countries and their wealth.

The total budget for the Cohesion Policy amounts to approximately 392 bn EUR over the 2021-2027 period. Support for Member States is allocated on the basis of partnership agreements, which set programming strategic directions and include arrangements for the effective and efficient use of funds. Such an agreement with Poland was concluded on 30 June 2022. Under this agreement, Poland has been allocated funds in the amount of 76.5 bn EUR, of which approximately 72.2 bn EUR comes from funds dedicated exclusively to the Cohesion Policy and almost 3.9 bn EUR from the Just Transition Fund. Funds from the Cohesion Policy should be allocated towards the implementation of the 6 Objectives of the Cohesion Policy (CP), which include:

- a more competitive and smarter Europe (CP1),
- a greener, low-carbon Europe (CP2),
- more connected Europe (CP3),
- more social and inclusive Europe (CP4),
- Europe closer to its citizens (CP5),
- Just Transformation (CP6).

The largest pool of funds, nearly 22 bn EUR, is allocated towards the implementation of CP2 - a greener, low-carbon Europe. Activities in this area include improving the energy efficiency of enterprises, residential buildings and public buildings, construction and modernisation of heating systems, construction and reconstruction of networks into smart networks that enable the reception of energy from renewable sources, expansion of energy storage systems, and investments aimed at strengthening the circular economy, measures to protect natural heritage and biodiversity, strive for sustainable sewage and water management, and adaptation to climate change.

From the entire pool of funds from the Cohesion Fund, 17.9 bn EUR are planned to be used in the field of renewable energy sources and the circular economy. The allocated funds will support the implementation of, among others, the European Funds for Infrastructure, Climate, Environment (FEnIKS program, supporting initiatives such as energy modernisation of buildings or the development of combined production of electricity and heat in the process of high-efficiency cogeneration), and the European Funds for Eastern Poland program (the purpose of the fund is, among others, to support investments related to the development of smart energy networks).

Table 7.3 | Planned support from the Cohesion Policy from 2021 to 2027

Total budget	Poland's share	Funds for Poland in the field of renewable energy sources and circular economy
392 bn EUR	72.2 bn EUR	17.9 bn EUR

Source: Own study based on data from the European Commission

Just Transition Fund

The Just Transition Fund is part of the Just Transition Mechanism and the EU Cohesion Policy. The purpose of the Fund is to support regions affected by the energy transition by offsetting its negative impact in the socio-economic area and supporting land rehabilitation. Support from the Fund is provided on the basis of the Territorial Just Transition Plans. From a total budget of 19.3 bn EUR for 2021-2027, Poland will be granted 3.85 bn EUR for specific regions within the Śląskie, Wielkopolskie, Dolnośląskie, Łódzkie, and Małopolskie Voivodeships.

Table 7.4 | Planned support from the Just Transition Fund from 2021 to 2027

Total budget	Poland's share	Funds for the implementation of Just Transition goals in Poland
19.3 bn EUR	3.85 bn EUR	3.85 bn EUR

Source: European Commission, "Multiannual Financial Framework 2021-2027 (in commitments) - Current prices"

Additional funding opportunities from the EU budget for 2021-2027

In addition to the aforementioned instruments, the EU budget includes funds and programs supporting the energy transition and achieving climate goals, in which the pool of available funds is not directly distributed among the Member States; it is allocated on the basis of applications and planned projects, often taking into account the aspect of international cooperation. These funds are managed centrally by the European

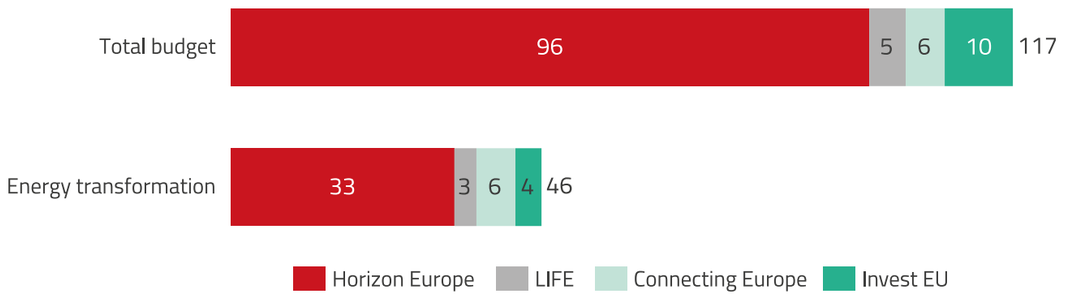
Commission[95]. Such programs are:

- Invest EU – The successor to the Investment Plan for Europe, which was in effect from 2015 to 2020. The purpose of Invest EU is to fill the investment gap and improve investment levels by providing an EU guarantee for lending by the EIB, national development banks, and other financial institutions to:
  - Sustainable infrastructure,
  - Research, innovation, and digitalization,
  - Small and medium-sized enterprises (SMEs),
  - Social investment and skill development.

  Support under Pillar I (Invest EU Fund) is to be provided in the form of investment guarantees. Funds of approx. 10.2 bn EUR have been allocated in the EU budget, which is expected to translate into 26.2 bn EUR in support and enable the implementation of investments totalling over 372 bn EUR. 75% of the pool is to be provided by the European Investment Bank, and the remaining 25% by partners selected for this purpose,
- Public Sector Loan Facility (PSLF) – the facility is part of the Just Transition Mechanism and is intended to support the public sector in just climate transition. 1.5 bn EUR is to be earmarked for this purpose from the EU budget as the grant part and this pool is to be supplemented by 10 bn EUR from the EIB as the loan part. This amount is expected to translate into approximately 25-30 bn EUR of investment. Nevertheless, the possibilities of using these funds in the field of transformation of the commercial energy sector will be marginal,
- Connecting Europe Facility – a program supporting EU integration in terms of digitization, transport, and energy. In the field of energy, the program's budget amounts to 5.8 bn EUR and its purpose is to support projects concerning energy networks connecting European countries, as well as cross-border RES projects. By the end of 2019, approx. 14% of the program budget was allocated to investments in Poland,
- Horizon Europe – a program supporting research and innovation in many areas of the economy. The total budget of the program is 95.5 bn EUR, increased by 5.4 bn EUR under NextGenerationEU. At least 35% of the program budget – 33.4 bn EUR – is to be allocated to climate action,
- Program for Environment and Climate Action (LIFE) – the program covers a wide range of environmental and climate action. Funds from the LIFE program are distributed under 4 sub-programs:
  - Nature and biodiversity,
  - Circular economy and quality of life,
  - Climate change mitigation and adaptation,
  - Switching to clean energy.

  The total budget of the program is 5.4 bn EUR, of which contribution to climate action is expected to be at least 61% – around 3.3 bn EUR. In 2014-2020, 36 projects implemented in Poland received support under the LIFE program in the amount of 27.7 mln EUR, out of 1.2 bn EUR allocated to 700 projects[96].

Fig. 7.4 | Available financial support for the energy transition under programs without national allocation [bn EUR]



Source: Own study based on data from the European Commission

95 In the case of support from funds managed centrally by the European Commission, there is no indication of using state aid.
96 LIFE program 2014-2020 data hub; accessed on 2 August 2022.

7.2.2. Funds obtained from the EU from the sale of EU ETS

Innovation Fund

In addition to the funds planned in the EU budget, support without national allocation in 2020-2030 is provided from the Innovation Fund, which is financed from funds from the sale of emission allowances under the EU ETS. This fund supports innovative projects in the field of low-emission technologies, covering areas such as: innovations for energy-intensive industry, carbon capture and storage/carbon capture and utilization technologies (CCS/CCU), innovations in the field of renewable energy sources and energy storage. The total allocated number of allowances is 450 mln tonnes, which, with the average price of 82 EUR/EUA, may constitute a budget of approx. 37 bn EUR.

Modernisation Fund

The Modernisation Fund is intended to finance investments in Member States with a GDP per capita below 60% of the EU average (relative to 2013). The Fund is managed by the beneficiaries, the EIB, and the Investment Committee, which consists of ten representatives of each beneficiary Member State[97] of the Modernisation Fund, three representatives of non-beneficiary Member States, one representative of the EIB, and one representative of the European Commission each. The Fund's budget is supplied with revenues from the sale of 2% of all available emission allowances under the EU ETS and additional allowances allocated to five EU countries (Czech Republic, Croatia, Lithuania, Romania, Slovakia) under derogation. At least 70% of investments implemented from the Modernisation Fund are to support priority programs set out in the ETS Directive[98] dedicated to the development of renewable energy sources, energy storage, and energy networks, improving energy efficiency, and supporting just transition. The remaining part of the funds is to support non-priority programs that meet the Modernisation Fund's objectives and contribute to GHG reduction, but have not been included in the ETS directive. These programs, unlike the priority programs, require due diligence on the part of the EIB and the consent of the Investment Committee. The total number of allowances whose sale will contribute to the budget of the Modernisation Fund is over 643 mln EUR, of which almost 120 mln EUR is the share allocated to Poland. Assuming the average price of allowances until 2030 at 82 EUR/EUA, the total budget of the Modernisation Fund will amount to approx. 52.7 bn EUR, of which almost 10 bn EUR is to be allocated to Poland. In the first three tranches in 2021 and 2022, Poland was granted over 568 mln EUR for the implementation of priority programs. As part of the work of the Investment Committee, 11 priority programs were approved for Poland, of which the National Fund for Environmental Protection and Water Management (NFOŚiGW) has already launched the following programs:

- Smart energy infrastructure (total program budget – about EUR 220 million, 1st call – about EUR 45 million),
- Development of electric power infrastructure for the development of electric vehicle charging stations (total program budget – about EUR 220 million, 1st call – about EUR 20 million),
- My Heat (total program budget – about EUR130 billion, continuous call),
- CHP for district heating (total program budget – about EUR 330 billion),
- CHP for energy and industry (total program budget – about EUR 220 million, 1st call – about EUR 45 million).

In addition to the programs indicated above, the following programs were approved at three meetings of the Investment Committee:

- Energy-intensive industry – improving energy efficiency,
- Energy-intensive industry – RES,
- Digitization of heating networks,
- Use of alternative fuels for energy purposes,
- Support for the use of storage facilities for network stabilization,
- EPC (Energy Performance Contract) Plus Renovation with savings guarantee.

97 Poland, Czech Republic, Romania, Hungary, Slovakia, Bulgaria, Croatia, Lithuania, Latvia, and Estonia.
98 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

Table 7.5 | Estimated support from the Modernisation Fund from 2021 to 2030

Total budget	Poland's share	Funds supporting the development of RES, energy efficiency, energy storage, energy networks, and just transformation in Poland
52.7 bn EUR	10 bn EUR	7 bn EUR*

*value approximated by EY

Source: Own study based on data from the European Commission

In the analysis of the potential support from the Modernisation Fund, it was assumed that funds for priority investments, 7 bn EUR, will be allocated to the energy transformation.

Energy Transition Fund

The Energy Transition Fund, which is planned to be launched in Poland at the earliest in 2023, is to support the modernisation, diversification, and sustainable transformation of the energy sector and is to be created with the use of funds from the sale of CO_2 emission allowances under the EU ETS system. The creation of this Fund is planned under the draft act amending the act on the greenhouse gas emission allowance trading scheme and certain other acts, which is currently being prepared. According to this project, the total budget of the Fund is to be almost 25 bn EUR by 2031, of which almost 13.5 bn EUR is to be spent by 2027. Due to the fact that the Fund is indicated only in the draft act, it is possible that its final shape will change or it might even be abandoned, and therefore all funds may be redirected to another purpose, hence acknowledging these funds is subject to risk.

Table 7.6 | Estimated support from the Energy Transition Fund from 2023 to 2027

Total planned budget	Planned expenditure until 2027
25 bn EUR	13.5 bn EUR

Source: Own study based on the draft act amending the act on the greenhouse gas emission allowance trading scheme and certain other acts; 21 March 2022

Summary of the potential funding from the EU and the state budget, and analysis of their impact on filling the investment gap

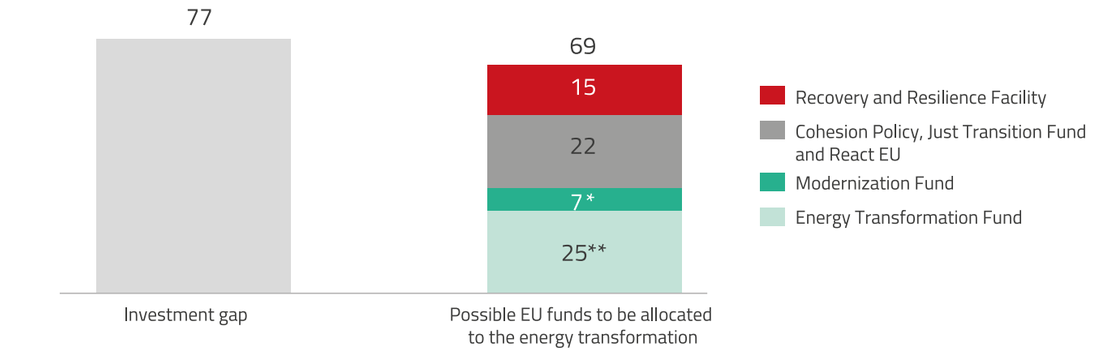
Effective use of funds from the EU budget may reduce the financial gap of planned projects in the energy transition sector and protective measures. Nevertheless, the amount of funds available at the level of 69 bn EUR for the energy transition in Poland from EU funds is insufficient to cover the entire investment gap in the electricity and heating sector, which is estimated at 77 bn EUR, including protective measures. In addition, the available EU funds will also be used in other sectors, such as gas or transport, and by households, which means that the energy sector will not be the largest beneficiary, and the investment gap will be further deepened.

At the same time, it should be noted that despite the availability of programs and funds at the EU and Polish level that can be used to finance the energy transition, the strict rules on state aid, such as CEEAG or GBER can be a serious limitation (especially with regard to the possibility of obtaining funds for investments in generation sources based on natural gas and investments in district heating). As for public aid for investments in heating networks, the crucial barrier is the requirement that the heating system must meet the criteria of an energy-efficient system. Taking into account the proposal to change the definition of an efficient system and the introduction of an emission criterion for high-efficiency cogeneration as part of the "Fit for 55" package, a large part of district heating systems, which are currently efficient systems, may lose this status. As a consequence, it may be the case that it will not be possible to obtain funds for projects in the field of heating networks.

On the other hand, it is possible to obtain additional funds from programs such as InvestEU or Horizon Europe, but obtaining funds from these programs will require competition with projects from entities from other EU countries. Nevertheless, the current perspective of the EU budget, excluding programs financed from the sale of GHG emission allowances, extends to 2027 and it can be assumed that due to the ambitious goals of climate neutrality by 2050, additional funds for transformation will appear in the next budget perspective.

It will be necessary to take steps to reduce the costs which will have to be incurred by the energy sector, including, among other things, through innovation and the search for additional sources of financing at the national and EU level.

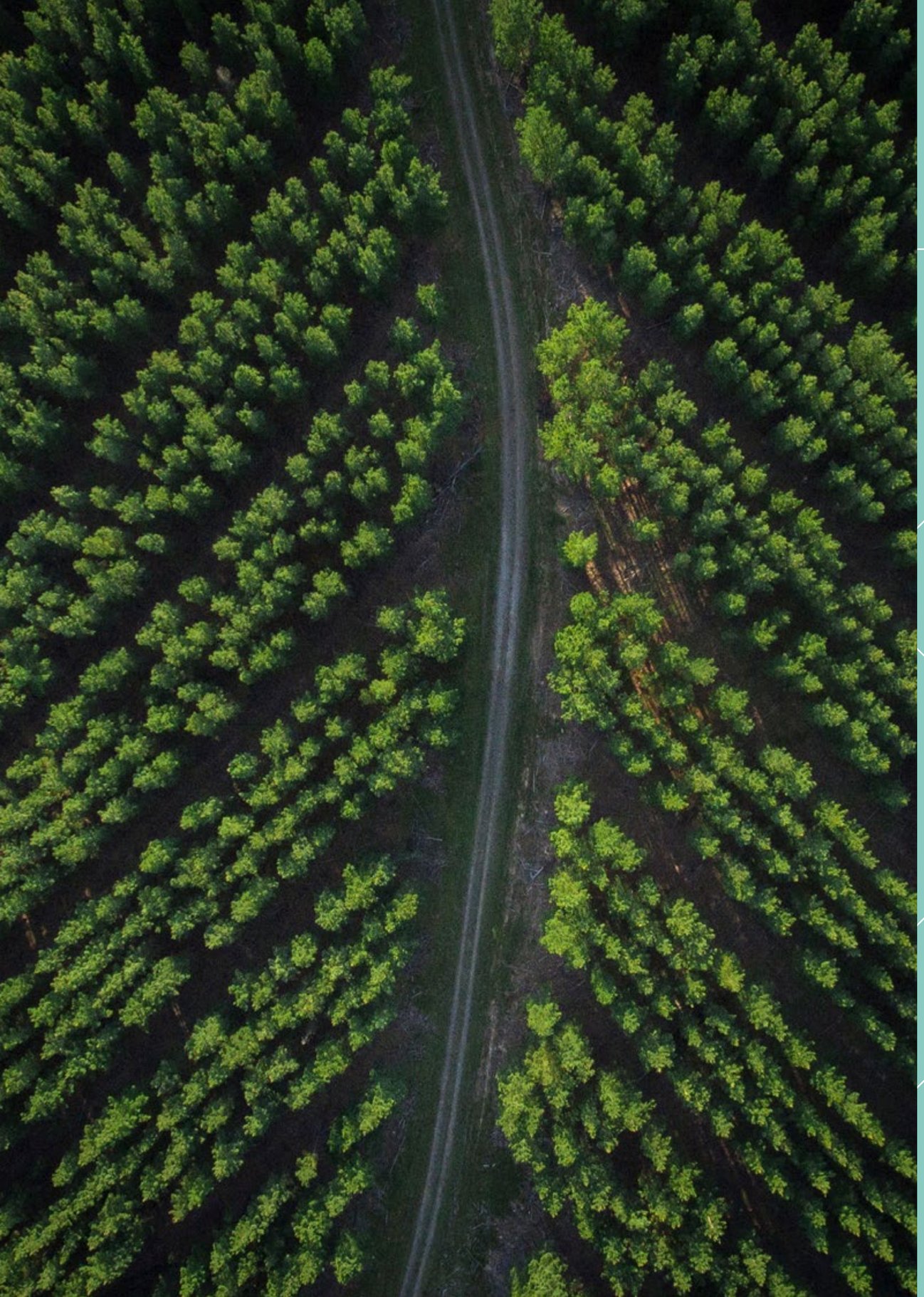
Fig. 7.5 | Possibility to cover the investment gap using EU and state budget funds [in billion EUR]



* till 2030

** till 2031

Source: Own study



Costs and financing of the energy transition – summary:

Nevertheless, even with the existing and planned possibilities of obtaining aid funds from the EU and the state budget, there is still a gap at the level of approx. 8 bn EUR. Additionally, this gap may grow as EU funds will be used in other sub-sectors, such as gas and transport, and due to the fact that market conditions and investment outlays may change.

It will be necessary to take steps to reduce the costs which will have to be incurred by the energy sector, including, among other things, through innovation and the search for additional sources of financing at the national and EU level.

Support for the energy transition in Poland from the EU budget for 2021-2027, the EU ETS (until 2030), and the national Energy Transition Mechanism (until 2031) is estimated at approx. 70 bn EUR.

Expenditures for the transformation of the energy sector by 2030 may amount to as much as EUR 135 bn, including protective measures for the mining sector related to the power and heat sectors.

The required outlays significantly exceed the investment possibilities of energy companies and potential investors.

Summary and recommendations

This document presents the input of the Polish energy sector in climate protection actions included in the global and EU policy taking into account its history and development plans for the sector. Despite unfavourable conditions mostly related to historical domination of coal technologies the efforts to reduce CO_2 emissions, increase RES share in energy generation, and prepare plans and development strategies clearly manifest an active commitment of the energy sector in the efforts to reach climate neutrality.

On the basis of the presented studies, it can be concluded that:

1. Poland is an active participant of climate protection actions both on a global and EU level. As a signatory to the UN Climate Convention, Poland fulfilled its global obligations to reduce GHG emissions, and as a Member State of the EU it reached its 2020 climate targets and continues to implement further reduction plans.

2. The historical conditions of the Polish energy sector established the domination of coal technologies in electricity generation. Domination of coal in the energy generation mix results in significantly higher costs of the transition towards climate neutrality and increases the time needed to reach its targets.

3. The electricity sector in Poland supports the EU in reaching its climate targets by making an important contribution towards the 2020 targets and continuously investing in RES energy efficiency and GHG and pollution emission reduction as a part of achievement of targets for the next period.

4. EU as a leader in climate actions sets more and more ambitious climate targets for 2030 and aims to achieve climate neutrality by 2050. Because of the increasing energy prices and the impact of the Russian aggression on Ukraine, latest EU proposals aim at increasing the pace of achieving climate neutrality and reducing reliance on imported fuels, especially from Russia.

5. Strategies and actions of major energy groups in Poland aim to reach climate neutrality while increasing the competitiveness and efficiency of the sector, which supports the energy security of Poland.

6. Key actions that help Poland move towards climate neutrality are investments in low-carbon and zero-emission energy sources including capital intensive offshore wind farms and nuclear energy. This process requires the development of transmission and distribution infrastructure together with electricity storage capacities including energy that could be easily transformed into electricity (e.g. potential energy of water, green hydrogen or green carbohydrates produced with electricity from RES or nuclear energy). The energy transition requires the implementation of technologies that have not fully reached a commercial status, that is why intensive research and development should be conducted to effectively use them. The need to use innovative but immature technologies involves unique challenges which need to be effectively addressed in order to minimize the barriers of entry for those technologies.

7. Moving away from coal in the energy sector, as well as mine closures, will have a significant impact on employment and will cause social changes in mining regions, where over 100,000 people work directly in the mining coal sector[99]. Conducting a just transition of mining regions and reducing energy poverty will require significant financial outlays as well as protective measures.

99 Data from 2018 based on Mandras, G., and Salotti, S. 2021. Indirect jobs in activities related to coal, peat and oil shale: A RHOMOLO-IO analysis on the EU regions. JRC Working Papers on Territorial Modelling and Analysis No. 11/2021, European Commission, Seville, JRC127463

Summary and recommendations

By 2030, the financial resources of Polish energy groups and other investors, as well as the funds available under EU policy measures, may not be sufficient to cover the total investment outlays for the energy transition, both in the generation and distribution segment within the 2030 horizon.

8

The destabilization of EU ETS, fuel, and electricity markets with very high prices are a threat towards the economic growth of the EU countries, an increase in energy poverty and slow down the energy transition process.

9

Observations from the last few months undoubtedly point out that the EU ETS, fuel and electricity markets are vulnerable to geopolitical situation and speculations of market actors. Collaborative actions at the EU level and rapid implementation of regulations limiting those factors and reducing the impacts of high prices are necessary.

10

Increase in electricity prices could be reduced through direct limitation (this solution was put forward by the EC proposal) or through decreasing the possibility to include the excessive risk estimation when calculating prices determined on the basis of justified costs.

11

Fuel prices are driven by global markets which make them difficult to regulate, nevertheless, solidarity between EU countries could significantly influence electricity prices.

12

Further effective transformation of the energy sector requires the use of all available resources to stabilize electricity prices as soon as possible. In the conditions of economic recession and growing energy poverty, there is a risk that the energy transition may be slower or even stops altogether. PKEE and their supporting members declare their will to participate in all kinds of stabilizing actions.

13

PKEE
Polish Electricity
Association