



**Analysis of the energy transformation
in Central European countries in the
context of the challenges of the
European Green Deal
Czech Republic, Poland, Slovakia,
Hungary as well as Austria, Germany,
Lithuania, Romania and Ukraine**



Fundacja

The project is financed with the support of the PGE Foundation

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Introduction

The consequences of anthropogenic climate change, the economic effects of the COVID-19 pandemic and the Russian attack on Ukraine and the resulting economic sanctions imposed on Russia by European countries are increasing the pressure on a just energy transformation. The war in Ukraine helped European Union leaders understand that Russia had been using the sale of fuels and energy resources as a hybrid weapon for decades, forcing European countries to be politically and economically dependent on it. The change in the political situation has become both the source of the most serious energy crisis in decades and

a motivation to accelerate the necessary changes to the European economic model, inspiring an increased pressure on diversifying sources of fuels and raw materials, improving the energy efficiency of the European economy and switching to renewable energy sources. Each crisis generates a number of key threats to the stability of vulnerable countries and tests the solidarity of allied societies, but also creates opportunities to introduce the required innovations, increasing social support for difficult and necessary actions of governments. After February 2022, the European Union countries have attempted a decisive and fundamental, but also solidary and fair transformation of the economic model, in which Central European countries – previously dependent on Russian exports of fuels and energy raw materials – must face threats and challenges, but can also benefit from the accelerated transformation and innovation.

The report presents – drawing on documents from the European Commission and other international institutions involved in monitoring the economy and energy markets – the economic, political and social context of a just energy transformation in the countries of Central Europe – the Czech Republic, Poland, Slovakia and Hungary, supplementing it with information regarding a perspective of economic and energy integration of Ukraine. At the same time, it broadens the view of the countries neighbouring the Visegrad Group, describing the situation in Austria, Germany, Lithuania and Romania. Therefore, the report makes it possible to propose a broad understanding of the potential Central European energy market, suggesting a new look at the prospects for intergovernmental cooperation within the European Union.

Regional cooperation and partnerships are important to respond to public sentiment that is hostile to EU initiatives aimed at energy

transformation. In this context, the implementation of the goals of the European Green Deal is of particular importance, and given its comprehensive nature the European Commission has placed it at the centre of the EU's economic development strategy and competitiveness strengthening as well as the energy autonomy of European countries. Social and political protests against the detailed goals of the European Green Deal have been put on the list of main threats diagnosed by the EC – susceptibility of energy markets to price instability, dependence of prices on growing subsidies, rapid impact of energy prices on high levels of inflation, threats to the security of European critical infrastructure and dependence on unreliable (politically or economically) sources of fuel and energy resources. The multi-level and diverse nature of the threats highlights how important stability and affordability on the energy market as well as the reliability and availability of energy for households, business entities and public institutions are for the position of the European Union in international economic relations.

Establishing a strong European cleantech economy is perhaps the most ambitious goal of the continent's economic transformation since the recovery process following the devastation of World War II. Incorporating climate and energy policy into the central part of the new economic model clearly threatens the competitiveness of less efficient sectors of the Member States' economies and producers forced to open competition with producers from countries far from the EU standards of climate, quality, consumer protection and protection of workers' rights. Taking into account the awareness of threats to the competitiveness of European production, the EC proposed mechanisms to protect the EU market against unfair competition – however, as examples from

the agricultural products market show, these mechanisms are still far from the efficiency ensuring proper protection of the interests of producers from EU countries and guaranteeing fair transformation.

The challenges encountered – especially those related to political and social protests against the detailed goals of the European Green Deal – do not change the importance of EU achievements in the area of energy transformation achieved after 2022. In its report on the state of the Energy Union (COM, 2023, 650), the Commission pointed out:

- (1) diversification of energy import directions, enabling a reduction in dependence on Russia from 155 billion m³ in 2022 to approximately 45 billion m³ two years later,
- (2) increasing imports of natural gas and liquefied natural gas from Norway and the United States, dramatically reducing the dependence of EU countries on Russian supplies,
- (3) gradual transformation of the most energy-intensive sectors and reduction of demand for natural gas by 18%,
- (4) accelerating the development of renewable energy systems and significantly increasing the production of electricity from renewable sources,
- (5) installation of record-breaking photovoltaic systems in terms of capacity (41 GW in 2022, an increase of 60% y/y) and on-shore and offshore wind installations,
- (6) a 32.5% reduction in greenhouse gas emissions in EU countries compared to the 1990 level while maintaining stable economic growth,
- (7) a political intervention to protect households and entrepreneurs from the effects of the energy crisis and limit the

increase in the number of people suffering from energy poverty in the EU,

- (8) development of European gas infrastructure, in particular the Baltic gas pipeline, gas connections between Poland and Slovakia, Greece and Bulgaria and France and Germany, as well as new liquefied natural gas terminals in Greece, Finland, Germany and Italy,
- (9) accelerating the synchronization of the energy systems of Moldova, Ukraine and the Baltic States with the continental grid,
- (10) progress in the implementation of the Recovery and Resilience Facility, with particular emphasis on key achievements in the areas of energy efficiency, sustainable mobility, renewable energy and energy networks.

The challenges facing the European Union and its Member States – in particular when it comes to shaping a just energy transformation – highlight the importance of energy policy, which since the adoption of the Lisbon Treaty in 2007 has become a shared competence between the states and the EU. After the Russian aggression against Ukraine and in view of Europe's departure from the import of fuels and energy raw materials from Russia, harmonious cooperation between the EC and the nation states as well as regional cooperation towards establishing energy security and implementing a just energy transformation seem to be even more important.

Energy transformation and the European Green Deal

Initiated in December 2019, the European Green Deal is a strategy to transform the European Union towards a fair and prosperous society benefiting from a modern, cost-effective and competitive economy to achieve net zero greenhouse gas emissions by 2050. The pillars of the European Green Deal are maintaining the full competitiveness of European production, making economic growth independent of the extraction and use of natural raw materials, counteracting anthropogenic climate change, improving natural capital and nature protection, and caring for the well-being of citizens of EU countries. Energy transformation, social responsibility and economic development have become the central values of the European Green Deal, striving to reconcile the different goals set for the transformation policy.

The pillars of the European Green Deal are: achieving climate neutrality by the EU by 2050, providing clean, affordable and reliable energy for households and businesses, transforming industry towards a clean circular cycle of resources used, increasing energy efficiency of buildings, accelerating the transformation of transport towards sustainable and intelligent mobility, building a sustainable and environmentally friendly food system, protecting biodiversity of ecosystems and eliminating air, water and soil pollution. Achieving the planned goals requires re-modelling the EU's vision of sustainable development so that the energy transformation and counteracting climate change are a fair process and are focused on social needs. Therefore, in order to implement the European Green Deal, it is required to redirect part of the EU budget to financing a green and just transformation – the

mechanism is to focus on regions and sectors that will be most affected by the changes introduced due to their dependence on high-emission processes and the use of natural raw materials. Such deep political interference in the development model must lead to threats to the well-being and economic security of residents; hence it is necessary to take into account the obligation to take protective measures that will ensure stable employment and access to energy-efficient housing construction (European Regional Development Fund and European Social Fund Plus).

The European Green Deal was an extremely ambitious project and exposed to various threats even when it was initiated – the difficulties intensified with the economic and social consequences of the pandemic, and were even more accentuated by Russia’s aggression against Ukraine, prompting European countries to more quickly reduce their dependence on the import of Russian natural raw materials and fuels. The first five years of the implementation of the European Green Deal activities are a clear accumulation of political and regional security challenges, which forced the government to reformat the goals of the energy transformation – giving up cheap energy raw materials imported from Russia with simultaneous intensified economic efforts and humanitarian issues resulting from aid and support to Ukraine and the deepening migration crisis having made the issue of justice and social responsibility of the energy transformation even more important. It is clearly visible that the transformation goals and climate neutrality in 2050 may conflict with the values of the European Green Deal – a just energy transformation, social responsibility and economic development. One of the possible solutions to the problems that a possible collision of goals and values will generate is a stronger regionalization of cooperation for the energy transformation and

the strengthening of the role of regional multilateral energy partnerships, which can be implemented as part of broader EU modernization projects. Shifting the burden of responsibility for achieving the planned results from EU institutions to nation states can strengthen the fairness of the transformation process and maintain its direction towards protecting the well-being of EU residents while increasing concern for preserving the biodiversity of ecosystems.

Understanding the complexity of the challenges arising from the energy transformation in the context of the goals of the European Green Deal requires taking into account the comprehensiveness of the new economic development model, which is to be implemented in the EU by 2050. Its components include:

- (1) *Fit for 55* Package, which is a set of legal changes aligning climate, energy and transport regulations with the EU's climate goals, while ensuring a fair and socially responsible transformation and competitiveness maintenance by strengthening the innovation of the European economy,
- (2) The Just Transition Fund with a total budget of EUR 55 billion, which is to support investments in the private sector, research and implementation of innovations, clean technologies and the acquisition of new professional qualifications in sectors exposed to the negative consequences of the transformation,
- (3) Decarbonisation of the energy sector by supporting clean energy sources, integration of energy systems (including the creation of energy corridors) and focusing on energy efficiency (the Renovation Wave strategy from June 2021 assumes a doubling of energy renovations in construction by 2030),

- (4) European climate law specifying the rate of reduction of greenhouse gas emissions by 2050 and guaranteeing cost-effectiveness and social justice of the implemented transformations,
- (5) EU strategy on adaptation to climate change, including collecting climate data, building climate resilience and adapting fiscal policy to the challenges of the transformation,
- (6) The EU industrial strategy combining the need for transformation towards climate neutrality of production with innovation and striving to maintain constant economic growth in Europe – the update of the strategy in May 2021 to the strategic elements helped strengthen resilience and increase competitiveness of European economy,
- (7) Circular Economy Action Plan specifically targeting the production of electronics, electric vehicles, batteries, packaging, plastics, textiles, food and construction,
- (8) A farm to fork strategy supporting the implementation of a sustainable food system model in the EU to ensure access to affordable and nutritious sustainably produced food,
- (9) the EU Forest Strategy promoting sustainable forest management and the improvement of forest biodiversity,
- (10) the EU biodiversity strategy protecting Europe's land and sea areas and restoring degraded ecosystems.

Adapting the European Green Deal to new challenges resulting from the consequences of the pandemic prompted the EC to accelerate the social and economic transformation under the NextGenerationEU22 instrument – loans on capital markets that are used by Member States under the Recovery and Resilience Facility. The tool assumes that at least 37% of the Instrument's funds

will be used to finance the green transformation – adapting countries to the challenges of climate change, building a circular economy and protecting the biodiversity of ecosystems. Investments in clean energy within the Instrument are combined with mitigating the effects of the economic crisis and social responsibility of the energy transformation.

A similar course of action accompanied the EU's response to the energy crisis, which will be a consequence of the sanctions aimed at Russia after its armed attack on Ukraine – the aim of the REPowerEU plan from May 2022 was to focus on energy savings, diversify sources of energy and raw materials supplies and accelerate the transition to clean energy to gradually solve the problem of pro-inflationary increases in energy prices in the European market. In the long term, REPowerEU assumes a complete abandonment of Russian raw materials and fuels by 2027, using updated national plans under the Recovery and Resilience Facility. At the same time, initiatives undertaken by the EC contributed to increasing the stability and energy security of EU countries, including by reducing EU demand for gas by 18% and for electricity during peak hours, redirecting excessive profits of energy producers to consumers and industry, and strengthening energy solidarity with using the AggregateEU mechanism.

At the same time, as part of the Social Climate Fund adopted in April 2023, almost EUR 87 billion will be made available to member states to support the energy transformation, invest in the energy efficiency of buildings, reduce the emissions caused by heating and cooling, switch to renewable energy sources and increase the availability of sustainable mobility and transport. It is to be an important factor of change in the medium term, which will reduce the pressure on ad hoc measures, the cost of which in 2022

amounted to EUR 93 billion for households and EUR 53 billion for industry, and concerned only the mitigation of the social and economic effects of the increase in energy prices. While in the short term such measures are required to ensure the security of all EU residents, in the medium and long term a just energy transformation seems to be the only lasting solution. In 2021–2023, accelerating investments in installations of renewable energy sources (photovoltaic and wind ones) resulted in savings of EUR 100 billion, and estimates from the International Energy Agency indicate that without additional capacity installed in the EU, electricity prices in European markets would be higher on average by 8%.

This clearly shows that the implementation of the ambitious goals of the European Green Deal – in particular in the light of the experience of the pandemic and the war in Ukraine – will only be possible by redirecting budgetary effort to increased investments in energy infrastructure, integration of the European energy network and energy efficiency of all sectors of the European economy. Imposing responsibility for the entire process on EU institutions may be a factor limiting the effectiveness of the energy transformation and the adaptation of European countries to climate change. It seems that there is a need for a multi-level approach to the implementation of the goals of the European Green Deal and the sharing of responsibility for its success by the EU and national states, also taking into account the regionalization of energy cooperation and the creation of regional initiatives that guarantee the stability of the European energy market and facilitate diversification of energy sources.

A perfect example of shared responsibility and cooperation is the process of making European customers independent of Russian

natural gas supplies after 2022. A year earlier, Russia accounted for 45% of imports of this raw material to EU countries, while in 2022 the Russian share dropped to 24% and a year later to 15%. This was possible thanks to the diversification of natural gas import directions and a balanced approach to meeting the needs of European markets – the share of Norway increased from 24% to 30%, the United States from 6% to 18%, Great Britain from 2% to 7%, and at the same time increased imports of natural gas from Azerbaijan, Qatar, Nigeria and North African countries (COM, 2023, 650).

Challenges of the European Green Deal

The complexity of the European economic transformation program combines possible difficulties at the economic, environmental, political and social levels.

In the first group – of **economic** factors – the key challenge is the question repeated in the literature regarding the shape of the future, fair European economy after abandoning fossil fuels and the accompanying doubt about the resources necessary to achieve pro-development conditions in a climate-neutral economy. This is directly related to the question of financing the transformation towards the goals of the European Green Deal – success requires creating conditions for the coherent involvement of the EU budget, budgets of nation states, local government resources and private sector investments. The transformation program will not be viable if all entities are not equally involved, and at the same time if the climate agenda does not integrate technological innovations, transformations of the economic and social model and a coherent system of legal regulations.

The **environmental** perspective provides further challenges to the implementation of the goals of the European Green Deal, the fundamental goal of which is a clearly climate-related goal – achieving neutrality in 2050. However, as at the economic level, this requires coherence and synergy so that green policies are introduced simultaneously in individual sectors, strengthening sustainable development, structural change and ecological responsibility. While the EU's political commitment to achieving climate goals seems to be stable, it may be problematic to achieve the required level of social involvement and private sector investment that would accelerate the energy transformation of EU countries.

The scale of the challenges exceeds the budgetary capabilities of European countries; therefore, without the decisive involvement of the private sector and societies in achieving climate neutrality in 2050, the implementation of the goals of the European Green Deal seems to be impossible if it is driven only by the political factor.

Especially as **political** challenges are also noticeable and are commented on much more often in the face of growing social protests against the detailed goals of the European Green Deal. Politically, the involvement of EU institutions in implementing the climate goal seems to be stable, but it is not certain to what extent it will have a stable and lasting impact on the level of co-deciding nation states. It is the lower level of state involvement and less scrupulous implementation of goals at national or local levels that may lead to a slowdown in the transformation of the European development model or its multi-track nature.

In this respect, it seems crucial to develop an effective system motivating states and local governments to engage in the process, but an alternative may be the regionalization of responsibility for the energy transformation and the strengthening of regional, multi-level energy partnerships. Despite the political changes following the Russian aggression against Ukraine in 2022, it is impossible to exclude from the political context the influence of the traditional model of cooperation between European countries and Russia, which allowed access to cheap energy resources and fuels, transformed into hybrid weapons, but at the same time marginalized the importance of Russia's growing superpower ambitions.

While today Europe is dominated by a strong desire to cut off imports of Russian raw materials as expressed in REPowerEU, the European Green Deal strategically focuses on 2050, so it is not possible to guarantee whether the political pressure from pro-Russian circles to resume trade in energy resources with Russia will not increase over time by recognizing its superpower ambitions in the post-Soviet area.

Economic and political challenges clearly overlap with possible social problems arising from the EU's energy and economic transformation process. Although undoubtedly – strategically, the European Green Deal assumes reducing social and interregional inequalities by using energy transformations to promote a new model of the European economy with climate neutrality and fair access to resources as key requirements, it seems problematic to define the path leading to the implementation of these policies. There are voices in the public debate indicating that, despite its equality and solidarity assumptions, the European Green Deal and the energy transformation towards climate neutrality may lead to the accelerated enrichment of the already rich regions of Europe at the expense of slowing down the development of less developed areas of EU countries – this is reminiscent of the recurring theme over the last two decades of questions about the two-speed Europe model. The fairness of the energy transformation and the protection of regions and sectors particularly affected by changes seem to be a key challenge for the European Green Deal, both at the level of financing changes and protective programs, implementing innovations in a spatially and sectorally equitable manner, as well as legislation and guidelines explaining the green transformation. Preventing the social consequences of transformations is not only an important goal from the perspective of

social responsibility, but also political responsibility for the success of the European Green Deal – without strong social support and involvement, political support for changes will systematically decrease, and at the same time it may lead to a situation where the resources used for the energy transformation will prove to be insufficient to achieve the goals.

Maintaining further support for the European Green Deal will depend on a number of factors: the stability of the EU's cooperation with nation states, encouraging the private sector to invest in the energy transformation, transferring the changes to the local level, maintaining a high level of public investment, reformatting the labour market, practical implementation of mechanisms of fair and socially responsible changes, an innovative approach to green projects and a new model of European development, combining the climate goal with sustainable development and economic competitiveness through innovation and digitalization. However, the entire complex problem structure can be reduced to a simple question about energy prices in the European market, its fair regulation and the resulting changes in the level of energy exclusion. Each of these factors will inspire possible positive or negative changes in the factors indicated above – the lower the costs of energy transformation from the perspective of an average EU resident, the higher will be the social, political and economic commitment to climate and environmental goals, and at the same time it will be easier to narratively encourage Europeans to increase their involvement in the process of change. However, if – as was the case of the reaction to Russian aggression in Ukraine – this causes an inflationary energy crisis in which a significant part of the cost of switching is transferred to consumers, especially households or small and medium-sized businesses, this will trigger a cascade of political, social and economic consequences leading to weakening the effectiveness – or perhaps even

abandoning – the energy transformation. There is only one alternative to energy autonomy and increased energy efficiency of the European economy – dependence on the import of Russian raw materials and fuels, which leads to political dependence and can be used in a hybrid way against European countries.

Challenges of energy transformation:

The Czech Republic

Basic data on the economic situation of the country:

GDP (2022): \$438 billion (45th in the world)

GDP per capita (2022): 41 thousand dollars (49th)

GDP by sectors:

agriculture – 2%, industry – 37%, services – 61%

Inflation: 15.1% (2022), 3.2% (2020)

Industrial production growth (2022): 0.9%

Unemployment (2022): 2.2%

Poverty level (2021): 10.2%

Gini Index (2021): 26.2

Export value (2022): \$217 billion (35th)

Import value (2022): \$218 billion (34th)

Most important partners (export):

Germany (32%), Slovakia (8%), Poland (7%), France, Austria

Most important partners (import):

Germany (24%), China (13%), Poland (10%), Slovakia, Russia

Challenges of energy transformation in the Czech Republic

The Czech energy market is characterized by a model of dependence on energy production from nuclear and coal-fired power

plants, which is specific to the region, as well as the lack of an accelerated transition of the economy towards renewable energy sources. This constitutes a fundamental challenge in implementing the goals of the European Green Deal, aimed at climate neutrality and environmentally friendly energy. In the literature, this state of affairs is justified by the industrial tradition of the Czech economy encouraging the use of large-scale infrastructure and the lack of social confidence in renewable energy sources as a sufficient, reliable and cheap solution to the country's energy needs.

The modernization pressure and inspiration for the energy transformation in the Czech Republic comes from external factors, in particular as a result of adaptation to the EU sustainable development policy and technological changes taking place in the European industry. Adaptation to environmental standards in the EU has mainly affected the extraction of brown coal, which was used in the Bohemian Massif for energy production.

Unique to the Czech energy model is the lack of political prioritization of a rapid transition to renewable energy sources, which is the result of social approval for the policy of decarbonizing the economy by strengthening nuclear energy, using innovative solutions to reduce greenhouse gas emissions in industry and increasing energy efficiency. Therefore, focusing on nuclear energy puts the Czech Republic in a different strategic position than most European partners that choose the path of energy transformation through installations of renewable sources. At the same time, the focus on nuclear energy is intended to make it easier for the Czech Republic to cope with the greatest challenge of the climate goals of the European Green Deal – moving away from the use of lignite as an important part of the country's energy mix.

This translates into regulatory activities of the Czech authorities, which focus on energy autonomy and preference for domestic energy sources – currently, nuclear and coal ones. Despite the proposals to move away from nuclear energy present in the Czech public debate, the available alternatives do not constitute a sufficient guarantee of cheap and reliable energy for the Czechs – therefore it should be assumed that while public support for moving away from the coal-based economy can be maintained, it seems unrealistic to build political support in the Czech Republic for abandoning nuclear energy.

The independence of the Czech Republic in the context of the energy transformation is primarily a challenge for the Western partners of the Czech economy, which use electricity exported from the Czech Republic. The country's gradual withdrawal from lignite-based production will mean a reduction in export opportunities, and as a result, it will require adaptation to the reduced supply of electricity in the markets of Czech neighbours. Predictive models created to predict the consequences of changes in the Czech Republic suggest that this will increase energy costs in the regional market, reduce its stability and result in a reduction in revenues generated by the Czech energy sector.

The pressure may be reduced by investments in renewable energy installations, which could allow the Czech Republic to maintain its position as an important energy supplier in the Central European market, helping to stabilize it in the long run. Experts indicate that the development of this segment of the energy market in the Czech Republic may be an important modernization impulse for less industrialized areas of the country and rural areas, providing access to new jobs.

A characteristic feature of the Central European energy transformation is the need to adapt to changes in the natural gas market, where until 2022 the Czech Republic was completely dependent on supplies of Russian raw materials. This means there is an urgent need to transform sectors dependent on natural gas, in line with the REPowerEU challenges.

In the context of the European Green Deal, the European Commission sees significant challenges when it comes to the implementation of its goals by the Czech Republic. The Czech energy transformation requires acceleration in terms of energy efficiency, sustainable mobility and sustainable management of the country's water resources. Reducing emissions is a key challenge for the Czech economy given the 2030 target increased from 22% to 37%, which means the need for further investments in infrastructure and energy efficiency. In the Czech National Recovery Plan, almost 42% of funds are earmarked for reforms and investments to help achieve the climate target.

Achieving the goals of the European Green Deal in the Czech Republic will require not only further investments, but also a number of improvements in the entire economy. The EC indicated among them: further increasing the efficiency of forest management, reducing the share of natural resources in the country's energy mix, replacing dependence on Russian raw materials and fuels with energy from renewable energy sources, increasing the energy efficiency of infrastructure in line with the REPowerEU goals, redirecting investment efforts towards sustainable mobility and the development of circularity in production.

Key data on the Czech energy transformation:

Components of the energy mix (2021):

Energy transformation in Central European countries

- solid fuels – 30%
- natural gas – 18%
- crude oil – 22%
- nuclear energy – 17%
- renewable energy sources – 13%

Components of the electricity mix (2021):

- solid fuels – 41%
- natural gas – 9%
- renewable energy sources – 14%
- nuclear energy – 36%

Components of the renewable energy mix (2021):

- hydropower – 4%
- solar energy – 4%
- thermal energy – 5%
- biomass – 86%

Energy exclusion (2022): 1.9%

Challenges of energy transformation:

Poland

Basic data on the economic situation of the country:

GDP (2022): \$1,388 billion (19th in the world)

GDP per capita (2022): 37.7 thousand dollars (55th)

GDP by sectors:

agriculture – 2.5%, industry – 40%, services – 57.5%

Inflation: 14.4% (2022), 3.3% (2020)

Industrial production growth (2022): 7.1%

Unemployment (2022): 2.9%

Poverty level (2021): 11.8%

Gini Index (2021): 28.8

Export value (2022): \$434 billion (22nd)

Import value (2022): \$421 billion (19th)

Most important partners (export):

Germany (27%), Czech Republic (6%), France (6%), Great Britain, Netherlands

Most important partners (import):

Germany (23%), China (11%), Italy, the Netherlands, the Czech Republic

Challenges of energy transformation in Poland

Due to its economic importance for Central Europe, the Polish energy market has a key impact on the possibility of achieving the

goals of the European Green Deal. The most important challenge of the energy transformation in Poland is to accelerate the transition from a coal-based economy – based on the use of hard coal and lignite to produce energy – to a climate-neutral economy while maintaining the pace of economic growth and high competitiveness of production in Poland. Moving in this direction requires not only a broad program of modernization and implementation of innovations, but also special social responsibility for the well-being and safety of residents who are sensitive to the consequences of the implemented changes. An important challenge is therefore to actively counteract energy poverty among citizens, in particular by using local energy production possibilities from renewable sources and social involvement in a just energy transformation of the economy.

The socially and politically dominant issue in the public debate is the need to prepare public investment in nuclear energy, the inclusion of which in the energy mix seems to be necessary to ensure a fair and socially responsible energy transformation. The dominance of the coal component means that in the medium term, only nuclear energy can ensure stability, affordability and reliability of electricity supplies to households and businesses in Poland. Therefore – taking into account the climate goal of the European Green Deal – the creation of a nuclear power plant in Poland seems to be a challenge that goes beyond the national dimension, but also provides an opportunity to carry out a just transformation throughout Central Europe.

In addition to the challenges related to prolonged investment in nuclear energy, one of the pillars of the Polish energy transformation is the implementation of instruments supporting investments in the renewable energy sector – in 2005 it was dominated

by hydropower installations, since 2016 by wind installations supported by photovoltaic ones often used by individual consumers. Ambitious plans to use the Baltic Sea to install wind energy infrastructure fit well into this trend. From today's perspective, the consequences of the crisis from a decade ago can no longer be seen in the Polish renewable energy market, and the growth rate of investments in renewable energy sources is one of the key development and modernization impulses of the Polish economy. The only obstacles to its further acceleration seem to be legislative and regulatory factors that limit further marketization of electricity distribution mechanisms and possible social protests against the interference of installations obtaining energy from renewable sources (especially wind) in the surroundings of buildings.

In Poland's case, regulations and bureaucratic restrictions come together at the point of moving away from a coal-based economy, strengthening the role of renewable energy in the energy mix and shielding society from the financial costs of achieving climate neutrality. In addition to the investment, infrastructural and strategic dimensions for the energy transformation in Poland, the legal, political and social dimensions seem to be equally important and may determine the model of moving away from the coal economy and its social cost.

The green transformation of Poland, due to the country's economic importance for the European Union and the country's production and demographic potential, seems to be one of the most important challenges of the European Green Deal. Therefore, assessing the implementation of its goals, the European Commission drew attention to the need for further actions in the promotion of renewable energy sources as an alternative to the coal-

dependent economy, a significant increase in the energy efficiency of the economy (including buildings), as well as reducing emissions from road transport and moving towards sustainable mobility.

So far, the problem in the EC's relations with the Polish authorities has been the state's limited involvement in strategic climate activities. Poland is currently on a path that makes it impossible to achieve the emission reduction target in 2030 – the current pace of change will allow for a reduction of 12% compared to the planned target of 18%. Obvious obstacles are dependence on the coal economy and the importance of transport and logistics to the national economy.

The Commission pointed out that the key barrier to Polish transformation will be dependence (over 70%) of the electricity mix on solid fuels, which necessitates quick action to avoid a drastic increase in market prices. In addition, it will be important to increase energy efficiency and reduce the energy intensity of the economy, energy modernization of buildings, taking into account the importance of public utility institutions, strengthening the role of rail transport as an alternative to road transport and a direction enabling the development of sustainable mobility, as well as further modernization of agriculture and forest management, to help Poland achieve the objectives of the European Green Deal. However, EU institutions emphasize that the Polish context is particularly strongly embedded in social responsibility for change, and the decarbonisation of the Polish economy will generate high economic, financial and social costs, which must be covered with protective measures and supported by regionalization of cooperation.

Key data on Poland's energy transformation:

Components of the energy mix (2021):

- solid fuels – 42%
- natural gas – 17%
- crude oil – 29%
- nuclear energy – 0%
- renewable energy sources – 13%

Components of the electricity mix (2021):

- solid fuels – 72%
- natural gas – 9%
- renewable energy sources – 17%
- nuclear energy – 0%

Components of the renewable energy mix (2021):

- hydropower – 2%
- wind energy – 11%
- solar energy – 3%
- thermal energy – 3%
- biomass – 82%

Energy exclusion (2022): 4.5%

Challenges of energy transformation: Slovakia

Basic data on the economic situation of the country:

GDP (2022): \$180 billion (71st in the world)

GDP per capita (2022): 33.2 thousand dollars (69th)

GDP by sectors:

agriculture – 4%, industry – 35%, services – 61%

Inflation: 12.7% (2022), 1.9% (2020)

Industrial production growth (2022): -0.4%

Unemployment (2022): 6.1%

Poverty level (2021): 13.7%

Gini Index (2021): 23.2

Export value (2022): \$115 billion (45th)

Import value (2022): \$121 billion (45th)

Most important partners (export):

Germany (20%), Czech Republic (11%), Hungary (9%), Poland, France

Most important partners (import):

Czech Republic (18%), Germany (15%), Poland (9%), Russia, Austria

Challenges of energy transformation in Slovakia

The Slovak energy market is the smallest of all the Visegrad Group countries, and at the same time it is historically characterized by strong dependence on imports of Russian raw materials and

energy fuels. In the context of the acceleration of the energy transformation in Europe after Russia's aggression against Ukraine, it is worth noting that the Slovak market has experienced the least significant changes – this relationship seems to explain the political and social reluctance of Slovaks to strengthen the EU's involvement in economic sanctions against Russia and support for Ukraine. At the same time, Slovakia remains an important recipient of Russian raw materials, which is due to the limited involvement of the state and the Slovak private sector in the dynamic development of renewable energy sources. This effect is additionally reinforced by structural barriers to increasing the energy efficiency of the economy.

The key features of the Slovak energy transformation model are dependence on Russian raw materials – especially controversial in the context of the war in Ukraine – and a slowed path of transition to renewable energy sources, as well as the dominance of the nuclear energy component in the electricity mix. As in the case of the Czech Republic, the use of nuclear energy results in reduced modernization pressure to move away from the coal-based economy because even the increasing cost of coal-based energy production does not result in a drastic deterioration of the consumers' situation.

The clear priority of Slovak energy policy is therefore to shape it around the central position of nuclear energy, which is ultimately to be supported by renewable energy sources. Despite the dramatic experience of a two-week cut off from natural gas supplies in 2009, which caused a social and economic crisis in Slovakia, Slovakia's dependence on natural gas has not decreased over the last fifteen years – in 2010 it accounted for 28% of the energy mix, and a decade later its share decreased by only 2%. The

government is trying to take action to promote renewable sources – biomass, solar energy and hydrogen installations – so that in the medium term they could reduce dependence on Russian raw materials. However, it seems that in this respect Slovakia would be a beneficiary of regionalization of responsibility and strengthening of regional cooperation as an element of the European Energy Union.

Politically and socially, it is difficult to achieve full involvement of Slovakia in the process of achieving climate neutrality. The first factor is the country's small share in global emissions of greenhouse gases and pollutants, which makes it a complex challenge to explain the costs of transformation to a financially sensitive part of society. Secondly, the competitiveness of the Slovak economy is strongly dependent on low energy costs, which means that climate neutrality may result in a slower development of the country. Thirdly, an important social argument against the energy transformation is the orientation of the Slovak market towards low-emission nuclear energy. However, in the national public debate, experts indicate that Slovakia has the potential to take advantage of the transition to hydropower generation and the implementation of innovations based on the use of hydrogen – both directions could significantly contribute to strengthening the competitiveness of the Slovak economy. The effect of this discussion is increased interest in hydrogen technologies on the part of the Slovak government, which should receive EU support.

In general, the Slovak authorities are committed to the modernization aspect of the energy transformation and are eager to promote innovative solutions for the economy. Slovakia's energy policy seeks to increase the role of renewable energy sources and implement the climate goal of the European Green Deal. An

important part of it is the modernization of the transport sector and the transition towards sustainable mobility, but also in this area Slovakia's difficulty in translating central government programs into the activity of local administration is noticeable. While activities at the state level are quite effective, the weakness of local governments means that they are not evenly transferred to local activities.

In the context of the European Green Deal, the European Commission has indicated that Slovakia needs more intensive investments in renewable energy sources, energy efficiency and sustainable transport. Moreover, further strategic and legislative actions are needed to significantly accelerate the reduction of emissions by the Slovak economy. Maintaining the current pace will only allow the country to achieve half of the planned pollution reduction target in 2030. The allocation of funds from the national reconstruction plan will significantly help in this regard, in which as much as 43% of funds are to be directed to reforms and investments related to the implementation of the climate goal.

In its recommendations for Slovakia, the EC drew attention to the need for a systemic change in the approach to the composition of the country's energy mix. It also recommended changes in activities aimed at decarbonisation, energy efficiency of buildings and their environmental friendliness, strengthening the role of sustainable mobility and reducing the role of road transport, a greater tax burden on entities polluting the environment, coherent state actions for biodiversity and the abandonment of subsidies for sectors dependent on solid fuels and energy raw materials to support their transformation towards renewable energy and circularity.

Key data on Slovakia's energy transformation:

Components of the energy mix (2021):

- solid fuels – 16%
- natural gas – 26%
- crude oil – 21%
- nuclear energy – 23%
- renewable energy sources – 14%

Components of the electricity mix (2021):

- solid fuels – 7%
- natural gas – 15%
- crude oil – 1%
- renewable energy sources – 24%
- nuclear energy – 53%

Components of the renewable energy mix (2021):

- hydropower – 16%
- wind energy – 0%
- solar energy – 3%
- thermal energy – 3%
- biomass – 78%

Energy exclusion (2022): 5.9%

Challenges of energy transformation:

Hungary

Basic data on the economic situation of the country:

GDP (2022): \$341 billion (54th in the world)

GDP per capita (2022): 35.4 thousand dollars (61st)

GDP by sectors:

agriculture – 4%, industry – 31%, services – 65%

Inflation: 14.6% (2022), 3.3% (2020)

Industrial production growth (2022): 2.1%

Unemployment (2022): 3.6%

Poverty level (2021): 12.1%

Gini Index (2021): 29.7

Export value (2022): \$162 billion (38th)

Import value (2022): \$169 billion (35th)

Most important partners (export):

Germany (24%), Italy (6%), Romania, Slovakia, Austria

Most important partners (import):

Germany (21%), China (7%), Austria (7%), Slovakia, Poland

Challenges of energy transformation in Hungary

The Hungarian energy market, in the context of the goals of the European Green Deal, is faced with significant economic and technological challenges, as well as significant development opportunities that allow for the strengthening of Hungarian

sustainable development. The measures taken by the Hungarian authorities in recent years have been aimed at preparing the country's economy for the challenges of climate neutrality in a way that is consistent with the model of Hungarian democracy and administration that has been changing since 2010. In the literature, this is referred to as the direction of soft renationalization of the energy sector, in which – through the actions of those in power – the share of foreign capital is reduced. Strategically, the aim of the national energy policy is therefore to secure supplies at a level corresponding to domestic demand and on principles favourable to the economic development of Hungary, and at the same time to achieve energy autonomy and independence, so that the market situation in the country could be less dependent on international market trends.

The soft renationalization model being created is therefore intended to secure the energy needs of Hungarian producers and provide stable, cheap energy to households, which is facilitated by the system's concentration on nuclear energy, obtained thanks to the Paks nuclear power plant with four units using VVER-440 reactors.

The motivations for the Hungarian model of renationalization and focus on nuclear energy go far beyond the ideological aspects of Fidesz's rule. The main reason is the consequences of the post-communist economic transformation of the country, which limited the investment potential of the Hungarian authorities and reduced the competitiveness of Hungarian producers – for this reason, the Hungarian authorities seek to use the energy transformation to reverse the trend through greater autonomy of the Hungarian market energy. However, the centralization of energy sector management results in a slower pace of green transformation and

at the same time a shift of responsibility for counteracting poverty and energy exclusion to the government (which makes it an important element of political mobilization).

Hungary's energy transformation has three main goals – reducing emissions by decarbonizing the economy, increasing the importance of developing renewable energy sources and maintaining the competitiveness of the economy through the use of nuclear energy. In terms of investments, the pace of transition towards renewable energy sources and sustainable (electro) mobility will be key to the success of the Hungarian transformation.

Hungary – unlike most countries in the region – has opted for a very strong state involvement in the energy transformation process, co-deciding on the climate goals set by the EC on a national level. First of all, this means significant investment and innovation involvement of the state, an increasing role of state capital in the energy sector and government interference in energy prices in the market, including extensive protective measures to prevent the costs of transformation being passed on directly to consumers. While this strategy has become common practice after the Russian aggression against Ukraine and has been programmatically included in REPowerEU, the Hungarian authorities implemented it before 2022, often encountering criticism from the governments of other countries and EU institutions.

In the medium term, thanks to the use of nuclear energy, the Hungarian economy is to remain competitive before the technological advantage is generated due to innovations supported by renewable energy sources (hydro, wind, solar, geothermal and biomass). At the same time, achieving climate neutrality is to be possible thanks to the government program for increasing energy

efficiency, which is to reduce the share of energy costs in the cost basket of households and businesses.

However, the European Commission has raised significant reservations about the level of advancement of Hungary's energy transformation in the context of the goals of the European Green Deal. Particularly important areas of the required acceleration are energy efficiency – the improvement of which was replaced by government protection programs – as well as water resources management and care for air quality. However, the key point is that the EC's estimates indicate that in 2030 Hungary should not only achieve the assumed goal of reducing emissions by 19%, but also probably exceed it, achieving a pollution reduction of 22%. This will be facilitated by the allocation of 48% of funds from the national recovery plan to activities, investments and reforms related to climate goals.

The EC's comments emphasize that on a Central European scale, Hungary has become one of the leaders in the energy transformation and, thanks to the legal changes in 2020, it is on the way to achieving climate neutrality within the deadline set by EU institutions. Of course, this requires a further move away from solid fuels, which was to be facilitated by cheap raw materials and Russian fuels for the Hungarian economy. In addition, the required actions include deregulation of the energy market, strengthening energy efficiency measures, continuing the shift towards sustainable mobility to combat air pollution, reforming environmental taxes and moving away from state subsidies for carbon-intensive raw materials used to produce energy.

Key data on Hungary's energy transformation:

Components of the energy mix (2021):

Energy transformation in Central European countries

- solid fuels – 5%
- natural gas – 35%
- crude oil – 31%
- nuclear energy – 15%
- renewable energy sources – 13%

Components of the electricity mix (2021):

- solid fuels – 9%
- natural gas – 27%
- renewable energy sources – 20%
- nuclear energy – 44%

Components of the renewable energy mix (2021):

- hydropower – 0%
- wind energy – 2%
- solar energy – 11%
- thermal energy – 5%
- biomass – 81%
-

Energy exclusion (2022): 8.6%

Environment of the Central European energy market in the context of the European Green Deal

Challenges of energy transformation in Austria:

The Austrian economy is strongly dependent on meeting the energy needs of industry and a wealthy society. Austria depends on imports of energy raw materials and fuels, without having the infrastructure and production capabilities to autonomously meet its needs. Technological innovations and an early focus on renewable energy sources have allowed Austria to become one of the leaders in the European energy transformation, setting investment trends in the hydropower infrastructure space.

Austria can also serve as a reference point for activities liberalizing the energy market with reforms initiated in 2001 – however, this market also has limitations resulting from high concentration and the relatively weakened position of the consumer in relation to the supplier. At the legislative level, it can be assumed that further changes will be needed to liberalize the Austrian energy market and empower smaller suppliers.

However, the transformation is not going smoothly in Austria – it is assumed that by 2030 it will bring significant macroeconomic consequences for the energy distribution system, as well as a possible negative scenario related to the increase in prices of natural gas, which is responsible for almost a quarter of the country's energy mix. Counteracting the negative effects of the transition to climate neutrality will require Austria to diversify renewable energy sources, modernize the electricity grid, replace natural gas

with another fuel and rebuild the model of heat supply to households, public institutions and businesses.

The literature notes that challenges for Austria may include optimizing the energy market and adapting the existing infrastructure to the new conditions of the European Green Deal. Hydroelectric power plants, which are to become the basic source of renewable energy – which together will be responsible for the target 85% of the energy mix in 2030 – must be effectively integrated into the existing economic model, and at the same time can create the basis for the dynamic development of new areas of the country. This was noticed in the national energy and climate plan, in which, in addition to decarbonisation, energy efficiency, stability of supplies and innovative solutions, the authorities drew attention to the prospects for the development of new sectors of the Austrian economy. One of the most important areas is the socialization of energy production – strongly promoted by the Austrian authorities – which is expected to bring not only a strengthening of the green transformation, but also the possibility of dispersing profits from energy production, and thus allowing smaller suppliers to participate in them.

Austria shows – also in the context of energy and environmental directives – that it wants to be one of the fastest transforming EU countries in terms of adapting to the goals of the European Green Deal. National legislation not only serves to implement common goals, but also to raise its own ambitious modernization goals, including the transfer of all electricity production to renewable energy sources by 2030. In this space, Austria is clearly taking a proactive approach to climate challenges, promoting innovative solutions and energy efficiency in various economic sectors.

The European Commission drew attention to Austria's further efforts to promote renewable energy sources and energy efficiency, because despite its proactive involvement, the effectiveness of actions is not fully satisfactory, as well as in the area of sustainable mobility and reducing pollution generated by the transport sector. However, all efforts do not ensure that the current pace of change will guarantee Austria's achievement of its climate goal in 2030 – the Austrian economy will reduce emissions by 27% against the assumed level of 48%. Therefore, as much as 59% of the funds in the national recovery plan will be directed to investments and reforms consistent with the energy transformation goals.

The key modernization efforts will concern reducing the economy's dependence on energy resources – solid fuels, natural gas and crude oil – as well as facilitating investments in renewable energy sources by reducing bureaucracy and market deregulation, significantly strengthening energy efficiency measures, moving towards sustainable mobility and reducing the country's sensitivity to the consequences of climate change. This will also involve necessary reforms in agriculture and forest management, as well as a shift towards more efficient taxation of sectors particularly harmful to the natural environment and a gradual departure from support of emission-based transport. Despite the earlier start of the energy transformation process and its further stage, the example of Austria shows numerous similarities with neighbouring Central European countries.

Key data on Austria's energy transformation:

Components of the energy mix (2021):

— solid fuels – 8%

Energy transformation in Central European countries

- natural gas – 23%
- crude oil – 35%
- nuclear energy – 0%
- renewable energy sources – 34%

Components of the electricity mix (2021):

- solid fuels – 3%
- natural gas – 15%
- crude oil – 1%
- renewable energy sources – 81%
- nuclear energy – 0%

Components of the renewable energy mix (2021):

- hydropower – 31%
- wind energy – 5%
- solar energy – 4%
- thermal energy – 4%
- biomass – 55%

Energy exclusion (2022): 2.6%

Challenges of energy transformation in Lithuania:

Geopolitical and economic conditions determine the particular importance of the Lithuanian market for the Energy Union, constituting a gateway connecting the continental system and the Baltic system. Equally important is the political factor and the importance of Lithuania as one of the leaders of the European support coalition for Ukraine, an important strategic component of which is cutting off from Russian raw materials and energy fuels. These factors put particular pressure on a rapid and effective

energy transformation and the transition towards a sustainable model of green economy in Lithuania.

The Lithuanian model shows that it is possible to create an effective energy model in which marketization and de-regulation allow for the supply of energy using renewable energy sources, but without the involvement of nuclear energy, balancing the energy transformation of the Czech Republic, Slovakia or Hungary. Despite this significant limitation, the Lithuanian energy industry is not dependent on solid fuels, natural gas and crude oil, making it realistic to achieve the goal of a climate-neutral Lithuanian economy in 2050. This is to facilitate the strategic implementation of intelligent and modern technologies in the economy, enabling the reduction of the country's energy demand while maintaining the competitiveness of its economy, as well as the strong focus of the Lithuanian authorities on energy efficiency. Together, this is intended to make the transition just and socially responsible, protecting the country's most vulnerable residents from the negative consequences of change.

The difficulty in the Lithuanian energy transformation model was the abandonment of nuclear energy resulting from the shutdown of the Ignalina power plant. This contributed to a much higher, than on average across the EU, dependence on imports of energy and energy raw materials, which in turn resulted in greater sensitivity to the energy crisis following the Russian attack on Ukraine. Awareness of the threats has additionally strengthened political and social commitment to Lithuania's energy transformation, with the goal of an 80% share of renewable sources in the country's energy mix in 2050.

Lithuania has a well-developed heating system, which in the national energy strategy is to be used to transition from dependence on fossil fuels to independence by integrating it with renewable energy sources. The Lithuanian heat pump market is also developing very dynamically, absorbing technological innovations and contributing to the increase in the energy efficiency of buildings across the country.

In general, the Lithuanian energy policy is consistent with the EU's climate strategy with a strong focus on the promotion of renewable energy sources. The Energy Act set up a catalogue of sectoral goals, stimulating the use of renewable energy sources and promoting them as an alternative for households. This was particularly important as a compensatory measure after the phasing out of the Lithuanian nuclear energy sector, which is included in the goals of the Sustainable Energy Strategy for 2012–2035.

The Lithuanian model must reconcile the pursuit of energy independence – and the resulting political sovereignty from hybrid pressures from Russia – strengthening the competitiveness of the economy and the goals of sustainable development. The promoted solution is to clearly redirect the Lithuanian economy towards the use of renewable energy sources while increasing innovation and technological advancement of production and investing in energy efficiency and sustainable mobility.

This is reflected in the recommendations of the European Commission, which, in the context of Lithuania's adaptation to the implementation of the European Green Deal, emphasized the role of promoting energy efficiency, clean transport and ecosystem biodiversity protection. Lithuanian measures are already exceeding the assumed efficiency goals, which will allow – while maintaining

the current pace of change – to reduce emissions by 23% in 2030 compared to the planned 21%. Maintaining the pace of modernization, or perhaps even accelerating it, may be possible as a result of investments and reforms planned in the national recovery plan, in which 38% of the funds are to be allocated to the implementation of climate targets and goals consistent with the European Green Deal.

The EC suggested that Lithuanian efforts should focus on continuing efforts to reduce the share of natural gas and solid fuels in the country's energy mix, further deregulation of the energy market to facilitate the inclusion of renewable energy installations, promoting energy efficiency in construction and modernization of buildings, popularizing electrical mobility as an alternative to vehicles with combustion engines, increasing activities to protect the natural environment (with particular emphasis on the Baltic coast of Lithuania), preparing the country to deal with the consequences of climate change and implementing tax tools to collect budgetary funds for compensatory activities for areas and groups of inhabitants, especially exposed to the negative effects of the energy transformation. Compared to the challenges faced by the Visegrad Group countries, the reservations about Lithuania seem to be less demanding for the country's authorities.

Key data on Lithuania's energy transformation:

Components of the energy mix (2021):

- solid fuels – 3%
- natural gas – 27%
- crude oil – 42%
- nuclear energy – 0%
- renewable energy sources – 28%

Components of the electricity mix (2021):

- solid fuels – 0%
- natural gas – 25%
- crude oil – 2%
- renewable energy sources – 73%
- nuclear energy – 0%

Components of the renewable energy mix (2021):

- hydropower – 2%
- wind energy – 6%
- solar energy – 0%
- thermal energy – 3%
- biomass – 88%

Energy exclusion (2022): 5.5%

Challenges of energy transformation in Germany:

The transformation of the German energy system in the long run is of great importance for the development of Europe because Germany is the largest continental economy – at the same time, German industry seems to be most dependent on the effectiveness of adapting to changes at an early stage of the path to the goals of the European Green Deal. In addition to the economic factor and position in the European energy system, the German energy transformation will be crucial for the political trajectory of the modernization of the European Union, and thus influence the community's ability to respond to political events such as Russian aggression against Ukraine. At the same time, an analysis of the challenges of the German economy indicates that its transformation

is complexly interdependent with technological, environmental, social and economic changes across the continent.

On the one hand, Germany is treated as one of the pioneers of the transformation towards renewable energy sources. However, despite the changes initiated during Angela Merkel's government, Germany lags behind compared to the standards for highly developed countries, in 2023 holding only the 16th position in the climate change index ranking – therefore the ambitious emission reduction goals by 2030 seem to be uncertain. The failure to implement the goals of climate policy by the EU's largest economy may increase social and political pressure in countries emitting less pollution to abandon the ambitious targets and climate goal of the European Green Deal in favour of actions less focused on the EU's climate neutrality.

The German energy transformation program – Energiewende – assumes a transition to a low-emission economy through the development of energy-efficient infrastructure and obtaining energy from renewable sources. In the German model, modernization is carried out primarily thanks to investments in wind and solar energy, and at the same time assumes a dynamic departure from the use of nuclear and coal energy. Particularly controversial is Germany's departure from nuclear power, which was dictated by both environmental and ideological reasons – the consequences of this model were visible in the negative impact of the decision on the plasticity of Germany's political action after the Russian aggression against Ukraine. The low political involvement of the German government at the initial phase of the war was explained by researchers by the country's significant dependence on cheap energy resources imported from Russia, which were necessary to

compensate for the deficit resulting from the phasing out of nuclear energy.

However, the danger does not outweigh the possible benefits resulting from the German transformation model – the most important opportunities include the development and dissemination of advanced technologies that can strengthen Germany's position as a leading exporter of modern industrial products. In the long run, the development of new sectors and the creation of jobs in them may compensate for the costs resulting from the modernization of energy-intensive branches of the German economy, which have been the driving force of its development for decades. Energy-intensive sectors and individual consumers are perceived as most vulnerable to the negative effects of the German model, although in the case of households the government is trying to limit the consequences with federal protection programs. It seems that the final balance of innovations and lost profits in energy-intensive sectors, as well as financial benefits resulting from energy and fuel savings in industries that are the pillars of German industry, will be crucial for the success of the energy transformation.

The EU's climate goal and pursuit of climate neutrality are to be achieved in Germany by way of investing in renewable energy sources, focusing on energy efficiency and implementing innovations that reduce the impact of the economy on the environment. The key question – also from the perspective of the global climate effort – is the extent to which the transition to low-emission technologies will affect the competitiveness of the German economy and its ability to maintain the dynamics of economic growth.

An important aspect of the German model is the strong harmonization of EU and national regulations, supporting the implementation of the provisions of the European Green Deal. The regulatory framework mainly concerns the timetable for phasing out coal-fired energy, strengthening emission allowance trading procedures, the functioning of the energy market and federal and local mechanisms for supporting renewable energy infrastructure. The key task of German climate legislation is to create financial instruments and a system of incentives that will accelerate the modernization of the energy system and contribute to the dissemination of low-emission innovations.

In the opinion of the European Commission, the green transformation of Germany requires further intensive actions to strengthen the position of renewable energy sources in the country's energy mix, greening of transport, heating networks and buildings, sustainable water management and advanced investments in carbon dioxide absorption technologies. These spaces will be crucial for the effectiveness of the implementation of the goals of the European Green Deal in Germany, and, as indicated in the introduction, due to the position of the German economy in the EU, they will also define the dynamics of changes in European energy policy.

The ineffectiveness of German efforts visible in the data for 2021 is pessimistic, i.e. even before the forced acceleration resulting from the reduction of imports of energy raw materials and fuels from Russia after that country's aggression against Ukraine. The current pace of modernization indicates that in 2030 Germany will reduce its emissions by 29%, a level far from the strategic 50% reduction target. Therefore, the German authorities should visibly accelerate the energy transformation to get closer to the assumed

level. This will be helped by the allocation of 42% of funds from the Recovery and Resilience Facility for activities and investments related to the goals of the European Green Deal in the German national recovery plan. Additional investment pressure should be generated by the German climate law, which assumes achieving climate neutrality earlier than in the EU plans, i.e. already in 2045. Therefore, it should be assumed that in the coming years Germany will become one of the largest global investors in renewable energy sources, sustainable mobility and energy efficiency.

These spaces overlap with the EC recommendations. The Commission detailed that Germany should particularly increase its commitment to independence from high-emission raw materials, reducing energy consumption in the economy, promoting sustainable mobility while maintaining the direction of intensifying rail transport, protecting the biodiversity of the ecosystem and restoring the natural environment on the coast of the North and Baltic Seas and changing legislative and fiscal measures to increase the involvement of the private sector in green innovations.

Key data on Germany's energy transformation:

Components of the energy mix (2021):

- solid fuels – 18%
- natural gas – 16%
- crude oil – 33%
- nuclear energy – 6%
- renewable energy sources – 17%

Components of the electricity mix (2021):

- solid fuels – 30%
- natural gas – 16%

Energy transformation in Central European countries

- crude oil – 1%
- renewable energy sources – 41%
- nuclear energy – 12%

Components of the renewable energy mix (2021):

- hydropower – 4%
- wind energy – 21%
- solar energy – 11%
- thermal energy – 3%
- biomass – 60%

Energy exclusion (2022): 4.2%

Challenges of energy transformation in Romania:

Romania's energy transformation is a key macroeconomic challenge for the country, consistent with the challenges of the European Green Deal and the goals of climate neutrality. It is assumed that Romania can be a key beneficiary of the new model of European economic development if the modernization of the energy system and decarbonisation proceed in a timely and orderly manner, unlocking the potential of wind energy and hydrogen technologies.

However, the process of transition to a low-emission economy itself is associated with high economic, financial and social costs, because for Romania it means intensive investments in the energy system, modernization of buildings and sustainable mobility, reaching a level of expenditure estimated by the World Bank at

3.2% of its cumulative GDP by 2050. Additionally, the changes mainly affected sectors that were key to the Romanian economy and clearly dependent on energy-intensive technologies.

An important motivation for the Romanian transformation is counteracting the effects of climate change, which exposes Romania to floods, heat and droughts. However, this motivation is also a potential limitation to the transformation process, resulting in the need for ad hoc actions and the involvement of public support in investments that mitigate climate change. An opportunity for Romania may be the regionalization of responsibility for achieving the climate goal and the involvement of the private sector in the modernization of the energy sector and the implementation of technological innovations that increase the competitiveness of the Romanian economy.

The Romanian government is committed to implementing the energy transformation in line with the goals of the European Green Deal, creating conditions favourable to investments aimed at the future development of energy generation. The energy sector requires decisive infrastructure investments that will develop the potential of wind and solar energy and the use of hydrogen technologies in order to move away from the current composition of the national energy mix. However, the literature review indicates the presence of three important barriers – low energy prices, ensuring the competitiveness of the economy and reducing the financial justification of investments in renewable energy sources, highly bureaucratic procedures and corruption threats.

Another limitation is the lack of political consensus around the Romanian energy transition model and limited public support for the decarbonisation process and the goal of climate neutrality.

The lack of a coherent modernization model results in chaotic development of renewable energy sources, which is why the potential of wind energy in Romania has not yet been fully exploited – however, this requires improving regulations, deregulating the market and boosting public support mechanisms for investments.

Ultimately, the Romanian economy will benefit from stable nuclear energy sources and wind and solar energy infrastructure. However, the path to climate neutrality will lead Romania to success if it is carried out in a fair and socially responsible way, ensuring stability and security for consumers and eliminating the key risk of deepening energy poverty in groups exposed to the negative effects of the transformation.

From the Romanian perspective, the key factor influencing the implementation of the goals of the European Green Deal will be the energy price and fair distribution of transformation costs – it seems that in this respect Romania is similar to the cases of Poland and Slovakia, where the climate goal is also not universally supported by public opinion, and the involvement of society and the private sector will be regulated by the impact of changes on the competitiveness of the national economy. The accelerated development of renewable energy is therefore a development opportunity for Romania, but if it has too strong an impact on the costs borne by energy consumers, it may lead to stagnation or a crisis resulting from reduced competitiveness. Unlike in the case of Germany, Romania cannot count on technological innovation coming from energy-expensive sectors or, more broadly, the private sector. Therefore – it is worth emphasizing it again – a more common approach to responsibility for the modernization of the energy system and the regionalization of responsibility favouring

technology transfer and foreign investments in renewable energy are crucial for the Romanian model of energy transformation.

The European Commission noted that the green transformation in Romania requires increased investment in renewable energy sources, sustainable mobility, reducing air pollution and adapting the country to climate change. Without the involvement of additional funds, it will not be possible – maintaining the current pace of change – to achieve the goal of reducing emissions by 13% in 2030 because currently it seems possible to reduce it by 2%. The impetus for change is to be the allocation of 41% of the Romanian National Recovery Plan to climate action and the implementation of the provisions of the decarbonisation law.

Key data on Romania's energy transformation:

Components of the energy mix (2021):

- solid fuels – 12%
- natural gas – 29%
- crude oil – 31%
- nuclear energy – 8%
- renewable energy sources – 20%

Components of the electricity mix (2021):

- solid fuels – 18%
- natural gas – 17%
- crude oil – 1%
- renewable energy sources – 45%
- nuclear energy – 19%

Components of the renewable energy mix (2021):

- hydropower – 23%

Energy transformation in Central European countries

- wind energy – 9%
- solar energy – 2%
- thermal energy – 0%
- biomass – 65%

Energy exclusion (2022): 17.8%

Challenges of energy transformation in Ukraine:

Due to the ongoing armed conflict since 2014 violating Ukraine's territorial integrity and full-scale Russian aggression in 2022, the challenges of the country's energy transformation have lost their priority for the government. However, considering Ukraine's accession to the EU, it should be assumed that after the end of the war, achieving climate neutrality will become one of the country's key development challenges, next to the reconstruction and reintegration of the state.

Even before the outbreak of the conflict, Ukraine was faced with a decision regarding the development model of its energy sector, striving to green and decarbonize its economy previously based on fossil fuels. Before 2014, coal accounted for one third of the country's energy supply drawing on rich coal resources primarily located in the east of the country in the Donetsk Region. For this reason, the Ukrainian economy was forced to start transformation in order to avoid deepening dependence on coal imports by 2019 (45% compared to 27% a decade earlier). An additional difficulty was the decision to withdraw from the import of Russian natural gas in 2016 in order to become politically and economically independent from Russia, which uses raw materials and energy fuels as a hybrid tool of pressure on the Ukrainian authorities.

A slight increase in energy production from renewable sources and nuclear energy has not reduced Ukraine's dependence on energy resources accounting for 70% of the energy produced in 2020. Today, it seems that the technological advancement of new solutions represents the greatest opportunity for Ukraine's energy transformation, promoting a dynamic shift towards renewable energy sources. However, the lack of a coherent model of energy transformation may be a serious limitation as even before the Russian aggression experts noticed that Ukraine's involvement in the green transformation was more declarative than actual, and there is a lack of political consensus in the country regarding the path to achieving climate goals and modernizing the economy.

An opportunity for Ukraine may be the implementation of solutions tested by European countries as part of adapting to the goals of the European Green Deal. Reconstruction of the country focused on the use of renewable energy sources, integration of the country with the continental energy system, investments in construction and energy-efficient industries, and promotion of sustainable mobility – these factors may make Ukraine able to implement the ambitious climate policy after the end of the war. An additional advantage may be the harmonization of its law and adaptation of its legislation to EU regulations using the best practices of neighbouring countries.

The main challenges of the Ukrainian energy transformation in the conditions of post-war recovery will include: creating an alternative energy market based on renewable sources, meeting the needs of the market and consumers as well as strategic development priorities, transitioning the economy to a green low-emission model without loss of competitiveness and a drastic increase in energy prices, requiring a broad program of protective

measures protecting groups of vulnerable consumers from energy poverty, attracting private sector investments in the Ukrainian energy system and creating a coherent model of energy transformation, harmoniously integrating Ukraine with EU Member States.

Even before 2022, the problem of the Ukrainian economy was frequent power outages, which can be limited by moving towards an economy based on renewable energy sources, which Ukraine has good geographical conditions for developing. Ukraine's transition towards a fiscal system that shifts the costs of transformation to energy-intensive sectors will also require a solution, which may be hampered by the oligarchic structure of the Ukrainian economy, institutional and staff weakness of the administration, excessive bureaucratization of the country and corruption.

Action will also be required to adapt the energy market – its liberalization and deregulation – to include renewable energy sources, allowing for a more decentralized distribution of electricity and empowering smaller producers. The pace of change and the dynamics of the transition to renewable energy sources will depend on the effectiveness of legislation and modernization of administration.

Politically and socially, Ukraine's energy transformation will be of fundamental importance for the security of Central Europe, and its economic independence from Russia may be a long-term guarantee of Ukraine's inclusion in the process of European integration and the European model of sustainable development. It will also be of key importance for the competitiveness of the economies of the neighbouring countries, influencing a just energy transition throughout Central Europe. Making Ukraine a state integrated with the European Energy Union and jointly pursuing the

goal of climate neutrality can help in the fair and socially responsible implementation of a new model of European development in the region.

Key data on Ukraine's energy transformation:

Components of the energy mix (2020):

- solid fuels – 27%
- natural gas – 28%
- crude oil – 16%
- nuclear energy – 23%
- renewable energy sources – 6%

Components of the electricity mix (2020):

- solid fuels, natural gas and crude oil – 38%
- renewable energy sources – 6%
- nuclear energy – 56%

Components of the renewable energy mix (2020):

- hydropower – 55%
- wind energy – 22%
- solar energy – 18%
- thermal energy – 0%
- biomass – 5%

Energy exclusion (2019): 19%

Energy transmission infrastructure in Central Europe

The analysis presented in the report made it possible to diagnose the existing cross-border transmission infrastructure in Central Europe, indicating directions for possible regionalization of responsibility for a just energy transformation and achieving the climate goal in 2050 in accordance with the objectives of the European Green Deal. For the Visegrad Group countries, we can specify networks enabling the transmission of electricity and infrastructure to integrate national natural gas systems.

Czech Republic (electricity):

- Germany: Hradec-Rohrsdorf, Hradec/Prestice-Etzenricht,
- Austria: Slavetice-Durnrohr, Sokolice-Bisamberg,
- Slovakia: Albrechtice-Varin, Liskovec-Povazska Bystrica, Sokolice-Stupava/Senica/Krizovany,
- Poland: Alberchtice-Wielopole, Liskovec-Bujaków.

Poland (electricity):

- Germany: Krajnik-Vierraden, Mikulowa-Hagenwerder,
- Czech Republic: Bujaków-Liskovec, Wielopole-Alberchtice,
- Slovakia: Krosno-Lemesany, Wielopole-Varin,
- Ukraine: Rzeszów/Zamość-Dobrotvirska,
- Lithuania: Etk-BtB,
- Switzerland: Stupsk-Starno.

Slovakia (electricity):

- Czech Republic: Stupava/Senica/Krizovany-Sokolice, Povazska Bystrica-Liskovec, Varin-Albrechtice,
- Hungary: Gabčíkovo-Győr, Levice-God,
- Ukraine: Velke Kapusany-Mukachevo.

Hungary (electricity):

- Austria: Győr-Wien, Szombathely-Zumdorf,
- Slovenia: Heviz-Cirkovce,
- Croatia: Heviz-Zerjavinec, Pécs-Ernestinovo,
- Serbia: Sandorfalva-Subotica,
- Romania: Bekescsaba-Nadab, Sandorfalva-Arad,
- Ukraine: Albertirsa/Sajószögéd/Kisvárdá-Mukachevo,
- Hungary: God-Levice, Győr-Gabčíkovo.

Czech Republic (natural gas):

- Germany: Brandov-Stegal, Waidhaus,
- Slovakia: Dolni Bojanovice, Lanzhot,
- Poland: Cieszyn.

Poland (natural gas):

- Germany: Gubin-Basów, Mallnow,
- Czech Republic: Cieszyn,
- Slovakia: Vyrava,
- Ukraine: GCP GAZ-SYSTEM/UA TSO,
- Lithuania: GIPL.

Slovakia (natural gas):

- Czech Republic: Dolni Bojanovice, Lanzhot,
- Austria: Baumgarten,
- Hungary: Velke Zilevce,

- Ukraine: Velke Kapusany/Bundice.

Hungary (natural gas):

- Austria: Mosonmagyaróvár,
- Croatia: Dravaszerdahely,
- Serbia: Kiskundorozsma,
- Romania: Csanádpalota,
- Ukraine: Bereg,
- Slovakia: Balassagyarmat,

Additionally, Austria has five infrastructure systems connecting with Germany, two with Switzerland, one with Italy and two with Slovenia, which form the entire regional network in addition to the above-mentioned connections with the Czech Republic, Slovakia and Hungary. Lithuania – in addition to the connection with Poland – has four connections with Latvia, as well as two each with Belarus and the Kaliningrad Region of Russia. Germany – in addition to the above-mentioned connections with Austria, the Czech Republic and Poland – has infrastructure integrating the energy system with Belgium, Denmark, France, the Netherlands, Luxembourg, Sweden and Switzerland. However, Romania, in addition to two connections with Hungary, is also integrated with Bulgaria, Moldova, Serbia and Ukraine.

The natural gas infrastructure includes connections of Austria with Germany (6), Slovenia (1) and Italy (1), Lithuania with Latvia (1) and Russia (2), Germany with Belgium (2), Denmark (1) and France (1), the Netherlands (10), Luxembourg (1) and Switzerland (2), as well as Romania with Bulgaria (2), Moldova (1) and Ukraine (3).

Summary

The literature review leads to the diagnosis of key spaces for an effective, fair and socially responsible energy transformation. In the general model, they include (1) legislative activities, (2) deregulation of the energy market and (3) promotion of green energy – renewable energy sources and nuclear energy. The implementation of the goals of the European Green Deal should encourage those in power to harmonize energy policy, including the transformation of the energy system and adjustment of tariff plans, investments in renewable energy sources and research into future energy technologies, monitoring energy demand and supply while caring for responsible energy reserves, energy efficiency and systemic resource management, as well as counteracting the inflationary effect of the energy transformation.

The detailed model assumes that activities will be focused on strengthening energy efficiency and modernizing the energy market – it includes measures related to:

- for energy efficiency – regulating energy consumption, including the demand for electricity and moving away from the coal economy, as well as effective energy policy, including the promotion of renewable energy sources, green transformation and investments in innovative low-emission technologies and scientific research conducive to future innovation;
- for the energy market modernization – energy production, assessment of the risk of energy transformation, strengthening competitiveness through deregulation and market liberalization, strengthening the position of smaller energy producers and pricing policy, as well as applied market

research allowing the implementation of new technologies, observing consumer behaviour and managing changes in energy mix.

From the perspective of the most developed economies of Central Europe, the catalogue of the required modernization activities includes the creation of a sustainable development model, regionalization of responsibility for the energy transformation, modernization of energy systems, use of alternative energy sources, including nuclear energy, modernization of transmission networks and increasing energy efficiency, as well as implementing innovative technological solutions and moving towards a modern digital economy and sustainable mobility. Among the available tools, actions regulating the import of energy, raw materials and fuels, harmonization of energy policy, adjustment of energy-intensive sectors of the economy, advanced macroeconomic analytics and climate convergence are of key importance.

Thanks to the conducted analysis, it is possible to further map the opportunities and threats for the implementation of the climate goals of the European Green Deal in the Visegrad Group countries, taking into account the broader context of Central European cooperation and the perspective of regionalization of responsibility for a just energy transformation of the European Union.

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