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The Economic and Social Dimension of Energy Transformation in the Face of the Energy Crisis: The Case of Poland

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Abstract: Energy transformation in Poland, including the need to accelerate the shift away from hard coal and lignite in the power system, has been taking place in the face of the energy crisis. Ambitious climate and economic goals force the development of renewable energy sources, but they require legislative changes for the benefit of socially vulnerable consumers. This is important from the point of view of counteracting energy poverty. Energy transformation is not only a change in the fuel used, but most of all, the path and basis of low-carbon development that changes many socio-economic systems. The aim of this study is to link the development and environmental challenges in the studied subject matter with social challenges. The analyses show that it is necessary to strengthen the use of local energy potential and resources, and to activate local communities. The construction of nuclear power plants is also crucial. The results of the presented theoretical and empirical studies can be the basis for a revision of the energy policy in Poland in the area of the social dimension of the energy sector.

Keywords: energy transition; renewable energy; sustainable development; energy policy; Poland

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1. Introduction

Energy transformation is a very current topic, especially in the situation of excessive use of conventional energy sources (mainly coal) and little use, under particular natural, technical, economic, and social conditions, of the possibility of developing renewable energy sources. Considering the global consumption of fossil fuels, energy transition is a significant issue and challenge in China and India [1–4]. Taking the EU-27 countries as a point of reference, these issues relate to such countries as Poland, the Czech Republic, Bulgaria, and Romania to a significant extent [5–8]. In energy transformation, it is particularly important to change the system, from a centralized to a distributed system, including increasing the importance of prosumers in the electricity market. Energy transformation is a key process in the pursuit of climate neutrality, the basis for determining long-term low-emission development paths in other sectors of the economy. In this sense, the fuel and energy sector and the changes taking place in it are the basis for environmentally friendly development in all sectors of the economy, with a high level of reliability of the electricity supply network, guaranteeing increased competitiveness and the durability of the achieved changes [9,10].

A great deal has been discussed and written about the Polish energy sector in recent years, especially in the context of comparisons with other European Union (EU) countries. The basis for the discussions being undertaken is often the least diversified mix of electricity generation sources in Poland among all EU states. In the context of the most important tasks of public policy, the most important in Poland is the need for energy transformation, which will enable the achievement of the ambitious goals of reducing greenhouse gas emissions and increasing the share of renewable energy sources in electricity generation [11–13]. It is worth emphasizing that the European Union has adopted very ambitious plans for the

transition to renewable energy sources (RES) in its member states [14,15]. This is one of the three main goals of climate policy, along with reducing greenhouse gas emissions and improving energy efficiency [16–18].

The energy transformation mentioned above is identified not only with environmental protection, but also with economic and social development. In Poland, the change in the base of primary energy sources, from fossil fuels (hard coal and lignite) to more ecological energy sources, is associated with many challenges in the legal, technological, and social spheres. Such a transformation began in the 1980s in many European countries. In the literature on the subject, a large number of publications were devoted to the characteristics of energy transformation in Germany (Energiewende) [19–22]. Energy transformation, on the basis of the above-mentioned works, is analysed not only in the context of environmental protection, but also economic and social development. The implementation of similar solutions in the Polish economy must take into account the goals of energy security, competitiveness in the area of the energy market, and climate protection. As emphasized by Jałowiec et al. [23], these goals are often contradictory in practice.

Reducing greenhouse gas emissions through a greater use of low- and zero-emission sources in energy production is undoubtedly the greatest challenge for the energy policy in Poland. The functioning mechanisms and economic instruments, including those relating to the costs of carbon dioxide emissions and trading CO_2 emissions via exchanges, affect the costs of energy purchase by consumers. Huge increases in electricity prices, also resulting from the implementation of the assumptions of energy transformation, make it necessary to increase the activity and extend the scope of competences and responsibilities of the state and public authorities for system solutions in this area. As emphasized by Rabiej-Sienicka [24], society expects cheap electricity, which is always available.

The aim of this paper is to link the development and environmental challenges in the studied subject matter with social challenges. Paying special attention to social aspects is essential from the point of view of optimizing social security (social assistance, family benefits), education, and social services. Analyses in this area are extremely important because the creation of a low-emission energy system requires the transformation not so much of technical systems but of socio-technical systems, including social practices, cultural symbols, and economic networks [25]. This article identifies the positive and negative social consequences of energy transformation in Poland, and includes a description of measures to overcome these barriers and promote energy-saving practices. Thus, this article fills a gap with regard to the social aspects of energy transformation in Poland. This paper articulates the complexities associated with the transition to a low-carbon economy and the need to further explore the various social elements affected at different levels of analysis (local, regional, and national), in order to develop appropriate mechanisms to facilitate the transition. A framework for a holistic and trans- and interdisciplinary research perspective on the low-emission transformation in Poland has been proposed.

This article is divided into several parts. After the introductory part, an outline of the research methodology and information sources is presented. Then, an outline of the energy policy in Poland starting in 1918 (when Poland regained independence) is described. There, particular attention is paid to the use of coal as the basic source of energy production. Further on, the positive and negative social consequences of energy transformation in Poland are presented. The work ends with a summary in which further research directions and research challenges are indicated.

2. Materials and Methods

This paper is an attempt to identify the determinants and social consequences in terms of issues related to the energy transformation of the Polish economy. An attempt at a preliminary, basic, general understanding of this phenomenon takes into account the historical outline, including the centuries-old tradition related to the use of coal in Poland. This is very important because a large number of studies focus on current issues, ignoring the historical background and political and economic foundations of the current situation.

Exploratory research is conducted in order to describe a phenomenon that has been little known so far, and about which there is insufficient information.

The presented review material is based on widely available reliable materials, some of which are of a historical nature. This paper also presents statistical data from the Central Statistical Office in Poland, the ARE S.A. newsletter (the company was established on 24 February 1997 to conduct statistical research and system analyses, including economic simulations in the field of energy management), and PSE S.A. (transmission system operator on the electricity market in Poland). Statistical data on electricity production and consumption enriched the possibilities of interpreting the analysed results. The main time scope of the analyses is 2012–2022. The adopted time range is important from the point of view of capturing the pace of energy transformation in Poland. Since 2012, Poland has experienced a significant increase in installed capacity in power plants and a dynamic development of the renewable energy sector, which is presented in this paper.

3. Poland as a "Coal Island" and an Outline of Energy Policy in Poland (1918–2021)

Poland regained independence in 1918 after 123 years of partitions. From the beginning of the new, sovereign development path, economic growth and development were built on conventional energy sources—coal. In 1918, the territorial borders of Poland included the Dąbrowskie and Krakowskie Basins, and from 1922 the eastern part of the Upper Silesian Basin. The western part of Upper Silesia and the Lower Silesian Basin remained within the borders of Germany (in the Weimar Republic, the Third Reich). Since the end of World War II, as a result of the decision of the anti-Nazi coalition, all the above-mentioned coal basins were in the territory of Poland [26]. Poland also has rich lignite deposits located in central and western Poland (Figure 1). Over 150 deposits and carbon-bearing areas have been identified and documented in Poland. Over 14 billion Mg of resources in certain deposits has been documented, with over 60 billion Mg in estimated resources, and the possibility of occurrence in potentially carbon-bearing areas is estimated at over 140 billion Mg [27,28].

Figure 1. The occurrence of hard coal and lignite deposits in Poland [29].

In the first period after independence, almost 100% of energy was obtained from coal combustion. This period of history is characterized by a significant geographic differentiation (a different degree of development in the three partitions—Russian, Prussian, and Austrian). An important, institutional aspect of the development of the Polish power industry was the passing of the Electricity Act by the Legislative Sejm in 1922. It was one of the most modern, few such acts in Europe [30]. The interwar period was also a time of development of a social organization associating electricians (the Association of Polish Electro-technicians, and from 1928 the Association of Polish Electrical Engineers),

as well as the organization of higher education for the needs of the power industry [30]. The interwar period initiated the construction of social capital in the studied subject matter, which was a very essential aspect considering the further history of Polish statehood. It is worth mentioning the outbreak of World War II and the German occupation, followed by socialism, subordinating the power sector to the goals of a centrally planned economy. The output of hard coal in 1927 reached the record level of 38 084 086 tonnes after the war, while in 1936 the volume of hard coal output in Poland amounted to 29,748 thousand tonnes. The number of active hard coal mines in 1936 was 64, of which 36 deep mines and 3 shallow mines were located in the Śląskie region [31–33].

The post-war reconstruction was associated with an increase in electricity consumption, also for industrial purposes. Poland based its electricity system on coal. Shortly after World War II and during the PRL (Polish People's Republic—the official name of the Polish state in 1952–1989), energy policy was part of the energy policy of Comecon (Council for Mutual Economic Assistance), in which the USSR clearly dominated. The entire period of 1946–1989 coincided with the electrification of the country (including the process of electrification of villages completed in 1979) and the further development of the electricity sector based on hard coal and lignite. Most of the electricity and heat in Poland at that time was generated in coal-fired power plants and heating plants [25]. Moreover, many industrial plants and public utilities had their own coal-fired boiler houses. Until the end of the 1980s, coal mining grew rapidly. In the 1970s and 1980s, Polish coal extraction exceeded 5% of the total global production (higher extraction was only recorded in China, the United States, Germany, and Russia). In 1989, i.e., at the beginning of the political transformation in Poland, the production was recorded at the level of 178 million tonnes [34].

The political transformation in Poland, initiated in 1989, led to the holding of fully democratic parliamentary elections in 1991. The changes after 1989 affected many sectors of the economy, including mining. In 1991, work began on a new Energy Law, which was passed in 1997. From the beginning of the 1990s, there was a gradual process of decentralization and market liberalization. The restructuring of the mining industry was progressing and the economic conditions in the sector were changing; for example, from the beginning of 1995, there was a wholesale electricity market in Poland. There was a gradual inclusion of Poland into the Western European electricity security space. As a result of transformations in the public sphere, including the adoption of political documents and legal solutions directing pro-ecological development, renewable energy was gaining importance. One of the first solutions in this area that did not require costly technological changes was the co-firing of coal and biomass [35–37]. After Poland joined the EU, as a consequence of adopting the provisions of, among other things, climate policy, the importance of renewable energy sources grew. It should be emphasized that in the past 10 years, the amount of installed capacity in power plants in Poland has increased significantly (Table 1).

As of 31 December 2022, the installed capacity in the National Power System (KSE) was 60,446 MW, of which 38 867 were commercial power plants. In 2012–2021, the installed capacity in Polish power plants increased by 53.9%. It is important to emphasize that in the mid-1960s, this power was approx. 10,000 MW, and in the years 2000–2010, it was approx. 35,000 MW.

Wind energy has been one of the main pillars of renewable energy in Poland for many years. In recent years, however, there has been no constant increase in installed capacity, and in 2017–2018, a crisis in this area of renewable energy can be traced. In May 2016, the Distance Act (commonly referred to as anti-windmill) entered into force, which prohibited the construction of wind farms at a distance of less than 10 times the height of a single installation from buildings. Changes in legal regulations resulted in a slowdown or abandonment of investments in wind energy (Figure 2). It is worth emphasizing that changes in legal regulations have limited the intensive development of wind energy at the expense of supporting other technologies (especially agricultural biogas plants).

Table 1. Average annual amounts of achievable power, loads, power losses, and reserves in domestic power plants from daily load peaks on working days in the years 2012–2022 [38].

Specification	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
						[MW]					
Achievable power	37,264	37,749	38,216	38,891	40,491	42,584	43,777	46,299	48,064	50,715	57,357
Load	22,349	22,587	21,937	22,541	22,211	22,569	22,364	21,841	21,023	23,578	23,653
Power reserves	4349	4064	4446	4241	5869	6131	6498	8047	8977	6339	5167
Major and medium repairs	3563	3321	3697	3760	2732	2910	3410	3814	5005	3530	3077
Emergency overhauls	954	1114	1163	1138	1007	1074	921	792	640	1329	1326
Other losses minus overloads and investment start-up	6048	6663	6972	7211	8612	9900	10,581	11,801	12,418	15,939	23,993

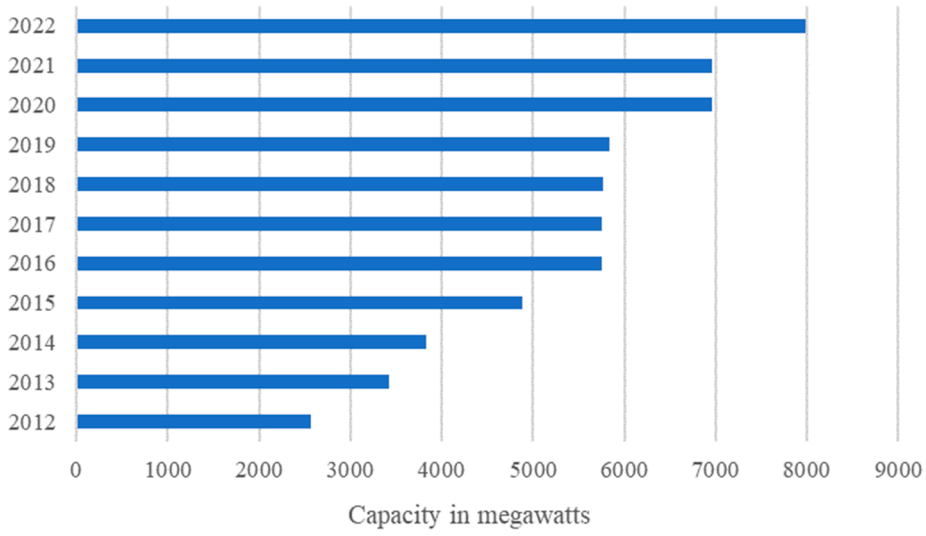

Figure 2. Total installed wind power capacity in Poland in 2012–2022 [39].

In 2022, a total of 80 new onshore wind farms with a capacity of 935.84 MW were installed in Poland. However, this increase concerned projects that received building permits before the introduction of the previously mentioned 10 H rule [40].

The current, strong development of RES in Poland concerns photovoltaics. For example, the installed photovoltaic capacity at the end of 2021 in Poland amounted to 7.67 GW, which means an increase of over 3.7 GW year on year. A very large percentage of this power are photovoltaic micro-installations, i.e., renewable energy installations that do not exceed 50 kW. The main contributor to this was the "My Electricity" government programme. The "My Electricity" programme has contributed to approximately 2 GWp of installed PV capacity in 2019–2021 [41]. The largest RES producer in Poland in 2021 was wind energy (Figure 3).

In 2022, the share of coal in the structure of energy production sources in Poland was 69.21%. In turn, the share of the wind turbines category contributed about 11.02 percent to the power mix, the most of any renewable source.

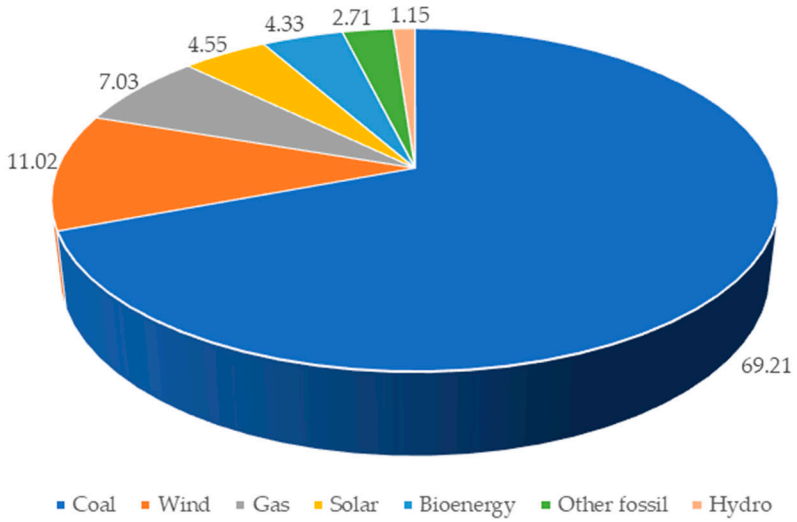

Figure 3. Distribution of electricity generation in Poland in 2022 [42].

4. Social and Economic Consequences of Changes—Prosumer Development, Energy Poverty, etc.

As mentioned in the introduction, the issues of social costs and benefits as well as behavioural changes lie at the heart of the energy transition. The social consequences of energy transformation underlined in this paper are both positive and negative (Table 2).

Table 2. Positive and negative social consequences of energy transformation in Poland.

Positive	Negative
- Activation of pro-ecological activities and development of awareness of a responsible community and social innovation	- Limitation or liquidation of mining and production activities based on hard coal and lignite in the cultural and economic dimension
- New development opportunities for regions and communities related to the transformation of coal regions	- Energy poverty
- Commitment to individual prosumption	- Deepening of the processes of impoverishment and income disparities, a factor disturbing the stability of the social structure
- Changes in the education system (development of new knowledge, skills, and competences) as a consequence of the development of new technologies	- A decline in the income of municipalities in mining areas, and, consequently, a lower investment potential and a decrease in the quality of life of residents

Positive changes in the social sphere, which are a potential consequence of energy transformation in Poland, are primarily the broadly understood social change, which will modify the existing structures, where certain behaviours, habits, or customs will be limited (e.g., the existence of social consent to the use of inappropriate fuels). The shaping of future attitudes towards the necessity to reduce emissions and adapt to a changed climate will be influenced not only by the ability to independently decide on heat sources, thermo-modernization, etc., at the microeconomic level, but also by growing social pressure. The widespread use of renewable energy sources and low-carbon technologies inspires optimism towards the development of modern societies and a sustainable future. Positive social consequences will be associated with changes in the area of energy economy as a whole, in particular the establishment of new roles, models, and techniques in the electricity market (e.g., the role of a prosumer, distributed market model, and smart grids/metering).

Development issues for mining regions are also important and will be phased out as they move away from coal. One should take into account the diverse sensitivity of regions

to energy transformation, which is a derivative of, among other things, the differentiation of the socio-economic situation in Poland in terms of regions. The main issue is to launch programs to support vocational reorientation, as well as changes in the education system. Moreover, economic (investment) incentives for people and companies leaving the mining and conventional energy sectors may work. Changes in spatial management, infrastructure, etc., are important. The modernization of economic structures, both in the extraction and commercial and service units related to fossil fuels, should be followed by the development of modern clean energy technologies. It is necessary to update and/or create new legal regulations (at the central and local government level) that will facilitate the development of green economy and integrate social revitalization with economic revitalization within the energy economy. In Poland, it is necessary to modernize the energy infrastructure, including a thorough modernization of the Polish energy distribution and transmission system. As emphasized by Busch et al. [43], it may be important to strengthen intermediary organizations and provide administrative support to community energy initiatives.

The negative spheres in the study area include the possible increase in energy poverty, i.e., a situation where households cannot afford energy or energy services to ensure basic needs: heating/cooling, cooking, and lighting. According to statistical data and research, the phenomenon of energy poverty is a serious problem in Poland, and a significant percentage of economically poor households are located in rural areas. It is necessary to adopt appropriate protection systems for these households, especially in the event of drastic price increases on the energy market. Additionally, as emphasized by Karpińska and Śmiech [44], households in Poland are also largely exposed to hidden energy poverty (HEP). Their research shows that in 2017, the scale of exposure to HEP in Poland was 23.7%, and this phenomenon is related to income poverty. A great deal of research is being conducted on transition mechanisms and interventions that can help overcome this exclusion, but appropriate institutional structures are needed to coordinate these efforts in practice [45,46].

The phenomenon of energy poverty does not only concern Poland, but most European Union countries. Moreover, apart from economic factors (the ratio of income to energy prices), other elements that may affect the scope and dynamics of energy poverty are also important, e.g., household composition, education level, labour force status, building energy efficiency degree/class, existing heating system, etc. [47–49]. In recent years, Poland has seen significant increases in electricity prices (Table 3).

Table 3. Average price * of electricity for households in Poland [50].

Years	Electricity Price for a Household Consumer Including the Fee for the Provision of Electricity Distribution Services [PLN/kWh]
2022	0.7297
2021	0.5947
2020	0.5374
2019	0.4862
2018	0.5055
2017	0.5046
2016	0.4987
2015	0.5017
2014	0.4927
2013	0.5048
2012	0.5047

* The price includes excise tax and does not include VAT.

According to the data presented, over the years 2012–2022, the retail price of electricity in Poland increased by 44.6%. In the years 2012–2019, a relatively stable price

situation was recorded, and the last three years (especially 2022) have been characterized by sharp increases.

Based on the above findings, important implications for current policies and future research are highlighted. Firstly, further increases in electricity prices in Poland will deepen the problems related to energy poverty and may result in social dissatisfaction with regard to the direction of changes (sustainable, pro-ecological). This requires a great deal of commitment in terms of information, and this type of action should be undertaken by government and local government institutions. New initiatives in the field of financial assistance for energy-poor households are also necessary.

Secondly, actions aimed at reducing transformation costs for mining-related employees are crucial. The gradual cessation of mining in Poland, which is currently one of the basic sectors, especially in Silesia province, means that mine workers need to look for alternative employment. In most cases, this will be less financially beneficial for these people than working in mining. For miners and other mine workers forced to change their employment sector, the benefits of transformation may be lower than the costs. There may be not only lower income, but also less satisfaction in new jobs, especially for employees with long experience in the mining industry. It is necessary to take actions to improve and change professional qualifications, as well as to support job seekers and prevent exclusion from the labour market. Nevertheless, the transformation of the economy will lead to the creation of many new jobs, hence changes in education are also important.

5. Energy Transformation in Poland—Challenges and Actions

In 2021, measures were taken in Poland to mitigate the energy poverty phenomenon mentioned in the previous part of this article. A cover allowance to protect households with the lowest incomes was introduced, among other things. On 17 December 2021, the Sejm of the Republic of Poland adopted the act on the shield allowance as an element of the government's Anti-Inflation Shield. The shield is to offset not only the rising prices of energy and gas, but also food. The support will cover nearly 7 million households, which accounts for almost half of all households in Poland. An amount of over PLN 4 billion (approximately EUR 870 million) has been allocated for this purpose [51].

The high share of lignite and hard coal in energy production in Poland is unique in the European Union. The production of energy from coal has decreased significantly in many countries, which had a similar structure in the energy mix, but decided to close their coal-fired power plants, including Spain and Greece. In general, the reason for lower coal consumption in Europe is the shift towards natural gas and renewable energy sources in recent years. This is largely determined by the EU's environmental and climate policy.

In recent years, as a result of the low pace of changes in the direction of mine extinction, including between the EU's climate goals and Polish economic priorities, a conflict has been growing. Symptoms of this conflict include Poland's objection to the order of the European Court of Justice to close the lignite mine in Turów. Another example is the debate sparked off in Poland on the rightness of Poland's participation in the Fit for 55 package, which is to accelerate the decline in the emission intensity of the EU economy. It is worth emphasizing that the Turów Power Plant is the fourth largest coal-fired thermal and condensing power plant in Poland. In 2020, the Turów Power Plant supplied just over 3% of the electricity consumed in Poland, and the Turów mine and power plant employed 3536 people at the beginning of April 2021.

Furthermore, the geopolitical situation in Eastern Europe, exacerbating the energy crisis and the drastic increase in gas prices, is an argument to increase energy production from coal. This is an important argument for many supporters of such a solution, who take into account the technical, economic, social, and political conditions, and opt for a rational and effective use of coal, which for centuries has been the main source of primary energy and the basic raw material in the Polish fuel and energy balance. In this approach, it is possible to implement the coal and gas fuel and energy economy.

On the other hand, numerous activities are undertaken in Poland to diversify the supply of energy resources, especially natural gas and crude oil. In 2015, the LNG Terminal was commissioned in Świnoujście (on the Baltic Sea). This is a liquefied natural gas reloading and regasification terminal. Currently, there are deliveries from Qatar and the USA. Contracts with American and Qatari companies ensure the annual volume of LNG supplies at a level exceeding 12 billion m^3 of fuel after regasification. This significantly limited the import of gas from Russia (before the launch of the terminal in Świnoujście, almost 90% of gas imported to Poland came from Russia, whereas currently imports from this direction account for approx. 60%) [52,53]. Additionally, the Baltic Pipe was launched in 2022, i.e., a system of gas pipelines connecting Norway, Denmark, and Poland with a capacity of 10 billion m^3 per year [54]. This project, strategic from the point of view of the energy market in Poland, based on a new gas supply corridor from Norwegian deposits, may contribute to the elimination of the need for long-term contracting of Russian gas [55].

The topic of including nuclear power plants in the energy system in Poland is becoming more and more frequent in the Polish public space. It is often emphasized in discussions that the further prospect of increasing demand for electricity and the need to modernize the power system to meet the requirements of environmental protection necessitates the construction of this type of power plant. Additionally, and importantly from a social point of view, nuclear energy offers a relatively cost-effective source of energy. In Poland, since the 1970s, efforts have been made in the field of nuclear energy, which is perceived as a supplement to coal-based energy. Due to the high costs of construction and maintenance (mainly the cost of fuel enrichment), the development of nuclear energy is to be supported by various forms of public aid. In the "Poland's Energy Policy 2040", a document adopted by the Polish government in February 2022, it is planned to launch the first block of a nuclear power plant in 2033 with a capacity of approx. 1–1.6 GW. Subsequent blocks will be implemented every 2–3 years, and the entire nuclear program provides for the construction of six blocks. Apart from launching a nuclear power plant, a special role is assigned to the implementation of offshore wind energy in the Polish power system. These will be two strategic new areas and industries that will be built in Poland.

Currently, in the era of the post-pandemic economic crisis, with the geopolitical situation exacerbated by the situation in Ukraine, the very high prices of natural gas do not allow for a significant development of utility power plants and combined heat and power plants based on gas fuels in Poland. In the absence of other options (development of coal-fired power plants) or a long investment period (in the case of nuclear energy), the basis for ensuring continuity of electricity supply to society and the economy in the coming years will probably continue to be conventional power plants, with improvements in new low-carbon technologies. However, political will and commitment to implement them as part of the state's active economic policy are necessary.

The experiences of other countries in the field of socio-technical transitions towards sustainable development in the energy sector are interesting. For example, in Great Britain, the coal industry, similarly to Poland, was an example of deeply rooted, politically and socially important industries. The destabilization and radical change in this segment resulted from major changes in economic policy (Thatcher's liberalization) [56,57]. Although there are some similarities between the situation in Great Britain under Margaret Thatcher [58] and the situation in Poland, it is important to remember the current climate challenges and the geopolitical situation. Current problems related to the energy transformation in Poland (in terms of mining regions) are similar to those in Germany—the Lusatia mining region (Lausitzer Revier), the Rhineland mining region (Rheinisches Revier), and the Central German mining region (Mitteldeutsches Revier). In these regions, as in many places in Poland, fundamental changes in sustainable development must take place [59].

6. Summary

Poland has significant hard coal and lignite resources, as well as rich technological traditions in terms of mining and processing methods, and in the area of mining culture

(mining ethos, traditional patterns of behaviour). Fossil fuel energy has been developing for decades in Poland. To this day, its largest customers are power plants and combined heat and power plants. The current volume of coal extraction in Poland is approx. 55 million tonnes, which is the level that was achieved in the 1950s.

There is no doubt that coal resources should be used for energy purposes in Poland to a maximum extent. The still very high share of coal in the structure of electricity production in Poland, due to the relationship with CO_2 emissions, is in contradiction with the implemented EU climate policy. Decisions to move away from fossil fuels have been made by many European countries, including Germany. There, the issue of energy transformation is implemented through the development of renewable energy sources, with the simultaneous abandonment of nuclear energy.

As presented in this article, Poland entered years of systemic transformations at the beginning of the 1990s, with the permanent dominance of coal as the primary energy source. In recent years, technical and political projects are gradually and relatively slowly being implemented, aimed at independence from Russian gas and reducing the importance of coal in the energy mix. The adopted development path concerns the expansion and creation of the possibility of obtaining energy from renewable sources and the construction of nuclear power plants.

There is also no doubt that the advancement of technical and technological works in the area of energy transformation must go hand in hand with the appropriate regulation of social issues related to the transition to a low-carbon economy. Without clear, systemic support for the social consequences of energy transformation in Poland, significant delays in the implementation of strategic projects may occur. There may also be protests as energy poverty worsens (rising energy prices at the level of retail prices). Additionally, the educational component in society should be strengthened, including knowledge about sustainable development in the context of energy with elements of knowledge about energy security. This requires public policies of the nature of long-term strategies, taking into account the specificity of Polish society.

Undoubtedly, further research is necessary on the social aspects of energy transformation in Poland. The next research steps may concern determining the necessary awareness changes at the microeconomic level (households, especially those earning a living from mining), including necessary actions and obstacles on the path of change. Analyses at other levels, meso- and macroeconomic, are also important, regarding the interactions between technology, economy, environment, and society.

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