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Climate neutrality in Poland: the role of the coal sector in achieving the 2050 goal

Abstract: The article discusses the challenges and opportunities of the coal sector in the context of Poland's pursuit of climate neutrality by 2050. Key energy transformation strategies are analyzed, focusing on the modernization of coal combustion technologies, the development of carbon capture, utilization, and storage (CCUS) technologies, and the gradual diversification of energy sources. The text emphasizes that the role of the coal sector extends beyond emission reduction to include investments in innovative technologies and ensuring a just transition for mining regions.

The paper also examines the impact of energy policy and regulation on the future of the coal sector. It pointed out that transition support mechanisms, such as the Just Transition Fund and EU funding for energy modernization, are crucial. It emphasizes that achieving climate neutrality requires a gradual shift away from coal towards renewable energy sources, the development of energy storage technologies, and the implementation of smart grids.

The analysis of technical, economic, and social aspects points to the necessity of considering the interests of coal sector workers and local communities. Based on the study, the authors conclude that the future of the Polish energy sector depends on a skillful combination of technological innovation, effective transformation strategies, and appropriate support policies for regions dependent on coal mining. The article concludes with a summary and the most important findings.

Keywords: coal sector, carbon capture, energy transition, climate neutrality, just transition

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Introduction

Climate neutrality is a commitment that requires significant changes in the way energy is produced and consumed. According to the objectives of the European Green Deal, every EU Member State, including Poland, is to achieve climate neutrality by 2050 (European Green Deal 2020). This ambitious task assumes that net greenhouse gas emissions are to be reduced to zero, which requires not only a reduction in emissions but also an increase in CO_2 sequestration capacity.

Poland represents a unique case in the context of European efforts to achieve climate neutrality. As a country that has based its economy on hard coal for decades, it is facing the need for a profound transformation of its energy sector. In 2024, hard coal and lignite still form the basis of the country's energy mix, which puts Poland in a challenging situation compared to other European countries (Globenergia 2024).

An important aspect of analyzing this process is also to look at other countries that have taken on similar challenges. For example, the Energiewende process in Germany showed how effective long–term investments in renewables and energy efficiency can be, but they required significant financial expenditure and social adaptation (Szczerbowski 2022).

Additionally, in Poland, it will be important to look at geopolitics and energy security, especially in the context of volatile energy markets and rising natural gas prices (Chmielarz 2023; Bałamut and Ruszel 2023). Technologies such as smart grids and energy management systems can play a key role in increasing efficiency. Climate neutrality, according to the European Green Deal, means balancing greenhouse gas emissions by absorbing or avoiding them by 2050 (Słupik 2020). Poland, as a country historically dependent on coal, faces a challenging task. Currently, the coal sector generates a significant proportion of CO_2 emissions and influences the economic structure of regions such as Silesia and Lubelszczyzna (Polish Economic Institute 2023). Poland's energy transition towards climate neutrality requires a profound economic and social reorientation that will affect all aspects of economic and social life.

A crucial aspect of the energy transition is its social and economic dimension in a regional context. Mining regions such as Silesia face the challenge of comprehensively restructuring not only the mining sector but also the entire economic ecosystem that has developed for decades around the coal industry. The experience of other European regions, such as the Ruhrgebiet in Germany or the Nord–Pas–de–Calais region in France, shows that successful transformation requires long–term planning, significant investment in infrastructure, and the development of new industries (Soltysik and Mazur 2022; Sulimowska 2022). It is also crucial to provide retraining programs for coal workers and to support small and medium–sized enterprises in adapting to the new economic conditions.

The financial and technological aspects also play an important role in the transformation process. Financing the costs of the transformation will require the effective use of available EU instruments, such as the Just Transition Fund or NextGenerationEU, as well as the mobilization of private capital through innovative financial mechanisms. In the technological context, not only the expansion of renewable energy sources but also the development of energy storage

technologies, smart grids, and energy demand management systems will be crucial. Particular attention should be paid to the potential for the development of hydrogen economy and carbon capture and storage (CCS) technologies, which can be important elements in achieving climate neutrality goals.

This article aims to identify the key challenges for the transformation of the coal sector in Poland. An assessment of the potential of new energy technologies, green hydrogen, and renewable energy sources is essential to develop effective strategies. It will also include an analysis of fair transition policies and their impact on mining regions and the possible development of recommendations for a fair transition of Poland by 2050. The article will consider various energy transition scenarios, taking into account both economic, social, and technological aspects.

1. The state of the coal sector in Poland – relevance and challenges

The coal sector plays a key role in the Polish economy and energy system, supplying around 70% of electricity in 2022 (Polish Economic Institute 2023). Throughout the EU, hard coal has held an important place in the structure of primary energy consumption (Stala-Szlugaj 2016). Hard coal and lignite remain the dominant energy sources, but their exploitation generates about 30% of the national greenhouse gas emissions (Central Statistical Office 2023). In the face of EU climate policy, Poland faces the need to transform its coal sector, which poses a number of challenges.

When analyzing the level of hard coal consumption in Poland between 2010 and 2021, a general downward trend can be observed (Fig. 1). Despite some fluctuations, the dominant trend over the period was a gradual reduction in the use of this raw material. Several key moments can be distinguished.

At the beginning of the period under review, in 2010, the level of hard coal consumption remained relatively high (Grudziński and Stala-Szlugaj 2014). As early as 2011, however, declines began to be recorded, possibly as a result of changes in energy policy and the increasing diversification of energy sources. Between 2012 and 2016, there was a phase of relative stabilization, after which consumption started to decline again. The growing role of alternative, cleaner energy sources and technological advances in the energy sector may have caused this. Another apparent reduction occurred between 2017 and 2021, which could be attributed to the further transformation of the energy mix and the intensification of measures to promote renewable energy sources. The overall downward trend over the period under review was most likely due to energy policy modifications, increased environmental awareness, and the development of modern technologies that enable more efficient energy management. However, it is worth noting that in 2021, hard coal consumption was 69.6 million Mg, an increase of 11.6% compared to 2020 (CSO 2022).

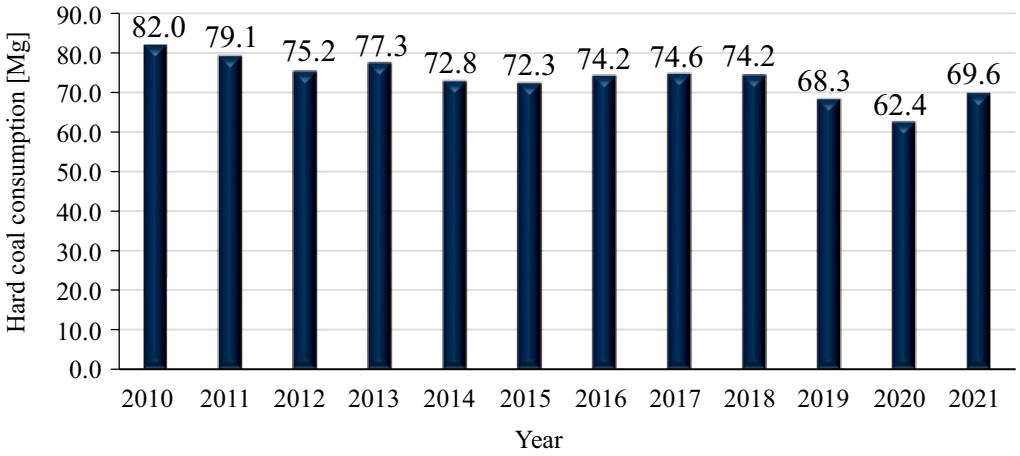

Fig. 1. Total hard coal consumption in Poland in 2010–2021 [million Mg]
* does not include direct consumption for heating in entities classified in Section D as "Electricity, gas, steam, hot water, and air conditioning supply"
** also, the own consumption of the mines and the consumption for the charge of transformations in the coking plants
Source: own compilation based on: CSO (2022f)

Rys. 1. Całkowite zużycie węgla kamiennego w Polsce w latach 2010–2021 [mln Mg]
* nie obejmuje bezpośredniego zużycia na ogrzewanie w podmiotach zaklasyfikowanych do Sekcji D „Wytwarzanie i zaopatrywanie w energię elektryczną, gaz, parę wodną, gorącą wodę i powietrze do układów klimatyzacyjnych",
** również zużycie własne kopalń oraz zużycie na wsad przemian w koksowniach

Achieving climate neutrality requires profound changes in the coal sector, such as transforming mining regions, reducing dependence on fossil fuels, and developing renewable energy sources (RES). Critical is the issue of the long–term process of mine closure, which affects the stability of the labor market in regions such as Silesia. According to an analysis by the European Commission (2021), effective decarbonization requires investment in alternative economic sectors and support for affected communities.

The first half of 2024 brought noticeable changes in the coal sector. Hard coal output fell to 21.56 million tonnes, a reduction of 1.68 million tonnes compared to the same period in 2023. Thermal coal sales declined by 7.8% (IDA 2024). Despite these declines, coal remains the dominant source of energy in Poland, delaying the decarbonization process and hindering the rapid development of RES.

The high cost of CO_2 allowances is another challenge. In August 2024, allowance prices averaged €70 per tonne, which significantly increases the cost of coal-fired power generation (Energy 2025). However, the high cost of emissions may provide an incentive to explore alternative, less carbon-intensive energy sources.

As mentioned, Poland is one of the largest coal producers in Europe, and the coal mining and coal–fired power generation sectors play an important role in the national economy. However, coal mining is becoming increasingly unprofitable for a number of reasons, which include:

- Increasing labor and deposit exploitation costs. Increasing labor and mining costs of coal and lignite deposits increase the financial burden on mining companies (IDA 2024).
- Low competitiveness against imports of cheaper coal: Poland has to compete with cheaper imported coal, e.g., from Russia or Australia, which makes it challenging to maintain the profitability of domestic mines (Central Statistical Office 2023).
- Increased emission prices in the EU ETS: The burden of high CO_2 allowance prices under the EU ETS further increases the cost of coal-fired power generation.

In addition, the coal industry in Poland faces social and regulatory pressures. The development of environmental awareness in society and increasingly restrictive EU regulations are forcing Poland to accelerate its energy transition. The introduction of the Carbon Boundary Adjustment Mechanism (CBAM) by the European Union, which aims to eliminate the risk of CO_2 emissions displacement (carbon leakage), further increases the pressure on Polish energy companies.

In the context of these challenges, Poland needs to look for new solutions and strategies that will allow for a smooth and equitable transformation of the coal sector. Investments in new technologies, such as Carbon Capture and Storage (CCS) and the development of green hydrogen, can be key elements of this transformation. In addition, support for mining regions, including financial and educational support, is essential to ensure social and economic stability during the transition.

Finally, a key element for the success of the energy transition in Poland will be international cooperation, exchange of experience and technology, and joint actions for sustainable development. Poland has the opportunity to become a leader in the region in terms of sustainable development if it can effectively use its resources and potential.

In response to growing social discontent in Poland, the national authorities entered into negotiations with representatives of the coal mining sector. These talks resulted in an agreement known as the Social Agreement concerning the restructuring of the coal mining industry and selected aspects of the transformation of the Silesian Voivodeship (Social Agreement 2021). This document contains agreements on the financing of mining companies, the principles of wage indexation, the implementation of clean coal technologies, the creation of the Silesian Transformation Fund, as well as employment guarantees, and a social benefits package for employees of closed mining plants.

On the basis of the agreement, legislators, in cooperation with trade unions representing the interests of miners, established a timetable for the phasing out of hard coal mining in Polish mines. According to the adopted arrangements, this process is to be completed by the end of 2049. A detailed plan for the closure of individual mines is presented in the hard coal mining sector transformation schedule, which is attached to the document (Table 1).

Table. 1. Timetable for the transformation of the coal mining sector in Poland

Tabela 1. Harmonogram transformacji sektora górnictwa węglowego w Polsce

Year	Action
2021	Closure of the Wujek Coal Mine with the Murcki-Staszic Coal Mine
2021	End of exploitation Coal Mine Ruda Ruch – Pokój
2022	Analysis of the possibilities of using coking hard coal resources from Coal Mine Ruda Ruch Bielszowice
2023	Merger of Coal Mine Ruda Ruch Bielszowice and Coal Mine Ruda Ruch Halemba
2028	End of exploitation at Coal Mine Bolesław Śmiały
2029	End of exploitation at Coal Mine Sośnica
2034	End of exploitation at Coal Mine Ruda Ruch Bielszowice and Coal Mine Ruda Ruch Halemba
2035	End of exploitation at Coal Mine Piast-Ziemowit Ruch Piast
2037	End of exploitation at Coal Mine Piast-Ziemowit Ruch Ziemowit
2039	End of exploitation at Coal Mine Murcki–Staszic
2040	End of exploitation at Coal Mine Bobrek
2041	End of exploitation at Coal Mine Mysłowice–Wesoła
2043	End of exploitation at Coal Mine ROW Ruch Rydułtowy
2046	End of exploitation at Coal Mine ROW Ruch Marcel
2049	End of exploitation at Coal Mine ROW Ruch Chwałowice and Coal Mine ROW Ruch Jankowice

Source: own compilation based on (Social Contract 2021).

2. Socio-economic aspect

The transformation of the coal sector implies major socio–economic changes in coal regions. The European Commission emphasizes the need for fair transition mechanisms that minimize the negative impacts on miners and local communities. These measures include:

- Worker retraining programs. The introduction of practical training and retraining programs is essential to ensure that coal workers can find employment in new, low–carbon sectors of the economy. It is crucial to involve educational institutions and private companies in creating tailored curricula that take into account the needs of the labor market.
- Investment in new technologies and industrial infrastructure. Investment in innovative technologies and industrial infrastructure is key to creating new jobs and increasing the competitiveness of mining regions. It is worth noting that the development of local energy clusters and technology centers can foster the economic diversification of these regions.
- Job creation in low–carbon sectors. The development of sectors such as renewable energy sources (RES), green hydrogen, and electromobility can provide new jobs for former coal workers. However, this requires access to adequate funding and active support from public administration and the private sector.

The energy transition also requires wide-ranging socio-economic changes. In regions such as Silesia, the retraining of workers in the coal sector and the creation of new jobs in the RES sectors are crucial. Germany's experience shows that investment in education and support for local communities can effectively mitigate the adverse effects of the transition. For example, training and education programs can prepare workers for new sectors such as renewable energy or digital technologies.

From a societal perspective, achieving climate neutrality requires broad public support and the involvement of citizens in the transition process. Legislative reforms, investment in innovation, and the development of new technologies can significantly accelerate the decarbonization process. However, it is crucial to maintain the competitiveness of the Polish economy, which relies heavily on heavy industry and coal–fired power generation. In this context, support for small and medium–sized enterprises and investment in innovation can be key elements in the success of the transition.

Ensuring social stability in mining regions is also an important aspect. It is necessary to support local communities to ensure their economic and social security during the transition. Social programs, such as financial support for miners' families and investment in social infrastructure, can significantly mitigate the adverse effects of the transition.

In addition, the energy transition requires an integrated approach that takes into account different aspects of social and economic life. Cooperation between different sectors of the economy, including the public sector, the private sector, and NGOs, is essential to successfully managing the transition process. Working together for sustainable development can benefit all parties involved.

Finally, a key element for the success of the energy transition in Poland will be to maintain a balance between the goal of decarbonization and the need to ensure economic and social stability. Investment in new technologies, support for local communities, and effective management of the transition process can contribute to achieving climate neutrality while maintaining the competitiveness of the Polish economy.

3. Energy transition – technologies and opportunities

Modern coal technologies can play an important role in the energy transition, helping to increase energy efficiency and reduce emissions. Carbon Capture, Storage, and Storage (CCUS) technologies can play a key role in reducing emissions from coal-fired power plants, allowing the sector to reduce its environmental impact. The International Energy Agency (2022) indicates that CCUS enables a gradual transition away from coal without the risk of a sharp increase in energy prices, which is important for economies heavily dependent on this resource, such as Poland. However, the implementation of CCUS requires significant investment and technological development to ensure effective and safe storage of CO_2.

Therefore, it is necessary to create appropriate financial and regulatory support mechanisms for the development of this technology.

Modern renewable energy technologies play a key role in the energy transition, contributing to the decarbonization of the energy sector and increasing the security of energy supply. Among the most promising solutions are wind power, photovoltaics biomass, and biogas technologies, which offer significant benefits in both environmental and economic terms. Wind power remains the dominant renewable source in Poland, accounting for 14.7% of the country's electricity production. In 2024, 0.5 GW of new wind power plants were put into operation, contributing to a total installed wind power capacity of 10.5 GW by the end of the year (RES World 2025).

The Energy Forum's analyses (2023) confirmed that the development of offshore wind farms can significantly increase the share of renewable energy in Poland's energy mix. More stable wind conditions characterize offshore installations compared to onshore turbines, which translates into greater efficiency and predictability of energy production. In addition, the development of this technology creates new opportunities for the Polish shipbuilding and energy industry, generating added value in the domestic sector and supporting the development of local supply chains.

An equally important area of energy transition is the development of photovoltaics, which is gaining momentum as the cost of the technology falls, making it more competitive in the energy market. The decentralization of the energy system through photovoltaic installations on rooftops of residential buildings, businesses, and public facilities is significant. Distributed energy production increases the resilience of the electricity system to disruptions while allowing consumers to participate actively in the energy market. In addition, the integration of photovoltaics with modern energy storage systems allows for more efficient management of energy supply and consumption, which is an important part of the future energy system.

Biomass and biogas technologies offer significant opportunities for agricultural regions, allowing for the efficient use of local resources and the creation of new jobs. Biomass and biogas can be used to produce electricity and heat, supporting the decarbonization of the energy sector. The development of local biogas plants contributes to a circular economy, enabling the efficient management of agricultural and municipal waste. In the context of the energy transition, these technologies are an important complement to other renewable energy sources, offering a stable source of power independent of weather conditions.

Green hydrogen is a key part of the decarbonization strategy for industry and transport, offering solutions to reduce greenhouse gas emissions in energy–intensive sectors. Produced using renewable energy, it has the potential to replace fossil fuels in energy-intensive industries such

as steel, chemicals, and heavy transport. The authors emphasize the important role of investment in hydrogen infrastructure and the need to cooperate with other European Union countries to build a pan–European grid. One of the key advantages of green hydrogen is the possibility of storing surplus energy from renewable sources, which contributes to increasing the stability of the energy system and better-balancing energy supply and demand.

However, the development of hydrogen technology is associated with significant challenges, including the need to allocate significant resources to research and development and financial support for companies investing in this technology. In addition, effective regulatory mechanisms

must be created to enable stable development of the hydrogen market in Poland. The implementation of an appropriate legal framework and investment incentives can accelerate the commercialization of this technology and increase its competitiveness in the energy market.

In addition to green hydrogen, an important element of the energy transition is the development of smart grids, which enable the integration of renewable energy sources with traditional electricity systems. The use of smart grids allows flexible management of the energy system, which significantly increases its stability and efficiency. With variable energy production from renewable sources such as wind and photovoltaic energy, optimal management of energy supply and demand becomes a key challenge.

Modern technologies such as energy storage systems, intelligent demand response management, and the digitalization of electricity grids play an important role in improving system flexibility. The implementation of these solutions contributes to reducing the risk of blackouts, as well as to a more efficient use of available energy resources. Digital technologies enable dynamic balancing of the grid, allowing energy production to be better matched to actual consumer demand. Integrating these innovative solutions into the energy transition is a key step toward building a modern, sustainable, and resilient energy system.

4. A transition policy

Faced with the global challenges of energy transition, the European Union is developing comprehensive financial instruments to support coal regions in the transition process. A key mechanism in this regard is the Just Transition Fund, which is a fundamental tool to support the areas most affected by the decarbonization process (Upham et al. 2022). This fund offers significant funding targeted at local development and job creation, which is key to mitigating the socio–economic impacts of the energy transition.

An important complement to the support system is the research programs implemented under the Horizon Europe initiative, which focuses on funding innovation in the energy sector (Weber et al. 2019). These programs play a fundamental role in the development of new energy technologies and solutions, with a particular focus on renewable energy sources, energy storage systems, and hydrogen technologies. This two–pronged support strategy–combining direct regional funding with investment in research and development – provides a comprehensive framework for a successful energy transition.

In response to the transformational challenges, the Ministry of Climate and Environment has developed the Fair Transformation Plans, which presents a multi-dimensional approach to the energy transition process (Now Environmental 2021; Drobniak et al. 2022). The plan calls for increased investment in renewable energy sources, including wind power, photovoltaics, biomass, and biogas. In parallel, special attention has been given to supporting mining regions through worker retraining programs and the creation of new jobs in low–carbon sectors.

The modernization and expansion of energy infrastructure are fundamental to implementing a fair transition policy. The development of smart grids and the implementation of advanced energy storage technologies are key factors for the stability and flexibility of the energy system during the transition. At the same time, Poland's active participation in international initiatives, such as the Carbon Boundary Action Mechanism (CBAM), opens up opportunities for additional funding and facilitates knowledge and technology transfer.

The educational and social aspects are of particular importance in the context of a just transition policy. Educational programs aimed at raising public awareness of climate change and energy transition play a key role in building public acceptance of the changes taking place. Effective implementation of these programs requires coordinated cooperation between government institutions, local authorities, and NGOs.

The success of the fair transition policy in Poland is contingent on the effective coordination of activities at different administrative levels and the efficient use of available financial instruments. From a broader perspective, the energy transition provides an opportunity for Poland to become a regional leader in sustainable development, provided that its resources and development potential are used optimally. The key challenge remains to maintain a balance between achieving climate goals and maintaining economic and social stability in the transition process.

Summary and conclusions

The analysis of the transformation of the coal sector in Poland in the context of achieving climate neutrality by 2050 shows its complexity and multidimensionality. The research presented in this article allows for the formulation of several key conclusions regarding the role of the coal sector in the decarbonization process of the Polish economy.

Firstly, achieving climate neutrality by 2050 is an ambitious but achievable goal, provided that a comprehensive transformation strategy is implemented. This strategy must take into account both technological and socio-economic aspects. The analyses carried out indicate that a key element of this transformation will be the systematic modernization of the energy sector, in particular through the development of renewable energy sources and the implementation of innovative technologies such as CCUS (carbon capture, utilization, and storage) or hydrogen technologies.

Secondly, the analysis showed that the transformation of the coal sector, although a significant challenge for the Polish economy, can become a catalyst for modernization and technological innovation. In this context, the effective use of available financial instruments, including funds from the Just Transition Fund and Horizon Europe research programs, is particularly important. The analysis indicates that effective management of these funds requires a coordinated approach at national and regional levels.

Thirdly, the research carried out highlights the fundamental importance of the social aspect in the transformation process. The international experience, as well as the analysis of the Polish context, points to the necessity of providing comprehensive support to coal regions and their communities. Of key importance here is the development of retraining programs, the creation of new jobs in low–carbon sectors, and the building of social acceptance for the changes taking place.

Another important conclusion from the analyses is the importance of international cooperation in the energy transition process. Transfer of knowledge and technology, exchange of experience, and participation in international climate initiatives may significantly accelerate the process of decarbonising the Polish economy. The role of support mechanisms offered by the European Union and opportunities for cooperation within regional energy initiatives are vital here.

The research conducted also concludes that synergies between the public and private sectors are key to the energy transition process. Practical cooperation between these sectors can contribute to optimizing the investment process and accelerating the implementation of innovative technological solutions.

In conclusion, the transformation of the coal sector in Poland is a complex socio–economic challenge, and its success depends on the effective coordination of activities at many levels. The analyses conducted indicate that Poland has the potential to become an example of a successful energy transition in the region, provided that the adopted strategies are consistently implemented and the available resources and support instruments are used effectively. It will be crucial to maintain a balance between climate goals and socio–economic stability in the transition process.

The presented conclusions also open up space for further research into optimizing the energy transition process in Poland, in particular with regard to the development of innovative low-carbon technologies and support mechanisms for coal regions. Future research should focus on developing detailed solutions for the implementation of the adopted strategies and monitoring the effectiveness of the transformation activities undertaken.

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References

Bałamut, A. and Ruszel, M. 2023. Evolution of the definition of energy security and local component (clusters) in the theoretical perspective. *Energy Policy Studies* 2(13), pp. 3–13, DOI: 10.62316/ZNBZ9903.

Central Statistical Office 2023. Fuel and energy economy in 2022 and 2023 (*Gospodarka paliwowo-energetyczna w latach 2022 i 2023*). Warsaw (*in Polish*).

Chmielarz, P. 2023. The policy of natural gas supply security in Poland in 2017–2021 against the background of the energy security strategy of the European Union (*Polityka bezpieczeństwa dostaw gazu ziemnego*

w Polsce w latach 2017–2021 na tle strategii bezpieczeństwa energetycznego Unii Europejskiej) (Doctoral dissertation) (*in Polish*).

CSO 2022. Główny Urząd Statystyczny (2022) – Consumption of fuels and energy carriers in 2010–2021 (*Zużycie paliw i nośników energii w latach 2010–2021*). Warsaw (*in Polish*).

Drobniak, A. ed. 2022. Sprawiedliwa transformacja regionów węglowych w Polsce: impulsy, konteksty, rekomendacje strategiczne. Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.

Energy Forum 2023. Energy transformation in Poland (*Transformacja energetyczna w Polsce*). Warsaw (*in Polish*).

Energy 2025. CO_2 allowance prices rise (Ceny uprawnień do emisji CO_2 rosną). [Online] https://energetyka24.com/elektroenergetyka/wiadomosci/ceny-uprawnien-do-emisji-co2-rosna [Accessed: 2025-02-02] (*in Polish*).

European Green Deal 2020. Communication from the European Commission. [Online] https://ec.europa.eu/info/strategy/priorities – 2019 – 2024/european – green – deal_pl. [Online] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_pl [Accessed: 2024-10-01].

Globenergia 2024. Renewables: this is what it was in 2024, and this is what it will be soon We analyse the changes in the energy mix (*OZE: tak było w 2024, a tak będzie już zaraz. Analizujemy zmiany w miksie energetycznym*). [Online] https://globenergia.pl/oze-tak-bylo-w-2024-a-tak-bedzie-juz-zaraz-analizujemy-zmiany-w-miksie-energetycznym/ [Accessed: 2025-01-31] (*in Polish*).

Grudziński, Z. and Stala-Szlugaj, K. 2014. The role of hard coal in the Polish fuel and energy balance. *Polityka Energetyczna – Energy Policy Journal* 17(3), pp. 49–66.

IDA 2024. Industrial Development Agency SA 2024 – Basic information about the market and the hard coal sector in Poland in the years (*Podstawowe informacje o rynku oraz sektorze węgla kamiennego w Polsce w latach*). Katowice (*in Polish*).

International Energy Agency 2022. World Energy Outlook 2022. Paris: IEA Publications. Ministry of Climate and Environment (2022). Plan for a just transition. Warsaw.

Now Environmental 2021. Polish Territorial Just Transition Plans under citizens' scrutiny (*Polskie Terytorialne Plany Sprawiedliwej Transformacji pod lupą obywatelską*). [Online https://www.teraz-srodowisko.pl/aktualnosci/terytorialne-plany-sprawiedliwej-transformacji-raport-10797.html [Dostęp: 21.02.2025] (*in Polish*).

Polish Economic Institute 2023. Energy transformation in Poland: Current state and prospects for development (*Transformacja energetyczna w Polsce: Stan obecny i perspektywy rozwoju*). Warsaw: PIE (*in Polish*).

RES World (2025). Record low share of coal in the energy mix! Summary 2024 (*Rekordowo niski udział węgla w miksie energetycznym! Podsumowanie 2024 roku*). [Online] https://swiatoze.pl/rekordowo-niski-udzial-wegla-w-miksie-energetycznym-podsumowanie-2024-roku/ [Accessed: 2025-01-17] (*in Polish*).

Słupik, T. 2020. The European Green Deal – merit – based foundations for climate neutrality in terms of the resource economy (*Europejski Zielony Ład–merytoryczne podstawy neutralności klimatycznej w aspekcie gospodarki surowcowej*). *Energetyka* 11, pp. 615–621 (*in Polish*).

Social Agreement 2021. Social Agreement Concerning the Transformation of the Coal Mining Sector and Selected Transformation Processes of the Silesian Voivodeship. [Online] https://solidarnosckatowice.pl/wp-content/uploads/2021/04/Umowa-Spoleczna.pdf [Accessed: 2025-02-02].

Sołtysik, M. and Mazur, K. 2022. The transformation of brownfield sites on the example of the Ruhr Metropolitan Area and the Upper Silesian – Zagłębi Metropolis (*Przekształcenia terenów poprzemysłowych na przykładzie Metropolii Ruhry i Górnośląsko-Zagłębiowskiej Metropolii*). *Builder* 302(9), pp. 45–49, DOI: 10.5604/01.3001.0015.9543 (*in Polish*).

Stala-Szlugaj, K. 2016. Trends in the consumption of hard coal in Polish households compared to EU households. *Gospodarka Surowcami Mineralnymi – Mineral Resources Management* 32(3), pp. 5–22, DOI: 10.1515/gospo-2016-0024.

Sulimowska, A. 2022. Workers' estates of the Nord-Pas-de-Calais coalfield (*Osiedla robotnicze zagłębia węglowego Nord-Pas-de-Calais*). *Builder* 26(6) (*in Polish*).
Szczerbowski, R. 2022. Germany's energy policy after the shift away from nuclear and coal power (*Polityka energetyczna Niemiec po odejściu od energetyki jądrowej i węgla*). *Wiadomości Elektrotechniczne* 90(7), pp. 8–14 (*in Polish*).
Upham et al. 2022 – Upham, P., Sovacool, B. and Ghosh, B. 2022. Just transitions for industrial decarbonisation: A framework for innovation, participation, and justice. *Renewable and Sustainable Energy Reviews* 167, DOI: 10.1016/j.rser.2022.112699.
Weber et al. 2019 – Weber, M., Lamprecht, K. and Biegelbauer, P. 2019. Shaping a new understanding of the impact of Horizon Europe: the roles of the European Commission and Member States. *Journal for Research and Technology Policy Evaluation* 47, pp. 146–154.

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Neutralność klimatyczna w Polsce: rola sektora węglowego w osiągnięciu celu na rok 2050

Streszczenie

W artykule omówiono wyzwania i szanse sektora węglowego w kontekście dążenia Polski do osiągnięcia neutralności klimatycznej do roku 2050. Przeanalizowano kluczowe strategie transformacji energetycznej, skupiając się na modernizacji technologii spalania węgla, rozwoju technologii wychwytywania, wykorzystania i składowania dwutlenku węgla (CCUS) oraz stopniowej dywersyfikacji źródeł energii. W tekście podkreślono, że rola sektora węglowego wykracza poza redukcję emisji, obejmując inwestycje w innowacyjne technologie i zapewnienie sprawiedliwej transformacji regionów górniczych. W artykule zbadano również wpływ polityki energetycznej i regulacji na przyszłość sektora węglowego. Zwrócono uwagę, że kluczowe znaczenie mają mechanizmy wsparcia transformacji, takie jak Fundusz Sprawiedliwej Transformacji i finansowanie modernizacji energetycznej przez UE. Podkreśla się, że osiągnięcie neutralności klimatycznej wymaga stopniowego odchodzenia od węgla na rzecz odnawialnych źródeł energii, rozwoju technologii magazynowania energii i wdrożenia inteligentnych sieci. Analiza aspektów technicznych, ekonomicznych i społecznych wskazuje na konieczność uwzględnienia interesów pracowników sektora węglowego i lokalnych społeczności. Na podstawie przeprowadzonych badań autorzy dochodzą do wniosku, że przyszłość polskiego sektora energetycznego zależy od umiejętnego połączenia innowacji technologicznych, skutecznych strategii transformacji i odpowiedniej polityki wsparcia dla regionów zależnych od wydobycia węgla. Artykuł kończy się podsumowaniem i najważniejszymi ustaleniami.

Słowa kluczowe: sektor węglowy, wychwytywanie dwutlenku węgla, transformacja energetyczna, neutralność klimatyczna, sprawiedliwa transformacja