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Fossil fuels in the energy transition – the case of Romania

Introduction

The accession of Romania to the European Union (EU) in 2007 boosted the state's economic development and forced the revamping of the energy sector. The achievements in this field are clearly visible and for several years, Romania has been moving towards the balanced development of the energy sector. Taking into consideration rich deposits of some of the strategic energy raw materials, such as natural gas or coal, the question of energy security is not as problematic as it is in the case of other countries in the region. Additionally, Romania's energy mix also works to the country's advantage so electricity comes from various sources. The green energy sector has also been developing dynamically.

The document that is currently in force which regulates Romanian energy sector is The 2021–2030 Integrated National Energy and Climate Plan. It defines central aims of the energy transition (MOR 2021). The energy policy is also described in detail in the energy strategy of Romania. The draft strategy for the years 2022–2030 with a perspective until 2050 is currently being considered (ME 2022). Romania has a flexible approach towards the energy

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security which makes it possible to adapt the energy transition to dynamically changing circumstances. Mostly, the main aim of the Romanian strategy is to efficiently modernize all energy sectors through gradual decarbonization and transition to low-carbon energy in the fastest possible way. A crucial element is also to maintain the energy independence through the development of the nation's own energy potential and diversification of the strategic raw materials, such as crude oil.

The purpose of this paper is to present the current status of the Romanian fossil fuels sector in the context of the energy transition process. An attempt has been made to answer the questions of what methods are used in this process and what roles are played by fossil fuels

The first part of the paper presents the definition of the energy transition with a special focus on decarbonization. The energy potential of Romania is then described with a division into fossil fuels and renewable energy sources. The next part of the paper concentrates on the energy sector in Romania, the electricity generation and the current status of the fossil fuels sector, including crude oil, natural gas and coal. Finally, the paper shows a comprehensive analysis of the energy strategy of Romania in the context of investments planned until 2030, taking into account fossil fuels.

1. The energy transition through decarbonization – the theoretical aspect

In recent years, the energy transition has become a burning issue taken up by the majority of countries worldwide. What turned out to be milestones were the Paris Agreement in 2015 and the Glasgow Climate Pact in 2021, which significantly influenced the energy strategies of multiple countries. The International Renewable Energy Agency also contributes to the cause – it has created a plan of implementing low-carbon technologies by the year 2050 (IREA 2020). One of the key projects of the transition involves decarbonization, which basically means reducing or eliminating carbon dioxide from the energy sources in order to reach net zero emissions of CO_2 and consequently reduce greenhouse gases (Fay et al. 2015). One should notice that the emission factor of CO_2 for the most frequently used fuels in the energy sector is diverse and accounts for 93.46 kg/GJ for hard coal, 107.13 kg/GJ for lignite, 55.43 kg/GJ for natural gas, 73.30 kg/G for crude oil and 112.00 kg/GJ for firewood and waste of wood origin (KOBiZE 2019). It is clearly visible that the emission of coal (especially lignite) in relation to other fuels (e.g. natural gas), let alone renewable energy sources (RES), is much higher. In this context, the decarbonization of the energy sector will involve from the abandonment of fossil fuels – initially coal and then natural gas and crude oil. This process cannot successfully work without alternative energy sources which are supposed to replace fossil fuels. Here, special attention is paid to renewable energy sources, biomass and nuclear power.

The EU aims to become the first climate neutral continent by the year 2050. In order to reach this goal, decarbonization of the energy sector is of utmost importance since the

production and usage of the energy accounts for over 75% of greenhouse-gas emissions in the EU. The essential fact is that the energy system of the EU is mostly based on fossil fuels (Zachmann et al. 2021). Different European countries follow various paths when it comes to the decarbonization of the energy sector, all of which are directly dependent on the economic and social situation of a given state. Naturally, countries with highly developed economy have better opportunities e.g. Germany (Maruf 2021), Ireland (Yue at al. 2020), Italy (Frilingou 2023) and Greece (Hebda 2021) than those with developing economies e.g. Poland (Malec 2022; Hebda 2022), Hungary, Slovakia, the Czech Republic (Mindeková et al. 2022) and Serbia (Ćorović et al. 2022). Since the economic development is different for various states, any implementation of a transnational model of the energy transition poses a challenge. This is caused by the fact that countries offer different possibilities when it comes to financing modern technologies but, most of all, the fact that the energy sectors of some states remain underdeveloped. This issue is particularly common in countries for which the power engineering system is based on coal (Nocoń 2022). Decarbonization brings about multiple benefits but also poses a threat to the energy security of a state. One of the key threats is the potential destabilization of the power-engineering system, soaring prices of energy production and the economic and social depletion of coal regions. However, it is worth mentioning that decarbonization may offer substantial, long-term benefits. It can reduce the air-pollution related mortality, stabilize the costs of energy supply or might contribute to creating new workplaces. Each and every country has different possibilities in this regard; therefore, the energy transition or decarbonization should be harmonized with economic and social capabilities. It must be stated that the revamping process cannot destabilize the energy security of a state.

As is the case with most post-socialistic countries, the energy sector in Romania is noticeably underdeveloped with regard to technology in comparison to West-European countries. Nevertheless, for almost a decade, Romania has been gradually undergoing the energy transition, mostly through decarbonization. Its main aim is to reduce fossil fuel consumption, particularly that of coal. One should, however, still bear in mind that this country can boast having a well-developed sector of fossil fuels, which generates a number of challenges and doubts in the context of the dynamically ongoing process of decarbonization.

2. The energy potential of Romania

2.1. Fossil fuels

In comparison with its neighbors, the resources of energy raw materials in Romania are significant yet still insufficient for the growing needs of the country. There are some documented deposits of crude oil and natural gas located mostly on the Moesian Platform (Branoiu 2016). According to the National Agency for Mineral Resources (in Romanian, Agenția

Națională pentru Resurse Minerale) the deposits of crude oil account for slightly more than fifty-two million tons (mt). Considering the current extraction of 3 mt annually, the country will run out of its natural resources within the next sixteen years. Most of them are located in the southern part of the country, between Craiova and Bucharest, but are also on the border with Serbia and Hungary (Figure 1).

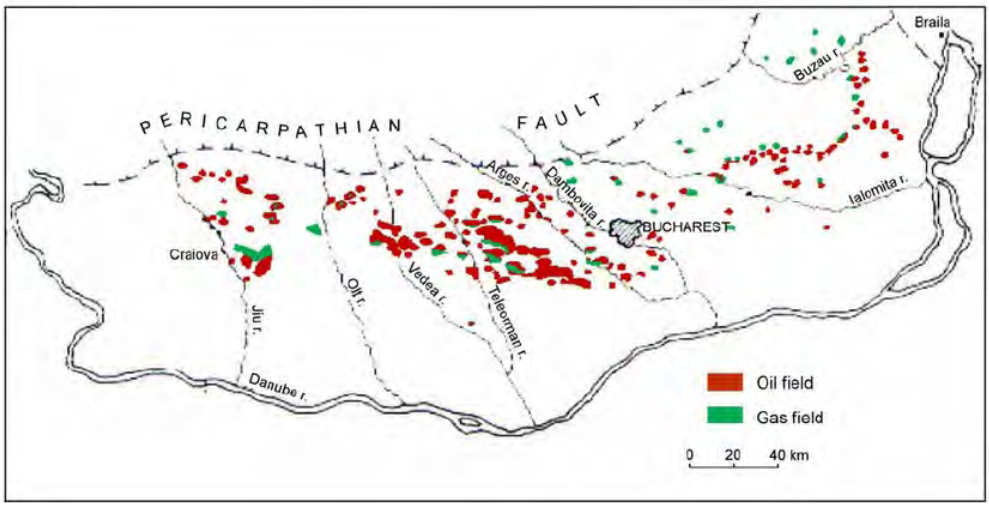

Fig. 1. Crude oil and gas field in the Moesian Platform (Pene et al. 2006)

Rys. 1. Pokłady ropy naftowej i gazu ziemnego w obrębie Platformy Mezyjskiej

Natural gas, at an amount of ca. 153 billion m^3 (bcm), is located in the central part, mostly in Transylvania (Mureș County and Sibiu). Rather scarce amounts of oil and gas are also present in the Romanian shelf in the Black Sea. It should also be mentioned that in Romania, there is over 1.4 bcm of recoverable wet shale gas (third biggest deposits, after Poland and France) (Papatulica 2014). When it comes to coal, the deposits are not impressive. The research shows that there are around 373 mt, out of which 290 mt is lignite (ME 2022). This resource is located in three coal-mining areas in the south of the country (the Jiu Valley, Oltenia and Ploiești) but the majority of the coal is present in Oltenia, where the coal industry is located. As a matter of fact, although geological deposits of coal are several times bigger, its exploitation is economically unprofitable.

2.2. Renewable energy sources

The potential of renewable energy sources in Romania is huge, although the greatest possibilities are connected with biomass and wind power. Importantly enough, the green

energy can be successfully used in every region of Romania. Wind power may appear to be the leading source of energy. The research shows that the potential in this aspect is truly enormous and equals 23 TWh per year (Cirstea et al. 2018). The best conditions for the development of wind power are undoubtedly in Dobruja (one of the greatest in Europe) and along the mountain range of the Eastern and Southern Carpathians, stretching across the whole country (Dragomir et al. 2016). The development of solar power also looks promising. In Romania, there are approximately 210 sunny days annually (Cirstea et al. 2018). From the geographical perspective, the best conditions for solar parks are in the southern part of the country (in a wide strip of land along the border with Bulgaria). The next source of clean energy is biomass, biofuels and biogas. Due to the fact that large areas of Romania are used for agricultural crops (20% of the territory) or are afforested (27% of the territory), there are great possibilities in this regard. Taking into consideration the fact that only one third of households is supplied with gas, biomass can be successfully used in heat engineering or in the scattered energy system. According to the Romanian Association of Biomass and Biogas (rom. *Asociația Română de Biomasă și Biogaz*), Romania generates 200 mt of waste annually. This mostly includes wood biomass and agricultural biomass (Iancu 2018). From the perspective of bioenergy, each region can offer different qualities, e.g. agricultural biomass dominates in the Southern and Western Plain as well as in Moldova. Meanwhile, wood biomass can be obtained in afforested areas of central and northern Romania (Chirila 2016). For many decades, hydropower has played a major role in the Romanian energy sector. In fact, 69–75% of the hydropower potential is currently being used (Cirstea et al. 2018). It is estimated that annually, Romania can obtain around 36 TWh of energy located in several rivers, e.g. the Danube, Lotru, Bistrița, Someș and Argeș, as well as 2,500 water reservoirs. Both geographical and economic conditions suggest using the remaining part of hydropower potential in large hydroelectric power stations, for instance, through the development of the already existing infrastructure on the Danube. However, some regions, such as Transylvania, are more suitable for the development of small hydroelectric power stations. There are 200 places already chosen to have such items of infrastructure built (Chirila 2016). Surprisingly enough, geothermal power remains rather unpopular despite the Romanian potential being quite impressive in this regard. In fact, Romania is ranked third in Europe (after Greece and Italy) when it comes to geothermal possibilities. There were over 250 exploratory boreholes drilled at depths of between 800 and 3,500 m, which have proven the presence of geothermal deposits of low enthalpy (50–120°C). The best location for investments is the region of Bihor, close to the cities of Oradea and Beiuș. Sites of significant potential are also located close to the border with Hungary and in the southern part of the country, next to Bucharest (Antal and Rosca 2008).

3. The energy sector of Romania

3.1. Electricity generation

Romania can boast having a well-balanced and diversified structure of electricity generation. The four most dominant are sources are hydropower, nuclear, coal and gas power. To a smaller extent, wind and solar power potentials are used. In 2021, the electricity generation was almost 57,050 GWh and this rate has been stable for the past few years (in 2020 – 53,740 GWh, in 2019 – 57,020 GWh). As previously mentioned, for decades, hydroelectric power stations have played a major role in the Romanian energy sector. During that time, they generated more than 17,590 GWh (30.85%) of electric energy. Slightly lower results were achieved in nuclear power plants – 10,960 GWh (19.21%), gas – 10,260 GWh (17.99%) and coal – 10,210 GWh (17.9%). In recent years, there have been major investments made in the wind power sector, as a result of which in 2021 it accounted for 6,900 GWh (12.1%). The remaining sources, such as solar power, crude oil or biomass, rather marginally contribute to Romanian power engineering (altogether ca. 2%) (RERA 2021) (Figure 2).

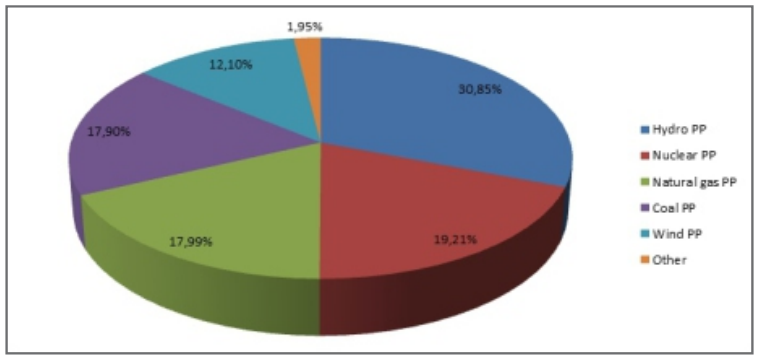

Fig. 2. Electricity generation by energy resources in 2021 (in percents).
Own work based on (RERA 2021)

Rys. 2. Produkcja energii elektrycznej z podziałem na źródła w 2021 r. (w procentach)

The network of hydroelectric power stations is well-developed –there are currently about 200 plants located in various areas in Romania. The most efficient unit is the power station located on the Danube called the Iron Gate I (rom. *Porțile de Fier, serb. Djerdap*). Along with the Iron Gate II, it has the capacity of 1,330 MW. The Lotru river also plays a similar role – there are hydroelectric power stations, such as Lotru-Ciunget (510 MW) or Brădișor (115 MW). Other large power stations include Râul Mare (335 MW), Mărișelu (221 MW), Vidraru (220 MW), Bicaz-Stejaru (210 MW), Ruieni (153 MW) and Nehoiașu (152 MW) (Năstase et al. 2017).

Another source of electrical energy in Romania is coal-fired power plants. Although their significance has dropped in the recent years, they remain a foundation of the energy sector in Romania. In 2021, there were seven power plants equipped with thirteen coal-fired units with a total capacity of 2,895 MW. The power plants, along with the mines, are managed by two state-owned companies: Oltenia Energy Complex (OEC) and Hunedoara Energy Complex (HEC). OEC owns four power plants and ten lignite mines while HEC manages hard-coal production, which is delivered to three power plants. The biggest coal-fired power plant is still Rovinari, which has a total capacity of 1,320 MW (four coal-fired units of 330 MW each) (Tomescu et al. 2022). In order to prolong its functionality, it has been revamped for many years. Another power plant is Turceni, and its capacity is gradually being reduced – currently 990 MW (three coal-fired units of 330 MW each). The Mintia power plant is also one of the more efficient plants (1,285 MW), but in 2021, the production of electric energy was halted there because of exceeding the SO_2 emission limit. Minitia was supposed to be revamped; however, it was sold to the foreign company Mass Group Holding, which promised to make investments in a new power unit which is to use natural gas or RES (BGEN 2022). The remaining coal-fired power plants (Craiova, Isalnita, Govora, Paroseni and Iasi) do not exceed the capacity of 315 MW and in the nearest future they will be either closed or equipped with gas units. One of the newest gas power plants opened in 2012 is Petrom Brazi (close to the city of Ploiești) with a capacity of 860 MW. The capital city is also supplied with energy from natural gas (București Sud, București Vest, Progresu, Grozăvești). By the end of 2026, Mintia will have been equipped with a gas unit with a capacity of 800 MW. What still plays a crucial role in the Romanian electrical system is the Cernavodă nuclear power plant, which is equipped with two units (1,400 MW) and with the possibility of being expanded to three more. The nuclear power sector will definitely be developed (MSCP 2022). Along with the gas sector, it is supposed to stabilize the energy system after the coal-fired power plants are shut down.

Clearly, Romania does not take full advantage of the green energy sector, especially wind power. Thus far, the largest completed wind park has been Fântânele-Cogealac, located north of Constanța and several kilometers from the coast of the Black Sea. Perfect conditions allowed the Czech investor CEZ Group to construct 240 wind turbines with a total capacity of 600 MW (Rusu et al. 2021). Meanwhile, the majority of smaller units (e.g. in Constanța and Tulcea) were built by the Italian company Enel Green Power. Other renewable energy sources, such as biomass or solar power, have been developed to a rather limited extent.

3.2. The level of production and import of crude oil, natural gas and coal

3.2.1. Crude oil

As previously mentioned, Romania has deposits of crude oil which has been extracted there for decades. However, bearing in mind its rather limited amount, production has grad-

ually been decreasing in recent years. In 2011, it was around 4.2 million tons (mt), in 2016, 3.8 mt while in 2021, it was only 3.3 mt. Despite this fact, Romania remains one of the major producers of crude oil in Europe (after Norway, Great Britain and Italy). The production covers around 30% of the Romanian demand and for many years, the consumption of oil has remained on a stable level of about 9–10 mt (in 2021 – 10.3 mt) (BP 2022). The biggest producer of crude oil is OMV Petrom (about 90% of the whole production). This raw material is mostly extracted from oil-rich areas between Piteşti and Ploieşti (north of Bucharest), although there is a noticeable increase in the oil production in the shelf of the Black Sea. The remaining proportion (7–8 mt) was imported in recent years by sea from Russia and Kazakhstan through the oil terminal in Constanța. At this point, it should be mentioned that due to the EU embargo on Russian crude oil, Romania has increased shipments from Kazakhstan, Azerbaijan and Saudi Arabia. The network of oil pipelines is small and accumulated in the south-eastern part of the country. Its main aim is to distribute crude oil from the oil terminal in Constanța to the four refineries that are still in operation (there were once twelve), for which the total capacity is over 13 mt annually (Petrobrazi Ploiești, Petrotel Lukoil Ploiești, Petromidia Năvodari, Vega Ploieşti) (Pachiu and Mustaciosu 2020). The largest refinery – Petromidia Năvodari – is owned by the Rompetrol Group, which was taken over by Kazakh KMG International NV in 2010.

3.2.2. Natural gas

Although Romania has deposits of natural gas, the downward trend in its production is becoming more visible. In the nineteen-seventies and nineteen-eighties, more than thirty billion m^3 (bcm) of gas were extracted but in the decades to come, the production was dropping. In 2021, it reached 8.5 bcm and, compared to the previous year, there was a minor decrease (from 8.6 bcm) (BP 2022). In fact, the level of gas extraction managed to cover 74% of the Romanian demand in 2021 (11.4 bcm). The remaining share of the gas is mostly imported from Russia (70%) and from the EU (30%). There are two major gas producers in Romania: state-owned Romgaz (57% of the production in 2021) and Petrom – a subsidiary of Austrian OMV (41% of the production in 2021) (ANRE 2021). The gas extraction is mostly located in Transylvania, especially in two regions: Sibiu and Mureș County. In this area, there are also a few gas fields, e.g. the largest Deleni (Băgaciu village) where gas has been extracted since 1915. It is reported that there is a possibility of increasing Romanian gas production in the coming years as a result of the recently discovered natural gas deposits in the shelf of the Black Sea. This raw material is distributed through a network of gas pipelines (with a total length of thirteen thousand kilometers) managed by the state-owned company, Transgaz. It is worth mentioning that the existing infrastructure is not fully used since its annual transmission capacity accounts for almost 30 bcm. There are also a few gas connectors with the neighboring countries which enable both import and gas transit. Gas interconnectors with Ukraine are of utmost importance. They connect the countries in two places. One of these is the Tekovo (Ukraine) to Medieșu Aurit (Romania) gas pipeline, which enables the delivery

of Russian gas to the north-western part of the country. Meanwhile, the second gas interconnector is mostly used for transit: Orlivka (Ukraine) – Issacea (Romania) – Negru Vodă (Romania) – Kardam (Bulgaria) (Guşilov 2014). In 2016, a new connection with Bulgaria was opened (Giurgiu – Ruse). It is supposed to be a part of the Turkey to Austria gas corridor. Additionally, there is also a gas connector with Hungary (Arad to Szeged) and Moldova (Iaşi to Ungheni) (Guşilov 2018). In the near future, there will also be a gas connection with Serbia. The transmission system secures eight gas-storage facilities with a total capacity of 3.1 bcm. The largest one is located in Bilciurești (50 km from the capital city) and its storage capacity is 1.3 bcm (StepMap 2012). The main gas consumers in Romania are households (especially during the winter season) and that is why a dynamic gasification of the country is planned. Relatively low amounts of gas are used by the industry and the energy sector.

3.2.3. Coal

Coal remains a strategic raw material for the Romanian energy sector, although its production and consumption are dropping every year. This results from the process of the intensive decarbonization of the energy system. Over the course of one decade, the coal mining was decreased by more than a half: in 2011 the production still accounted for about 6.7 mtoe while by 2021, it reached only 3.1 mtoe (BP 2022). The lower production along with decarbonization also led to the decreasing level of coal consumption. In 2021, the coal demand was 4 mtoe while in 2011, it was 8.1 mtoe (BP 2022). The majority of coal is mined in the country – in most cases, this is lignite located in Oltenia and extracted by the joint-stock company Societatea Complexului Energetic Oltenia (77% of shares of the State Treasury). A major advantage is the fact that coal deposits are accumulated in a relatively small area and therefore the whole production is limited to a few mine workings. Apart from lignite, hard coal is also extracted (the Jiu valley) but in rather small amounts. In 2012, a national energy complex was created – Hunedoara. This includes hard coal mines and coal-fired power plants. Moreover, during recent years, most of the mines were shut down with only two still operating: Hunedoara and Oltenia (Tomescu et al. 2022). The decrease in its own coal production has forced Romania to import coal (until 2022, from Russia).

4. Fossil fuels in the energy transition of Romania

4.1. The strategy for development of the energy sector in Romania until 2030

The ongoing economic growth as well as the dynamically changing geopolitical situation of Romania is reflected by the equally dynamic energy policy of this country. The strategy for development of the energy sector in Romania for the years 2022–2030 pursues a few fundamental goals:

- Decarbonization of the power engineering sector – it is assumed that there will be a growing number of investments in the low-carbon production of electricity and replacing coal with natural gas and renewable energy sources. This aim is to be realized by revamping the existing power plants (also combined heat and power plants) and building new gas and steam alternatives. The energy complex Oltenia and Hunedoara is supposed to be shut down. The coal is going to be phased out but not before new energy capacities are developed. Additionally, the plan for the development of post-mining lands will have to be implemented. In such a way, the Hunedoara Energy Complex is to be replaced with a new economic entity. This will ensure the energy continuity of the mines which will provide coal until 2030. In the next stage, the Hunedoara complex will be sold in a public auction to an investor who will build new generation energy capacities based on low-carbon technologies.
- Clean energy – decarbonization will be performed through increasing energy production from renewable sources, especially from wind power and photovoltaics. The energy sector highly contributes to the substantial emission of greenhouse gases, sulfur oxide, nitrogen oxide and particulate matter in the atmosphere. The strategic aim of sustainable development is to protect the natural environment and reduce global warming. Romania is bound by EU law to revamp its energy sector and to introduce clean, low-carbon energy. Therefore, the state is aiming to develop renewable energy sources and reduce the coal consumption. It is the state institutions' duty to support any investment which is aimed at modernizing the energy sector and promoting eco-friendly ways of distributing energy among Romanian citizens.
- Nuclear power – it is planned to increase nuclear capacity through revamping Unit 1 and opening Units 3 and 4 in the nuclear power plant in Cernavodă. Additionally, investments into small modular reactors (SMR) are planned. It is worth mentioning that completing Units 3 and 4 in Cernavodă is supposed to be the key factor in covering the shortfall in electrical energy production expected for the years 2028–2035 (a consequence of the shutdown of coal units). Furthermore, the development of SMR-type energy power with zero CO_2 emission, located on the premises of closing coal-fired power plants (2028–2030) will facilitate a reduction followed by the complete cessation of coal-based energy production by the year 2032.
- Digitalization of the energy sector – investments into cutting-edge technology and modernization of the power network through digitalization and creating the so-called smart grids are intended to increase the efficiency of the Romanian energy system. Additionally, digitalization will highly influence the state's security, making it possible to react in case of any system failure or cyber-attacks. This issue is a priority since the Romanian power system uses nuclear power.
- Cross-border energy cooperation – cross-border mergers with the neighboring countries are to be completed (with the EU members and the third parties). This concerns both natural gas and electric infrastructure. In the gas sector, the main aim is to consolidate the national transmission system with the neighboring countries through the

building of gas interconnectors of a proper bandwidth. Romania is to become a key transition country in the BRUA project (interconnector Bulgaria-Romania-Austria, receiving gas from the coast of the Black Sea). Moreover, another goal is to complete the vertical gas corridor Greece-Bulgaria-Romania, and, at a later stage, to create a bidirectional trans-Balkan corridor (Turkey-Bulgaria-Romania-Ukraine-Moldova). The Romanian gas infrastructure can provide neighboring countries with access to new gas sources, e.g. from the Caspian Sea. In case of cross-border infrastructure transmitting electrical energy, Romania is obliged to complete the EU projects which are to integrate the power systems of the member states. One of them is NSI East project which aims to connect the Romanian energy network with Bulgaria and Hungary by the year 2030.

- Energy storage – in recent years, storing energy has become highly important, considering the need to ensure energy security in the event of political or economic crises. For his reason, in the years to come, Romania will increase its fossil fuels storage capacity, with a particular focus on hydrogen. This will enable synergy and balance between all energy sectors. The priority for the energy transition is to revamp and optimize the infrastructure to introduce new sources of energy, such as hydrogen and renewable gases. New strategies of the European Commission regarding hydrogen and sector integration also seem to be favorable for Romania (ME 2022).

4.2. Investments into the Romanian power engineering

4.2.1. The energy system

As time passes, the problem of obsolete, inefficient energy infrastructure seems to be becoming an increasingly pressing issue. This concerns both power units completed in the nineteen-seventies and gas and electricity transmission grids. In order to ensure stability and energy security, investments into the Romanian power sector are inevitable. In the nearest future, the coal sector will be undergoing the most substantial of changes, both in the context of mining industry and in the production of electrical energy. This issue is closely connected with gradual withdrawal from the coal, but in such a way that it does not undermine energy stability. It is therefore planned to modernize old coal units and convert them into the gas alternatives (Tomescu et al. 2022). It is worth mentioning that by virtue of the regulation of June 2022, all currently operating coal-fired power plants are to be modernized or shut down by the end of 2032 (MOR 2022a). However, it remains possible that the process of Romanian decarbonization will be prolonged due to the energy crisis caused by the war in Ukraine. Consequently, the shutdown of coal units Rovinari 3 and Turceni 7 (Oltenia energy complex) has been postponed until October 1, 2023, although originally they were supposed to work until the end of 2022 (MOR 2022). As has already been mentioned, Romania is planning to perform decarbonization through converting coal units into gas units (Ștefănescu 2022).

From 2025, there will be a gradual growth in the capacity of gas power plants (reaching a maximum of around 3,000 MW in 2040). Furthermore, as a result of such investments, Romania will be able to increase the consumption of the gas of its own production. However, in this regard, one should take into consideration the EU policy which, after Russian aggression on Ukraine, is rather skeptical about the increased use of natural gas (Siddi 2022). Therefore, the decarbonization aims will have to include other sources, in particular RES. In the nuclear power sector, it is planned to keep the two reactors functioning and to implement new power capacities. The Cernavodă power plant has significant potential in this area as it was initially supposed to work on five reactors. In this way, Romania can open the next energy units without building a new nuclear power plant in a different place. In the coming years, the modernization of Unit 1 and the opening of Units 3 and 4 are planned (ME 2022). As a result of these investments, the capacities of the nuclear power plant will be doubled (to about 2800 MW). Additionally, the nuclear power sector will be facilitated by SMRs. In fact, in December 2022, the Romanian producer of nuclear power Nuclearenergetica signed an agreement with the American company NuScale Power LLC which is to implement the project of building the first SMR in Romania (NuScale 2023). When it comes to hydropower, the Romanian strategy focuses mostly on the revamping of the currently used plants. The main aim is to sustain the current level of the energy production and to facilitate functioning of hydroelectric power plants. It is estimated that by the year 2030, the energy system of Romania will be strengthened by an additional 200 MW coming from the hydroelectric power plants. Investments into other RES sectors are supposed to gain more intensity, wind and solar power along with biomass, in particular (ME 2022). These areas will undergo dynamic development; in fact, energy generated from the wind has already been exploited. Furthermore, between 2009 and 2015, the capacity of wind power plants increased from 7 to 2,990 MW (Dragomir et al. 2016).

It is worth making a reference to the plans for the next few decades predicting the capacities of power plants with regard to the energy source. No target scenario, delayed scenario or decarbonization scenario have only one thing in common. All these three scenarios assume the complete shutdown of coal-fired power plants by 2035. In the case of gas and nuclear power plants, no target scenario assumes increasing their capacity between 2025 and 2045 by 50% and 100%, respectively, compared to 2025. Similarly, delayed and decarbonization scenarios predict a reduction in the capacity of gas power plants by 50% and sustaining the potential of nuclear power plants. The differences in these three scenarios are particularly visible in terms of RES development. Decarbonization and delayed scenarios assume much larger capacity growth in wind, solar and hydroelectric power plants. Comparing the current electric capacity (2023) with that which is planned for 2025 shows that within the next two years, Romania will be closer to the no target scenario. In the 2025 perspective, the biggest challenge for the decarbonized scenario seems to be increasing the capacity in wind power plants by 50%. Additionally, between 2030 and 2040, all prognoses assume a reduction in the electrical capacity of Romanian power plants compared to its current status. The reason for such decisions is obviously excluding coal from the energy mix and, consequently,

the shutting down of all coal-fired power plants. Decarbonization of the power engineering sector will allow Romania to reduce CO_2 emissions by 87% between 2020 and 2040 (Koltsaklis et al. 2020) (Figures 3 and 4).

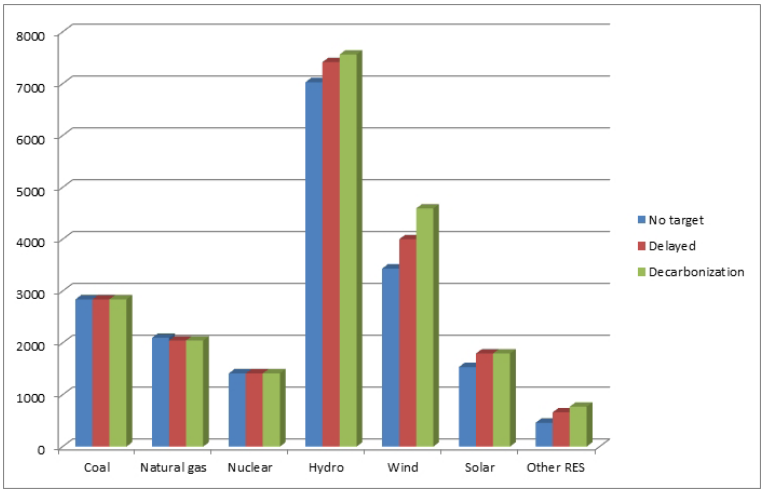

Fig. 3. Projected electric capacity (MW) installed in power plants in Romania in 2025 (no target, delayed, decarbonization scenario).
Own work based on (Szabó et al. 2017)

Rys. 3. Prognozowana moc elektryczna zainstalowana w elektrowniach w Rumunii w 2025 r. (scenariusz: bez celu, opóźniony, dekarbonizacja)

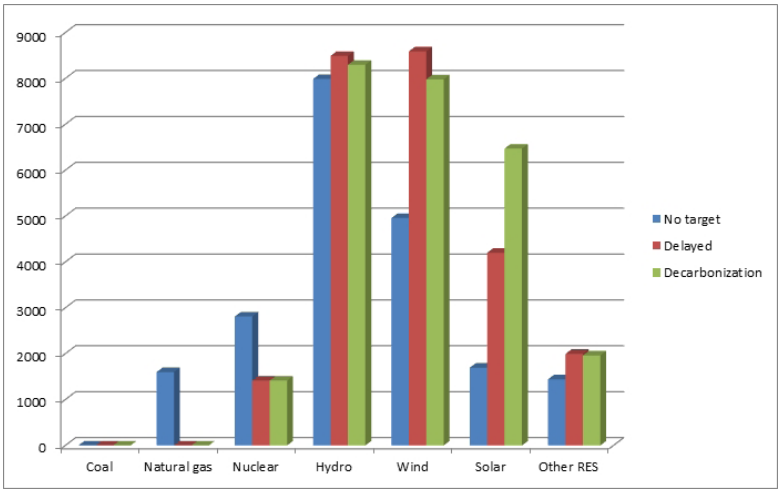

Fig. 4. Projected electric capacity (MW) installed in power plants in Romania in 2050 (no target, delayed, decarbonization scenarios).
Own work based on (Szabó et al. 2017)

Rys. 4. Prognozowana moc elektryczna zainstalowana w elektrowniach w Rumunii w 2050 r. (scenariusz: bez celu, opóźniony, dekarbonizacja)

4.2.2. Crude oil and natural gas sector

As previously mentioned, the national production of crude oil covers about 30% of Romanian demand. In comparison to other European countries in which oil production remains on a marginal or zero level, Romanian oil exploitation allows the country to reduce dependence on imports. As a result of deposits being limited, production will drop in the coming years. This means that Romania will need to look for larger amounts of crude oil on the worldwide markets. In recent years, the major oil suppliers were Russia and Kazakhstan. However, the EU embargo imposed in December 2022 on Russian oil shipped by the sea makes the distribution impossible and its resumption in the near future is highly unlikely. As a result, Russia has lately been replaced by increased import from Kazakhstan, Azerbaijan and Saudi Arabia. There are also high expectations around the potential of the Black Sea shelf, not only for gas but also for crude oil. Unfortunately, the lack of detailed geological research as well as financial limitations mean that all investments facilitating the exploitation of the deposits in the Black Sea are still being postponed.

The strategic aim will be to keep Romanian refineries working in order for production capacity to exceed the needs of the country. Moreover, for many years, their production has not only been targeted at the domestic market but also the international market (neighboring countries in particular). Moldova and Bulgaria are the top two recipients of Romanian petroleum products. In 2022, the main export direction was Ukraine the export of diesel grew from 1,000 to 700,000 tons, petrol – 17,000 to over 200,000 tons (in comparison to 2021). Romania has also become an important transit state for Ukraine. According to the Romanian customs office, in 2022 more than 152,000 tons of fuel were transported to Ukraine through Romania (in 2021, it was only 300 tons) (Bălășoiu 2022). Romanian refineries use crude oil mostly delivered through two oil terminals located on the coast of the Black Sea. A key role is played by the oil terminal in Constanța, equipped with a total storage capacity of 1,700,000 m^3 and production capacity which equals 24 mt annually. The second oil terminal, which was opened in 2008, is the Marin Midia floating terminal located around 8 km off the Romanian shore. The investment, which cost 175 million dollars, was financed by Rompetrol. The terminal is connected with crude oil storage facilities next to the Petromidia refinery. This took the load off the Constanța terminal which powered all four refineries with oil up until 2008. In the following years, Marin Midia was revamped and this increased the production capacity to 16 mt per year (Hebda 2019). However, the full potential of Marin Midia is not used – through Marin Midia, only 5 mt of crude oil flows annually. This is why negotiations have been taking place for a few years. It is hoped that 51% of the Marin Midia shares will be taken over by the energy giant China Energy Financials & Company (CEFC). The Chinese are planning to expand the terminal so that it could become the largest distribution hub of crude oil on the Black Sea (a part of the New Silk Road project) (Gheorghe 2017). The raw material would be expected to be delivered to the countries of the Black Sea basin and to Central and Western Europe. It is also reported that the Chinese investment would result in opening other Romanian refineries, with a special focus on Arpechim in Pitești and Rafo in Onești.

Taking into consideration the growing demand for natural gas and own deposits, the Romanians are planning to dynamically expand their infrastructure enabling both gas exploitation and efficient distribution. What seems to be crucial in this context is not only the increasing gas production from the already developed deposits but also making investments into new gas deposits, especially those located in the Black Sea. Therefore, in order to obtain accurate data regarding the amount of existing deposits of natural gas, detailed geological research will be conducted. Additionally, the expansion of the gas pipelines network is a priority – especially those of international significance since they will allow the transmission of the raw material from different directions. Another priority is opening the BRUA interconnector and increasing the capacity of gas transmission to Moldova (Roberts 2018). Creating new connections will allow Romania to not only reach the status of a transit state but also an exporter. For many years, there has also been an urgent need to expand domestic infrastructure because the country has a rather low level of gasification. The lack of access to the gas network makes it impossible to increase the consumption of gas, particularly in the industry sector. What draws attention among various projects is the plan to build a 300-kilometer-long gas pipeline which would connect gas deposits located in the shelf of the Black Sea with a village of Podișor where gas would be sent to the BRUA gas pipeline (the cost would be up to 330 million euros) (EBRD 2018). However, this investment is to a large extent dependent on further decisions regarding energy ventures undertaken on Romanian waters. In 2008, OMV Petrom along with ExxonMobil began exploratory drilling as a part of the project Neptun Deep. By 2016, more than 1.5 billion dollars were invested in the project. As a result, several drillings conducted proved the existence of natural gas deposits (gas fields Domino and Pelican Sud) (OMV 2017). Currently, some preparatory works have been performed in order to specify the location of the gas platforms. Additionally, in 2028 the gas terminal in Constanța is supposed to be open (DPNGTS 2022).

Another important investment for the gas sector in Romania is the international White Stream project. According to this project, a 1200-kilometer-long gas pipeline would transport natural gas from the Caspian states through the Black Sea to Romania and other European countries. The idea of creating a new gas connection first appeared in 2005, but in the following years, few actions were taken to realize the project (Vashakmadze 2009). Opening TANAP and Turkish Stream substantially decreased the possibility of building the White Stream gas pipeline. Therefore, the project stands no chance of success without the involvement of the EU and Azerbaijan.

Conclusion

When it comes to power engineering, Romania is a stable state, which ensures energy security. Such a varied energy mix is a result of Romania's huge potential. These are not only rich deposits of lignite but also natural gas and crude oil. Additionally, there is a potential lying in hydropower and other sources of renewable energy which started being

used only recently. The major goal for Romania is decarbonization and the switch into more advanced gasification with the use of own gas. A complete withdrawal from coal or a significant reduction in its consumption is expected to happen by 2032. It is predicted that the production of gas will remain stable so that the demand is covered at the highest possible level. Consequently, within the next few years, Romanian gas and oil deposits will be dynamically exploited. Another key element for the Romanian strategy is the expansion of the nuclear power plant, the production capacity of which is to be doubled, mostly due to decarbonization and the technological possibilities of the Cernavodă nuclear power plant.

Romania is not only an energy producer but also a transit state whose capabilities in that regard are not fully exploited. Currently, the transport of the energy raw materials and electricity takes place using the traditional corridor from north to south; however, there is definitely a scope for expansion into a westerly direction (mostly gas and oil transit but also electricity). The biggest challenge for the Romanian energy sector is the revamping of the transmission grids and power plants. Therefore, it will be crucial to synchronize all the investments well – shutting down coal-fired power plants and replacing them with new gas or RES units. Furthermore, a significant part of the investments is being performed by international investors so it is important to base the cooperation on favorable terms for Romania. In this matter, the growing influence of Chinese energy giants is becoming visible. What clearly poses a threat to the energy stability of Romania is the political, economic and social uncertainty of Ukraine and Moldova.

Fossil fuels, meaning coal, crude oil and natural gas are crucial for the energy security of Romania and their roles in the energy transition are varied. Coal, which was a fundamental source of energy a decade ago, will only be used over the next few years. It is likely that the coal sector will be completely shut down at the beginning of the twenty-thirties. One should remember that in that regard, Romania is bound by EU climate law (as are other member states). The situation in the gas sector seems a bit unclear, mostly because of the Russian aggression against Ukraine. Initially, gas was supposed to be the so-called bridge fuel during the process of decarbonization but right now, there is a visible trend in the EU to exclude gas much quicker than was planned. Despite this fact, Romania mostly replaces coal-fired power plants with gas units. They also invest in the development of gas infrastructure (domestic and international transmission, gasification of households). The consumption of natural gas will definitely be on rise in the next few years because Romania does not have alternative short-term solutions regarding decarbonization. When it comes to the crude oil sector, oil exploitation is predicted to be finished by around the year 2040. However, this does not mean that its production potential will be diminished. The strategic location of Romania along with the already existing infrastructure (oil terminals, oil pipelines, refineries) offers huge possibilities to produce petroleum products and to transport them to neighboring countries. Furthermore, the significance of hydrocarbons in Romania will depend on the use of the Black Sea deposits and actions taken by international investors.

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REFERENCES

ANRE 2021. *Report on the results of monitoring the natural gas market in December 2021 (Raport privind rezultatele monitorizării pieței de gaze naturale* în *luna decembrie 2021)*. București: Autoritatea Națională de Reglementare în domeniul Energiei (*in Romanian*).

Antal, C. and Rosca, M. 2008. *Current Status of Geothermal Development in Romania*. Reykjavik: United Nations University. Geothermal Training Programme, 8 pp. [Online:] https://orkustofnun.is/gogn/unu-gtp-30-ann/UNU-GTP-30-44.pdf [Accessed: 2023-05-01].

Bălășoiu, F. 2023. *România, cel mai mare furnizor de combustibil pentru Ucraina. Aproape un milion de tone livrate* în *2022*. [Online:] https://stirileprotv.ro/stiri/actualitate/romania-cel-mai-mare-furnizor-de-combustibil-pentru-ucraina-aproape-un-milion-de-tone-livrate-in–2022.html [Accessed: 2023-05-01].

BGEN 2022. *Romania sells decommissioned Mintia coal power plant*. Balkan Green Energy News. [Online:] https://balkangreenenergynews.com/romania-sells-decommissioned-mintia-coal-power-plant/ [Accessed: 2023-05-01].

BP 2022. *BP Statistical Review of World Energy 2022*. London: British Petroleum, 58 pp. [Online:] https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review–2022-full-report.pdf [Accessed: 2023-05-01].

Branoiu et al. 2016 – Branoiu, G.A., Frunzescu, D. and Stoicescu M. 2016. *Application of advanced mineralogical techniques to reservoir rocks characterization for an oilfield in South-East Romania*. Sofia: 16th International Multidisciplinary Scientific Geoconference SGEM 2016, Science and Technologies in Geology, Exploration and Mining Conference Proceedings, Oil and Gas Exploration, pp. 33–40.

Chirila, N. 2013. *Renewable Energy in Romania*. București: Flanders Investment & Trade, 56 pp.

Ćorović et al. 2022 – Ćorović, N., Gvozdenac Urošević, B. and Katić, N. 2022. Decarbonization: Challenges for the electricity market development – Serbian market case. *Energy Reports* 8, pp. 2200–2209, DOI: 10.1016/j.egyr.2022.01.054.

Cirstea et al. 2018 – Cirstea, S.D., Martiș, C.S., Cirstea, A., Constantinescu-Dobra, A. and Fülöp, M.T. 2018. Current Situation and Future Perspectives of the Romanian Renewable Energy. Energies 11(12), pp. 1–22, DOI: 10.3390/en11123289.

DPNGTS 2022 – *Development plan for the National Gas Transmission System 2022–2031*. SNTGN Transgaz SA Medias, 112 pp.

Dragomir et al. 2016 – Dragomir, G., Șerban, A., Năstase, G. and Brezeanu. A.I. 2018. Wind energy in Romania: A review from 2009 to 2016. *Renewable and Sustainable Energy Reviews* 64, pp. 129–143, DOI: 10.1016/j.rser.2016.05.080.

EBRD 2018 – *Podișor Pipeline: Execution of the gas transmission pipeline Black Sea Coast – Podișor*. European Bank for Reconstruction and Development. [Online:] https://www.ebrd.com/work-with-us/procurement/p-pn-190802b.html [Accessed: 2023-05-01].

Fay et al. 2015 – Fay, M., Hallegatte, S., Vogt-Schilb, A., Rozenberg, J., Narloch, U. and Kerr, T. 2015. *Decarbonizing Development. Three Steps to a Zero-Carbon Future*, Washington: World Bank Group, 164 pp.

Frilingou et al. 2023 – Frilingou, N., Xexakis, G., Koasidis, K., Nikas, A., Campagnolo, L., Delpiazzo, E., Chiodi, A., Gargiulo, M., McWilliams, B., Koutsellis, T. and Doukas, H. 2023. Navigating through an energy crisis: Challenges and progress towards electricity decarbonisation, reliability, and affordability in Italy. *Energy Research & Social Science* 96, pp. 820–846, DOI: 10.1016/j.erss.2022.102934.

Gheorghe, G. 2017. *KMG International plans to transform Midia Marine Terminal in major Black Sea energy hub*. Business Review. [Online:] https://business-review.eu/news/kmg-international-plans-to-transform-midia-marine-terminal-in-major-black-sea-energy-hub-141453 [Accessed: 2023-05-01].

Gușilov, E. 2014. *Romania's Natural Gas Infrastructure*, Bucharest: Romania Energy Center, 8 pp.

Gușilov, E. 2018. *Tracking Romania's cross-border gas cooperation*, Bucharest: Romania Energy Center, 10 pp.

Hebda, W. 2019. *Politics and energy sector in the selected countries of Southeast Europe (Serbia, Croatia, Bulgaria, Greece, Romania)* (*Polityka oraz sektor energetyczny w wybranych państwach Europy Południowo – Wschodniej (Serbia, Chorwacja, Bułgaria, Grecja, Rumunia)*, Kraków: Księgarnia Akademicka, 202 pp. (*in Polish*).

Hebda, W. 2021. Decarbonization of the energy sector in Greece – is Greek coal mining over? *Polityka Energetyczna – Energy Policy Journal* 24(1), pp. 49-66, DOI: 10.33223/epj/133420.

Hebda, W. 2022. Energy Policy of Poland until 2040. The Challenges and Threats to Energy Security in the Next Two Decades. *Politeja* 19, 4(79), pp. 167–186, DOI: 10.12797/Politeja.19.2022.79.10.

Iancu, J. 2018. *Biomass energy in Romania and the new target of 32%*. Energy Industry Review. [Online:] https://energyindustryreview.com/renewables/biomass-energy-in-romania-and-the-new-target-of-32/ [Accessed: 2023-05-01].

IREA 2020. *Global renewables outlook: energy transformation 2050*, Abu Dhabi: International Renewable Energy Agency, 54 pp.

KOBiZE 2019. *Calorific values and CO_2 ratios in 2016 for reporting under the Emissions Trading Scheme for 2019 (Wartości opałowe (WO) i wskaźniki CO_2 (WE) w roku 2016 do raportowania w ramach Systemu Handlu Uprawnieniami do Emisji za rok 2019)*. Krajowy Ośrodek Bilansowania i Zarządzania Emisjami. [Online] https://www.kobize.pl/uploads/materialy/WO_i_WE_do_monitorowania-ETS–2019.pdf [Accessed: 2023-05-01] (*in Polish*).

Koltsaklis et al. 2020 – Koltsaklis, N.E., Dagoumas, A.S., Seritan, G. and Porumb, R. 2020. Energy transition in the South East Europe: The case of the Romanian power system. *Energy Reports* 6, pp. 2376-2393, DOI: 10.1016/j.egyr.2020.07.032.

Malec, M. 2022. The prospects for decarbonisation in the context of reported resources and energy policy goals: The case of Poland. *Energy Policy* 161, DOI: 10.1016/j.enpol.2021.112763.

Maruf, M.N.I. 2021. Open model-based analysis of a 100% renewable and sector-coupled energy system–The case of Germany in 2050. *Applied Energy* 288, DOI: 10.1016/j.apenergy.2021.116618.

ME 2022. *Romania's Energy Strategy 2022–2030, with the perspective of 2050 (Strategia Energetică a României 2022–2030, cu perspectiva anului 2050)*. București: Ministerul Energiei, 72 pp. (*in Romanian*).

Mindeková et al. 2022 – Mindeková, T., Bart, I., Csernus, D., Kassenberg, A., Gavalcová, A. and Oravcová, V. 2022. *Decarbonisation and Just Transition in the V4: Experiences of the Visegrad countries*. Staré Město: EUROPEUM Institute for European Policy, 37 pp.

MOR 2021. *Decision no. 1.076 of October 4, 2021 for the approval of the National Integrated Plan in the field of energy and climate change 2021–2030 (Hotărâre nr. 1.076 din 4 octombrie 2021 pentru aprobarea Planului național integrat* în *domeniul energiei* și *schimbărilor climatice 2021–2030)*. Monitorul Oficial al României nr. 963, 8.10.2021. (*in Romanian*).

MOR 2022. *Decision no. 1.573 of December 28, 2022 regarding the approval of the postponement of the closure of some energy capacities operating on lignite and their related mining operations (Hotărâre nr. 1.573 din 28 decembrie 2022 privind aprobarea amânării* închiderii *unor capacități energetice cu funcționare pe lignit* și *a exploatărilor miniere aferente acestora)*. Monitorul Oficial al României nr 1272, 29.12.2022 (*in Romanian*).

MOR 2022a. *Substantiation Note – OUG nr.108/30.06.2022 (Nota de Fundamentare – OUG nr.108/30.06.2022)*. Guvernul României, Monitorul Oficial al României nr 659, 01.07.2022 (*in Romanian*).

MSCP 2022. *The World Nuclear Industry Status Report 2022*. Paris: A Mycle Schneider Consulting Project, pp. 351–352.

Năstase et al. 2017 – Năstase, G., Șerban, A., Năstase, A.F., Dragomir, G., Brezeanu, A.I. and Iordan, N.F. 2017. Hydropower development in Romania. A review from its beginnings to the present. *Renewable and Sustainable Energy Reviews* 80, pp. 297–312, DOI: 10.1016/j.rser.2017.05.209.

Nocoń, A. 2022. Towards climate neutrality in mining and energy companies in Poland – an approach to their financing. *Gospodarka Surowcami Mineralnymi – Mineral Resources Management* 38(4), pp. 69–89, DOI: 10.24425/gsm.2022.143631.

NuScale 2023. *NuScale Power and RoPower Announce Signing of the Contract for Phase 1 of Front-End Engineering and Design Work for First SMS Power Plant in Romania*. NuScale Power. [Online:] https://www.

nuscalepower.com/en/news/press-releases/2023/nuscale-and-ropower-announce-signing-of-the-contract-for-phase-1-engineering-and-design-work [Accessed: 2023-05-01].

OMV 2017. *Neptun Deep Exploration*. OMV Petrom. [Online] https://www.omvpetrom.com/en/our-business/exploration-and-production/neptun-deep [Accessed: 2023-05-01].

Pachiu, L. and Mustaciosu, R. 2020. Oil and gas regulation in Romania: overview. *Thomson Reuters Practical Law*. [Online] https://uk.practicallaw.thomsonreuters.com/2-566-0966?transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1 [Accessed: 2023-05-01].

Papatulica, M. 2014. Arguments pro and against shale gas exploitation worldwide and in Romania. *Procedia Economics and Finance* 8, pp. 529–534, DOI: 10.1016/S2212-5671(14)00124-5.

Pene et al. 2006 – Pene, C., Niculescu, B. and Coltoi, O. 2006. *Geological conditions of the oil and gas generation, migration and accumulation in the Moesian Platform (Romania)*. SEG Technical Program Expanded Abstracts, pp. 661–665.

RERA 2021 – *Electricity market monitoring report – December 2021*. Bucharest: Romanian Energy Regulatory Authority, 25 pp.

Roberts, J.M. 2018. The Significance of BRUA. [In:] *Three Pipelines and Three Seas: BRUA, TAP, the IAP and Gasification in Southeast Europe*. Atlantic Council, pp. 7–11.

Rusu et al. 2021 – Rusu, E., Onea, F. and Yildirir V. 2021. *Wind condition analysis and partial repowering concept for Fantanele-Cogealac Onshore Project*. Albena: 21st International Multidisciplinary Scientific GeoConference SGEM 2021, pp. 127–136.

Siddi, M. 2022. Assessing the European Union's REPowerEU plan: Energy transition meets geopolitics. *Finish Institute of International Affairs Working Paper* 130, pp. 4–12.

Ștefănescu, M. 2022. *The European ecological pact: opportunities and challenges for the sustainable development of Romania (Pactul ecologic european: oportunități și provocări pentru dezvoltarea sustenabilă a României)*. București: Institutul European din România, 117 pp. (*in Romanian*).

StepMap 2012 – *Gas Storage in Romania*. StepMap. [Online:] https://www.stepmap.com/map/gas-storage-in-romania-Ki23wCaQb8 [Accessed: 2023-05-01].

Szabó et al. 2017 – Szabó, L., Mezősi, A., Pató, Z., Kelemen, A., Resch, G., Liebmann, L. and Kácsor, E. 2017. *Romania Country report South East Europe Electricity Roadmap*, 52 pp.

Tomescu et al. 2022 – Tomescu, C., Cioclea, D., Boanta, C. and Morar, M. 2022. *Restructuring of coal mining in Romania between the climate crisis and the energy transition*. MATEC Web of Conferences 354, 10 pp.

Vashakmadze 2009. *The White Stream gas transportation project – a project to deliver Caspian gas to the EU*. Amsterdam: Energy Charter Secretariat Group on Trade and Transit, 25 pp.

Yue et al. 2020 – Yue, X., Patankar, N., Decarolis, J., Chiodi, A., Rogan, F., Deane, J.P. and O'Gallachoir, B. 2020. Least cost energy system pathways towards 100% renewable energy in Ireland by 2050. *Energy* 207, 17 pp., DOI: 10.1016/j.energy.2020.118264.

Zachmann et al. 2021 – Zachmann, G., Holz, F., Roth, A., McWilliams, B., Sogalla R., Meissner, F. and Kemfert, C. 2021. *Decarbonisation of Energy. Determining a robust mix of energy carriers for a carbon-neutral EU*. Bruegel: Policy Department for Economic, Scientific and Quality of Life Policies, 128 pp.

FOSSIL FUELS IN THE ENERGY TRANSITION – THE CASE OF ROMANIA

Keywords

fossil fuels, energy transition, decarbonization, Romania

Abstract

Nowadays, one of the biggest challenges faced by EU countries is the pursuit of zero-emission economies. Certainly, it is crucial to determine the role of fossil fuels in the energy transformation. In light of the European Green Deal, EU countries should cease the consumption of hydrocarbons, i.e. coal, crude oil and natural gas, by 2050. Nevertheless, there are significant differences regarding the possibility of decarbonizing the energy sectors of the different EU Member States. For many years, Romania has been successively implementing an energy transformation, the main goal of which is the significant reduction of fossil fuels in the energy mix. Just a few years ago, one of the most important energy resources was coal, which is to be eliminated within the next decade. However, a much greater challenge is the reduction and subsequent abandonment of natural gas and crude oil. The key task facing Romania is to ensure energy security, which is why decarbonization will be strongly coupled with the country's economic and political capabilities. The exclusion of fossil fuels in power engineering means that there is a need to develop alternative generation capacities, in particular in nuclear, wind and solar energy. This article presents the current condition of the energy sector in Romania, with a particular emphasis on the role of fossil fuels in its transformation. An analysis of documents and field research shows that there will be a dynamic decarbonization in the coming years, which will result in a significant reduction in the consumption of fossil fuels. The priority of Romania's energy policy is to achieve a zero-emission economy, but ensuring stability and security in the energy sector will be of key importance in this process.

PALIWA KOPALNE W TRANSFORMACJI ENERGETYCZNEJ – PRZYPADEK RUMUNII

Słowa kluczowe

paliwa kopalne, transformacja energetyczna, dekarbonizacja, Rumunia

Streszczenie

W obecnych czasach jednym z większych wyzwań, przed jakimi stoją państwa Unii Europejskiej, jest dążenie do zeroemisyjności gospodarek. Z pewnością w tym zakresie kluczowe pozostaje określenie roli paliw kopalnych w transformacji energetycznej. W świetle europejskiego zielonego ładu państwa UE do 2050 r. powinny zrezygnować z konsumpcji węglowodorów, tj. węgiela, ropy naftowej czy gazu ziemnego. Niemniej zauważalne są duże dysproporcje co do możliwości dekarbonizacji sektora energetycznego poszczególnych państw członkowskich UE. Rumunia od wielu lat sukcesywnie dokonuje transformacji energetycznej, której zasadniczym celem jest wydatna redukcja

paliw kopalnych w miksie energetycznym. Jeszcze kilka lat temu jednym z ważniejszych surowców energetycznych był węgiel, który w perspektywie najbliższej dekady zostanie całkowicie wyeliminowany. Natomiast zdecydowanie większym wyzwaniem będzie redukcja, a następnie rezygnacja z gazu ziemnego oraz ropy naftowej. Kluczowym zadaniem, przed jakim stoi Rumunia, jest zapewnienie bezpieczeństwa energetycznego, dlatego też dekarbonizacja będzie silnie sprzężona z możliwościami gospodarczo-politycznymi państwa. Wykluczenie paliw kopalnych w elektroenergetyce wiąże się z koniecznością rozwoju alternatywnych mocy wytwórczych, w szczególności w energetyce jądrowej, wiatrowej oraz solarnej. W artykule zaprezentowano obecną kondycje sektora energetycznego Rumuni ze szczególnym naciskiem na miejsce paliw kopalnych w jej transformacji. Analiza wskazuje, że w okresie najbliższych lat dokona się dynamiczna dekarbonizacja, której efektem będzie znaczna redukcja konsumpcji paliw kopalnych. Priorytetem polityki energetycznej Rumunii jest osiągnięcie zeroemisyjnej gospodarki, niemniej kluczowe w tym procesie będzie zapewnienie stabilności i bezpieczeństwa w sektorze elektroenergetycznym.