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Central and North Europe's road to energy transition: outlook in selected countries

Edited by
Michał Paszkowski and Maciej Mróz


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Executive summary

Ambitious North: Finland's course to energy transition

- Finland, given its existing energy system and public attitudes, is capable of achieving its energy transition goals. However, it will be a costly process and will require an appropriate overhaul of the energy system, including a reduction in crude oil, natural gas, and coal consumption in favour of renewables and nuclear energy. The change in the energy mix can be accelerated taking into account the efforts of the government, companies, and citizens to reduce greenhouse gas emissions as well as the reorientation of the security geography in Europe, which will force a faster shift away from energy resources imported from the Russian Federation.
- Finland faces numerous challenges, which will arise from both ensuring energy security in the changed geopolitical environment and the energy transition

process. Among the key challenges in the coming years will also be the construction of a zero-carbon economy based on nuclear technologies (mainly SMR), CCS/CCUS, the use of hydrogen, and the development of wind farms. An extremely important task will be to reduce emissions in non-ETS sectors, including transportation, which accounts for the largest share of emissions.

Norway's dual role as a leader in energy transition and European pillar of energy security

- As an energy-rich country, Norway has a natural advantage and a unique starting position on the road to energy transition. In many areas, Norway is leading the process and can be seen as an example of impressive cross-sectoral achievements, with high climate awareness, and an effective regulatory framework in place. Probably, the most notable example is the country's high electrification level, sourced almost entirely from hydropower. In fact, its renewables-based electricity system, with massive potential still for further electrification, is the key pillar of Norway's sustainable transition to becoming a climate-neutral society.
- The cornerstone of the country's economy and welfare is the oil and gas industry. On the one hand, it positions Norway as a key strategic supplier of energy to Europe, which has become particularly important after the Russian invasion of Ukraine. On the other hand, it creates serious climate challenges as the petroleum sector is one of the biggest polluters, responsible for around a quarter of total greenhouse gas

emissions in Norway. However, these two perspectives are not necessarily opposites; in fact, decarbonisation might be the answer for EU security in the long run.

The Visegrad Group Countries' road to energy transition: current and future perspective

- The Visegrad Group countries use fossil fuels to a large extent in the structure of their energy mix, but they do not have sufficient own energy resources. For this reason, they have been deeply dependent on crude oil and natural gas, mainly from the Russian Federation. Currently, an opportunity to radically change this situation is the use of the potential resulting from access to the Baltic Sea, which provides opportunities for full diversification of hydrocarbons as well as strengthening cooperation.
- The actions of the Visegrad Group countries can be considered twofold. On the one hand, V4 countries face the need to converge their economies and power systems in accordance with the common EU climate and energy policy (long term). On the other hand, Russia's war against Ukraine is suddenly shifting Europe's energy landscape (short term). Hence, the need for rapid but also permanent changes is determined by the limited supply of energy resources from Russia and the developing situation in UE green politics. Therefore, the V4 countries tend to act mostly based on economics and this crisis makes renewables and other postponed green investments cost-effective now.

Romania's approach to energy transition: too little, too slow

- Romania is both a late and unwilling implementer of energy transition. The state-owned energy companies have largely missed out on the renewable energy boom (2011-2015) and are showing interest only now, when faced with imminent disappearance from the market and when the EU legislation is forcing them to make a choice: restructure or die.
- The main locomotive for Romania's energy transition is EU energy policy, specifically the Green Deal and the multiple funding opportunities available for decarbonization projects. The EU's ambitious and transformative climate agenda is the only thing propelling Romania and its energy sector into the future, ready or not.

Germany's road to energy transition

- Germany excels as one of the pioneering countries in the early adoption of energy transition. Being a leader can bring benefits not only with positive environmental changes but above all with the acceleration of economic development. Germany has recognized the opportunities for the development of renewables. The benefits include increased electricity supplies, technological development, enhanced energy security, reduced dependence on imported energy resources, and shifts in social awareness. Yet, energy transition brings not only development opportunities but also a number of constraints and expenses.

- The energy transition strategy implemented by Germany was verified in 2022; however, this energy transformation started in 1990 and allowed for the implementation of a consistent policy of diversifying the energy mix and reducing dependence on imported energy resources. This energy transition has shown the positive aspect of modernization of the transmission and storage infrastructure. It set directions for changes and created opportunities for economic development and growth in competitiveness. At present, Germany is the most advanced of all European countries with respect to its transition project.

Introduction

Central European countries are facing a number of challenges that, in the energy dimension, are related to trends of a structural nature. On the one hand, the unstable geopolitical situation resulting from Russia's armed assault on Ukraine, and on the other hand, the energy transition process, is making the energy dimension more important. The trend of reducing the use of fossil fuels has already been set by measures taken for many years and can now only accelerate as a result of the introduction of various types of regulations at the European Union level. The goal of current government actions is primarily to be able to adapt national economies to the new challenges and, while the goal of achieving climate neutrality for most countries (as declared) is the same, the deadlines vary.

Central European countries also face challenges due to their level of fossil fuel use and economic development. A key task for these countries will be to modernize their economies and implement measures in national policies to reduce emissions through the development of zero-carbon

technologies such as those related to hydrogen, renewables, and nuclear power. Many countries in the region can benefit from the experience of northern European countries (including Finland and Norway), as well as Europe's largest economy, Germany. These countries also face numerous challenges, but the level of application of modern technologies in the economy compared to Central European countries is definitely greater.

There are many unknowns ahead for the countries of the European Union arising from the energy transition process. The paper examines this process in relation to several countries, namely, Finland, Norway, Poland, Czechia, Slovakia, Hungary (these last 4 countries are the Visegrad Group countries), Romania, and Germany. This selection makes it possible to show the different approaches of individual countries to this issue, especially since the group includes countries where the energy transition process is extremely advanced (Finland and Norway), countries where this process will require significant activity and financial outlays (Poland, Czechia, Slovakia, Hungary, Romania), and where the challenges will be the greatest given the scale of the level of economic development (Germany). Each of the sections of the paper has been divided identically to allow a better comparison of the situation of each country, that is, their potential and starting point as well as the strategies chosen in view of the energy transition process and, at the same time, the challenges.

It will be critical for Central European countries to maintain economic competitiveness in a changing international environment. The trend associated with the energy transition process sets the stage for the next decades for

measures to both protect the environment and ensure economic growth. The chosen activities must also be directed at ensuring energy security and being aware of the changes in the geopolitical environment.

Putting the European Union countries on the path of energy transition will require significant financial resources and a decision in some cases regarding what technology should play a key role in the process. Undoubtedly, this process will be extremely challenging for current energy producers, including Norway in particular. Therefore, the path to the goal of climate neutrality will be different in each of the analysed countries, which makes this, in the opinion of the authors, an extremely interesting area of research.

Michał Paszkowski, Maciej Mróz
Lublin and Warsaw, April 2023

Michał Paszkowski

Ambitious North: Finland's course to energy transition

1. Current energy market overview

Finland is one of the most ambitious countries in Europe in terms of reducing greenhouse gas emissions, which is due to a number of factors including its energy mix structure, public acceptance of environmental goals, and strong political legitimacy for such policies. Under these conditions, the implementation of climate and energy policy is being applied both domestically and internationally. Concern for climate change is one of the elements of the identity of the Nordic countries[1], and environmental issues are an important component of their foreign policy. As a result, Finland has set an ambitious goal of achieving climate neutrality by 2035, which will require appropriate changes in the energy system and, despite the change of government in 2023,

[1] K. Musiał, *Reconstructing Nordic Significance in Europe on the Threshold of the 21st Century*, "Scandinavian Journal of History" 2009, vol. 34, no. 3, p. 297.

this process should continue to a greater or lesser extent. The process of energy transition will thus deepen and accelerate given the geopolitical situation in the region (Russian-Ukrainian war).

The energy situation is affected by numerous factors, and the shape of the actions taken is determined, among others, by the energy mix structure. The share of individual commodities in the economy is different, and their share in the total energy supply (TES) is also different. Taking into account the existing energy mix base, biomass plays the largest role in this respect in Finland, which, in 2021, accounted for approx. 35.3% of TES. This is followed by crude oil at around 22.2%, nuclear energy at around 19.6%, and coal at 9.6%. The share of natural gas in the energy mix was slightly smaller, which amounted to approx. 6.7%, as well as energy generated in hydroelectric power plants at the level of 4.3%, and other renewables, i.e., energy generated from wind and solar, which corresponded to 2.3% of TES. Importantly, in total, all energy sources treated as renewables accounted for 41.9% of TES, and together with nuclear energy, 61.5% of TES[2]. Thus, Finland is one of the countries with the largest share of renewables in the energy mix, with a high level of energy security at the same time, because biomass is produced domestically. This security is also influenced by the high share of nuclear energy, which is still being developed as a result of investment works carried out in Finland over the years, the aim of which was to increase the share of nuclear in the energy mix. The approach of the Finns to this issue is constant and unchanging, which results from

[2] International Energy Agency, *Finland*, https://www.iea.org/countries/finland [24.03.2023].

their society's conviction of the need to protect both the environment and the investment in modern, environmentally friendly sources of energy.

The share of individual energy sources in the structure of electricity generation is slightly different, as nuclear energy dominates in this respect (share at the level of 32.9%). Importantly, the share of clean technologies is extremely high, because apart from nuclear energy, a very important role is played by renewables, which account for 53.6%. Thus, approximately 86.5% of the electricity generated in Finland comes from either renewables or nuclear energy, and this also means the level of energy security is extremely high. A smaller role is played by coal (7.4%), natural gas (5.5%), and others including heating oil (0.6%) produced from crude oil in refineries. The high share of renewables results in a different level of CO2 emissions. Taking into account the structure of the share of individual energy sources in the energy mix, the products produced in refineries play the largest role in emissions, i.e., fuels used in transport (for example, gasoline, diesel oil) and for heating purposes and electricity generation (heating oil). The share of these energy sources has been decreasing for many years, and in 2020 amounted to 19 million tons of CO2, which means a decrease of 29.6% compared to 1990 (the base year). Then, there is a large share of coal, whose emissions in 2020 amounted to 11 million tons of CO2, which means a decrease of 50.0% compared to the base year. On the other hand, the share of natural gas was the smallest, the emission of which in 2020 amounted to 4 million tons of CO2, which means a decrease of 20% compared to 1990. Importantly, thanks to the development of renewables and the decrease in the use of fossil fuels, the

level of CO2 emissions decreased, which in 2020 amounted to 20 million tons of CO2 compared to 54 million tons of CO2 in 1990 (35.2% less).

Over the past several years, the share of renewables in Finland has increased significantly, thus influencing the shape of the energy mix. The decline in emissions as a result of the implemented policies means that Finland is now one of the pioneers of energy transition. This process may yet accelerate given both the regulations at the EU level and Russia's war in Ukraine (reduction in imports of commodities from this country) as well as the widespread positive public attitude towards the need to protect the environment. However, the new government elected in 2023 will have to redefine energy and climate priorities.

2. The country's strategy towards energy transition

Finland's ambitious low-carbon targets will require large-scale investment projects. In this regard, the implementation of the strategy toward further energy transition will force the need for investment in technologies that are already known and widespread (nuclear power plants, wind farms) as well as those that are still in the research and development stage (hydrogen). Given stable and well-known targets, both domestic and international companies are ready to invest in low-carbon technologies in Finland. Importantly, public acceptance of such major efforts will play a key role in realising the energy transition process.

Finland's energy and climate strategy for its energy transition is based on several key areas designed to cover entire sectors of the economy. Actions taken in the coming years will focus on both fulfilling commitments to the EU

and implementing national environmental plans[3]. With the goals set by the Helsinki government in mind, six key tools can be identified to reduce the use of fossil fuels in the economy. First – the expansion of nuclear power generation capacity, including the construction of small modular reactors (SMRs), which would eventually replace fossil fuel-fired power plants. Second – expansion of onshore wind power generation capacity as well as investment in offshore wind farms. Third – promotion of energy efficiency, including by supporting efforts for unburned heat generation. In this regard, incentives will be introduced and energy efficiency measures will be promoted for businesses and municipalities. Fourth – technological development toward the use of hydrogen in industrial processes. Finland plans to build electrolysers with annual hydrogen production of 200 MW in 2025 and at least 1,000 MW in 2030 (it was 9 MW in 2021). Fifth – electrification of sectors where it is not possible to make full use of other energy sources (such as electrification). The leader in this regard is the Finnish company Neste Oyj, which is one of the few in the world developing the renewable fuels sector[4]. Sixth – development and use of carbon capture, utilization (CCS) and carbon capture, and utilization and storage (CCUS) technologies[5].

[3] M. Paszkowski, D. Szacawa, *Finlandia: ambitne cele klimatyczne wymuszają odpowiednie działania w sferze energetycznej*, "Komentarze IEŚ" 2022, no. 187(675), https://ies.lublin.pl/komentarze/finlandia-ambitne-cele-klimatyczne-wymuszaja-odpowiednie-dzialania-w-sferze-energetycznej/ [5.03.2023].

[4] A. Kauranen, *Finland's Neste flags need for new materials in rush for sustainable jet fuel*, 8 February 2023, https://www.reuters.com/business/energy/finlands-neste-q4-earnings-beat-forecast-2023-02-08/ [15.03.2023].

[5] The Ministry of Economic Affairs and Employment, *Carbon neutral Finland 2035 – national climate and energy strategy*, Helsinki 2022, pp. 20-70.

Implementation of such projects will require government support at both the legislative and financial levels. Thus, dedicated development programs are planned as well as assistance in obtaining support at the EU level. For Finland, it is of the utmost importance both to obtain funding and to redirect adequate money to new technologies. This is because it is recognized that the energy transition process will require large-scale investment projects and, in this regard, it will be important to ensure stability and transparency for the placement of funds given the capital-intensive and time-consuming investment process for clean technologies. The development of purely Finnish technologies that can be exported to international markets will also be an important aspect of ongoing activities.

Implementation of energy and climate policy would not be possible in Finland without public support for environmental protection. This widespread pro-environmental attitude affects the political scene. Thus, it is one of the key aspects of both the political debate and elements of the political programs of the various parties. At the same time, it is an important area of international activity for the Nordic countries, including Finland, to support various types of activity in the sphere of environmental protection. Such a pioneering attitude toward climate change is a feature of the thinking of the citizens of these countries and an important contribution to the international debate in this regard[6]. Such attitudes are also reflected in the results of surveys on climate change issues, which are then translated

[6] K. Dośpiał-Borysiak et al., *Polityki klimatyczne Litwy, Łotwy i Estonii. Priorytet czy margines?*, Lublin 2020, pp. 35-41.

into the expectations of citizens on the directions of implemented activities (for example, greater support for the development of low-carbon modes of transport in the form of railroads). Consequently, about 74% of Finns believe that climate change and its consequences are the greatest challenges for humanity in the 21st century, while at the same time, about 68% believe that climate change is affecting their daily lives (9% less than the EU average)[7].

Finland's strategy toward a zero-carbon economy stems from the public's belief in the need to protect the environment and the impact of climate change on the country's economy as well as its living conditions. Meeting ambitious climate goals will require the use of new technologies and the development of those already in place. It is extremely important for Finland to act not only as a technology consumer but also as an exporter, which is to be served by a stable system that supports companies toward the development of zero-carbon technologies.

3. Key takeaways and challenges

The emission reduction target set by Finland is extremely ambitious (even more so than the one set by the EU), as is the implementation path for energy transition measures. However, the new government elected in 2023 may prioritize things differently. Climate change is discernible in Finland

[7] European Investment Bank, *70% of Finns in favour of stricter government measures imposing behavioural changes to address the climate emergency*, 3 November 2021, https://www.eib.org/en/press/all/2021-374-70-of-finns-in-favour-of-stricter-government-measures-imposing-behavioural-changes-to-address-the-climate-emergency [20.03.2023].

itself, which has an even greater impact on public perceptions of such threats.

To achieve its energy transition goals, Finland has defined specific steps and actions, the implementation of which will not only reduce the environmental impact on society but also strengthen energy security and resilience to the impact of external threats. However, specific tools in the form of nuclear power capacity expansion, construction of wind farms, promotion of energy efficiency, application of hydrogen, electrification of certain sectors, and the use of CCS/CCUS technologies may face their limitations. Thus, three key challenges to the development of Finland's energy system can be identified. Firstly, the electrification of the transportation industry; undoubtedly, the biggest challenge will be the process of moving away from fossil fuels, primarily in transportation. This goal is served by, among other things, a strategy related to the development of technologies used in car batteries[8]. The aim of this project is to promote investment in the battery sector and support domestic companies, given the need to play an important role in this area and to support the electrification of the country. This is so important that currently, the country's passenger car fleet is almost obsolete, with the average age of vehicles in this segment of 12.5 years against an average of 11.8 years for all EU countries[9]. In the coming years, taking into account the large support from citizens, one can anticipate an increase in the share of electric cars in the fleet of vehicles used in

[8] The Ministry of Economic Affairs and Employment, *National Battery Strategy 2025*, Helsinki 2021, p. 28.

[9] The European Automobile Manufacturers' Association, *Vehicles in Use Europe 2023*, p. 10, https://www.acea.auto/files/ACEA-report-vehicles-in-use-europe-2023.pdf [24.03.2023].

Finland. Secondly, the development of electricity grids; with the abandonment of fossil fuels, there will be a process of attaching new generating capacity to the electricity system, resulting from the construction of nuclear power plants and onshore and offshore wind farms. Thus, increasing the share of renewables will require, on the one hand, ensuring the reliability of the electricity supply system, but also, on the other hand, the availability of energy. An extremely important aspect will, therefore, be the expansion of the grid infrastructure. Thirdly, the involvement of energy companies in new technologies. Undoubtedly, Finland faces numerous challenges, including those of a technological nature. The construction of new nuclear units, including the SMR type, as well as investments in hydrogen and CCS/CCUS technologies present both financial and technological challenges. It will be important for many companies to obtain adequate support to enable investment in new technologies of the future. Importantly, gaining a technological edge should be done in cooperation with the government.

In addition to the aforementioned challenges arising directly from the process of changing the structure of electricity generation, and thus the ongoing process of energy transition, an important variable in the implemented measures will be ensuring energy security. A key area in this regard remains the natural gas sector, whose share in the economy will be significant at least in the short term. Thus, Finland advocates the implementation of three measures: first – expansion of import capacity to diversify sources of natural gas supply through the operation of the LNG market (this goal was served primarily by the construction of the

Inkoo LNG terminal jointly with Estonia)[10]. Second – greater integration of the Finnish and Baltic markets, of which the functioning Balticconnector pipeline is an important element. Third – as part of greater integration, a key task for Finland will be to increase storage capacity in the Baltic States (here, the goal will be to conclude bilateral agreements). Such holistic measures should ultimately lead to the construction of a common natural gas market, diversification of supplies, and increased energy security for Finland.

In conclusion, it should be pointed out that the ongoing energy transition and the further challenges it entails allow for three general conclusions. The first: Finland has set extremely ambitious environmental goals, not only as a result of the experience of the energy transition already underway but also of the public's approach to the issue. The economic growth that is still being observed, with increasingly better conditions for citizens, is a catalyst for these changes. However, a new approach may be introduced by the new government. The second: building a modern economy requires ambitious goals but also tools in the form of programs to support the efforts of companies as major emitters. Only greater cooperation of all participants – as is the case in Finland due to the pro-climate attitude of society – will allow the development of modern zero-emission technologies. Third: Finnish society recognizes the emerging opportunity for an even greater leap forward in civilization, which is why an important role is given to promoting technology

[10] M. Paszkowski, *Finlandia: nowe kierunki dostaw gazu ziemnego w dobie wojny rosyjsko-ukraińskiej*, "Komentarze IEŚ" 2022, no. 236(724), https://ies.lublin.pl/komentarze/finlandia-nowe-kierunki-dostaw-gazu-ziemnego-w-dobie-wojny-rosyjsko-ukrainskiej/ [14.03.2023].

export-oriented companies. The activities carried out are thus intended not only to lead to increased energy and climate security but also to support the economic development of the country as a whole.

Magdalena Zabieglik

Norway's dual role as a leader in energy transition and European pillar of energy security

1. Current energy market overview

Norway has a very unique energy system. The cornerstone of the country's economy and welfare is the petroleum industry, backed by significant natural resources of oil and gas. At the same time, Norway exports the vast majority of its fossil fuels production abroad and has highly electrified energy demand, sourced almost entirely from renewables, namely from hydropower.

Norway has the natural advantage of being an energy-rich country, with substantial resource potential embedded in the continental shelf. Over the last 50 years, the petroleum industry has been a key determinant of Norway's wealth, with an economy-wide impact on businesses and individuals. The oil and gas sector is the largest in Norway measured in terms of value added, government revenues,

investments, and export value[1]. It is also a foundation of the country's future wealth as only half of the estimated total resources have been produced since the first commercial discovery in Norway back in 1969. This implies there is still strong potential for oil and gas production from the Norwegian continental shelf, presumably for the next few decades. On the one hand, this positions Norway as a stable supplier of affordable energy, which has become particularly important after the Russian invasion of Ukraine, but on the other hand, it creates serious climate challenges related to high greenhouse gas (GHG) emissions from its petroleum sector.

Abundant oil and gas resources result in a significant energy surplus in Norway. The country's total energy production amounted to 208 million tonnes of oil equivalent (Mtoe) in 2020, which was seven times higher than the total energy supply. The vast majority of Norway's energy production (over 90%) consisted of oil and gas, with natural gas being the largest contributor at around 50%. However, as fossil fuels are mainly exported abroad, their contribution to the country's energy supply is relatively low and equals slightly over 50%. Norway's total energy supply is covered to the largest extent (44%) by hydropower, which is the highest share among IEA countries. A distinctive feature of Norway's energy system is its high electrification, with electricity covering almost half of the total final consumption, which is also the highest share among IEA countries[2].

[1] Norwegian Petroleum Directorate and the Ministry of Petroleum and Energy, *The Government's revenues*, 6 December 2022, https://www.norskpetroleum.no/en/economy/governments-revenues/ [29.03.2023].

[2] International Energy Agency, *Norway 2022: Energy Policy Review*, June 2022, https://www.iea.org/reports/norway-2022 [20.03.2023].

Also characteristic is that electricity generation comes almost entirely from renewables, primarily from hydropower. Norway is the largest producer of hydropower in Europe, and the sixth largest producer in the world[3]. In fact, the renewable-based electricity system constitutes the key pillar of Norway's sustainable transition.

It is worth noting the strategic role of Norway as an important global supplier of oil and gas. Although Norwegian oil and gas production corresponds to only a small fraction of global demand, the country is a significant player as an exporter of hydrocarbons, especially natural gas. As domestic consumption of this commodity is very limited, Norway exports almost its entire natural gas production (around 98%) to other countries and is the largest natural gas exporter in the world after Russia and Qatar. Over the past few years, Norwegian natural gas has been crucial to the European market, covering around 20-25% of the EU demand. Norway's strategic role has strengthened even further since the invasion by Russia of Ukraine and the abrupt disappearance of Russian natural gas from the European market. In fact, by the end of 2022, Norway became the largest single natural gas supplier to the EU[4]. Equally important is the country's role as a provider of renewable electricity to neighbouring countries. Norway is well-integrated with the Nordic power market, and further, through interconnectors, with the wider EU electricity markets. In 2020, Norway outpaced France

[3] Ministry of Petroleum and Energy of Norway, *The History of Norwegian Hydropower in 5 Minutes*, 20 July 2016, https://www.regjeringen.no/en/topics/energy/renewable-energy/the-history-of-norwegian-hydropower-in-5-minutes/id2346106/ [14.03.2023].

[4] Norwegian Petroleum Directorate, *The Shelf in 2022*, 18 January 2023, https://www.npd.no/en/facts/publications/reports/the-shelf/the-shelf-in-2022/ [18.03.2023].

and became the largest electricity exporter in Europe, with a net export value of 20.5 TWh[5]. A large production capacity and export potential for both natural gas and renewables prove the significant importance of Norway for the EU's energy security and market stability.

2. The country's strategy towards energy transition

Norway is very much committed to the energy transition process and undertakes comprehensive and cross-sectoral actions to limit its climate footprint. Although not an EU member, Norway cooperates closely with the EU through membership in the Agreement on the European Economic Area. This cooperation involves, among others, full alignment with the EU climate and energy policy. An important milestone was achieved in October 2019, when Norway entered into an agreement with the EU to take part in climate legislation for the years 2021-2030[6]. Norway also cooperates internationally to combat climate change by following the Paris Agreement so, both European and international cooperation provides a solid formal framework for Norwegian climate policy in the coming years.

Over the past few years, Norway has consistently delivered in increasing its ambition to reduce GHG emissions, expressed in its Nationally Determined Contribution (NDC). The first national climate action plan was officially approved by Norway in 2015 under the Intended NDC and assumed

[5] International Energy Agency, *Norway…*

[6] Official Journal of the European Union, *Decision of the EEA Joint Committee No 269/2019 of 25 October 2019*, 12 January 2023, https://www.efta.int/media/documents/legal-texts/eea/other-legal-documents/adopted-joint-committee-decisions/2019%20-%20English/269-2019.pdf [15.02.2023].

GHG emission reductions of at least 40% by 2030 (compared to the year 1990). INDC became Norway's first official NDC after the Paris Agreement ratification back in 2016. In 2020, Norway took up the challenge and was the third country in the world to announce a more ambitious climate target: the updated NDC assumed emission reduction by at least 50-55% by 2030. The second NDC update took place in November 2022, wherein Norway enhanced the target even further and committed to an emission reduction of at least 55% by 2030[7]. The enhanced NDC proves the country's full commitment to combating climate change.

Norway's energy policy is best outlined in the Climate Action Plan 2021-2030, published in January 2021, with its supplementary white papers and amendments[8]. The action plan is comprehensive, economy-wide, and covers all sectors and industries as well as aspects of the everyday life of local communities and individuals. Great emphasis is placed on the balance between climate goals and social welfare. Norway believes that the reduction of GHG emissions should go hand in hand with access to sustainable and affordable energy, increased economic prosperity and, in a more general sense, better quality of life. In a nutshell, the climate action plan in Norway is not regarded as a stand-alone directive, rather it is seen as best practices and advancements to be implemented across the whole economy. The plan introduces

7 United Nations Climate Change, *Update of Norway's Nationally Determined Contribution,* November 2022, https://unfccc.int/sites/default/files/NDC/2022-11/NDC%20Norway_second%20update.pdf [16.02.2023].

8 Ministry of Climate and Environment of Norway, *Norway's Climate Action Plan for 2021-2030*, https://www.regjeringen.no/en/dokumenter/meld.-st.-13-20202021/id2827405/ [22.03.2023].

a full range of policy instruments, with few distinctive features, characteristic of Norwegian strategy towards energy transition.

One of the cornerstones of Norway's climate energy policy is its taxation system, designed to discourage GHG emissions and favour environmentally friendly solutions. Norway sticks to the "polluter-pays" principle and was one of the first countries in the world to introduce a carbon tax back in 1991. The tax burden for polluting entities is elevated year by year, with government plans to more than triple the carbon tax up to NOK 2,000 (around EUR 200) per ton of emitted CO2 equivalent by 2030. At the same, Norway has introduced many fiscal incentives to choose low or zero-emission solutions. The most notable example is the transportation sector, with numerous incentives related to electric vehicles (EVs) such as exemption from the registration tax and VAT, and material reductions in road taxes.

Special consideration in Norway's energy strategy is given to the oil and gas sector, with three main pillars including electrification of offshore installations, development of offshore wind power, and maturing of carbon capture and storage (CCS) technology. The electrification process is, in principle, a focal point of the country's energy transition. Access to hydropower has already enabled Norway to make tremendous progress in the electrification of buildings and businesses. The current focus is on the oil and gas industry, with electrification of offshore platforms being the key point on the agenda. Numerous offshore drilling fields are already getting power from onshore and more are underway, as the government requires oil and gas companies to include solutions supporting the reduction of GHG emissions when

planning field developments. To facilitate the process, Norway is looking for additional sources of renewables, with great potential embedded in offshore wind farms. The state-owned company Equinor is currently building a floating offshore wind farm, Hywind Tampen, which is the largest project of this kind in the world, with a system capacity of 88 MW and the potential to commercialize floating wind technology globally[9]. Last but not least, an important pillar of the country's climate policy is to develop full-scale CCS projects. According to the Intergovernmental Panel on Climate Change (IPCC), CCS technology will be essential in the energy transition process as it could allow for meeting the targets at the lowest possible cost[10]. Norway is fully in line with this philosophy and already has a world-leading position in this area, progressing alongside its Longship project. It comprises two full-scale capture facilities and one storage facility in the North Sea and its total cost is estimated at around NOK 27 billion (around EUR 2.4 billion)[11].

An integral part of Norway's energy strategy, binding all of the above policy instruments, is a strong focus on R&D. The government is providing financial support and public funding for education, research, and development of new technologies as well as early market introduction

[9] For more information see: Norwegian Petroleum Directorate, *The Shelf in 2022*, https://www.npd.no/globalassets/1-npd/publikasjoner/sokkelaret/sokkelaret-2022/the-shelf-2022.pdf [19.03.2023].

[10] Intergovernmental Panel on Climate Change, *Special Report on Carbon Dioxide Capture and Storage*, https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf [15.03.2023].

[11] For more information see: Norway's Ministry of Petroleum and Energy, *Questions and answers about the Longship project*, 10 October 2021, https://www.regjeringen.no/en/topics/energy/landingssider/ny-side/sporsmal-og-svar-om-langskip-prosjektet/id2863902/ [10.03.2023].

of solutions addressing climate actions. The main funding agency in Norway is the state-owned entity Enova, which has been given a very clear climate profile and a mandate to focus on GHG emission reduction projects. In the last decade, Norway's annual budget for energy R&D projects amounted on average to USD 380 million (around 0.1% of the country's GDP), which was the highest share among IEA countries[12]. A strong focus on technological innovation might be one of the key success factors in achieving climate goals not only in Norway but also globally.

3. Key takeaways and challenges

As an energy-rich country, Norway has a natural advantage and a unique starting position to become a climate-neutral society. In many areas, Norway is leading the transition and can be seen as an example of impressive cross-sectoral achievements, exceptionally high climate awareness, and an effective regulatory framework. The most notable example is the country's renewables-based electricity system, with still massive potential for further electrification. Another example is the progress made in electric vehicles (EVs). Norway already reports the highest share of EVs per capita in the world, with an expected upward trend, as the majority of all new cars sold in the country are electric (c. 54% in the year 2020)[13].

However, despite this great effort and all the achievements to date, there is still a long way ahead for Norway. To

[12] International Energy Agency, *Norway…*

[13] Norway's Ministry of Transport, *Norway is electric*, 22 June 2021, https://www.regjeringen.no/en/topics/transport-and-communications/veg/faktaartikler-vei-og-ts/norway-is-electric/id2677481/ [10.03.2023].

illustrate the challenge, it is worth looking at the current emission levels and progress made so far; the level of GHG emissions in Norway amounted to 48.9 million tonnes of CO2 equivalents in 2021, which is a 4.7% decline from 1990[14]. The 2030 target assumes a reduction of as much as 55%, which implies an emission level of only 23 million tonnes CO2 eq. in 7 years from now. It seems that most of the so-called "easy wins" have already materialized and further reductions will be more challenging, costly, and time-consuming. In this context, the achievements to date seem relatively modest and there is a need for intensified efforts across the whole economy to close the gap.

The biggest challenge is represented by the oil and gas sector, which is the cornerstone of the country's economy on the one hand but on the other hand, is one of the biggest polluters, responsible for around a quarter of total GHG emissions in Norway. In order to make the transformation real, the government's ambition is to electrify a significant portion of offshore installations. The electrification process, perceived as a pillar of green transition in Norway, at the same represents time a major challenge for the domestic electricity system. Offshore electrification projects will rely mainly on land-based hydropower resources. As the electrification process proceeds, there will be growing demand for electricity and presumably increasing pressure on the system. This could potentially be a source of conflicts of interest, as increased electrification offshore carries a risk of electricity deficits onshore, and thus increased prices for

[14] Statistics Norway, *Emissions to air*, 3 November 2022, https://www.ssb.no/en/natur-og-miljo/forurensning-og-klima/statistikk/utslipp-til-luft [19.03.2023].

consumers. Another major challenge related to the electrification process is the increase in demand for critical minerals like cobalt, lithium, nickel, manganese, and certain rare earth minerals. To combat these challenges, the government undertakes comprehensive measures to support the domestic electricity system as well as to secure access to critical minerals, including developing offshore wind power, expanding the national power grid, and initiating mineral activities on the continental shelf.

On top of country-specific challenges, Norway's climate policy is significantly influenced by the Russian invasion of Ukraine. The war is shaping the country's energy transition in many ways, adding a lot of uncertainty to the process and prioritizing energy security goals. Cutting-off Russian natural gas supplies to EU markets has caused all eyes to turn to Norway, which has proved itself to be a reliable supplier of energy to Europe. During the crisis year of 2022, Norway managed to increase its production of natural gas and became the largest single natural gas supplier to Europe. As the war continues, energy security remains one of the biggest priorities for the EU. The upstream sector in Norway is viewed more favourably as being capable of delivering stable and affordable energy. Reliance on the oil and gas sector, being one of the major polluters in Norway, might remain in conflict with the country's ability to reduce emissions. This may be evident particularly in the short and mid-term perspectives until a new redefined energy mix is established. However, it does not undermine the possibility to reach the ultimate goal of net zero emissions by 2050. In fact, the war and resulting energy crisis might be a catalyst for more structural changes. We could see a convergence pathway in

the long term, where energy security becomes more aligned with climate goals. The EU is now more than ever driven by the desire to become energy independent. Ultimately, decarbonisation might be the answer for EU energy security. From this perspective, Norway, with its close links to the EU, could play a strategic dual role, both as a leader in the green transition process and as a stable supplier of clean, affordable energy to Europe.

Maciej Mróz

The Visegrad Group Countries' road to energy transition: current and future perspective

1. Current energy market overview

The Visegrad Group[1] is an informal means of cooperation between four countries from Central Europe, i.e., Poland, Czechia, Slovakia, and Hungary. The V4 countries are characterized by similar geographical conditions as well as common history and traditions, and similar genesis of shaping their economies. The common historical legacy can also be seen in the current shape of the energy sector of each of the V4 countries, which has been strongly based on fossil fuels obtained from Russia.

In the case of the V4 countries, the total consumption of fossil fuels (crude oil, natural gas, and coal) is at the level

[1] Further: V4.

of 92%, 78%, 76%, and 69%[2] of the share in the energy mix of Poland, Hungary, Czechia, and Slovakia, respectively[3]. However, in the use of solid fuels, i.e., hard coal and lignite, Poland remains the clear leader among the V4 countries, where coal still plays a dominant role in the production of heat and electricity, accounting for as much as 42% of the structure of energy consumption at the end of 2021 (coal comes from both domestic deposits and imports from Kazakhstan, South Africa, Russia[4], Colombia, USA, Indonesia, and Australia). In the case of the remaining V4 countries, Czechia is also characterized by relatively high coal consumption (34% of the energy mix), while in Slovakia and Hungary, energy from coal accounts for 15% and only 6% of the total energy consumption structure, respectively.

In the case of natural gas, large consumption is also visible in the V4 countries. For example, in Hungary, natural gas still dominates (electricity and heat) with a share of 38% of the energy mix (10.8 billion m^3/year). A significant share of natural gas in the energy mix also exists in Slovakia (27%), which, similarly to Hungary, sourced this fuel from Russia: 85% of supplies via Ukraine and 15% of imports from Czechia (but this is still natural gas sourced from Russia). In the case of Poland and Czechia, natural gas is also recognized as a transitional fuel for reducing CO2 emissions and meeting climate requirements as a certain alternative to

[2] BP, *Statistical Review of World Energy 2022*, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html [15.03.2023].

[3] Due to the different economic potential of the economies of the V4 countries (i.e., structure and size of GDP, population, area), it was decided to analyse the changes in the energy mix structure in percentages rather than nominal terms.

[4] Since the 2022 embargo.

coal, and consequently natural gas accounts for 19% of the energy mix of both these countries. However, in Poland, unlike Czechia, a significant increase in natural gas consumption has been recorded recently, from 16.5 billion m^3/year in 2011 to 23.2 billion m^3/year in 2021, while in Czechia this share remained relatively stable during this period (from 2011-2021, annual consumption ranged from 7.2 to 9.1 billion m^3/year).

On the other hand, in the case of crude oil consumption in the V4 countries, Hungary and Poland were characterized by significant consumption, where, in the years 2011-2021, the use of this commodity grew at the rate of 2.1% and 2% annually, finally constituting as much as 34% and 31% of the energy mix of these countries in 2021. In the case of Czechia and Slovakia, this share is lower, i.e., 24% and 25% of the energy mix, respectively (Table 1).

Renewables and energy from nuclear power plants are an alternative to fossil fuels. Hence, these sources of energy have been growing systematically in V4 countries recently. For example, energy production in hydro and nuclear power plants is the highest among the V4 countries in Slovakia, respectively 6% and 20% of the energy mix, and in the case of other renewable sources in Hungary – 8%. However, in the coming years, greater interest in the development of these energy sources can be expected due to the common EU climate and energy policy as well as due to the recent dynamics of geopolitical events initiated by the war in Ukraine. Nevertheless, these changes will probably be evolutionary rather than revolutionary, as the construction of stable energy potential primarily includes projects with a long implementation period, for example, the transformation of the

Table 1. Structure of the energy mix of the V4 countries in 2021

	2021						
	Oil	**Natural gas**	**Coal**	**Nuclear energy**	**Hydro-electric**	**Renewables**	**Total**
Czechia	0.41	0.33	0.54	0.28	0.02	0.1	1.68
	24%	19%	32%	17%	1%	6%	100%
Poland	1.38	0.84	1.88	-	0.02	0.32	4.44
	31%	19%	42%	0%	0%	7%	100%
Hungary	0.34	0.39	0.06	0.14	^	0.08	1.02
	34%	38%	6%	14%	0%	8%	100%
Slovakia	0.18	0.19	0.12	0.14	0.04	0.04	0.71
	25%	27%	17%	20%	6%	5%	100%
	2011						
	Oil	**Natural gas**	**Coal**	**Nuclear energy**	**Hydro-electric**	**Renewables**	**Total**
Czechia	0.39	0.29	0.77	0.27	0.02	0.07	1.81
	22%	16%	43%	15%	1%	4%	100%
Poland	1.16	0.63	2.3	-	0.02	0.15	4.26
	27%	15%	54%	0%	0%	4%	100%
Hungary	0.28	0.39	0.11	0.15	-	0.03	0.96
	29%	41%	11%	16%	0%	3%	100%
Slovakia	0.11	0.19	0.06	0.15	0.04	0.02	0.57
	19%	33%	11%	26%	7%	4%	100%

Source: Own study based on BP Statistical Review of World Energy 2022.

power system, expansion of connection networks at the local level, and finally the construction of nuclear power plants (estimated average period of construction of nuclear units is approx. 10 years). On the other hand, in the short term, Russia's act of aggression against Ukraine is a strong stimulus and contributes to the active search for alternatives to natural gas, crude oil, and coal imports from Russia, and to a clear reduction of that country's political and economic influence in the European space[5].

2. The country's strategy towards energy transition

The current pace of energy transformation in the V4 countries is dictated, on the one hand, by the EU's climate and energy policy, and, on the other hand, by the dynamics of geopolitical changes, including the war in Ukraine. The armed attack of the Russian Federation on Ukraine exposed not only the level of dependence of European countries on supplies of commodities from Russia but also pointed to the importance of geographical location, the degree of development of energy infrastructure, and the role of hydrocarbons in the economies of individual countries.

While the climate and energy policy of the European Union has become the leading trend in determining green energy transformation in recent years, the events of the war have forced the intensification of this transformation process. Currently, each of the V4 countries individually (but

[5] An example of a political and economic doctrine based on the construction of strong import dependencies in the context of hydrocarbons is the Falin-Kwiciński doctrine formulated back in 1989, according to which, the dependency architecture was to result from the "geopolitics of pipelines" replacing the existing military influence in order to achieve political benefits.

also collectively, as the Visegrad Group) is trying to gradually develop strategies and look for solutions that can improve their national and regional energy security and minimize the negative aspects of "international interdependence", while being increasingly more climate neutral. An example of efforts in this area is the further development of the natural gas infrastructure in the region (this commodity is still a transitional fuel) and Poland's efforts to create a regional gas transmission and trading centre (the so-called gas hub) for the countries of Central and Eastern Europe and the Baltic States. What is important is that, among the V4 countries, Czechia and Slovakia have expressed deep interest in this project. This undertaking requires, above all, significant investments in the area of already implemented projects, for example, the Baltic Pipe pipeline, further expansion of the LNG terminal in Świnoujście as well as the construction of new ones, i.e., FSRU in the Gdańsk Bay area, along with connections with neighbouring countries. It seems that, if the V4 countries coordinate their policy toward the region, they may be able to generate synergy, and this could also trigger greater political cooperation between V4 countries and the other EU countries, as long as their leaders are able to acknowledge their partners' interests and find a suitable compromise.

As far as natural gas supplies are concerned, Hungary's high dependence on this fuel made it necessary to look for alternatives to supplies from Russia, which is reflected in the commencement of talks on potential supplies of natural gas from Oman and Qatar, and interest in the expansion of the LNG terminal on the island of Krk in Croatia (import capacity is 2.9 billion m^3 per year, but in 2024-2025 it is expected to

increase to 6.1 billion m^3 per year). In addition, cooperation with Azerbaijan remains an important solution that can ensure greater diversification and, at the same time, guarantee supplies. At present, natural gas supplies can be carried out via the BRUA gas pipeline and the Csanádpalota point. However, in this case, the development of transmission capacity (an element of the expansion of the BRUA project) will be of key importance as well as the launch of new deposits in Azerbaijan to meet the energy challenges.

Additionally, the renaissance of nuclear energy is also a main direction of change for V4 countries. Poland has decided to return to the construction of a nuclear power plant, which had been postponed for years, something that is also reflected in the inclusion of this investment in the "Energy Policy of Poland until 2040" (Direction 5). It is true that the construction of this type of power plant was already the subject of heated discussions and investments in the 1980s (power plants in Żarnowiec and Warta locations), but this project was finally abandoned. In light of the current conditions, the implementation of nuclear energy seems to be highly justified again, as nuclear units are reliable sources of energy, stabilizing production capacity with zero air pollution emissions. Therefore, the development of nuclear energy is intended to contribute to the implementation of commitments in the field of climate and energy policy by reducing the scale of emission of dust and gas pollutants from the energy sector (both CO2 and others such as NOX and SOX) as well as to increase the scope of diversification of the directions of supply of primary energy carriers while generating energy at low cost. According to the schedule, the commissioning of the first unit (with a capacity of

1-1.6 GW) in the first nuclear power plant is scheduled for 2033, while according to the assumptions, in the following years, it is planned to commission another five such units at intervals of 2-3 years.

Further development of nuclear energy programs is also expected in both Czechia and Slovakia. Six nuclear reactors with a total capacity of 4 GW are currently operating in Czechia, producing about 1/3 of the electricity needed. In turn, in Slovakia, energy from nuclear units accounts for 52.3% of the total demand for electricity, and this energy is generated in four power plants (while two more power plants of this type are planned to be commissioned). By contrast, progress on the expansion of Hungary's Paks 2 plant is less clear given that Russia has been contracted to lead this project.

Finally, all the V4 countries are interested in further development of other renewables including wind, geothermal, solar, biomass, and waste. For example, there is record high development of solar power in Poland, while biomass is considered by the Slovak authorities to have an important position in decreasing its dependency on natural gas supplies from abroad. Nevertheless, part of these sources is characterized by production instability and their productivity results directly from natural conditions, so their potential is currently limited. Therefore, a further direction of changes can be expected in the development of nuclear energy as the basic source of electricity, rather than the renewables mentioned above. However, diversification of sources seems to be highly important as well. Additionally, the process of building nuclear energy facilities is more time-consuming.

3. Key takeaways and challenges

The trajectory of the energy transformation of the V4 countries is clearly outlined. On the one hand, these countries face the need to converge their economies and power systems in accordance with the common EU climate and energy policy. On the other hand, in light of the war in Ukraine, the need for change is determined by the limited supply of energy resources from Russia. Therefore, the actions of the V4 countries can be considered in both the short and long term.

In the short term, stable energy supplies to the economy at an acceptable price are necessary. The remedy for the energy security of the V4 countries understood in this way is greater diversification of sources and directions of supply of key energy resources, which increases the real stability of their imports, while at the same time allowing for the introduction of a market mechanism and thus improving the economic calculation of imports (reducing the monopolistic position of the supplier). Therefore, the diversification of supplies seems to be also a certain remedy to limit fluctuations in fossil fuel prices, although these possibilities depend directly on a properly developed infrastructural base (oil and gas infrastructure). The V4 countries are still struggling with their own historical legacy, however, and in the face of current geopolitical events, they are making efforts to improve their own energy situation. Hence, the opportunity to change this situation is the use of the potential resulting from access to the Baltic Sea, which provides the possibility of full diversification of sources of origin natural gas (Poland's gas hub). What is important for three of the V4 – Czechia, Hungary, and Slovakia – is that the fall

in deliveries via Russian pipelines has created significant problems. At the start of 2022, all three were dependent on Russian flows for virtually 100% of their natural gas consumption. Thus, it seems that the unanimity and cooperation of the V4 countries is crucial in this regard.

Additionally, in the coming years, an increase in the level of energy self-sufficiency of the V4 countries can also be expected. Thus, the activity towards both the development of domestic deposits of energy resources and the increased use of technologies supporting the development of a low-emission economy should be increased. Key in this regard will be financial incentives and the flow of capital, enabling technological development and the implementation of capital-intensive investment projects. However, this crisis is making green solutions cost-effective, hence these things are accelerating now.

In the longer term, climate challenges and supply disruptions combined with the global dynamics of crude oil, natural gas, and coal price volatility should be highly disciplining for the V4 countries and stimulate a two-wave process of change. Therefore, a significant departure from traditional fossil fuels is assumed in favour of alternative sources such as renewables or nuclear energy. This trend is noticeable through the prism of individual investment projects such as the development of nuclear energy in Poland, the Czech Republic, and Slovakia. However, it is essential to remember that these investments require significant capital outlays and extended implementation time, hence the sources of financing and EU support are extremely important.

Additionally, it is expected that energy transition and the resulting increase in energy savings, combined with

higher rates of renewables utilisation will positively contribute to the increase of energy efficiency in the V4 countries. The on-going effort to decrease energy consumption in all sectors of the economy combined with the increase of renewables production in both countries paves the way for a gradual decrease of fossil fuels utilisation for electricity generation. Moreover, the recent high price of fossil fuels and electricity intensifies this effort, as traditional power plants cannot currently provide more economically feasible solutions (especially if we add the EU ETS mechanism and rising prices of CO_2 emission allowances).

In conclusion, none of the V4 countries have been leaders in developing new technologies or policies connected to energy transition in the EU. Their position when it comes to energy transformation has been rather passive, with a dominant interest in energy security issues so far. However, due to the war and serious threat to energy security, this situation might change.

Eugenia Gusilov

Romania's approach to energy transition: too little, too slow

1. Current energy market overview

Romania's energy balance for 2022 shows a contraction of 4.5 TWh (7.7%) of domestic electricity consumption during the year (53.9 TWh) compared to 2021 (58.4 TWh). It also shows an increase of both electricity imports (7 TWh in 2022 vs 6 TWh in 2021) as well as exports (up by 2 TWh in 2022). Physical imports of electricity increased most from Bulgaria (by 1,322 GWh, totalling 3,652 GWh – the highest from all neighbours) while exports increased substantially to Moldova (+2,051 GWh from zero the previous year) and to Serbia (+589 GWh reaching 1,968 GWh in 2022)[1]. Romania had the good fortune to inherit a rather diversified energy mix from the communist regime. This positive start made

[1] Transelectrica, *Preliminary report for January-December 2022*, https://www.transelectrica.ro/documents/10179/14908582/Raport_Preliminar_ASF_2022.pdf/97ed373e-983a-4976-822e-24115d1c3b6e [25.04.2023].

Romania rather complacent during the three decades that followed, with very little in terms of greenfield investments in energy infrastructure (with a few notable exceptions).

Table 1. Generation capacity (net, by source, 2023, in MW)

Nuclear	**1,300**
Fossil hard coal	176
Wind onshore	2,957
Fossil brown coal/lignite	2,497
Hydro run-of-river and poundage	2,780
Hydro water reservoir	3,356
Solar	1,185
Fossil gas	1,988
Biomass	118
Total capacity	16,357

Source: ENTSO-E.

Two snapshots of electricity production, taken at a distance of exactly one week between them (the first on 11 April and the second on 18 April 2023), show that the predominant electricity source is now hydro (33-47%). It also shows two different consumption profiles – one for a normal week day (on 11 April, when 9,051 MW were used) versus the second one which is for a holiday (on 18 April, last day of the Orthodox Easter vacation, only 6,560 MW were used) – a difference of 28%. When it's windy, wind farms can account for almost 30% of electricity production (on 11 April), but when the wind doesn't blow, its contribution can fall by an order of magnitude (to as low as 3%, data for 18 April). Nuclear has a steady contribution in the range of 1.3-1.4 GW while coal

contributes about 1 GW (the rest of the coal-fired capacity was retired or put in "conservation").

For all intents and purposes, by now, Romania should have been an energy-sufficient country, since it does have all the premises to be autonomous in energy, i.e., good hydro reserves (6,645 MW installed hydro capacity, 3 GW of onshore wind capacity, 1.4 GW installed solar capacity – data for 2021), good prospects in gas production (new natural gas discoveries both offshore and onshore), an existing nuclear power plant (1,400 MW installed capacity) with plans to add two more nuclear reactors and build a first-of-a-kind power plant based on SMR technology (at Doiceşti). There are at least two key reasons which explain Romania's failure so far to achieve full energy independence and become an energy security provider in the region.

First, an inability to monetize Romania's advantages in the energy sector. The Black Sea natural gas discovery made in 2012 is not put into production to this day, 11 years later. Although, it looks like the two companies involved (OMV Petrom and Romgaz) are preparing to take the FID this year. Another example concerns unit 3 and 4 of Cernavodã NPP and the inability to move the project forward since 2007, so a 16-year delay. The format already changed twice; first, there was an SPV with several companies as shareholders, but the Romanian state insisted on having a majority stake, then the 2008 crisis hit and investors lost interest. The second attempt was to revive the project through cooperation with China. This dragged for 7 years (2013-2020), until cooperation with the Chinese regarding nuclear was officially

buried[2]. Now, at the third attempt, the plan is to do the project with Western (American) funding. This shows how slow Romania is in acting in its own interest, especially in the case of big, strategic projects.

Second, a pervasive nationalistic mindset in energy policy & policymakers circles: instead of embracing free market thinking upon its accession into the EU (in 2007), Romania has very often pursued a different course. Time and again, Romania said one thing in Brussels (i.e.: agreed to measures and reforms) and did another thing at home (i.e.: deliberately putting brakes on market liberalization processes (that were delayed, postponed, contested internally at almost every step since 2012). The market liberalization process which started in 2007 can be described in retrospect as "one step forward, two steps back". Finally, it was completed in July 2020 (full market liberalization for natural gas – which was the last sector to achieve it).

Fast forward to the energy crisis (Autumn 2021 & 2022) and the knee-jerk reaction of the Romanian government was to re-regulate the market in response to the price hikes occurring in the "free" market. So, the free market miracle did not last long, as the Romanian government has enacted a set of protection measures that effectively re-regulated the market until the end of March 2025.

Now, the majority of Romanian consumers live under a glass dome (regulated prices, for virtually all consumers)

[2] Bucharest Stock Exchange, *Nuclearelectrica report to the Bucharest Stock Exchange on the decision to cease all negotiations with China General Nuclear Power Corporation (CGN), Resolution number 8/12.06.2020 of the Extraordinary General Meeting of Shareholders of Nuclearelectrica*, 12 June 2020, https://www.bvb.ro/infocont/infocont20/SNN_20200612165319_SNN-12-06-2020--resolution.pdf [27.04.2023].

until the end of March 2025. So, one can conclude that price liberalization had a short life in Romania. At the first signs of trouble (especially, under the exceptional circumstances of 2022), the Romanian authorities reverted to what they know best – subsidized prices and market regulation. The European Commission allowed it on account of extraordinary market circumstances, essentially giving a free pass to member states to deal as they see fit to in order to best protect the consumers. Against the backdrop of far more generous energy subsidies granted by European countries with deeper pockets (Germany's EUR 200 billion "energy shield"[3], UK's GBP 150 billion[4], or France's EUR 75 billion[5]), Romania's subsidies and brutal market intervention do not seem so shocking any more.

2. The country's strategy towards energy transition

Romania's road to energy transition is thorny. The government does not want to commit to overly ambitious green targets, for fear of penalties in case of failure to achieve them. So, if one looks at current energy policy documents, the level of ambition is quite modest. However, Romania's National Energy and Climate Plan (NECP) is up for review this year, which means we shall most likely see an update of

[3] German Federal Government, *Relief for electricity and gas prices: 200 billion euros for economic protective shield*, 29 September 2022, https://www.bundesregierung.de/breg-en/news/protective-shield-2131014# [22.03.2023].

[4] A. Cooban, *The UK is preparing a huge energy bailout that could cost $172 billion*, 7 September 2022, https://edition.cnn.com/2022/09/07/energy/uk-energy-crisis-liz-truss/ [18.04.2023].

[5] M. Goar, *France claims it's doing the best job in Europe to protect citizens from energy crisis*, 16 September 2022, https://www.lemonde.fr/en/politics/article/2022/09/16/france-claims-it-s-doing-best-job-in-europe-to-protect-its-citizens-from-energy-crisis_5997104_5.html [20.04.2023].

national targets and objectives in line with the *Fit for 55* and *REPowerEU* packages, which will translate into an accelerated energy transition. The tools that the country intends to use in this process are coal phase-out, hydrogen phase-in, renewables scale-up, and nuclear.

Coal phase-out

Romania was a late adopter of coal phase-out, with serious steps towards abandoning coal in power generation only taken in 2021, at the very last minute, when Complexul Energetic Oltenia (the main coal mining and coal-fired power producer) was facing bankruptcy and the Romanian state was prevented by EU state-aid legislation to come to the rescue of the company, as it has done so many times in the previous three decades. The final aid package (EUR 251 million loan) was approved in 2020 on condition that the company adopts a decarbonization plan and closes down its remaining coal-fired power generation assets (a shut-down calendar was agreed and the government even committed to make this into law – the Law on decarbonization of 2022). This is one of the most significant developments in power generation in this decade. Initially entirely coal-based (all 3,240 MW), Complexul Energetic Oltenia (CEO) is to reduce its coal-fired generation to 1,980 MW by 2025 and add 1,400 MW of natural gas capacity and 300 MW of solar capacity by 2030 – a decarbonization of 54% of its generation assets in just 10 years. The bulk of the current coal capacity will be replaced by natural gas and renewables (solar PV). The company's initial plans were to build PV parks totalling 300 MW at Rovinari, Turceni, and Isalnita. In 2022, however, the company received funding for 8 PV parks (735 MW) from the Modernization Fund.

Hydrogen phase-in

In Romania (as elsewhere in Europe), hydrogen has so far been used exclusively in industry, mainly as feedstock in oil refining and fertilizer manufacturing. Romania produced and consumed 223,000 tonnes in 2020 (Fuel Cells & Hydrogen Observatory), all of it grey hydrogen (without carbon capture). Romania's annual production of hydrogen is in the range of 200,000-230,000 tonnes. However, despite having a tradition in hydrogen production and use, Romania did not hurry to embrace the more modern hydrogen utilization options (in transport, heat and power generation, or as storage for electricity). Regionally, Romania is the last country to be drafting a hydrogen strategy (Poland, Hungary, Czechia, Slovakia, Croatia, even Ukraine – all have adopted National Hydrogen Strategies ahead of Romania, which started drafting such a document only in late 2022, and then only because it is a requirement under the National Recovery and Resilience Plan, NRRP). Romania's interest in green hydrogen is driven by EU energy policy. It was Brussels' suggestion, not Bucharest's desire, to include funding for new green hydrogen production capacities in Romania's NRRP, i.e., building at least 100 MW green hydrogen electrolysers that would produce at least 10,000 tonnes of hydrogen / year from renewable sources. As a country with unsolved development issues, Romania will most likely choose a moderate speed for deploying clean hydrogen. As an oil and gas producer, Romania is poised to be interested in blue hydrogen production (from natural gas with carbon capture). As a country with nuclear energy, Romania is likely to have an interest in pink hydrogen (using electricity produced from nuclear). Green hydrogen production will be driven exclusively

by available European funding and the industry's interest for decarbonization projects. In terms of new uses for hydrogen, Romania cannot scatter its attention and efforts on all possible uses. So, it has chosen industry and transport as priority fields for green hydrogen application. The details of this vision (framework, numbers, targets) will be publicly available once the draft Hydrogen Strategy is put into public consultation later this year. One thing is clear, however, although a latecomer to the party, Romania's bad timing might actually work in its favour this time since it can benefit from the extra knowledge of countries that have already gone through this policy planning exercise.

Renewables scale-up

Romania added some 5 GW of new renewable capacity at a cost of EUR 8 billion between 2011-2020. Under its current NECP, Romania aims to install an additional 6.9 GW of new RES capacity to achieve a target of 30.7% for renewables in final energy consumption by 2030. This target includes onshore wind and solar, but no offshore renewables projects. The EU responded to Russia's aggression in 2022 with a multidimensional package which doubles down on the transition to clean energy. Therefore, it is quite possible that the review of Romania's NECP (due to take place in 2023) will bring at least a doubling of the new renewable capacity: 14 GW of new renewables installed by 2030 in lieu of the current 6.9 GW target. At the moment, Romania's wind capacity is situated exclusively onshore. However, the Black Sea is considered to hold significant potential for offshore wind. According to the World Bank, the offshore wind potential in the Romanian Black Sea segment is 76 GW, of which

22 GW is for fixed turbines and 54 GW for floating turbines[6]. State-owned hydro producer Hidroelectrica announced in 2020 that it plans to build 300-500 MW of offshore wind projects. However, Russia's subsequent hot war against Ukraine made the Black Sea (an area with active military operations) unattractive for the moment. When it comes to renewables, Romania has a huge pre-existent advantage in this market, where hydro is king (largest installed capacity with 6.4 GW). This advantage in hydro capacities pre-dates the European push for renewables and the 2008 Renewable Energy Directive. As of now, hydro power accounts for 30% (17 TWh) of electricity produced in Romania[7], making hydro the largest contributor in the energy mix. It is worth mentioning that wherever the decision is up to the Romanian state, the funding available is tailored in such a way as to benefit primarily the state-owned companies. The state is a significant player (80% of the energy sector) and whenever it has decision making power, it channels most of the funding to its own companies to the detriment of the private companies. Thus, a key feature of Romania's energy transition is that there is almost no level playing field and more discretionary allocation of capital that favours SOEs, especially in state-run funding programs. By comparison, Romania has been less preoccupied with improving the lot of the smaller consumer. Romania's default policy is to subsidize the energy price instead of making micro-investments

6 World Bank, *Offshore Wind Technical Potential in Romania*, March 2020, https://documents1.worldbank.org/curated/en/141221587050442759/pdf/Technical-Potential-for-Offshore-Wind-in-Romania-Map.pdf [15.03.2023].

7 Hidroelectrica, *Annual Report for 2021*, p. 36, https://cdn.hidroelectrica.ro/cdn/rapoarte_anuale/Raport_Anual_2021_ro.pdf [15.03.2023].

and encouraging self-production. From the beginning (in 2008), renewable deployment in Romania was focused on utility-scale projects (both wind and solar), with almost no attention to residential use (i.e., rooftop solar deployment). The prosumers are a recent phenomenon in Romania; at the start of 2020, the country had only 271 prosumers. However, Romania ended the year 2022 with 40,000 prosumers (423 MW installed), of which half (20,000) were added between August and December 2022. The overwhelming majority of prosumers (99%) opt for solar panels and 96% are individuals, not companies. In fact, these 423 MW represent the only new addition to Romania's renewable installed capacity so far.

3. Key takeaways and challenges

Potential challenges associated with the energy transition process include the deterioration of state-owned companies' ability to manage and see complex projects over the finish line. Romanians have been complacent during the last 3 post-communist decades, as they have enjoyed the fruits of the energy supply diversification efforts of the communist regime. The current Romanian government apparatus and the politically appointed management of state-owned enterprises (SOEs) have proven to fall short of their communist predecessors in terms of project management ability for large infrastructure projects. State-owned energy companies resist reform and modernization efforts and prefer to live on government bail-outs for as long as they can. Only when it was no longer an option (as a result of EU state-aid rules limiting how much a government can keep loss-making enterprises on life-support), did the Romanian

government start restructuring, or SOEs (for example, Complexul Energetic Oltenia, the largest coal-fired electricity producer) start thinking seriously about "energy transition".

State-owned companies (SOEs) have made few large investments in energy in the past 20 years, SOEs have largely missed the renewable window of 2008-2016 and are interested in renewables only now, when the EU is pressing Romania hard to "green up" its infrastructure. It is puzzling that with 80% of the energy sector in Romania being state-owned, in the past three decades, the most important investments in energy infrastructure were not made by SOEs, but private companies (mostly in renewables). The only new gas-fired power plant built in Romania is OMV Petrom's 860 MW CCGT at Brazi, put into operation in 2012, which remains to date the largest greenfield investment in the country. State-owned Romgaz has been trying to finish a new CCGT at Iernut (430 MW) without success since 2013. Romgaz's Iernut project (at half the capacity of OMV's Brazi CCGT) should have been ready in 2020, yet we are in 2023, and the date for completion has been pushed to 2024. This tells us that the Romanian state has lost its knowledge of project management/implementation for large infrastructure projects. And it proves difficult for state-owned companies to get back in the saddle (building big infrastructure projects), after such a long pause.

Another challenge comes from the experience of the past two years which shows that liberalization can be rolled back (market re-regulation in extraordinary circumstances, which we had in 2022, with effects like subsidized gas and electricity prices for consumers – in place until March 2025). In practice, the Romanian government has legal tools

through which it can intervene into the market. For instance, the state has pre-emptive rights to buy the Black Sea gas production at the lowest price in order to replenish its state reserves. The state has the right to impose a subsidized price or re-regulate the market (when it so wishes) for a certain period of time – which it has already done in the autumn of 2021 and 2022. The subsidized energy price is valid in Romania until the end of March 2025, so it does not affect the sale of gas from Neptune Deep (which will start production in 2026-2027). But it has created a precedent for state intervention into the market, which means it can happen again in the future.

A third challenge to energy transition could be the slow roll-out of renewable energy projects due to Romania's weak administrative capacity. Oftentimes, when the state organizes competitive calls for projects, it gives a very short period (1-2 months) to applicants to write the proposal. This has an impact on the quality of projects that are submitted. On the other hand, the evaluation process, can last more than a year and frequently experiences delays. This can jeopardize Romania's ambitions in renewables.

A quick assessment of Romania's middle of the road state of affairs in this process of energy transition indicates that Romania is likely to go with the low hanging fruits (renewables, heat pumps) as well as use traditional solutions (nuclear and natural gas). Romania is very much risk averse and unlikely to opt for high-risk solutions (such as CCUS or developing a policy on strategic minerals or a home-grown production and supply chain for critical raw materials). Investor interest in Romania, by any measure, was and is not short. Romania's energy transition will thus unfold as an

interplay of several factors. Officially, Romania will "play it safe". It will count on the industry to drive decarbonization, on the EU to provide the financing, and it will impose some mandates for hydrogen use in transport. However, the biggest changes will happen as a result of EU policy shaping national policy (coal phase-out), of generous funding from the EU (such as Next Generation facility), or of strong support from a strategic partner (like the USA in the case of SMR technology).

Dorota Niedziółka

Germany's road to energy transition

1. Current energy market overview

Germany boasts one of the largest and most advanced economies globally, ranking fourth in terms of overall size. As of 2021, Germany ranked the 20th among the richest countries in the world. The German economy is a highly developed social market economy. Its economy's competitiveness and worldwide connections can be attributed to its high level of innovation and strong focus on exports. With its position as the top trading nation within the European Union, Germany is widely recognized as one of the most globally oriented economies worldwide, ranked just behind the USA, China, and Japan. The country's focus on innovation has resulted in many companies taking active steps to export manufactured products.

In 2016, Germany recorded the highest trade surplus in the world, worth USD 310 billion[1]. Six years later, its trade dropped significantly; in 2022, Germany's exports totalled USD 140 billion. Although annual exports increased by 14.3% in 2022 compared to 2021, imports climbed at a much higher rate of 24.3% due to increased energy prices prompted by Russia's invasion of Ukraine. This led to the trade surplus of the EU's biggest economy shrinking for the fifth consecutive year.

The strength of the German economy is its structure. Around 70% of the total GDP is contributed by the service sector, 29.1% by industry, and 0.9% by agriculture. The top 10 exports of Germany are vehicles, machinery, chemical goods, electronic products, electrical equipment, pharmaceuticals, transport equipment, basic metals, and food products as well as rubber and plastics. In terms of manufacturing, Germany is Europe's dominant economy. Germany conducts some applied research with practical industrial value and regards itself as a bridge between the latest university insights and industry-specific product and process improvements. It generates a great deal of knowledge in its own laboratories.

Having close relations with the world's most powerful economies, Germany is at the forefront of globalization. The competitiveness of the German economy is strongly influenced by the energy market, the types of energy sources, the structure of the energy mix, the cost of energy production, and energy supply and demand. Germany's energy

[1] *German trade surplus surges to new record in 2016*, https://www.reuters.com/article/germany-economy-trade-idUSL5N1FS5VG [19.03.2023].

consumption in 2022 declined by 4.7% compared to the previous year, thus reaching its lowest level since the country's reunification. The energy crisis has pushed Germany's energy consumption to its lowest level. While a growing population and economic production increased energy consumption, a surge in energy prices – which led to energy savings and energy efficiency investments – all contributed to the significant decline in consumption. Additionally, price-related production cutbacks in industry and warmer weather also played a role. High prices due to the energy crisis meant short-term savings by consumers and investments with medium to long-term impact as well as price-related production cuts in particular economic sectors.

Germany ranked seventh in global primary energy consumption in 2020. More than 70% of primary energy consumption was derived from fossil sources, 3.2% from nuclear energy, and 17.2% from renewables. The use of renewables as well as that of hard coal, lignite, and crude oil increased in 2022, while the consumption of natural gas and nuclear power decreased. Germany aims to increase the share of renewables in gross power consumption by 80% by 2030. Renewable energy in Germany is mainly based on biomass, the wind and the sun.

Other energy sectors look different. For decades Germany has been the global pioneer in applying renewables and environmental technologies. In 2019, 46% of the country's electricity mix came from wind, solar, biomass, and hydroelectric sources. A smaller share of renewables is used by the heating sector, namely 13.3%, and the transport sector, where renewable energy consumption is 5.3%. The German

energy market is characterized by an extremely dynamic growth of renewables in its energy consumption.

Table 1. Production, consumption, and import energy sources in 2021 in Germany

	Production	Consumption
Oil	-	95.5 million tonnes
Natural gas	4.5 bcm	90.5 bcm
Coal	126 million tonnes	232 million tonnes

Source: Own study based on Statistical Review of World Energy 2022.

Germany is the centre of the European power system. It is an important player on the European electricity market and is also exporting more and more electricity to neighbouring countries. The volume of imports and exports affects not only the level of prices but also shapes supply and demand, the structure of the energy mix, and the cost of energy production. Germany has the largest installed capacity of power plants in Europe, and also produces and consumes the most electricity. Electricity production means electricity generated from fossil fuels, nuclear power plants, hydropower plants, geothermal systems, solar panels, biofuels, the wind as well as electricity produced in purely electric power plants and combined CHP plants. Total gross electricity production in Germany is 544,894 GWh.

2. The country's strategy towards energy transition

Energy transition is the shifting of the energy sector from fossil fuels, i.e., crude oil, natural gas, and coal, in the energy production and consumption system over to renewables, namely wind, sun, and biomass. The key driving forces behind the energy transition are the growing role

of renewables in the energy mix, the possibility of storing energy, and the increase in energy efficiency. Germany has specific CO2 emission reduction targets following the Paris Agreement of the 21st Conference of the Parties (COP).

Germany has participated in various multilateral agreements and programs for global climate protection such as the Kyoto Protocol. It has also committed to a number of further climate protection measures and targets. Since 2005, for example, emissions from the domestic energy sector and heavy industry have been covered by the Emissions Trading Scheme (ETS). Germany was to reduce its emissions by 14% by 2020 compared to 2005. The main goal is to ensure a reduction of greenhouse gas emissions by at least 55% by 2030 and 80-95% by 2050 compared to the 1990 levels. Additionally, it is assumed that renewables will be responsible for at least 60% of energy consumption in 2050, and efficiency indicators should increase by 50%.

The first successes in decarbonizing the power sector have already been achieved as part of the German Energiewende; since 2010, as part of this policy, a number of decisions have been made on the decarbonization and decentralization of the German energy system and on the future concept of the energy scheme. Yet, further changes require energy transition in the power, heating, and transport sectors.

Energy transition is a priority in Germany with the main goals being to improve energy efficiency and develop renewables. By 2030, at least 80% of the electricity consumed in Germany is to come from renewables. It is assumed that this transition and achieving these targets will, firstly, make German industry climate-neutral and, secondly,

that renewables will cover the expected increase in demand, which is due, i.e. to the more widespread use of electric mobility. That is why such transformation contributes to the reduction of the dependency on crude oil and natural gas imports. Due to a lack of natural resources, Germany relies heavily on imported fossil fuels. A rapid transition to renewables, therefore, also serves to minimize and ultimately eliminate dependency altogether. The energy transition will guarantee cleaner, cheaper, and safer energy supplies in the future. This is in line with the economic policy.

As part of this effort, Germany has already begun retreating from nuclear and coal energy. In 2020, Germany decided that it will have eliminated coal from all its electricity production by the year 2038 at the latest. This decision is costly. The government has decided that the coal-mining regions affected by the changes will be assisted in implementing the necessary structural adjustments.

Germany was the first country to start promoting renewables in the 1990s and passed the Renewable Energy Act (EEG) in 2000. One of the tools used to achieve the objectives was investment fees. The EEG Act stipulated a levy to ensure that the increased costs of developing environmentally friendly generation were distributed proportionally among consumers. The second tool is the state funds. Owing to government subsidies, much of Germany's electricity comes from renewables; in 2022, it was about 49%. Further plans assume increasing the intensity of these projects. This means, among other things, the creation of new onshore and offshore wind farms, together with the use of roof space to generate solar energy also in agricultural areas.

Energy transition requires not only new generation equipment but also an appropriate power grid. Infrastructural investments are necessary, for example, in high-voltage lines. This will enable the transmission of electricity generated from wind farms in northern Germany to large industrial complexes in the south of the country. Infrastructural investments in national and local distribution networks are very important for the success of energy transition.

Germany's energy transition also means a wider use of green hydrogen. Green hydrogen is particularly important for the sustainability of industrial activities. It can be applied to the sectors where electrification seems either impractical or impossible such as the steel and chemical industries. The German green hydrogen strategy places great emphasis on international partnerships as Germany needs to import large amounts of green hydrogen, which is most easily produced in areas where there are adequate sources of renewables like solar or wind energy, for example, countries in the Middle East, North, South, and West Africa, and Australia. At the same time, Germany is promoting research and development in green hydrogen. Germany wants to be a leader in climate protection technologies on the international stage.

Energy transition means more efficient use of energy. Germany, like other highly developed countries, needs to produce more green energy and use more efficient energy production technologies. The goal is to achieve a 50% reduction in primary energy consumption by 2050, although it has already decreased significantly. In 2020, energy consumption fell by almost 17% compared to 2008. The German government provides funds to increase investment in energy efficiency, for example, helping property owners to

renovate their premises in an energy efficient way. This is crucial as Germany uses around 35% of its total consumption on things like heating and hot water.

Energy transition is also related to the introduction of digitization. The digitization of the energy market is primarily focused on smart measuring systems and electricity meters. The benefits of digitization lie in paying just for the electricity during working time actually used. This can make it easier for consumers to determine the best way to save energy for them. Smart metering systems also help to achieve the right balance between electricity generation and grid consumption.

3. Key takeaways and challenges

The current energy transition in Germany has been progressing rapidly, thereby generating numerous opportunities for positive change. These include new laws and regulations, innovative technologies, increased social acceptance, and additional incentives for industry, services, and agriculture. Moreover, the transformation is an impetus for positive social, economic, and environmental changes. New opportunities have been seen in sectors relevant to energy transition, such as the solar industry. This can help mitigate concerns about phasing out fossil fuels and nuclear power. It will also help transform the automotive sector. Positive changes increase social acceptance of the costs associated with energy transition.

Further impetus for the transition can be anticipated to come from industrial producers who will be eager to curtail the risks of energy price rises, of any curbs or disruptions in energy supplies, as well as of tougher global competition.

Table 2. German government energy and climate targets for 2020 and 2050 (set in 2010)

Targets		2020	2030	2040	2050
Energy efficiency	Reduction of primary energy consumption (base 2008)	20%			50%
	Reduction of electricity consumption (base 2008)	10%			25%
	Reduction of final energy consumption in the transport sector (base 2005)	10%			40%
Renewable energy	Share of renewable energies in electricity consumption	35%	50%	65%	80%
	Share of renewable energies in total final energy consumption	18%	30%	45%	60%
GHG	Reduction in GHG emission (base year 1990)	40%	55%	70%	80%-95%

Source: 2010 Energy concept and 2011 Energy package.

The important change, however, is that industrial policy is gaining importance in the European Union. Various laws can help industry as well as fostering competitiveness and decarbonization.

One of the biggest challenges for German energy transition appeared in 2022. The Russian aggression against Ukraine, the sanctions on Russian crude oil and coal, and the retaliatory withholding of natural gas supplies by Russia have forced Germany to verify its energy and climate policies and to redefine its priorities during its energy transition. Before the war, Germany clearly prioritized climate sustainability and the decarbonization of the economy. Until that time, energy supply from fossil fuels, especially natural gas, had been thought to have been highly secure and the competitiveness of the economy had been increasingly a function of this energy transition.

Germany has not abandoned its climate targets and plans to accelerate its energy transformation, but in the meantime it needs to maintain secure supplies and energy markets[2]. Germany is one of the European countries heavily dependent on imports of Russian energy resources. This dependence may increase as nuclear power and coal are to be phased out in 2022 and 2030 respectively. Natural gas is the best technology to complete the system. It stabilizes power grids during periods of higher demand or fluctuations in renewables production and is also crucial for setting electricity prices, as production costs in gas-fired power plants

[2] J. Wettengel, *Climate council warns Germany against "pushing off" responsibility to Europe*, https://www.cleanenergywire.org/news/climate-council-warns-germany-against-pushing-responsibility-europe [20.03.2023].

determine the prices of electricity produced by all other technologies. The German government could capitalize on the energy and price crisis to accelerate the transformation of the energy and industrial system.

In 2021, the updated climate law set an even more ambitious target of reaching net zero or carbon neutrality by 2045, and a new, higher emission reduction target of 65% by 2030. In April 2022, a new package of regulations accelerated the expansion of renewables and an increase in the share of renewables in electricity generation to 80% by as soon as 2030. Under the package, the development of renewables is now becoming a national priority. The package provides new areas for photovoltaic expansion, strengthens the commitment of municipalities to onshore wind power and photovoltaics, aims to extend connections to low-wind sites by expanding the electricity grid, and by enhancing the legal framework for the expansion of rooftop photovoltaic systems. The regulatory package supports the development of hydrogen as an energy, i.e., an electricity carrier, as well as the construction of hydrogen-fuelled power plants to replace natural gas.

Germany has committed to reducing its dependence on Russian gas as soon as possible; substituting Russian natural gas has become a necessity, rather than a choice. The approved strategy was to reduce domestic energy consumption by committing to a 20% reduction by the end of 2022 and by increasing energy efficiency. On the supply side, the strategy was largely focused on LNG volumes and infrastructure expansion, purchasing as much LNG as possible on the global market to fill the natural gas storage facilities. The government has also accelerated the construction of at least three

LNG terminals by 2025 and has been planning to build four floating LNG terminals in the next two years. Meanwhile, it has temporarily reactivated coal-fired power stations and partially postponed until April 2023 the decommissioning of two of the three nuclear power plants still operating.

Germany will need to accelerate the construction of renewables power plants, gas-hydrogen power plants, and CHP plants, expand its grid infrastructure, especially north-south transmission lines, and boost renewables in the industrialized southern regions. Without these investments in infrastructure, it will be difficult to meet the growing demand for electricity.

High natural gas prices make renewables technologies even cheaper and provide an impulse for deep decarbonization of sectors that are difficult to reduce such as transport or industrial processing. However, high electricity and natural gas costs can also delay much-needed transformation processes, particularly in heavy industry. This could trigger a wave of deindustrialization, the spill over effects of which will not only impact employment and the country's socio-economic stability but also Germany's ability to innovate.

Natural gas imports from a geographic direction other than Russia will continue to act as a bridging technology, and Germany will remain dependent on a highly volatile and unstable market for years to come. Unstable supplies will also mean business risk for further decarbonization. Meanwhile, the global LNG market remains tight and under-supplied. New projects are needed. Germany will not

only have to build LNG infrastructure[3] on the coast but also expand and adapt its gas transmission network to reverse the flow of natural gas, from the traditional East-West to West-East and North-South directions[4].

[3] Idem, *German government plans extensive LNG infrastructure build-up to ensure security of European supply*, https://www.cleanenergywire.org/news/german-government-plans-extensive-lng-infrastructure-build-ensure-security-european-supply [20.03.2023].

[4] J. Pepe, *Germany Energy Policy in turbulent times: between transition chances and lock-in risks*, Italian Institute for International Political Studies, 23 November 2022, https://www.ispionline.it/en/publication/germany-energy-policy-turbulent-times-between-transition-chances-and-lock-risks-36778 [28.03.2023].

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There are many unknowns ahead for the countries of the European Union arising from the energy transition process. The paper examines this process in relation to several countries, namely, Finland, Norway, Poland, Czechia, Slovakia, Hungary (these last 4 countries are the Visegrad Group countries), Romania, and Germany. This selection makes it possible to show the different approaches of individual countries to this issue, especially since the group includes countries where the energy transition process is extremely advanced (Finland and Norway), countries where this process will require significant activity and financial outlays (Poland, Czechia, Slovakia, Hungary, Romania), and where the challenges will be the greatest given the scale of the level of economic development (Germany).

In the paper, the authors try to analyze not only the current overview of the energy situation of the analyzed countries, but also the strategies and challenges of energy transition. Undoubtedly, this will be a key process that will shape the decisions of the European Union countries in the coming decades.

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