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HARD COAL AS A NECESSARY ENERGY RESOURCE IN POLAND

The geopolitical situation in Europe has changed dramatically due to the war waged by the Russian Federation in Ukraine. This makes it necessary to become independent from supplies of mineral resources, especially energy from Russia. According to the authors, ensuring Poland's energy security will require a longer use of coal as the primary energy resource than initially expected. The expected increase in energy demand may cause a negative energy balance in the country. Renewable energy sources dependent on weather conditions cannot with certainty ensure energy security. On the other hand, nuclear requires large financial outlays and a longer time for reactors' construction. In addition, it has other disadvantages (the problem of waste, environmental impact in the event of a malfunction and the need to import uranium). In these circumstances, coal may be a raw material that meets the economic needs and ensures the energy security of the country.

Keywords: energy resources; hard coal; energy security

1. Introduction

The economic development of countries around the world is possible only on the basis of mineral resources. These are divided into:

- energy resources (e.g. hard coal, lignite, crude oil, natural gas, uranium ores),
- metal ores (e.g. copper, zinc, lead, silver and iron),
- chemical raw materials (e.g. rock salts and potassium salts, sulphur, gypsum, phosphates),
- waters: mineral, medicinal, brine and thermal,
- rock materials (e.g. sand, gravel, limestone, granite, basalts).

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The activity of mines of various raw materials is supervised by the Mining Offices. According to the State Mining Authority [1], at the end of 2020, under its jurisdiction were as follows:

- 37 underground mines, including hard coal mines: 21 active, 1 under construction and 8 in liquidation, 3 copper ore mines, 1 zinc and lead ore mine (decommissioned in December 2020), 1 salt mine, 1 gypsum and anhydrite mine and 1 brine mine. The underground mines employed 87,566 people.
- 7,361 open-pit mines, including 10 mines extracting mineral resources from deposits covered by mining ownership (5 active lignite mines) and 7,351 mines extracting raw materials from deposits covered by the ownership of land (mainly rock materials). Open-pit mines employed a total of 28,540 people.
- 96 borehole mining plants, extracting crude oil and natural gas – 8, methane – 3, salt – 2, sulphur – 2, medicinal, thermal and brine waters – 78, as well as 2 underground natural gas storage facilities and 1 underground landfill site.

Mining in Poland and especially in Silesia is associated with hard coal which, as can be seen from the above information, is fundamentally wrong. Mineral resources are used in all sectors of the economy, which confirms the validity of Max Planc's view expressed in the sentence: "Mining is not everything, but everything without mining is nothing."

The role, situation and prospects of the Polish mining industry are comprehensively presented in the work [2] and energy at work [3]. The purpose of this article was not to show the already-known truth about the role of mining in the modern economy. The authors intended to provoke a discussion on the possibility of using energy resources and renewable energy sources to ensure Polish energy security.

2. General characteristics of the energy sector in Poland

2.1. Current state

The Polish energy sector is based on hard coal and lignite. Fig. 1 shows the percentage share of individual energy sources in 2021.

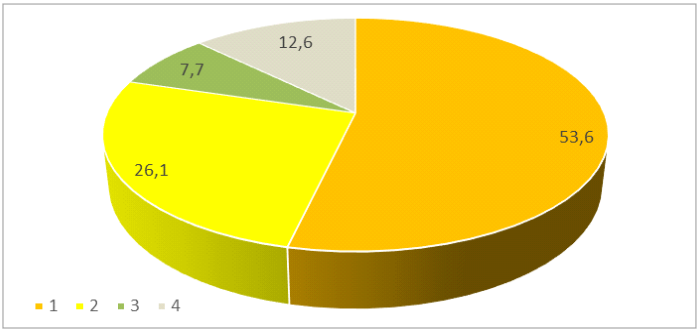

Fig. 1. Percentage share of individual energy sources in 2021 in Poland [4].
1. Power plants producing energy by combustion of hard coal; 2. Power plants producing energy by combustion of lignite; 3. Gas power plants; 4. Renewable energy sources (water, wind and photovoltaics)

As seen in Fig. 1, the combustion of lignite and hard coal generates, on average, 79.7% of energy in Poland. This is related to the presence of rich coal deposits in Poland, the low cost of coal-based energy production and certain socio-political or historical conditions. However, due to the turmoil caused by the war in Ukraine in the first quarter of 2022, Poland produced 91.3% of its electricity from fossil sources and only 8.3% from renewable sources. In recent years, the issue of the impact of these power plants on the environment related to the emission of greenhouse gases, especially CO_2, has been raised more and more distinctly. Despite meeting the emission requirements resulting from national and EU regulations on environmental protection, high CO_2 emissions mean that these power plants are burdened with very high costs of the EU ETS system [5]. Globally, 61.3% of the power (32.9 MW) was installed in coal power plants [4]. These power plants produce 138.4 TWh. To a lesser extent, the power installed in the National Power System was based on the following sources:

- wind and other renewable power plants (mainly photovoltaic installations): 15.1 GW, i.e. 28.1%,
- gas power plants: 3.3 GW, i.e. 6.1 %,
- hydropower plants: 2.4 GW, i.e. 4.5 %.

The above data is presented graphically in Fig. 2.

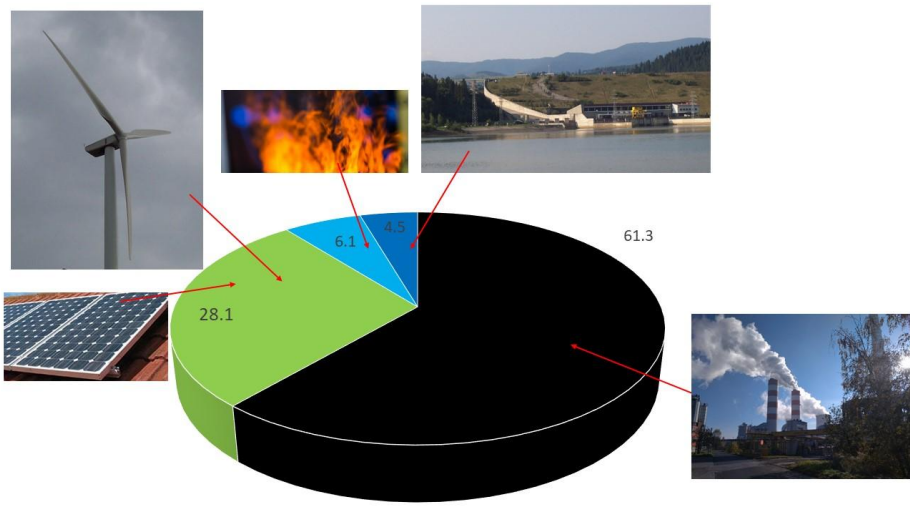

Fig. 2. Installed power in particular types of power plants

2.1. Planned transformations of the energy sector in Poland

In February 2021, the government of our country approved the "Energy Policy of Poland until 2040". The implementation of the energy policy takes into account the goals set by the European Union and Polish commitments related to the reduction of CO_2 emissions. This document defines the government's planned activities in the field of transforming the energy sector and the directions of changes in the so-called "energy mix". It is assumed that electricity generation in high-emission coal-fired units will be phased out while increasing the share of energy production

from low and zero-emission sources. The content of this document shows that domestic coal resources will remain a significant element of the Polish "energy mix", but the increase in energy demand will be covered by units other than conventional coal installations. Namely, it is planned:

- increase electricity production from renewable energy sources,
- greater use of gas as a transition fuel,
- construction of six nuclear units is planned, with the first unit scheduled for launch in 2033, followed by new units commissioned every 2-3 years.

It is estimated that the scale of investment outlays related to the energy transformation in 2021-2040 may reach approx. PLN 1.6 trillion [5]. Hard coal will be used for the longest time in power plants commissioned in recent years because these power plants are characterised by lower emissions and more efficient use of fuel. Each of them is built in the CCS-ready formula – ready to capture, transport and store CO_2. The Polish Energy Policy until 2040 assumes that in 2030, the share of coal in electricity generation will not exceed 56% (26.4 million Mg). According to a less optimistic scenario for coal mining, only 37% (14.7 million Mg) – Fig. 3. For comparison, in 2021, this share was as much as 79.7% [5].

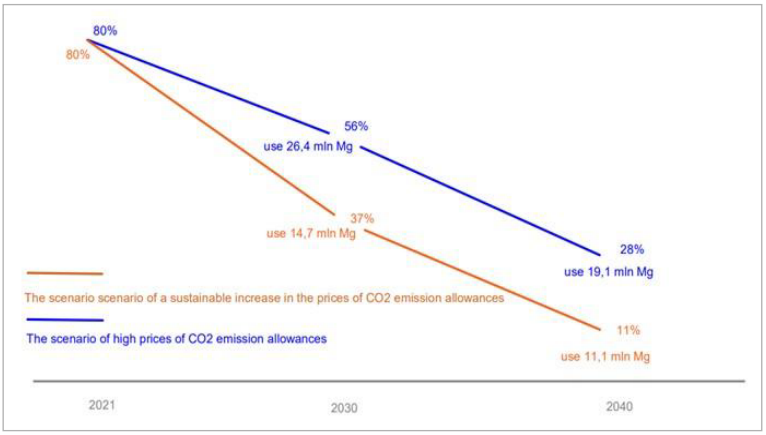

Fig. 3. Share of coal in energy production in 2021-2040 [6]

In the decade 2030-40, there will be a significant increase in the share of production from renewable sources [6]:

- power installed in photovoltaics is expected to amount to approx. 5-7 GW in 2030 and approx. 10-16 GW in 2040.
- offshore wind energy is expected to reach power of approx. 5.9 GW in 2030 and approx. 11 GW in 2040.

It should be noted that the conditions for obtaining solar energy in Poland differ significantly from those in southern European countries. During the spring and summer seasons, they are at their best. – then about 80% of the total annual energy is obtained [7]. The average annual amounts of energy per 1 m^2 of the area of Poland vary (approx. 1000 kWh/m^2) – Fig. 4 [8]. As can be seen, the best conditions are in Roztocze Lwowsko-Lubelskie, where the amount of energy per

unit of area is the largest (approx. 1200 kWh/m^2), and the worst in the northern part of Poland and the south – approx. 900 kWh/m^2).

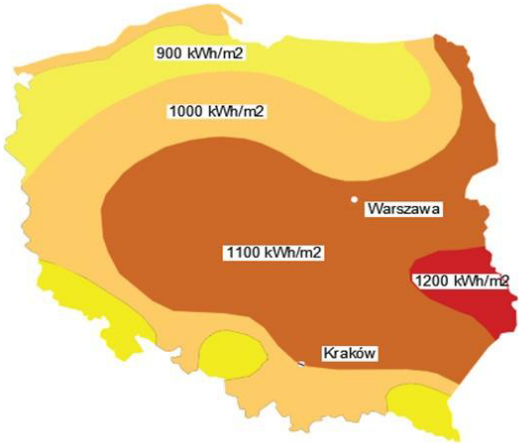

Fig. 4. Average annual amounts of solar energy per area unit [8]

There is also a certain diversification of conditions conducive to obtaining wind energy. Fig. 5 shows the conditions in different parts of Poland. Therefore, not all parts of the country can obtain energy sufficiently and efficiently.

Fig. 5. Map of wind conditions in Poland [9].
The wind zone: 1 – the excluded areas, 2 – the very unfavourable areas, 3 – the unfavourable areas, 4 – the quite favourable areas, 5 – the favourable areas, 6 – the highly favourable areas

According to [6], the commissioning of the first unit with power of 1-1.6 GW, the first nuclear power plant, is scheduled for 2033. In the following years, it is planned to launch another five such units at intervals of 2-3 years. These dates result from the power balance in the national power system. Without additional investments in new energy sources, it is precisely at this time that further losses will occur in covering the increase in power demand resulting from the exploitation of existing generation units, especially coal-fired ones [6]. Construction of the first nuclear unit should start no later than in 2026, and by 2043, 6-9 GW of power should be launched. The detailed schedule and implementation activities are specified in the Polish Nuclear Energy Program [6].

This program assumes investment outlays in the years 2020-2045 at the level of approximately PLN 105 billion. It should be noted that the average construction time of a nuclear reactor from its commencement is approximately 8 years [10]. Analysing the time required for construction, it can be seen that it has practically not changed over the last 30 years. Therefore, it is difficult to be optimistic about shortening the time needed to implement such investments, although, on the other hand, in Japan, reactors have been built in about 4 years [10]. Construction of a reactor in Argentina took 33 years due to financial difficulties. Some hopes are raised by the construction of SMR reactors, which, thanks to their small size, can be fully delivered to a workplace. They can also be combined into modules to obtain more power. One reactor can generate 77 MW [11]. The portal energetyka24.pl reported that the cost of 4 reactors is USD 1 billion [12]. The transition of the economy to nuclear energy also creates some problems that should be kept in mind. These include the problem of disposal (storage) of radioactive waste, ecological disasters in the event of a failure, or dependence on imported raw materials. Renewable energy sources are very attractive due to their inexhaustibility. Their disadvantage, however, is their high dependence on weather conditions over which we have no influence. Hence, it is difficult to assume that they will provide full energy coverage. The extraction of natural gas in Poland does not allow for independence from supplies from abroad, as it covers only about 16% of the demand [13]. The demand for energy in Poland is constantly increasing. In the 20th century, demand peaked in autumn and winter. Currently, due to global warming, there are two peaks of demand each year: winter and summer, so in periods of low and high temperatures (common use of air conditioning). The demand peaks were [4]:

- in January – February: approx. 27 GW,
- in May: approx. 22 GW,
- in July: approx. 24 GW,
- in September: approx. 22 GW,
- in November: approx. 26 GW.

Domestic energy demand in 2021 amounted to 174.4 TWh, and according to EPP2040, it will increase by 1.5% annually, reaching 199.4 TWh in 2030 and 231 TWh in 2040 [6]. Considering the fact that the Polish energy sector is currently based mainly on hard coal and lignite, it is worth analysing the situation of coal mining, especially hard coal mining.

3. Current state of hard coal mining

In the last 10 years, hard coal mining in Poland has been steadily decreasing [14]. In 2020 and 2021, it was lower by approx. 25 million Mg than in 2012 – Fig. 6 [15]. Domestic hard coal

mining does not cover the demand for this raw material, creating the need to import coal. Fig. 7 shows the amount of coal imported in total and imported from the Russian Federation. As can be seen, most of our coal is imported from the Russian Federation. The import peak was in 2018.

In 2020, the amount of coal imported was 12,823 million Mg (9,448 million Mg from the Russian Federation). At the same time, 4,626 million Mg of hard coal were exported. Thus, the shortage of coal on the domestic market amounted to 8,197 million Mg.

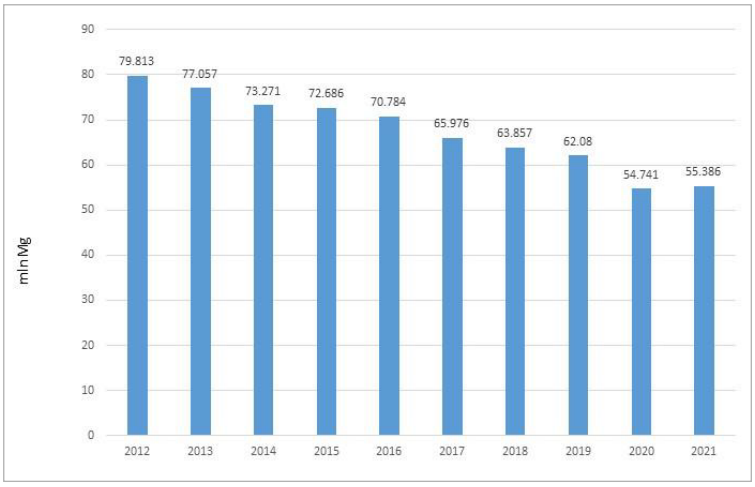

Fig. 6. Hard coal extraction (power and coking coal) in 2012-2021 [15,16]

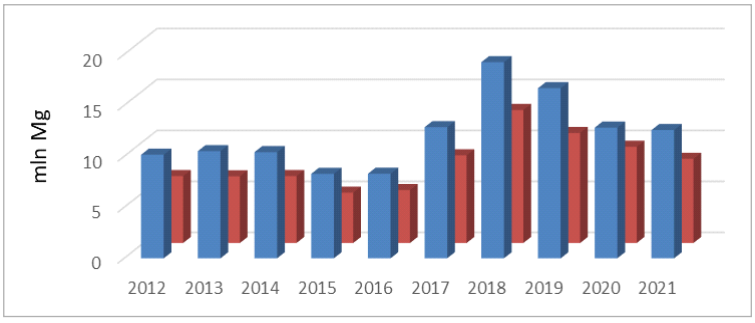

Fig. 7. Hard coal imports in total (blue) and from the Russian Federation (red) in 2012-2021 [15,17]

According to [18], in 2019 78.5 thousand people worked in the hard coal mining industry in Upper Silesia. 94% of them worked in mines, 4% in industrial plants near mines and 2% in company headquarters. Underground workers accounted for 78% of the total number of employees, while supervisors accounted for 17% of the total number of employees. It seems interesting that 73% of supervisory staff are holders of engineer and master's degrees. Employment in the hard coal mining sector at the end of December 2021 amounted to 77.5 thousand people [18]. This number includes employees of companies conducting activities related to hard coal mining and

Spółka Restrukturyzacji Kopalń S.A., which deals with the liquidation of mines and the management of the assets of closed mines. It should also be noted that one job in mining generates 5 jobs in companies cooperating with the mining industry. Extraction of lignite in subsequent years is shown in Fig. 8. As can be seen, there was a decrease in extraction by approx. 20 million Mg in 2020 compared to 2012.

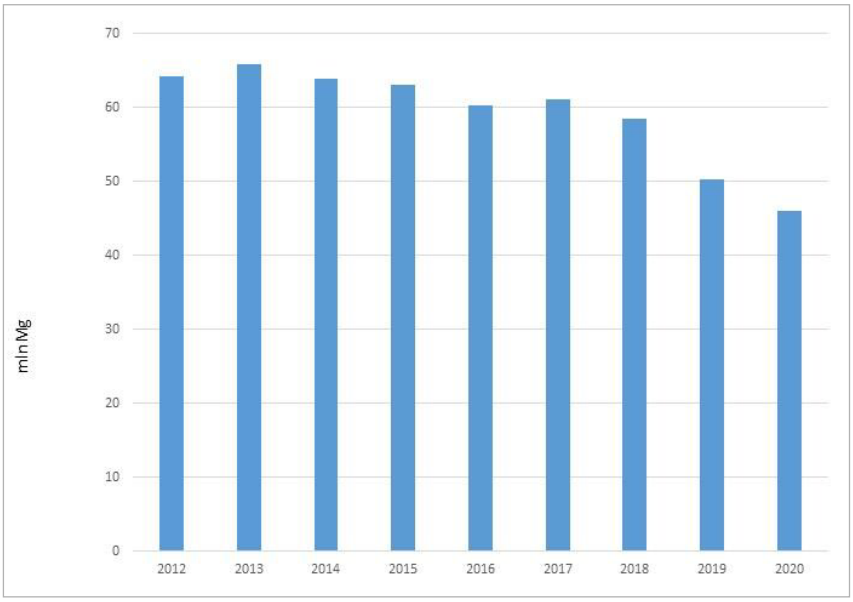

Fig. 8. Lignite mining in 2012-2020 [15]

4. Analysis of the presented material

From the presented statistical data, the following facts are visible:

- Currently, the Polish energy system is based on hard coal and lignite. In 2021, coal power plants produced 138.4 TWh of electricity (79.7%) with an installed power of 32.9 GW. Renewable sources produce 21.8 TWh (12.6%) with a power of 15.1 GW. The energy produced to power ratio is higher in traditional coal power plants than in renewable energy sources. It should be noted that renewable energy generation is dependent on weather conditions, which are beyond our control. With a very probable increase in demand for energy, relying solely on renewable sources will not ensure the energy security of the country. Certainly, more reliable sources of energy should be available as basic sources. Nuclear power plants are more reliable sources of energy. However, attention should be paid to several factors that must be taken into account when planning the extensive use of nuclear energy: high cost and relatively long construction time, the problem of waste disposal, environmental threats and, in the case of Poland, the need to launch a new mine whose extraction capacity could not meet the domestic demand. The latter factor deserves particular attention in connection with the war waged by the Russian Federation

in Ukraine. After all, Russia is the main exporter of uranium to the European market. The use of natural gas as a transition fuel is also problematic for the above reasons. According to PGNIG [13], in 2021, gas sales in Poland amounted to 34.48 billion m^3, and domestic production to 5.39 billion m^3.

- Hard coal and lignite remain. Attention should also be paid to the large amount of hard coal imported from Russia. In this situation, it is worth considering relying on Polish coal (especially hard coal) [19-22]. Of course, the problem of CO_2 emissions remains. However, this problem can be solved by capturing and storing underground. The possibility of coal gasification should also be considered, whether underground (currently considered unprofitable) or on the surface [23, 24]. Further operation of hard coal mines requires solving one more problem, which was pointed out by Tajduś [2] – the problem of having qualified engineering staff. As can be seen from the material presented above, engineering supervisors account for approx. 17% of all employees in the hard coal mining industry. Even with the reduction of extraction by half and the employment of approx. 40,000 people, supervision is about 8.6 thousand people. If about 70% of the supervisors are engineers, then about 5,000 of them will be needed. Taking into account the almost complete liquidation of mining technical schools and the low popularity of mining studies among young people, one can expect large shortages in the employment of this group of employees, especially in the view of lowered retirement age.

5. Summary

The demand for energy in Poland is constantly increasing, on average by approx. 1.5% per year. In the current geopolitical situation, achieving Polish energy independence is of key importance. It requires giving up energy supplies from the Russian Federation. Renewable energy sources do not ensure continuous energy supply and full coverage of the country's demand. Nuclear energy entails high costs and other disadvantages mentioned in this paper. It also requires dependence on supplies of raw materials from abroad. Energy independence can be achieved reliably based on its own raw material base, especially hard coal. In this situation, in the transitional period, increasing the role of coal as a reserve for the national energy system seems to be a necessity. The mining industry, which includes more than just hard coal, plays a crucial role in the development of a country's economy. Therefore, the government should pay special attention to its functioning, as well as ensure that there are enough engineering and technical experts available to support the industry. However, there is a risk of a severe shortage of such staff in the coming years.

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