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GREEN DEAL AS ONE OF THE DETERMINANTS OF ENERGY POVERTY

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Purpose: The aim is to investigate whether the obligations of the European Green Deal have an impact on energy poverty in Poland.
Design/methodology/approach: The paper seeks to indicate whether the decarbonisation, renewable energy and energy efficiency commitments of the European Green Deal (EGD) have an impact on the scale of energy poverty. The paper uses two research methods. The first was a diagnostic survey method to determine whether households perceive climate issues as an important part of their well-being. The second is regression analysis to assess the impact of climate factors on the scale of energy poverty.
Findings: The results of the study indicated that, in the long term, energy poverty is influenced by macroeconomic stability of households, RES production and energy efficiency, while in the short term, since the introduction of the Green Deal rules, macroeconomic stability has proved to be the strongest influence.
Research limitations/implications: Unfortunately, there is a lack of long-term data on energy poverty as measured by the indicators recommended by the European Commission, which makes long-term analyses impossible.
Practical implications: The European Green Deal was implemented only a few years ago, so its long-term effects will take a few years to develop. For now, we can only analyse the short-term effects.
Social implications: The legislation does not distinguish between fuel poverty and energy poverty and, in addition, does not cover the full, including social, effects of energy poverty.
Originality/value: To the author's knowledge, this article is the first to analyse energy poverty not only in terms of energy prices, but also taking into account the climate dimension. So far, only the availability of energy on the grid or the financial possibilities for energy consumption have been analysed. This article also draws attention to the issues of access to clean energy and decarbonisation, understood as access to an environment with ever lower CO2 emissions. This has practical implications for both households and industry.
Keywords: energy poverty, European Green Deal, decarbonisation, Poland.
Category of the paper: research paper.

1. Introduction

The European Green Deal (EGD) is a set of policy initiatives and regulations that set the European Union's climate goals for 2050 (European Commission, 2024a). According to it, the aim is to achieve climate neutrality, i.e. zero net greenhouse gas emissions, the transformation of the economy towards sustainable development, a sustainable food system and the protection of biodiversity. Most important, however, is the decarbonisation of the economy. However, the drive to reduce greenhouse gas emissions is not the novelty in the European Union's economic policy, as this task has been pursued since 2005 when the Kyoto Protocol treaty came into force. What distinguishes these regulations is the fact that the targets are ambitious and commit governments to green goals up to zero emissions. In terms of energy, the Green Deal aims to ensure an affordable and secure energy supply, energy efficiency and the development of renewable energy sources (RES). It is impossible to see how this indirectly affects both industry (Gajdzik et al., 2024a) and households (García-Vaquero et al., 2024). Industry is mainly affected in the form of necessary investments to reduce greenhouse gas emissions or production productivity (Halkos, Aslanidis, 2024; Nagaj et al., 2024), while households are affected in the form of prices and expenditures on energy carriers (Wysokińska, 2024), which may consequently affect the phenomenon of energy poverty.

To date, the literature has not analysed the impact of the EGD on the economy, energy prices or other spheres of social life very extensively. There have, of course, been some such analyses, but not many so far. Figure 1 shows the research areas that the literature addresses in the analysis of the EGD and the relationship between the EGD and energy prices.

The most extensively analysed so far has been the impact on energy policy, what types of energy feedstocks are used in industry, changes in the supply of fossil fuels, environmental changes and how demand has responded to the assumptions made in EGD. There have also been analyses of how the Green Deal has affected the functioning of energy markets (Nagel et al., 2023), energy prices (Wysokińska, 2024), or the challenges facing energy markets in the face of the war in Ukraine (Arrayo, 2023). Analysing the literature to date, it is noticeable that changes in industry, energy policy and the area of energy prices are highlighted. All this raises the question of whether the EGD arrangements will also affect consumers, their ability to purchase energy carriers and, more broadly, their accessibility to energy carriers. The aim of this manuscript is to investigate whether the regulations adopted under the European Green Deal have an impact on energy poverty in Poland. This objective is guided by three research tasks (RTs):

RT1: to estimate the energy poverty rate in Poland.

RT2: to review the literature concerning potential effects of European Green Deal and factors that may determine energy poverty.

RT3: to analyse the impact of EGD package on the level of energy poverty in Poland.

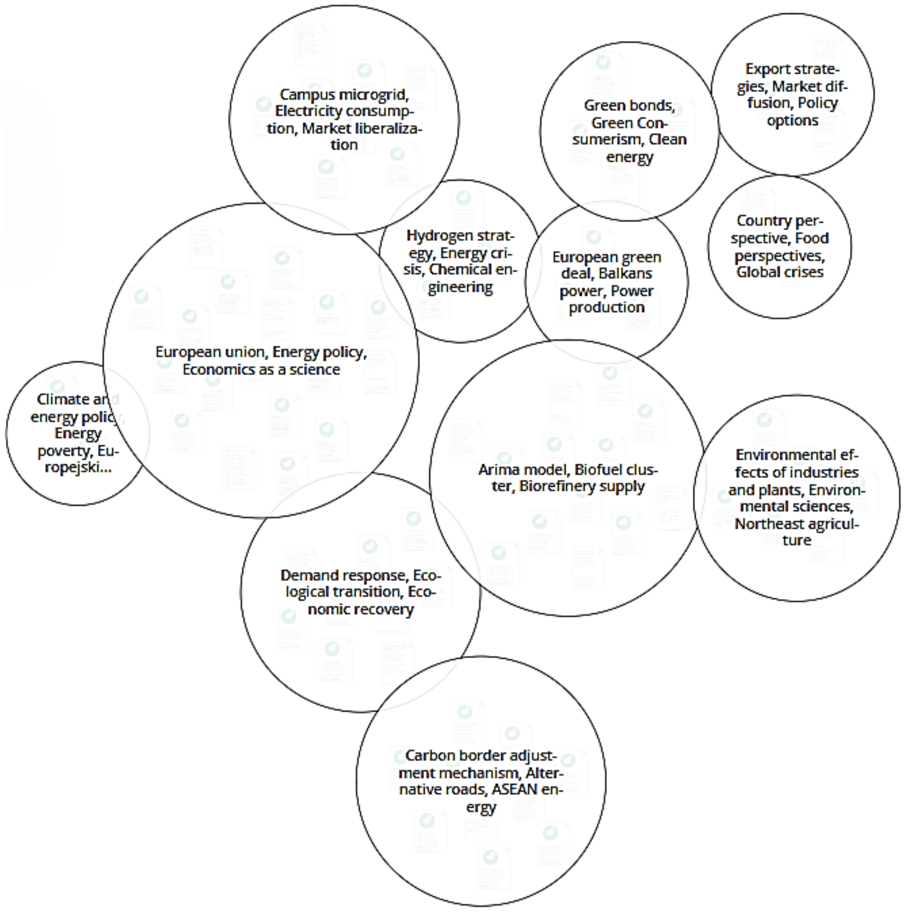

Figure 1. Topics of works in the literature analysing the role of the European Green Deal and the relationship with energy poverty and energy prices.

Source: Open Knowledge Maps (2024). Knowledge Map of green deal and energy prices. Retrieved from: https://openknowledgemaps.org/map/15b6398b6d0803bf8d8c4fe0083bfde8, 10.11.2024.

The research tasks formulated in this way are accompanied by the following research questions (RQs):

RQ1: What are determinants of the energy poverty rate in Poland?

RQ2: What is the effect of European Green Deal package on energy poverty in Poland?

RQ3: What is the impact of CO2 emissions on the level of energy poverty in Poland?

So far, the links between EGD and fuel poverty have not been analysed in the literature. When analysing the literature in detail, the connection between the two phenomena was only found in one paper by García-Vaquero et al. (2024). In this paper, the authors pointed out that the green transition in Austria influences a decrease in GDP and, thus, an increase in poverty. More studies on this topic are unavailable, making this study a novelty to the literature.

In addition to filling a research gap, this work's formulated aim seems relevant for several reasons. First, the effects of EGD on energy poverty have not yet been analysed. Second, if such a potential impact exists, it also justifies the need for deep decarbonisation changes in industry, which is one of the main emitters of greenhouse gases, including CO2, in the Polish economy. Third, the existence of such links would highlight the need to redefine the concept of energy poverty.

The analysis covers the period 2005-2023. As the Green Deal is linked to decarbonisation policy, to capture the impact of the resulting commitments, the base period covers a period before comparable data is available.

The work structure is as follows: the first section presents the background of the analysis based on a narrative literature review about energy poverty and its determinants; the second section concerns the materials and methods used during the empirical analysis; the next section presents the research results of the analysis and discusses them; and the last section is a set of conclusions.

2. Background for analysis

The issue of energy poverty is defined differently in the literature and, most significantly, addressed to different target groups (Mathen, Sadath, 2022; Zainudin et al., 2023). Most commonly, it is defined in the literature as the inability to consume energy due to a lack of affordable energy carriers (Li et al., 2014; Nagaj, 2022) or due to insufficient income or socio-environmental factors (Makridou et al., 2024), regional (Andreoni, 2024) or related to a lack of physical access (Acharya, Sadath, 2019; Mathen, Sadath, 2022). In the first case, instead of the term energy poverty, the literature uses the term fuel poverty (Bouzarovski, Petrova, 2015), indicating that poor energy is "in fact" a fuel-poor household that is unable to meet its energy needs due to the high price of energy carriers. Since this type of poverty is associated with a lack of access to affordable energy resources, it most often affects developed countries. In the second understanding of energy poverty, this phenomenon most often involves societies or people living in regions where, due to low-income levels or membership in a particular social group or for environmental reasons, they cannot afford to purchase sufficient amounts of energy resources. Region, gender and culture are also considered responsible for energy poverty here (Betto et al., 2020). A third understanding of energy poverty is related to a lack of physical access to energy services. Most often, being energy-poor means difficulties for children with studying and doing their homework, using computers due to lack of electricity, difficulties finding jobs, or securing sufficient life services such as medical services (Acharya, Sadath, 2019; Lenz et al., 2017). However, regardless of how fuel poverty is understood, the literature distinguishes several factors that determine the extent of fuel poverty. Table 1 presents a literature review on the factors of fuel poverty. This review includes publications covering post-European Green Deal analyses.

Table 1.
Factors of energy poverty

Literature	Factors
Tasinga et al. 2024	Socio-economic factors, scalability of microgrids
Lehtonen et al. (2024)	Socio-economic status, charakterystyka zasobów budowlanych
Chan, Delina (2023)	Socio-economic factors, urbanisation and warmer temperatures, accessibility, affordability, flexibility, energy efficiency, needs, and practices
Lippert, Sareen (2023)	Stan infrastruktury
Hihetah et al. (2024)	Geographic coverage, gender, life stage, ethnicity, peoples abilities
Jayalath et al. (2024)	Local climate conditions, building stock and specific energy consumption patterns of the occupants
Nagel et al. (2023)	ETS allowance prices
García-Vaquero et al. (2024)	Social well-being, GDP

Source: own study.

As Tasinga et al. (2024) point out, renewable energy microgrids contribute to socio-economic development by improving living conditions. This results in higher GDP change, environmental benefits and consequently increased access to energy services. Hihetah et al. (2024) point out that there are many determinants of vulnerability to energy poverty. Therefore, they distinguish here such as geographic coverage, gender, life stage, ethnicity, and people's abilities. They all determine vulnerability to being energy-poor, especially in developing countries. Similarly, socioeconomic status, albeit along with building stock characteristics, is pointed out by Lehtonen et al. (2024). They note that energy poverty affects not only developing countries but also developed economies. Meanwhile, factors related to climate, the local climate conditions, building stock and specific energy consumption patterns of the occupants are highlighted by Jayalath et al. (2024). According to them, these factors determine the level of energy efficiency, which translates into the consumption needs of society. In addition to those mentioned above, Chan and Delina (2023) further distinguish accessibility, affordability, flexibility, energy efficiency, needs, and practices that, according to the authors, influence a household's vulnerability to energy poverty. Lippert and Sareen, on the other hand, point out that the state of the infrastructure, especially the energy infrastructure that would provide the opportunity for transitioning to low-carbon energy, may be necessary at present. Somewhat continuing this kind of analysis are the conclusions presented by Nagel et al. (2023), who, analysing the impact of the Green Deal on the Nordic energy market, pointed out that the effect to date has been increases in the price of CO2 allowances (ETS) and more significant fluctuations in energy prices. They found that decarbonisation measures to date have resulted in a slight impact on electricity production and a slight impact on the heat market. In contrast, they found increased conversion of electricity to heat. Thus, energy prices are rising, negatively affecting cheap energy availability. Somewhat similar conclusions are drawn by García-Vaquero et al. (2024), who point out that the green energy transition in Europe leads to inflation and structural poverty. They point out that it is possible to speak of a green financial bubble and a paradox according to which, in order to achieve greater future social welfare through the Green Deal, the effect is now a decrease in GDP.

Analysing all the drivers of change in energy poverty levels identified, it was found that in addition to the usual factors of income and level of socio-economic development, attention was also given to factors related to decarbonisation. This is perfectly illustrated by the division introduced by Chan and Delina (2023), who, as part of their analysis, mention the so-called 'hidden energy poverty', where, in the context of energy poverty, they divide this phenomenon into the poverty of clean and non-clean fuels. In this context, it is essential to mention the assumptions of the Green Deal and its implications. The Green Deal aims to achieve energy neutrality by 2050 (with an intermediate target of a net reduction of at least 55% by 2030 compared to 1990). The means to do this is to promote renewables, with a RES target of 42.5% in the energy mix. by 2030 and an improvement in energy efficiency by 11.7% by 2030 (European Commission, 2024b). Its implementation involves significant changes in the industrial sector and households.

The main impacts on the industry are:

- a reduction in the carbon footprint of industry (Gajdzik et al., 2024b),
- increased production costs in sectors dependent on fossil fuels, especially in mining industries (Moita et al., 2024; Mali et al., 2024),
- the need to invest in new technologies, especially RES (Gajdzik et al., 2024a),
- an increase in investment in low-carbon technologies that promote the reduction of CO2 emissions would increase the energy efficiency of production. Mainly, innovations in the area of clean hydrogen and energy storage are expected (Na et al., 2025),
- transformation of business models towards improved energy efficiency and a closed-loop economy (Na et al., 2025).

The main impacts on households are:

- increased energy prices (Wysokińska, 2024),
- increased cost of living and the risk of worsening energy poverty in some regions (García-Vaquero et al., 2024),
- anticipated improvements in the energy efficiency of buildings, resulting from increased funding to support households insulating buildings (Nagel et al., 2023),
- environmental education and awareness, to which the EU is devoting increasing resources. The anticipated result should be increased environmental awareness and changes in consumer behaviour (Liang et al., 2024).

3. Materials and Methods

The literature review indicated that the European Green Deal aims to decarbonise the economy, improve energy efficiency, mainly in the industrial sector, promote greater use of renewable energy sources and ensure sustainability of economic development. As the aim of this paper is to examine what impact the Green Deal, and more specifically its targets, has on energy poverty in Poland, the analysis will follow the model presented in Figure 2.

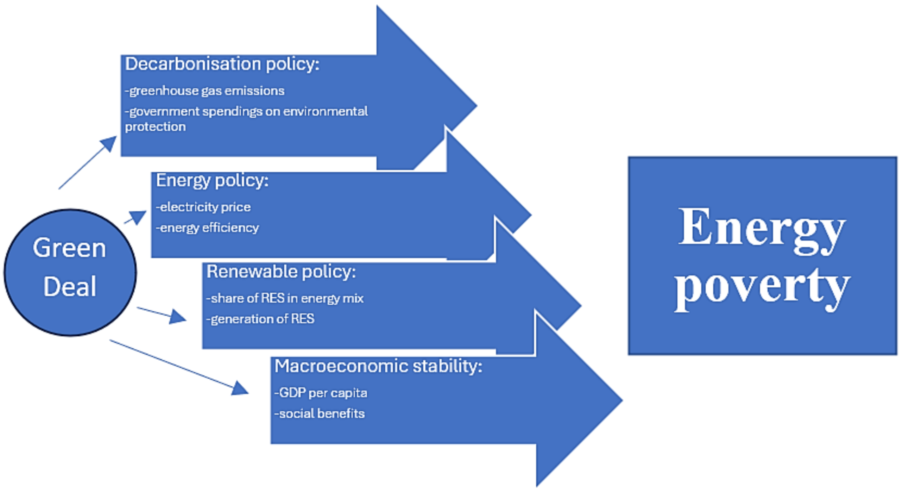

Figure 2. Model for analysing the impact of the Green Deal on energy poverty.

Source: own method of analysis.

Based on the assumptions of EGD, the model assumes 4 areas of influence: decarbonisation policy, energy policy, renewable policy, and macroeconomic stability. In each of these areas of EGD influence, 2 impact indicators were used for the analysis. Their selection is justified by the literature on energy poverty (see Table 1).

In turn, the Energy Poverty Index (EPI), which is a two-dimensional measure, i.e. consisting of 2 indicators, was applied to measure energy poverty:

- inability to keep home adequately warm (IKHAW) (European Energy Network, 2019),
- share of households in the country whose expenditure on energy carriers exceeds 10% of their disposable income (HEECDI) (Boardman, 1991; Nagaj, 2022).

This takes the approach that the weights to the indicators for measuring the EPI index will be equal. This approach can be employed if the importance of the dimensions does not differ significantly (Atkinson et al., 2003), and is additionally consistent with the literature on multicriteria energy poverty indices (Koomson, Danquah, 2021). In accordance with the methodology for creating such indices, the variables are weighted equally when constructing the availability or access to energy carriers index. Thus, the shares will be 0.5 and 0.5, and the EPI will be calculated according to the formula:

$$EPI = \sum_{i}^{t}(w_i \cdot IKHAW_t + w_i \cdot HEECDI_t), \quad (1)$$

where:
w_i – the weight value of a given indicator, where i = 1, 2;
t – period, i.e. the year for which the indicator is calculated;
$IKHAW_t$ – value of the indicator of inability to keep home adequately warm in a given period t;
$HEECDI_t$ – share of expenditures on energy carriers in disposable income of households in given period t.

Therefore, the econometric model by which the regression analysis will be carried out is as follows:

$$Y = a + b_1 \cdot X_1 + b_2 \cdot X_2 + b_3 \cdot X_3 + b_4 \cdot X_4 + b_5 \cdot X_5 + + b_6 \cdot X_6 + b_7 \cdot X_7 + b_8 \cdot X_8, \quad (2)$$

where:
Y– energy poverty index in Poland (dependent variable);
a – constant parameter, ie. Y intercept;
$b_{1,\ldots,8}$ – coefficients of the regression function for independent variables (i = 1, …, 8);
$X_1, X_2, \ldots, X_n$ – independent variables affecting the dependent (n = 1, …, 10).

According to the model (see Figure 2), the following indicators were used to measure the independent variables used in the econometric model:

X1 – CO2 emissions per capita (Jones et al., 2024 – with major processing by Our World in Data);

X2 – general government expenditure on environmental protection (mln euro) (Eurostat, 2024b);

X3 – electricity prices for household consumers - band DB (in national currency) (Eurostat, 2024a);

X4 – energy efficiency measured by the primary energy consumption per GDP (kWh per international-$) (U.S. Energy Information Administration, 2023; Energy Institute – Statistical Review of World Energy, 2024; Bolt, van Zanden - Maddison Project Database, 2023 – with major processing by Our World in Data);

X5 – share of primary energy consumption that comes from renewables (Energy Institute - Statistical Review of World Energy, 2024 – with major processing by Our World in Data);

X6 – Production of modern renewable electricity (from wind, hydro, solar, other renewables including bioenergy in TWh) (Ember, 2024; Energy Institute – Statistical Review of World Energy, 2024 – with major processing by Our World In Data);

X7 – GDP per capita in current prices in USD (World Bank, 2023 – with minor processing by Our World In Data),

X8 – Share of social benefits to households in GDP (OECD, 2024).

Calculations are performed using Statistica 13.1 software, at α = 0.05. The research period is 1995-2023. The research period results from the fact that data have been available since 1995.

4. Results

When proceeding with the analysis, the EPI value was first calculated. The results of these calculations are shown in Figure 3.

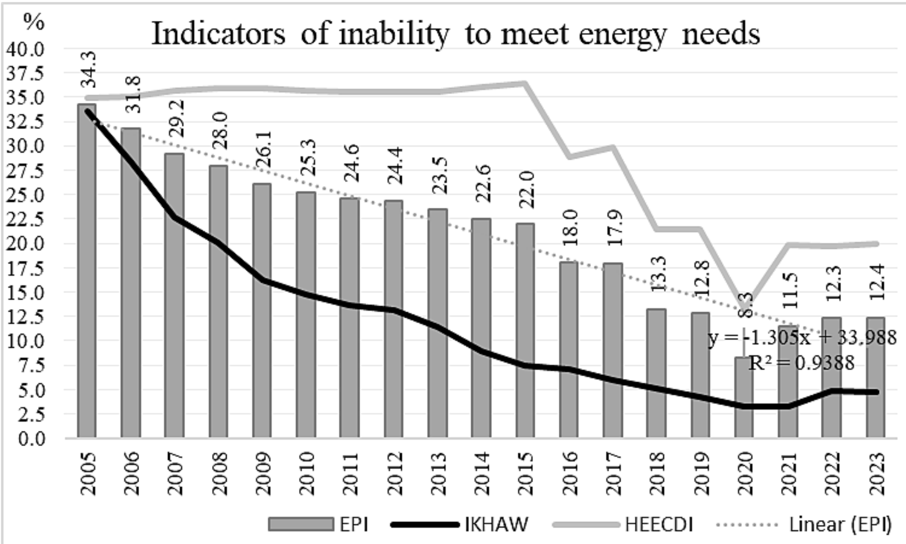

Figure 3. Indicators of inability to meet energy needs and energy poverty index in 2005-2023 in Poland.

Source: European Commission, Energy Poverty Advisory Hub. *National indicators.* Retrieved from: https://energy-poverty.ec.europa.eu/epah-indicators (13.11.2024); own calculations based on: Budżety gospodarstw domowych [Household budgets], GUS, Warsaw. Publications for years 2006-2023.

Analysis of the development of the EPI indicated that there was a decreasing trend of energy poverty in Poland over the research period. This concerned both inability to keep home adequately warm and too high a percentage of income spent on energy carriers. It is worth noting, however, that with regard to keeping home adequately warm, the percentage of the energy-poor society was low at only 4.7%, while with regard to spending on all energy carriers, this percentage of households in Poland was much higher at 20% in 2023. However, when analysing the development of the energy poverty index value in the context of the European Green Deal, it is worth noting that the scale of this poverty increases from 2021 onwards. Crucially, such a relationship is observed for both components of the EPI.

The development of EPI levels indicated that there was undoubtedly an increase in the proportion of energy-poor households after 2020, the adoption of the EGD regulations. This raises the assumption that the EGD provisions and the intensification of related activities were the driving factor. However, in order to find out which dimensions had a decisive influence, a regression analysis will be used. The analysis was carried out for annual data from 2005 to 2023. The results of the regression analysis are shown in Table 2.

Table 2.
Results of regression analysis for the energy poverty index in Poland

	Coefficients b^*_i	Standard error of b^*_i	Coefficients b_i	Standard error of b_i	t-statistic	p-value
N = 19	Regression statistics: R = 0.9930; R2 = 0.9860; Adjusted R2 = 0.9816; F = 228.26; p < 0.0000; Standard error: 1.0161					
Constant			42.4193	8.6810	4.8864	0.0003
Variable X4	-0.8747	0.1328	27.0736	4.1094	6.5881	0.0000
Variable X6	0.8152	0.1640	0.6222	0.1252	4.9704	0.0003
Variable X7	-0.8180	0.1458	-0.0011	0.0002	-5.6102	0.0001
Variable X8	-0.2332	0.0396	-2.4362	0.4132	-5.8958	0.0001

Source: own work.

The results of regression analysis indicated that a statistically significant impact on energy poverty is caused by 4 variables (X4, X6, X7, X8), i.e. energy efficiency, level of production of renewable energy sources, GDP per capita and level of social benefits in Poland. The remaining variables, despite correlations at an average level, do not have a statistically significant impact on the level of EPI. It is also worth noting that, throughout the research period, the greatest influence was exerted by the level of energy intensity - X4 (the value of the relationship with energy intensity is negative, indicating a positive relationship with energy efficiency). However, when considering the aggregate impact of each of the dimensions affected by the EGD, the dimension of household macroeconomic stability, represented in the model by GDP per capita and the level of social benefits, proved to be the most significant.

It is also worth comparing the level of correlation of the independent variables with the dependent variable for the entire research period (2005-2023) and the period under EGD regulation (2020-2023). This comparison will indicate which variables in the last 4 years have had the highest correlation with the development of the level of energy poverty and thus the changes that have occurred in the level of EPI.

Table 3.
Correlation coefficients of independent variables having a statistically significant impact on the EPI calculated for the years 2005-2023 and 2020-2023

	2005-2023	2020-2023
Variable X4	0.9465	-0.5960
Variable X6	-0.8874	0.7422
Variable X7	-0.9602	0.9298
Variable X8	-0.52735	-0.9079

Source: own work.

A comparison of the levels of the correlation index for the whole period under study (2005-2023) with the correlation values for 2020-2023 shows that there was a change in the direction of the relationship with the EPI for energy efficiency, RES production and GDP per capita. This may explain why there was a change of direction in the EPI level after 2020. However, it is also worth noting that the macroeconomic dimension, for which the correlation coefficients remained high, proved to be very important.

6. Discussion and Conclusions

The aim of the article was to investigate whether the regulations undertaken as part of the European Green Deal have an impact on energy poverty in Poland. This objective was due to the fact that the literature so far has not analysed the relationships between the Green Deal and energy poverty. The literature review indicated that there are few analyses of the impact of the EGD on socio-economic development and none for Poland in relation to energy poverty. As EGD implies decarbonisation of the economy, improvement of energy efficiency, promotion of renewable energy sources while ensuring sustainable economic development, hence the author of this manuscript focused on the analysis of what are determinants of the energy poverty rate in Poland (RQ1), the effect of EGD on energy poverty in Poland (RQ2) and the assessment of whether changes in the level of CO2 emissions affect the level of energy poverty in Poland (RQ3).

The study concludes that the long-term energy poverty rate in Poland shows a decreasing trend, and this applies both to the inability to keep home adequately warm and to the too high percentage of income spent on energy carriers. However, the analysis indicated that after 2020 there was a change in the trend from declining to increasing, coinciding with the enactment of the EGD regulations. In verifying the answer to RQ1, it was found that of the dimensions of the impact of EDG regulations, three of them have a statistically significant impact on energy poverty, i.e. energy policy and within it the development of energy efficiency, RES promotion policy and especially the level of production of renewable energy sources, and the macroeconomic stability of households, i.e. the level of GDP per capita and social benefits in Poland. These findings are consistent with those presented by Tasinga et al. (2024), Lehtonen et al. (2024) and García-Vaquero et al. (2024) on the leading role of socio-economic factors. Findings in this paper are in contrast to findings presented by Nagel et al. (2023), which is linked to the fact that electricity prices have been subsidised by the government in Poland in recent years. Responding to RQ3, it was found that decarbonising the economy by reducing CO2 emissions has no direct impact on the level of energy poverty in Poland, which is in contrast to the findings articulated by Jayalath et al. (2024).

Responding to RQ2, the analysis carried out in this manuscript indicated that EGD influenced the increase in the value of EPI, and the macroeconomic dimension of EGD appeared to be the most relevant here. This can be explained by the findings indicated by García-Vaquero et al. (2024), according to which the green energy transition in Europe leads to inflation, structural poverty and negatively affects GDP, with a consequent impact on the macroeconomic well-being of society. Hence, the role of GDP per capita and social benefits in shaping the level of energy poverty in Poland in the period from 2020 proved to be most crucial here.

The findings provided in this paper appear to be a valuable added value to the study of energy poverty and contribute to the literature by analysing the role of EGD in shaping this phenomenon. It is also a valuable recommendation for decision-makers and industry representatives that energy efficiency, which reduces the demand for energy consumption, is not only an important action for companies in the form of costs reductions, but also has a social dimension by contributing to a reduction in the level of energy poverty among households. The author is also aware of the research limitations of this work. The main one is that the research period for the analysis of the impact of the EDG is too short. This is due to the objective limitations that the EGD regulations are only in force from 2020. This makes long-term analyses impossible. Undoubtedly, such cause-and-effect analyses would enrich this analysis. However, this is a recommendation for future research in this scientific area.

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