doi: 10.15678/PG.2023.66.4.01

Journal of Public Governance
No. 4(66)/2023
ISSN 2956-6061
e-ISSN 2956-6398

Paweł Bajołek, Michał Król

Poland's Energy Transition from 2015 to 2020 in the International Perspective

Abstract

Objective: This paper discusses a new composite indicator illustrating Poland's energy transition from 2015 to 2020. Specifically, it addresses the following research questions: 1. How did energy transition in Poland evolve between 2015 and 2020?; 2. How did Poland's energy transition efforts compare with those of the other EU countries before the energy crisis?; 3. What internal factors limited Poland's capacity for energy transition between 2015 and 2020?

Research Design & Methods: The analysis is based on existing data for 2015–2020 downloaded from the Eurostat database. Selected indicators were divided into four categories and normalised, as well as stimulants and destimulants were determined to obtain composite indicators for individual countries.

Findings: 1. For 2020, Poland had the lowest score (–26.92) among 22 EU countries on the new indicator. 2. From 2015 to 2019, Poland ranked among the bottom three EU countries. 3. The structure of the energy mix had the greatest impact on the indicator.

Implications/Recommendations: The composite indicator developed for the purpose of this study makes it easier to compare the energy transition process across the EU countries and demonstrates in which areas specific economies perform better or worse.

Contribution/Value Added: The new indicator offers a somewhat different perspective on energy transition in the EU. Unlike other composite indicators in the literature, it focuses on four key areas of energy transition, i.e. economy, energy mix, energy prices, and import dependency.

Article classification: research article

Keywords: energy transition, energy policies, composite indicators, comparative analysis

JEL classification: *Q43, Q48*

Paweł Bajołek (corresponding author), Kraków University of Economics, Doctoral School UEK, ul. Rakowicka 27, 31-510 Kraków; e-mail: bajolekpawel@gmail.com; ORCID: 0000-0003-2190-2030. **Michał Król**, Department of Public Economics, Kraków University of Economics, Rakowicka 16, 31-505 Kraków; e-mail: krolm@uek.krakow.pl; ORCID: 0000-0001-9648-3139.

Introduction

Electricity plays a key role in everyday operations of both individuals and the economy as a whole. Increasing globalisation and the dynamic development of economies dictate the pressing need for adaptation, which can be described as an ongoing and sustained process of energy transition, with the goal of switching from conventional sources, such as coal and oil, to more environmentally-friendly ones, including solar and wind power. It is also associated with lower greenhouse gas emissions and greater energy efficiency. All of these changes in energy systems not just indicate a passing trend, but, rather, mark a point of no return and constitute a necessary response to climate change and geopolitical unpredictability. They also offer hope for a better future in which economies attain environmental and climate neutrality while simultaneously ensuring a higher degree of energy security.

Poland has significant potential to harness biogas and wind and solar energy, but still relies heavily on coal. Ill-considered government interventions, such as the act (the 10H Act) specifying the minimum distance of wind turbines from buildings (e.g. residential), have slowed the energy transition process, significantly limiting the development prospects for onshore wind farms (Mamica et al., 2022; Rozakis et al., 2021). While the construction of a nuclear power plant in Poland is scheduled for the upcoming years, all prior attempts to achieve this goal have been unsuccessful. For these reasons, the authors devised a composite indicator to quantitatively illustrate the trajectory of Poland's energy transition from 2015 to 2020. Due to a scarcity of data from before 2015 and after 2020 for key indicators regarding independence from gas and oil supplies, the study focuses on the stated time period. Subsequent years have also been marked by crisis situations (the global pandemic, the conflict between Russia and Ukraine, and the oil crisis). As a result, the data after 2021 may have been substantially affected by external variables with varying impacts on individual economies. Looking at the studied period makes it possible to capture the transition process in a relatively stable period (excluding 2020, which coincided with the outbreak of the global pandemic).

The composite indicator discussed in this paper is based on 12 indicators available in the Eurostat database. The latter were divided into four groups: Economy, Energy mix, Energy pricing, and Import dependency. Energy mix was further subdivided into two categories: Non-renewables use and Renewables use. In the opinion of the authors of this paper, the selected indicators are optimal for analysing how the Polish economy coped with energy transition. The new indicator takes a slightly different approach to energy transition, focusing on its core components while disregarding other factors that may affect the process, such as political ones. A major advantage of this indicator is that it provides for a quantitative representation of changes occurring in the economy and facilitates the creation of rankings to serve as a starting point for further analysis.

To achieve the stated aim, the following research questions have been addressed:

1. How did energy transition in Poland evolve between 2015 and 2020?
2. How did Poland's energy transition efforts compare with those of the other European Union (EU) countries before the energy crisis?
3. What internal factors limited Poland's capacity for energy transition between 2015 and 2020?

This paper is structured as follows: 1. Introduction; 2. Review of the literature on Poland's energy transition and its existing indicators; 3. The description of the research methods; 4. Results and discussion; and 5. Conclusions.

Literature review

The energy system in Poland – history and the current state

After World War II, the production and use of energy in Poland increased dramatically. In 1979, hard coal mining output reached 201 million tons, making it a significant export commodity. Lignite mining also increased considerably, reaching 67 million tons in 1990. This was accompanied by growing production and consumption of electricity, natural gas, and liquid fuels. Nonetheless, Poland's per capita use of both primary energy and electricity was about half that of the wealthier Western European states (Soliński & Gawlik, 2012). During the economic transition in the early 1990s, as a result of a significant decline in the activities of energy-intensive heavy industry, demand for fuels and energy, particularly coal and electricity, was greatly reduced (Dolfsma & Mamica, 2020). Prices regained their rightful status as an economic indicator. Costs are now a key component in the energy economy's rationalisation process, coal supplied to power plants is of higher quality, and electricity production is more efficient. Furthermore, the local economy saw a remarkable fall in heat losses, and the energy industry launched a number of projects to prevent and, where feasible, reverse environmental degradation. With the country's economic expansion beginning in 1993, the structure of its energy balance began to shift. Energy use, both primary and electric, gradually began to increase (Polish Member Committee of the World Energy Council, 2014). In 1995, Poland's power system was integrated into the Western European grid. In 1997, the Polish Parliament passed the Energy Act, which governs the legal and economic solutions for its energy sector (Soliński & Gawlik, 2012).

Currently, Poland's energy sector is primarily based on the combustion of hard coal and lignite (Marks-Bielska et al., 2020); thus, in the light of the potential depletion of natural resources and the need to reduce CO2 emissions, measures to promote and implement renewable energy sources must be implemented without delay. This is not an easy task, as coal has been utilised in Poland for over a century (Kochanek, 2021) and has become a substantial barrier to the larger-scale implementation of renewable energy, with numerous attendant implications. Reluctance to alter the *status quo* and fear of a comprehensive infrastructure transformation have led to Poland's strong endorsement of its 'carbon culture' (Juszczyk & Shakeel, 2020). It should be noted that Poland is a world leader in hard coal and lignite mining (Kochanek, 2021), whereas among European Union countries, it leads in hard coal mining and ranks second in lignite mining. Therefore, it should come as no surprise that in 2009, the Council of Ministers adopted a strategic document called 'Energy Policy in Poland until 2030', which provided that to ensure the country's energy security, the Polish economy would still be based on coal, which will remain the main source of fuel in heating and energy (Sobczyk & Sobczyk, 2021). In 2018, at the 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24) in Katowice, the President of Poland Andrzej Duda declared that the country does not currently plan to completely abandon coal, suggesting that the industry is actively safeguarded by policy (Brauers & Oei, 2020). However, given the damaging effects of fossil fuels on the environment, Poland will eventually need to begin decarbonising its economy (Kampas et al., 2021; Król & Gomola, 2022). Among a host of other challenges, many current mining jobs will be eliminated as unproductive mines are phased out, but so far, more than half of miners who resigned from their employment remain out of work, because they typically lack the education necessary to achieve comparable earnings in other industries (Wójcik-Jurkiewicz et al., 2021).

In 2009, Poland adopted the ‘Energy Policy of Poland until 2040’ strategy, identifying six priority areas for which a number of projects were implemented with a view to improving energy end-use efficiency. Between 2008 and 2018, primary energy use fell by 2.6%, while final energy use decreased by 2% annually. The industrial sector recorded the fastest rate of increase in energy efficiency. One of the main success factors was the implementation of new regulations for the prices of co-generated district heat, which has resulted in the economisation of producer operations. The Energy Efficiency Act of 2015, which introduced a range of regulations in the construction sector, was also instrumental in boosting building energy performance (Ministerstwo Gospodarki, 2009). The Act also provided for systemic solutions that, apart from the existing means and programmes at the national, regional, and local levels, allow for increased efficiency in the generation and supply of energy and fuels, as well as energy use by final consumers (Dolega, 2018). The latter also requires increased energy literacy of end users (Białynicki-Birula et al., 2022). Far-reaching modernisation efforts in heat and power plants, whose original goal was to bring the greenhouse gas emissions into compliance with EU regulations, have also contributed to improved efficiency. Last but not least, a number of pro-efficiency activities – such as advertising campaigns, educational films, and guides – have successfully promoted desirable attitudes in this area. The PEP2030 strategy placed a high priority on maintaining sufficient energy resources. In the case of coal, it provided for a proper management of the available resources and consistent supply of fuel of appropriate quality (Ministerstwo Gospodarki, 2009).

Although Poland had put in place a strategy that was intended to serve as the cornerstone of its energy transition, the 10H Act of 2016 effectively prevented the country from developing wind energy (Szczepańska, 2021; Wiśniewski, 2020), despite the very high potential of onshore wind farms (Kalda, 2013; Soliński et al., 2008). The acceleration of work related to the energy transition of the Polish economy is inextricably linked with Poland’s membership in the EU structures. As a member of the European community, Poland is obliged to respect EU law and, therefore, to implement assumptions of the ‘Fit for 55’ package, which assumes a reduction of greenhouse gas emissions by 55% by 2030 compared to the emission level in 1990. Part of the ‘Fit for 55’ package is the Renewable Energy Directive, which assumes that by 2030, 42.5% of energy in the EU will come from renewable sources (Widuto, 2023). Therefore, Poland must implement policies to accelerate the country’s shift from a coal-based economy to one that uses renewable energy and heat sources. The year 2019 saw the adoption of a new renewable energy strategy named the European Green Deal, which aims to reduce the economy’s emissions intensity (particularly from conventional sources), transform the structure of energy generation (Brodny et al., 2020), and accelerate the transition from carbon to green economy. The new document anticipates that the proportion of renewable energy in heating and cooling will rise by 1–1.3% annually. According to the estimations, renewable energy will thus account for 21% of Poland’s total energy consumption in 2030. Photovoltaics and wind farms will be critical in meeting the stated energy targets (Rabe et al., 2020). Since the 1980s, nuclear power plants have been proposed as a potential remedy to revitalise Poland’s inefficient, coal-oriented, and ageing energy infrastructure. However, no nuclear power plant units have been built in Poland to date. At that time, a decision was made to construct a nuclear power plant in Żarnowiec. After the economic transformation, due to the economic situation and protests from residents who remembered the recent Chernobyl disaster, the construction work was halted. In 1990, the Council of Ministers passed a resolution to dismantle the unfinished power plant (Olkuski & Grudziński, 2019). A breakthrough occurred in 2020 when the Polish Nuclear Power Programme was updated, specifying the launch date, the technologies to be used, and the capacity of the first nuclear reactors. It is currently assumed that by 2045, about one-quarter of Poland's energy mix should come from nuclear power plants (Sawicki & Horbaczewska, 2021).

Ways of measuring energy transition

Several energy transition indicators have been devised so far. One of them (mentioned above) is the World Economic Forum's Energy Transition Index (ETI), which is divided into two sub-indices: System performance and Transition readiness. The first one consists of three categories (Equitable, Secure, and Sustainable), while the other is further divided into two categories (Regulatory framework and Investment as well as Enabling factors). The overall 2023 index is based on 46 detailed indicators, with each category drawing on inputs from variable numbers of supplementary metrics. The ETI, apart from energy-specific issues, is informed by a range of other factors – such as political stability, legal rules, and the quality of education – that either promote or hinder the energy transition potential (World Economic Forum, 2023).

Another index for measuring energy transition is the World Energy Trilemma Index (WETI) developed by the World Energy Council. The WETI is comprised of three categories: Energy security, Energy equity, and Environmental sustainability. Like the ETI, the WETI takes into account the national context and uses 59 datasets in total (Kopeć & Lach, 2021; World Energy Council, 2022).

Modified Energy Transition Index 2020 (METI2020) is an interesting new indicator that "uses advanced statistical methods to minimise the impact of discretion on composite indicator construction" (Kopeć & Lach, 2021). As its originators point out, METI2020 "is consistent with the current recommendations of the Organisation for Economic Co-operation and Development (OECD) and the European Commission's Joint Research Centre (JRC) regarding the construction of composite indicators." METI2020, which is a proposed improvement of the ETI index, comprises 39 detailed indices (Kopeć & Lach, 2021). Some studies (e.g. Luty & Zioło, 2023) which focus in part on energy transition apply multidimensional statistical analysis to assess EU countries' progress towards energy and climate policy goals. This metric, which can be seen as an important aspect of the energy transition process, consists of six variables that reflect energy-related factors and climate-related ones in equal measure.

Research methodology

In developing his composite indicator, the authors opted to divide it into four parts, namely Economy, Energy mix, Energy costs, and Import dependency, with a total of twelve sub-indicators. Each category was assigned sub-indices, the values of which were normalised to calculate the composite indicator. Thus, Energy intensity and Energy productivity serve as inputs to Economy. For Energy prices, indicators such as Energy prices for household consumers and Energy prices for non-household consumers were used. Energy mix was subdivided into Non-renewables use and Renewables use. The former consists of Supply, transition, and consumption of solid fossil fuels, as well as Supply, transition and consumption of gas. The other subcategory consists of the Use of renewables for transport, the Use of renewables for heating and cooling, and the Use of renewables for electricity. Finally, Import dependency comprises Energy imports dependency, Natural gas imports dependency, and Oil/petroleum products imports dependency.

In order to create the composite energy transition indicator, the above-mentioned metrics were divided into stimulants and destimulants. The former group includes: Energy productivity; Supply, transition and consumption of gas; Use of renewables for transport; Use of renewables for heating and cooling; and Use of renewables for electricity. The latter comprises Energy intensity; Supply, transition and consumption of solid fossil fuels; Electricity prices for household consumers; Electricity prices for non-household consumers; Energy imports dependency; Natural gas import dependency; and Oil/petroleum products import dependency.

Table 1. Indicator structure by category

Economy	Non-renewables use (energy mix)	Renewables use (energy mix)	Energy prices	Import dependency
• energy intensity; • energy productivity.	• the supply, transition, and consumption of solid fossil fuels; • the supply, transition, and consumption of gas.	• the use of renewables for transport; • the use of renewables for heating and cooling; • the use of renewables for electricity.	• electricity prices for household consumers; • electricity prices for non-household consumers.	• energy imports dependency; • natural gas import dependency; • oil/petroleum products import dependency.

Source: Own study.

The values of the composite energy transition index were estimated for EU countries using Eurostat data from 2015 to 2020. Due to missing data, countries such as Austria, Cyprus, Denmark, the Netherlands, and Malta were excluded from further study. As a result, the final analyses comprised 22 EU countries with complete data on the topic of interest. All data required for analysis was downloaded on 26th–28th November, 2022. The following formula was used to calculate the standardised measures:

$$t_{ij} = \frac{x_{ij} - \overline{x}_y}{s_j},$$

where:
t_{ij} – value of the standardised measure j,
X_{ij} – value of j in country i,
$\overline{x}_y$ – arithmetic average of j,
s_j – standard deviation.

The normalised value was calculated for each of the twelve indicators listed above. Thus, 12 normalised values were assigned to each of the 22 EU countries. The sum of these normalised values was then calculated for each country and divided by the number of countries included in the study. The resulting index was multiplied by 100 to obtain the composite indicators of the energy transition, which are discussed in this paper. In a similar way, indicator values were calculated for each of the four distinct categories, i.e. Economy, Energy mix, Energy prices, and Import dependency.

The indicator proposed in this paper provides a somewhat different perspective on the energy transition process by focusing on its core components while disregarding other factors that affect it. In other words, the new indicator disregards supplementary metrics that are frequently included in other indexes, such as political stability, the quality of education, and greenhouse gas emissions. Naturally, the latter are vital for the energy transition, but in the authors' opinion, the factors selected for study reveal specific future opportunities rather than reflect the current conditions. Likewise, greenhouse gas emissions are partially subsumed under solid fuel use; therefore, considering environmental factors separately from the energy system may have a twofold negative effect on the standing of certain countries in this kind of analysis, because heavily coal-dependent economies, like Poland's, inherently emit more CO2. As a result, after evaluating the available indicators, the authors opted to focus on the key challenges for energy transition, or the categories listed in Table 1.

In summary, the ETI is a well-known indicator that encompasses a range of specific metrics extending beyond the scope of the energy transition, considering many economic aspects. These categories include, among others, Education & Human Capital, Innovation, and Finance & Investments. It is worth noting that many of the indicators in the ETI are very general, which can somewhat improve or worsen the ranking position of individual countries. Similarly, the WETI includes categories such as Macroeconomic Environment, Governance, and Stability for Investment and Innovation, so these indices share certain similarities. The METI2020, on the other hand, is an indicator developed only for a given year, so it does not show how the energy transition process has progressed in individual EU countries, which is an added value in this work. The indicator proposed in this paper is transparent; its overall value shows the realities of the energy transition in the studied period by answering the question of how it was, without considering the conditions favourable to the transition (which allows answering the question of how it may be in the future). This indicator also allows for a good verification of which factors slow down the transition process, as well as indicating the sensitivity of the economy to future energy crises.

Results and discussion

According to the research findings, Poland has the lowest value of –26.92 for the proposed composite indicator (Table 2). Previously, Bulgaria had ranked last, but a significant decrease in oil imports in 2020 helped it climb the ranking. It should be noted, however, that data for that year may be skewed, since it marked the beginning of the COVID-19 pandemic. Moreover, assessing Poland's year-by-year performance reveals that the indicator's overall value remained consistently low. Poland ranked in the bottom three almost every year for the studied period, which was caused by several factors: 1. its economy's relatively high energy intensity and low energy productivity; 2. reliance on coal; 3. limited use of renewable energy sources; and 4. comparatively high reliance on gas and oil supplies from Russia. Nevertheless, based on the individual components of the index, it should be noted that Poland's low scores are mostly due to the unfavourable energy mix, as shown in Tables 3 and 4, namely excessive reliance on non-renewables (coal) accompanied by insufficient share of renewables.

In the proposed approach to measuring energy transition, Sweden is the highest scoring country (49.96) owing to the fact that its economy, unlike Poland's, is characterised by a significantly lower energy intensity, higher energy productivity, extensive use of renewable energy sources, and low reliance on raw material supplies from abroad. Luxembourg, Finland, Slovenia, and Croatia complete the top five. It is worth noting that Sweden was also the leader in the *Energy Transition Index 2020: From Crisis to Rebound Report* (World Economic Forum, 2020), and Finland came third, which suggests that the present analysis is accurate, since despite the use of different metrics, the positions of some of the studied countries are similar. Poland ranked 69th out of 115 surveyed countries (the lowest in the EU), which confirms that the pace of its energy transition at the time was too slow.

Table 2. Values of the composite indicator in 2015–2020 for selected countries

Country	2015	2016	2017	2018	2019	2020
Sweden	58.99	60.93	55.20	54.27	55.19	49.96
Luxembourg	34.56	32.94	37.55	37.87	39.71	35.50
Finland	29.90	20.45	25.15	23.80	23.80	25.38
Slovenia	11.42	11.06	13.95	13.75	12.55	14.40
Croatia	14.97	17.29	15.30	9.13	11.15	9.74
Estonia	–2.18	–5.44	–5.48	0.05	3.76	8.26
Ireland	1.71	7.07	10.87	11.05	13.28	7.14
France	8.47	9.62	7.55	7.36	6.85	4.98
Latvia	–0.55	–3.40	–2.82	7.67	4.09	0.31
Portugal	0.21	–3.01	–6.75	–4.04	0.59	–0.88
Romania	5.07	5.97	3.06	1.29	0.14	–1.65
Spain	–4.55	–0.77	–0.32	–2.39	–2.67	–3.43
Hungary	–5.60	–3.13	–3.43	–4.16	–5.50	–3.55
Italy	–3.01	–0.59	1.83	–0.41	–6.40	–4.90
Belgium	–3.19	–5.74	–7.77	–9.91	–9.52	–8.85
Lithuania	–8.73	–11.92	–10.74	–11.48	–13.53	–12.08
Bulgaria	–33.68	–36.22	–35.55	–35.81	–37.24	–12.61
Greece	–29.49	–22.75	–21.63	–21.92	–18.47	–17.52
Slovakia	–17.66	–17.36	–17.16	–20.82	–22.55	–18.23
the Czech Republic	–16.67	–15.05	–17.77	–18.44	–20.52	–20.55
Germany	–19.41	–18.81	–16.63	–13.88	–13.00	–24.49
Poland	–20.58	–21.15	–24.40	–22.95	–21.71	–26.92

Source: Own study.

In another well-known study, the *World Energy Trilemma Index 2020 Report* (World Energy Council, 2020), Sweden came in second (Switzerland ranked first, but was excluded from the analysis as it is not a member of the EU), followed by Denmark, Austria, and Finland. Poland ranked 41st out of 108 surveyed countries. The METI2020 index shows similar trends: Poland ranks below most EU economies, ahead of only Cyprus, Croatia, and Bulgaria (Kopeć & Lach, 2021). Other studies demonstrate that Poland's energy transition is far from ideal. For example, a report issued by the Association of Renewable Energy and Clean Technology (REA) in collaboration with Eaton ranked the potential of the energy transition in Poland at 3 on a five-point scale (REA, 2022).

A comparison of the composite indicators assigned to individual categories from 2015 to 2020 (Table 4) reveals that almost all of them declined, with the exception of Renewables use, which shows a minor improvement. This demonstrates that throughout the period in question, the energy transition in Poland was slower than in the other countries.

Table 3. Values of the composite indicator by category for 2020

Category / Country	Economy	Energy Mix			Energy prices	Import dependency
		Non-renewables use	Renewables use	Index value for Energy mix		
Belgium	0.26	13.24	–3.84	9.40	–10.50	–8.01
Bulgaria	–19.43	–14.53	–6.46	–20.99	11.17	16.64
Croatia	–3.47	3.11	–3.17	–0.07	5.79	7.49
the Czech Republic	–7.58	–9.53	–4.67	–14.20	3.64	–2.40
Estonia	–6.88	–2.08	3.73	1.65	8.46	5.03
Finland	–0.85	–2.77	24.38	21.62	6.02	–1.40
France	5.21	0.87	–4.58	–3.71	–0.11	3.60
Germany	6.75	0.85	–1.57	–0.72	–24.71	–5.81
Greece	1.78	–4.60	–7.15	–11.74	3.34	–10.90
Hungary	–6.58	4.82	–7.38	–2.56	7.79	–2.19
Ireland	23.96	7.73	–3.70	4.03	–9.86	–10.98
Italy	7.12	9.01	–4.70	4.32	–10.78	–5.55
Latvia	–3.88	1.44	1.95	3.39	3.30	–2.50
Lithuania	–4.50	4.67	–4.03	0.63	4.82	–13.02
Luxembourg	11.84	8.24	13.52	21.75	2.30	–0.39
Poland	–6.58	–10.51	–7.66	–18,17	1.65	–3.83
Portugal	2.71	1.04	–1.53	–0.50	–4.31	1.22
Romania	–3.62	–1.69	–7.38	–9.07	3.40	7.64
Slovakia	–5.31	1.44	–6.33	–4.89	–4.08	–3.96
Slovenia	–0.83	–7.32	0.07	–7.24	3.06	19.41
Spain	4.40	2.26	–4.55	–2.29	–5.52	–0.01
Sweden	5.46	–5.70	35.07	29.38	5.16	9.96

Source: Own study.

Table 4. Values of the composite indicator for Poland in 2015–2020 by category

Category / Year	Economy	Energy mix			Energy prices	Import dependency
		Non-renewables use	Renewables use	Index value for Energy mix		
2015	–6.40	–8.95	–7.85	–16.80	4.96	–2.34
2016	–6.77	–9.81	–8.22	–18.04	6.19	–2.54
2017	–6.72	–9.53	–8.38	–17.91	3.67	–3.43
2018	–7.15	–9.53	–7.15	–16.67	4.66	–3.79
2019	–6.78	–9.98	–7.55	–17.52	5.90	–3.31
2020	–6.58	–10.51	–7.66	–18,17	1.65	–3.83

Source: Own study.

Poland's energy transition remained sluggish until 2020; however, since then, the share of photovoltaic systems in the production of electricity has significantly increased, with over 60% rise in new capacity between 2021 and 2022 (Ciuła et al., 2023). In November 2022, the government approved the construction of the first nuclear power plant (Rada Ministrów RP, 2022). Between 2033 and 2043, six nuclear power stations with a combined capacity of 6 to 9 GW are projected to be built. Furthermore, the state-owned company PKN Orlen is actively developing small modular reactors (SMR) to deliver energy to industry, power plants, and for heating purposes (Orlen Synthos Green Energy, 2024). Finally, the controversial 10H Act was repealed, allowing wind turbines to be built 700 meters away from populated areas (Filipiak & Mielczarski 2023).

It should be noted that, despite the overall favourable trends, some government policies are not necessarily beneficial to energy transition as such. As of 1st April, 2022, a new net billing system replaced the net metering scheme that had been in place since 2016 (Kancelaria Sejmu, 2021), leading some prosumers to doubt the benefits of investing in renewable energy. Under the new arrangement, prosumers will pay more for the energy they consume and less for what they produce; some even anticipate that the investment costs may outweigh the advantages (Niklewicz-Pijaczyńska, 2022).

Conclusions

The key findings from the analysis of Poland's energy transition between 2015 and 2020 in comparison with other EU countries are listed below. They also address the research questions posed in this paper:

1. In 2020, Poland ranked bottom with a score of –26.92 on the composite indicator discussed in this study. The reading peaked in 2015, but remained low from 2016 to 2020.
2. Poland was among the three EU nations with the lowest composite indicator scores between 2015 and 2019, but it recorded the poorest performance in 2020. Other studies that address a similar topic – such as the Energy Transition Index, World Energy Trilemma Index, and METI2020 – also highlight Poland's stalled energy transition in 2020.
3. Several factors contributed to this outcome: 1. high energy consumption and low energy efficiency; 2. the economy's reliance on coal; 3. minimal use of renewable energy sources; and 4. excessive reliance on gas and oil imports from Russia. However, the structure of the energy mix had the greatest impact.

Finally, various legal constraints imposed by the Polish government, such as the 10H Act, hampered the development of renewable energy sources. Although this study does not address political decisions, the resultant failure to harness the potential of wind power undoubtedly affected the reported value of the composite indicator. Based on the presented analysis, we recommend further investment in renewable energy sources (RES). However, due to the predominant use of solar panels, it is necessary to invest in energy storage, the continuation of decarbonisation efforts (using EU funds to carry out a just transition for the most vulnerable regions), the modernisation of transmission networks – which are not adapted to the realities of the energy transition – as well as the creation of appropriate support programmes that will allow for investment in energy-efficient heat pumps or energy storage, with particular emphasis on energy-poor individuals.

Acknowledgments:

The publication was financed from the subsidy granted to the Kraków University of Economic Project No. 047/GAG/2022/POT.

Reference List

Białynicki-Birula, P., Makieła, K., & Mamica, Ł. (2022). Energy Literacy and Its Determinants among Students within the Context of Public Intervention in Poland. *Energies*, *15*(15), 5368. https://doi.org/10.3390/en15155368

Brauers, H., & Oei, P.-Y. (2020). The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels. *Energy Policy*, *144*, 111621. https://doi.org/10.1016/j.enpol.2020.111621

Brodny, J., Tutak, M., & Saki, S. A. (2020). Forecasting the Structure of Energy Production from Renewable Energy Sources and Biofuels in Poland. *Energies*, *13*(10), 2539. https://doi.org/10.3390/en13102539

Ciuła, R., Gajkowski, J., Kowalak, T., Grochowski, K., Kalinowski, K., Krzyżanowska, A., Sulej, A., & Wiśniewski, K. (2023). *Rynek fotowoltaiki w Polsce*. Available at: https://raporty-branzowe.cire.pl/files/portal/186/news/334162/cbf06a97d3d51dc783b5eda66ea6123a2e01638301db91fb316f383b-7b3511ab.pdf [accessed: 15.04.2023].

Dolega, W. (2018). *Energy efficiency—Case study Poland*. 1–6. https://doi.org/10.1109/IMITEL.2018.8370463

Dolfsma, W., & Mamica, Ł. (2020). Industrial Policy—An Institutional Economic Framework for Assessment. *Journal of Economic Issues*, *54*(2), 349–355. https://doi.org/10.1080/00213624.2020.1743143

Juszczyk, O., & Shakeel, S. R. (2020). Comparative Analysis of Barriers for Renewable Energy Technologies Diffusion in Finland and Poland. In J. I. Kantola, S. Nazir, & V. Salminen (Eds.), *Advances in human factors, business management and leadership. Proceedings of the AHFE 2020 Virtual Conferences on Human Factors, Business Management and Society, and Human Factors in Management and Leadership, July 16–20, 2020, USA* (Vol. 1209, pp. 269–275). Springer. https://doi.org/10.1007/978-3-030-50791-6_34

Kalda, G. (2013). *Perspektywy rozwoju energetyki wiatrowej w Polsce do 2020 roku*. Available at: https://scholar.archive.org/work/tt3ihiktfzdwtmvgwplcybycta/access/wayback/http://doi.prz.edu.pl/pl/pdf/biis/68 [accessed: 15.03.2023].

Kampas, A., Rozakis, S., Faber, A., & Mamica, Ł. (2021). Assessing the Green Growth Trajectory throughResource and Impact Decoupling Indices: The Case of Poland. *Polish Journal of Environmental Studies*, *30*(3), 2573–2587. https://doi.org/10.15244/pjoes/128585

Kochanek, E. (2021). The Energy Transition in the Visegrad Group Countries. *Energies*, *14*(8), 2212. https://doi.org/10.3390/en14082212

Kopeć, S., & Lach, Ł. (2021). Jak mierzyć postępy transformacji energetycznej? *Energetyka Rozproszona*. https://doi.org/10.7494/er.2021.5-6.133

Król, M., & Gomola, A. (2022). How to Reduce Low-Stack Emissions? An Assessment of the Willingness of Residents of Single-Family Houses to Replace Fossil Fuel Heating Systems. *Journal Public Governance*, *2(60)/2022*, 48–63. https://doi.org/10.15678/PG.2022.60.2.04

Luty, L., & Zioło, M. (2023). Differentiation of climate and energy policy in the countries of the European Union. *Scientific Papers of Silesian University of Technology. Organization and Management Series*, *2023*(166), 505–517. https://doi.org/10.29119/1641-3466.2022.166.32

Mamica, Ł., Mazur-Bubak, M., & Wróbel-Rotter, R. (2022). Can Biogas Plants Become a Significant Part of the New Polish Energy Deal? Business Opportunities for Poland's Biogas Industry. *Sustainability*, *14*(3), 1614. https://doi.org/10.3390/su14031614

Marks-Bielska, R., Bielski, S., Pik, K., & Kurowska, K. (2020). The Importance of Renewable Energy Sources in Poland's Energy Mix. *Energies*, *13*(18), 4624. https://doi.org/10.3390/en13184624

Ministerstwo Gospodarki (2009). *Polityka energetyczna Polski do 2030 roku*.

Niklewicz-Pijaczyńska, M. (2022). *Paradygmat prosumenta wobec aktualnych wyzwań transformacji energetycznej*. *Folia Iuridica Universitatis Wratislaviensis*, *11*(2), 84–101. https://doi.org/10.34616/145039

Olkuski, T., & Grudziński, Z. (2019). Polityka energetyczna Polski–nowe wyzwania. *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią PAN*.
Orlen Synthos Green Energy. (2024). *Małe reaktory modułowe dla Polski*. Available at: https://osge.com/ [accessed: 15.03.2023].
Polish Member Committee of the World Energy Council. (2014). *Energy sector of the world and Poland Beginnings, Development, Present state second edition, updated*. World Energy Council. Available at: https://www.worldenergy.org/assets/images/imported/2014/12/Energy_Sector_of_the_world_and_Poland_EN.pdf [accessed: 15.03.2023].
Rabe, M., Streimikiene, D., & Bilan, Y. (2020). Model of Optimization of Wind Energy Production in the Light of Legal Changes in Poland. *Energies*, *13*(7), 1557. https://doi.org/10.3390/en13071557
REA (2022). *Energy Transition Readiness Report 2022*. Available at: https://www.r-e-a.net/resources/etri-2022-energy-transition-readiness-index-report/ [accessed: 15.03.2023].
Rozakis, S., Bartoli, A., Dach, J., Jędrejek, A., Kowalczyk-Juśko, A., Mamica, Ł., Pochwatka, P., Pudelko, R., & Shu, K. (2021). Policy Impact on Regional Biogas Using a Modular Modeling Tool. *Energies*, *14*(13), 3738. https://doi.org/10.3390/en14133738
Sawicki, Ł., & Horbaczewska, B. (2021). Role of the state in implementation of strategic investment projects: The SaHo Model for nuclear power. *International Journal of Management and Economics*, *57*(4), 343–359. https://doi.org/10.2478/ijme-2021-0020
Sobczyk, W., & Sobczyk, E. J. (2021). Varying the Energy Mix in the EU-28 and in Poland as a Step towards Sustainable Development. *Energies*, *14*(5), 1502. https://doi.org/10.3390/en14051502
Soliński, I., Soliński, B., & Solińska, M. (2008). *Rola i znaczenie energetyki wiatrowej w sektorze energetyki odnawialnej*. Available at: https://se.min-pan.krakow.pl/pelne_teksty22/czi/k22_solinski_z.pdf [accessed: 15.03.2023].
Soliński, J., & Gawlik, L. (2012). Rys historyczny, rozwój i stan obecny światowego i polskiego sektora energii. *Energetyka*, *3–4*, 142–149. Available at: https://elektroenergetyka.pl/upload/file/2012/3-4/Solinski.pdf [accessed: 15.03.2023].
Szczepańska, S. (2021). *Czkawka 10H* (1–nr 5-6(81)/2021). Nowa Energia. Available at: https://bibliotekanauki.pl/articles/2080427.pdf [accessed: 15.03.2023].
Uchwała Nr 215/2022 Rady Ministrów z Dnia 2 Listopada 2022 r. w Sprawie Budowy Wielkoskalowych Elektrowni Jądrowych w Rzeczypospolitej Polskiej (2022). Available at: https://monitorpolski.gov.pl/MP/2022/1124 [accessed: 15.03.2023].
Ustawa z Dnia 29 Października 2021 r. o Zmianie Ustawy o Odnawialnych Źródłach Energii Oraz Niektórych Innych Ustaw (2021). Available at: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210002376/U/D20212376Lj.pdf [accessed: 15.03.2023].
Widuto, A. (2023). Revision of the Renewable Energy Directive: Fit for 55 package. *European Parliament: Strasbourg, France*.
Wiśniewski, G. (2020). Projekty wiatrowe w Polsce a ustawa 10H. *Elektroinstalator*, *nr 10*. Available at: https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-8c42cfc0-04b1-470d-96bf-d45a168b2423 [accessed: 15.03.2023].
Wójcik-Jurkiewicz, M., Czarnecka, M., Kinelski, G., Sadowska, B., & Bilińska-Reformat, K. (2021). Determinants of Decarbonisation in the Transformation of the Energy Sector: The Case of Poland. *Energies*, *14*(5), 1217. https://doi.org/10.3390/en14051217
World Economic Forum (2020). *Fostering Effective Energy Transition 2020 edition*. Available at: https://www.weforum.org/publications/fostering-effective-energy-transition-2020/ [accessed: 15.03.2023].
World Economic Forum (2023). *Fostering Effective Energy Transition 2023 Edition*. Available at: https://www.weforum.org/publications/fostering-effective-energy-transition-2023/ [accessed: 15.03.2023].
World Energy Council (2020). *World Energy Trilemma Index 2020 Report*. Available at: https://www.worldenergy.org/publications/entry/world-energy-trilemma-index-2020 [accessed: 15.03.2023].
World Energy Council (2022). *World Energy Trilemma Index 2022*. Available at: https://www.worldenergy.org/publications/entry/world-energy-trilemma-index-2022 [accessed: 15.03.2023].

Funding
This research received no external funding.
Research Ethics Committee
Not applicable.
Conflicts of Interest
The authors declare no conflict of interest.

Data Availability Statement
All data will be available and shared upon request.