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DETERMINANTS OF THE DEVELOPMENT OF THE RENEWABLE ENERGY MARKET IN POLAND

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ABSTRACT: The aim of this study was to identify the conditions for the development of the renewable energy market in Poland in comparison with other European Union countries, and to highlight the opportunities and obstacles for the development of this sector of the economy. The article is a literature review, but in order to assess the development of the renewable energy market in Poland compared to other European countries, EU countries were grouped according to the average share and percentage change of energy from renewable sources in gross final energy consumption in 2017-2022. None of the countries reached a high level for either variable over the analysed period. One third of the EU countries are still underdeveloped in terms of renewable energy use. Poland was classified as a developing country in this respect. The main conditions for this status were divided into economic, social, political, legal and administrative, environmental and technological. The main obstacles to the development of renewable energy sources are of an economic nature, while environmental conditions and technological development offer opportunities for development.

KEYWORDS: sustainable development, renewable energy sources

Introduction

Environmental protection, climate change, and measures aiming to combat or mitigate their adverse impacts are critical challenges for the future of the world. In this context, renewable energy sources (RES) offer a pathway to sustainable development in the coming decades and are expected to make a significant contribution to meeting the global demand for energy. Renewable energy sources and factors that determine their development have attracted growing interest in recent years in an attempt to raise public awareness of the benefits of renewable energy. Consumers are becoming increasingly aware that clean air and effective energy generation techniques are important not only for human health and safety but also for future generations.

Renewable energy sources, including solar, wind, hydroelectric, geothermal, and biomass energy, are presently the most popular alternative to fossil fuels. Renewable energy sources have the potential to meet the growing demand for electricity; they are non-depletable and do not exert a negative impact on the environment (Młynarski, 2017). Other advantages of RES include high availability, low cost, lower dependence on fuel imports, and new employment opportunities in the renewable energy sector and in regions affected by depopulation (Guangul & Chala, 2019; Domac et al., 2005). The diversification of energy sources also contributes to energy independence (Kamprowski, 2021; Olczak, 2020). Research studies examining the relationship between RES and economic prosperity have shown that high levels of economic growth can be achieved, maintained, or improved through the use of RES. However, research findings concerning the presence and strength of the relationship between RES and GDP are sometimes inconclusive (Saidi, 2024). The prevailing view that has emerged in recent years postulates that in the European Union (EU) countries, a positive relationship exists between economic growth and the use of RES, especially in the long-term perspective (Ntanos et al., 2018; Alper & Oguz, 2016; Armeanu et al., 2017). The cited authors have argued that more economically developed countries tend to use more RES, and vice versa. The implementation of RES projects can create new jobs and stimulate local economies, thus driving the sustainable socio-economic development of entire countries (Babuchowska & Marks-Bielska, 2017; Rio & Burguillo, 2009; Dvorák et al., 2017; Gonda, 2011).

Obviously, there are some limitations to the increased use of RES. Economic barriers (such as high installation costs or high maintenance and repair costs for wind farms), technical difficulties, and administrative and legal problems are the main obstacles. However, in the face of global climate change, the indicated benefits of RES will most likely drive the growth of the renewable energy sector.

Literature review

The problem of barriers to the development of RES has been addressed by many authors (Dzikuć et al., 2021; Standar et al., 2021; Blanco-Canqui, 2016; Borrelli et al., 2016; Havrysh et al., 2022). The author has grouped them into political, legal, economic, social and environmental conditions. They are discussed below. The renewable energy market is governed by the provisions of the Polish Energy Law, which stipulates, among other things, the scope of investments in RES and the requirements for renewable energy producers (Chludziński & Rokicka-Murszewska, 2021). In the Polish law, the development of RES is regulated by the Act on Renewable Energy Sources of 2015 with subsequent amendments (Act, 2015) and the Energy Law (Obwieszczenie, 2024). These acts constitute a legislative and regulatory framework for the renewable energy market, and they set forth the terms and conditions for supporting and financing RES projects (Kosiorek & Jarzynka, 2017). The auction system, which enables buyers and sellers to conclude power purchase agreements (PPA) and which provides other types of support for RES development, is an important element of the regulatory framework (Przybylska, 2022). Other regulations pertaining to RES development can be found in environmental protection laws and the Act on Spatial Planning and Management (Act, 2003).

Political factors also influence the growth of the RES market. Poland's energy policy is based on strategic and long-term goals relating to energy security, sustainable development, and economic competitiveness (Szczerbowski & Ceran, 2017). It is also significantly influenced by the energy policy of the EU (Paska et al., 2020). The EU energy policy aims to gradually decrease the share of carbon in the energy mix and to promote investments in RES (Janik et al., 2018; Przybylska-Cząstkiewicz,

DOI: 10.34659/eis.2025.92.1.1033

2017). International cooperation plays an important role in Poland's energy policy by facilitating the acquisition of funds, the transfer of modern technologies, and the exchange of experiences in the process of developing and implementing renewable energy solutions (Wiśniewski, 2017). Poland participates in European initiatives and programs supporting the development of RES, such as the European Green Deal and the 2030 climate and energy framework (Nawrot & Bąk-Filipek, 2017). Poland can rely on the experiences and knowledge of other EU Member States and cooperate with these countries in implementing joint RES projects and initiatives. Not only international, but also regional cooperation can speed up the energy transition in Poland (Tomaszewski, 2018). Regional cooperation can facilitate the acquisition of funds for RES projects and promote the transfer of technologies and know-how between countries and regions (Tomaszewski & Sekściński, 2020). Local governments and authorities play a significant role in this process (Frankowski, 2017). Local governments can accelerate the green transition in regions by developing local energy strategies, creating a favourable environment for investors, and implementing renewable energy development projects.

Economic factors, including investment costs, operating costs, and the cost of accessing electric power infrastructure, constitute the second group of determinants of RES development (Janik et al., 2018; Nawrot & Bąk-Filipek, 2017). Changes in the prices of non-renewable energy and national support schemes for renewable energy projects also play an important role (Przybylska-Cząstkiewicz, 2017). Support schemes can include subsidies, tax concessions, credit guarantees, and programs for financing innovative technologies, such as those offered by the National Fund for Environmental Protection and Water Management and the Polish Development Fund (Wiśniewski, 2017). In addition, the Act on Renewable Energy Sources has introduced tax allowances for individuals who invest in residential renewable energy systems, including solar panels, wind turbines, and biomass boilers. As part of this scheme, residents can deduct the cost of purchasing and installing renewable energy systems from their personal income tax (OZE, 2024).

The development of the RES market is also influenced by social factors because innovative technologies require social approval as well as changes in some consumer behaviours (Babuchowska & Marks-Bielska, 2017). Information, educational and promotional campaigns should be implemented to encourage social support and active community engagement in the green transition (Micek, 2020). Renewable energy education programs can involve information campaigns, training programs for various social groups, as well as school and university curricula dedicated to renewable energy (Motowidlak, 2018). The introduction of civic participation schemes, such as energy cooperatives or local prosumer initiatives, can also increase public acceptance of RES and support renewable energy deployment at the local level. The Polish government has introduced a number of measures to support these initiatives. These include the "My Electricity" program, which entitles households to subsidies for photovoltaic installations (Mojprad, 2024). In addition, energy cooperatives have been established to bring together local producers and consumers of renewable energy and to promote the development of the civic energy model. Energy cooperatives provide residents with access to local energy sources, thus reducing their dependence on large, centralised power plants and contributing to the decentralisation of the energy sector (Marzec, 2021). The civic energy model and energy cooperatives have the potential to increase renewable energy production and encourage community participation in energy production and management at the local level (Marzec, 2021).

Technical infrastructure is a key determinant of renewable energy development. Technological progress and access to modern sources of renewable energy affect the efficiency of power generation and competitiveness of renewable energy relative to conventional energy sources (Janik et al., 2018). Investments in wind, solar, biomass, and biogas technologies play a particularly important role in Poland (Nawrot & Bąk-Filipek, 2017; Przybylska, 2022; Ballak, 2022). Technological advancements in these areas reduce investment costs, increase energy efficiency, and improve the performance of RES (Wiśniewski, 2017). Innovative energy storage solutions also play an important role by contributing to the stability and flexibility of the energy system (Janik et al., 2018). Modern energy storage technologies, such as batteries or pumped storage hydropower plants, help stabilise electrical grids by responding to fluctuations in supply and demand. These solutions also facilitate the integration of RES with conventional energy sources (Nawrot & Bąk-Filipek, 2017).

Last, but not least, the performance of the renewable energy market is also influenced by environmental considerations. Poland's Energy Policy until 2040 (PEP 2040) outlines the prospects and challenges associated with the efforts to reduce greenhouse gas emissions and improve air quality

DOI: 10.34659/eis.2025.92.1.1033

(Mazanek & Świat, 2022). This goal alone guides the development of the RES market. However, the development of various types of RES proceeds at a different rate due to specific environmental conditions.

Research methods

The development of RES is key to achieving climate goals and reducing greenhouse gas emissions. The RES market has been growing rapidly in recent years, and investments in renewable technologies have increased significantly. For this reason, the determinants of RES development, as well as the potential and limitations of the RES market, should be explored in detail. The resulting knowledge can guide decision-making in energy policy and RES investment. Therefore, the aim of this study was to identify the conditions for the development of the renewable energy market in Poland in comparison with other European Union countries, and to highlight the opportunities and obstacles for the development of this sector of the economy.. These conditions were identified in the previous paragraph using the critical literature review method, but in order to assess the development of renewable energy sources in Poland against the background of EU countries, the share of energy from renewable sources in gross final energy consumption in the EU countries between 2017 and 2022 was analysed. The average share of renewable energy in gross final energy consumption and the rate of change in this indicator were determined in the analysed period.

The EU countries were divided into groups based on two variables:

1. The average share of renewable energy in gross final energy consumption in 2017-2022. The EU Member States were divided into groups where this parameter was below and above the EU average of 23.2%.
2. The rate of increase in the share of renewable energy in gross final energy consumption in 2017-2022. The EU Member States were divided into groups where this parameter was below and above the EU average of 35%.

The EU countries were divided into the following groups:

1. Countries with a high share of renewable energy in gross final energy consumption;
2. Countries with a moderate share of renewable energy in gross final energy consumption;
3. Countries with a low share of renewable energy in gross final energy consumption.

The main challenges and problems on the RES market were identified, and the prospects and directions for RES development in Poland were discussed in light of the identified conditions. The determinants were only identified, but no research was conducted on them. This is an interesting direction for further scientific research.

Results

Renewable energy has been recognised as a key mitigation strategy in reducing the impact of climate change. Poland and other countries are facing numerous challenges during the transition to clean energy, which aims to increase the share of renewable energy in the overall energy mix. Table 1 presents the share of renewable energy in gross final energy consumption in the EU countries between 2017 and 2022. These data were used to assess and compare the development of the RES market in Poland and other EU Member States.

Table 1. Share of energy from renewable sources 2017-2022 (% of gross final energy consumption)

Country	2017	2018	2019	2020	2021	2022	Awerage 2017-2022	% Increase 2022/2017
Belgium	9.1	9.5	9.9	13	13	13.8	11.4	52%
Bulgaria	18.7	20.6	21.5	23.3	17	19.1	20.0	2%
Czechia	14.8	15.1	16.2	17.3	17.7	18.2	16.6	23%
Denmark	34.4	35.2	37	31.7	24.7	41.6	34.1	21%

DOI: 10.34659/eis.2025.92.1.1033

Country	2017	2018	2019	2020	2021	2022	Awerage 2017-2022	% Increase 2022/2017
Germany	15.5	16.7	17.3	19.1	19.2	20.8	18.1	34%
Estonia	29.5	30	31.7	30.1	37.6	38.5	32.9	31%
Ireland	10.5	10.9	12	16.2	12.5	13.1	12.5	25%
Greece	17.3	18	19.6	21.7	21.9	22.7	20.2	31%
Spain	17.1	17	17.9	21.2	20.7	22.1	19.3	29%
France	15.8	16.4	17.2	19.1	19.3	20.3	18.0	28%
Croatia	27.3	28	28.5	31	31.3	29.4	29.3	8%
Italy	18.3	17.8	18.2	20.4	19	19.1	18.8	4%
Cyprus	10.5	13.9	13.8	16.9	18.4	19.4	15.5	85%
Latwia	39	40	40.9	42.1	42.1	43.3	41.2	11%
Lithuania	26	24.7	25.5	26.8	28.2	29.6	26.8	14%
Luxembourg	6.2	8.9	7	11.7	11.7	14.4	10.0	132%
Hungary	13.6	12.5	12.6	13.9	14.1	15.2	13.7	12%
Malta	7.2	7.9	8.2	10.7	12.2	13.5	10.0	88%
Netherlands	6.5	7.4	8.9	14	12.3	15	10.7	131%
Austria	33.1	33.8	33.8	36.5	36.4	33.8	34.6	2%
Poland	11.1	14.9	15.4	16.1	15.6	16.9	15.0	52%
Portugal	30.6	30.2	30.6	34	34	34.7	32.4	13%
Romania	24.5	23.9	24.3	24.5	23.6	24.1	24.2	-2%
Slovenia	21.7	21.4	22	25	25	25	23.4	15%
Slovakia	11.5	11.9	16.9	17.3	17.4	17.5	15.4	52%
Finland	40.9	41.2	43.8	43.9	43.1	47.9	43.5	17%
Sweden	53.4	53.9	55.8	60.1	62.6	66	58.6	24%
Average	20.9	21.5	22.5	24.4	24.1	25.7	23.2	35

Source: author's work based on Eurostat (2024).

The average share of renewables in gross final energy consumption increased by 4.8% in the analysed period. The highest values of this parameter were noted in Sweden (66%), Finland (47.9%), and Latvia (43.3%). The evaluated parameter approximated 13% in Ireland (13.1%), Malta (13.5%), and Belgium (13.8%). The share of RES increased most rapidly in the Netherlands, Malta, and Cyprus. In turn, the smallest increase in RES contribution was observed in Austria, Italy, and Bulgaria. The share of RES decreased by 2% in Romania in the analysed period. The rate of increase in the share of renewable energy in gross final energy consumption in the EU reached 35% on average. Twenty EU Member States ranked below, and the remaining seven (including Poland) ranked above the average. In the studied period, the average share of RES in gross final energy consumption was highest in Sweden, Finland, and Latvia, and lowest in Luxembourg, Malta, and the Netherlands. Sixteen EU Member States (including Poland) achieved below-average growth, whereas eleven countries ranked above the average in this respect. In the analysed period, Sweden emerged as the European leader in terms of the average share of RES in gross final energy consumption, whereas the greatest increase in the proportion of renewable energy was noted in the Netherlands, a country which is on course to exceed the EU's green energy targets. Romania made the least progress in the clean energy transition.

DOI: 10.34659/eis.2025.92.1.1033

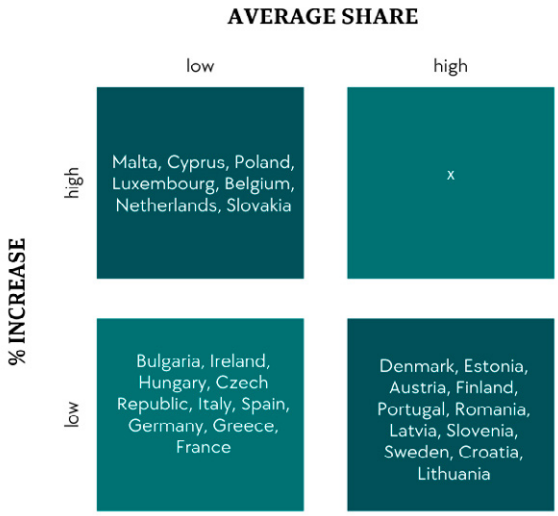

Figure 1. Matrix of average share/percentage increase

It was found 11 countries with a high share of renewable energy in gross final energy consumption, 7 countries with a moderate share of renewable energy in gross final energy consumption and 7 countries with a low share of renewable energy in gross final energy consumption.

None of the EU countries achieved high values of both parameters between 2017 and 2022. The share of RES in gross energy consumption continues to be low in a third of all EU Member States. These differences could be attributed to various factors, including energy policy, economic growth, or changes in the composition of the energy mix. These factors should be analysed to develop effective strategies for speeding up the transition to a greener economy. Poland has made significant progress in recent years, but the proportion of RES in its energy mix is still low relative to many EU countries. In the analysed period, the share of RES in gross final energy consumption increased by 52% in Poland, which ranked seventh in the EU in terms of its RES capacity. Poland belongs to the group of countries with a moderate share of renewables in its energy mix. The observed increase indicates that Poland is making steady progress in the clean energy transition. However, the average share of RES in gross final consumption reached only 15%, which implies that Poland ranked below the EU average in this respect. These findings indicate that Poland needs to increase its renewable power deployment to catch up with the European leaders. This process can be accelerated by investing in the development of renewable energy technologies and creating a favourable political and economic climate for the renewable energy industry.

Discussion

The development of various types of RES proceeds at a different rate due to specific conditions, which are discussed above. The share of biogas and biomass in Poland's renewable energy mix continues to increase (Kasperek, 2020; Czarkowski & Czarkowska, 2021). Poland has a thriving agricultural sector with a strong potential for their production. Wind and solar power are the most rapidly growing segments of the Polish RES market (Tomaszewski & Sekściński, 2020; Igliński, 2020), while this is a problem, RES such as solar and wind farms require considerable land resources and have a high land footprint (Iwaszczuk, 2019).

Poland has considerable potential for wind power generation, especially in coastal areas and in the northern regions of the country, and solar energy is becoming increasingly efficient and competitive due to technological advancements and the resulting decrease in production costs. Hydropower has been developing at a slower rate than wind or solar power, but it also makes an important contribution to Poland's energy mix. Small hydropower plants can be integrated into local energy systems to guarantee energy security and promote the diversification of energy sources (Ballak, 2022).

DOI: 10.34659/eis.2025.92.1.1033

Small hydropower plants play a particularly important role in the context of climate change because the power of water can be harnessed to generate energy in a sustainable and environmentally friendly manner. However, the development of hydropower in Poland faces numerous challenges, including geographic, hydrological and environmental constraints, as well as administrative, legal and financial barriers (Kasperek, 2020).

The energy transition and the efforts to increase the deployment of renewables in the energy sector pose significant challenges for Poland (Motowidlak, 2018). The most significant challenges are:

a) Coal dependency: The Polish economy is heavily dependent on brown and bituminous coal as the main energy source (Szczerbowski & Ceran, 2017);
b) Transition costs: The transition to clean energy entails high investment costs that could overburden the national economy, businesses, and consumers (Motowidlak, 2018);
c) Electric power infrastructure: To effectively transition to a green economy, Poland has to upgrade its electric power infrastructure and build new transmission lines and energy storage systems (Tomaszewski & Sekściński, 2020);
d) Social and regional considerations: The coal phase-out can lead to changes on the job market and affect local and regional communities (Szczerbowski & Ceran, 2017).

Other barriers to the development of renewable energy in Poland include: insufficient financial, administrative, and legal support for RES projects, or limited access to the appropriate technologies (Ballak, 2022). An analysis of the legal environment revealed that many environmental requirements, planning regulations, and licensing procedures for the production, distribution, and sale of renewable energy have been implemented in Poland to safeguard social interests, protect the environment, and promote the sustainable development of the RES sector. A stable system of legal norms and processes is a positive factor that supports a fair and effective green transition.

Renewable energy development is also influenced by political factors. Poland's energy policy aims to foster the growth of the RES market and gradually phase out coal. The development of the RES market is also regulated at the European level (Bajczuk et al., 2024). The EU's energy policy has been approved by all Member States, and it is expected to provide numerous benefits by promoting cooperation, exchange of experiences, and transfer of the most efficient renewable energy technologies. Regional cooperation can also stimulate renewable energy development by facilitating the further integration of energy markets and increasing energy security in regions (Tomaszewski, 2018). Local authorities can also promote RES development by communicating the benefits of the green transition, subsidising RES projects, and incorporating RES schemes into local development plans.

The development of RES is often thwarted by economic barriers. High startup and operating costs discourage investments in renewable energy facilities. Government subsidies and EU grants play an important role in overcoming these barriers. In Poland, RES projects are also co-financed by EU funds and national support programs (Nawrot & Bąk-Filipek, 2017; Bełdycka-Bórawska & Zuchowski, 2023).

An analysis of the social determinants of renewable energy development revealed that Polish citizens are increasingly aware of the benefits of RES and the need to reduce the country's dependence on fossil fuels. Nonetheless, further efforts are needed to boost public awareness of the advantages of green energy and to engage local communities in renewable energy projects (Tomaszewski & Sekściński, 2020). Educated and informed communities can become strong advocates for accelerating the green transition and achieving energy self-sufficiency at the local and regional level.

Advances in science and technology can also speed up Poland's transition to a low-carbon economy. The development of innovative technologies, such as more efficient batteries, smart grids or alternative methods of generating energy from renewable sources, can increase energy efficiency and reduce the cost of RES investments (Motowidlak, 2018). Scientific cooperation with foreign partners, participation in international research projects, and public support for innovation are key to propelling the growth of the Polish research and technology sector.

Environmental considerations play an equally important role by stimulating the development of RES in Poland. Green energy solutions improve air quality, reduce environmental pollution, and contribute to the health and well-being of humans and ecosystems (Przybylska, 2022). Renewable energy is crucial in the fight against climate change, and given the growing demand for renewable energy in

DOI: 10.34659/eis.2025.92.1.1033

Poland, the outlook for RES development is optimistic (Janik et al., 2018; Nawrot & Bąk-Filipek, 2017).

In summary, inadequate funding is the greatest barrier to RES development and research in Poland. Social support for investments in the green transition is still low, and funds for renewable energy research are difficult to acquire (Janik et al., 2018). For this reason, there is a general scarcity of research into effective methods of overcoming the obstacles to RES development in Poland. The results of this study set the future directions for research on green energy solutions in Poland.

Conclusions

The development of the renewable energy market is a crucial concern because greenhouse gas emissions must be reduced on a global scale. Countries that diversify their energy sources also enjoy greater independence and energy security. This study demonstrated that the RES market creates new jobs, increases economic competitiveness, and contributes to development not only in the environmental dimension but also in the economic dimension. As a result, the RES market stimulates sustainable socio-economic development.

Poland was classified as a developing country in the RES market. The main conditions for this status were divided into economic, social, political, legal and administrative, environmental and technological. They include factors that exert a positive or negative impact on the growth of the RES market. These factors should be identified to harness the potential of stimulating factors and to minimise the adverse effects of factors that inhibit renewable energy development.

To phase out coal, Poland should increase public spending on new technologies and restructure the energy and mining sectors. Economic and technical barriers significantly obstruct RES development. Poland should develop strategies for financing the energy transition to minimise the relevant costs. It should also prepare and implement plans for developing electric power infrastructure that will facilitate the integration of RES with the energy system. Efforts should also be made to increase public awareness and support for the phase-out of coal. Social support for the green transition is on the rise, but is still inadequate. Despite the above, Poland has favourable environmental conditions and a supportive political and legal climate for RES development.

In conclusion, numerous factors should be taken into consideration in Poland's renewable energy policy. These include legal regulations, support from policy-makers, investment costs, the need to transition to a low-carbon economy, the development of new technologies, changes in consumer attitudes, as well as international and regional cooperation. At the same time, Poland has to face numerous challenges during its clean energy shift, including coal dependency, the cost of the green transition, energy infrastructure modernisation, and the impact of RES development on local and regional communities. Sustainable development of renewable energy in Poland requires coordinated action on many levels, including cooperation with the private sector, society, and international partners.

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DOI: 10.34659/eis.2025.92.1.1033

Agnieszka STANOWICKA

UWARUNKOWANIA ROZWOJU RYNKU ODNAWIALNYCH ŹRÓDEŁ ENERGII W POLSCE

STRESZCZENIE: Celem opracowania jest ocena rozwoju rynku odnawialnych źródeł energii w Polsce na tle innych krajów Unii Europejskiej, identyfikacja uwarunkowań rozwoju tego rynku, a także wskazanie perspektyw oraz barier rozwoju tego obszaru gospodarki. Dokonano grupowania krajów UE pod względem średniego udziału oraz % zmiany energii ze źródeł odnawialnych w końcowym zużyciu energii brutto w latach 2017-2022. W badanym okresie żaden z krajów nie osiągnął wysokiego poziom obydwu zmiennych. Jedna trzecia krajów UE jest jeszcze słabo rozwinięta pod względem wykorzystania OZE. Polskę zakwalifikowano do grupy krajów rozwijających się w tym zakresie. Główne uwarunkowania tego stanu podzielono na ekonomiczne, społeczne, polityczne, prawno-administracyjne, środowiskowe oraz technologiczne. Największe bariery rozwoju OZE maja charakter ekonomiczny, szansę rozwoju zaś stanowią uwarunkowania środowiskowe oraz rozwój technologii.

SŁOWA KLUCZOWE: rozwój zrównoważony, odnawialne źródła energii

DOI: 10.34659/eis.2025.92.1.1033