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Article

Energy Transition Scenarios for Energy Poverty Alleviation: Analysis of the Delphi Study

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Abstract: Energy poverty is a phenomenon that is affecting an increasing number of EU citizens. It occurs when people are unable to buy enough energy to meet their needs at a socially acceptable level. Despite the many efforts and measures taken to prevent this negative phenomenon, the looming energy crisis could exacerbate it. On the one hand, efforts towards energy transition are intended to prevent this phenomenon, but on the other hand, inadequate restraint on the energy market may lead to its escalation. Various scenarios need to be analysed to ensure that the risks associated with energy shortages do not lead to even greater levels of energy poverty, with negative consequences for societies, economies, and the environment. Using a scenario approach and expert research, as well as mathematical–statistical tools, the article presents possible scenarios related to the implementation of measures affecting energy transformation and the transition to renewable energy sources in economies. These measures can change the phenomenon of energy poverty. The results of the analysis conducted in the article showed that there is a relationship between the increase in GDP per capita and the degree of energy consumption from renewable sources. In addition, there is a negative correlation between the degree of use of energy from renewable sources and the problem of energy poverty, especially in countries with a relatively lower level of GDP per capita. The current economic and political situation requires research in this area and the identification of possible solutions, as energy poverty is becoming a major social problem. The measures taken to promote sustainable development in an energy crisis situation might not be able to be implemented in a highly satisfactory manner.

Keywords: energy poverty; energy transformation; renewable energy; scenario; energy management

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1. Introduction

The European Union's climate policy assumes that by 2030, 32% of energy will come from renewable sources [1]. This means that energy transformation is becoming an undeniable fact, the assumptions of which are embedded in the environmental policies of individual Member States. On the other hand, it is an undeniable fact that the European Union countries are struggling with the problem of energy poverty [2], the causes of which arise from various sources. In common understanding, because of the low use of renewable energy resources, they are difficult to access and are expensive. Therefore, it should be considered whether the already occurring energy transformation will contribute to greater availability, and whether the proposed and used technologies will allow for reducing the costs associated with its use [3]. In addition, it is worth considering whether the energy poverty that affects the inhabitants of European economies can be eliminated precisely through the use of cheap, efficient, and widespread renewable energy for this purpose [4]. The phenomenon of energy poverty affects about 10% of the population of the European Union. Estimates may vary depending on the measurement method and scope of the energy poverty indicator; however, the 10% poverty scale [5] in economically developed Europe appears to be very high. Therefore, steps should be taken and solutions should be sought to overcome this problem. The energy transition should be the basis not only for changing the use of resources, from non-renewable to renewable, but also for reducing energy poverty [6].

An extremely important fact when considering issues related to both the transformation of energy policy [7,8] and the methods of influencing energy poverty is the use of renewable energy in various areas of social and economic life. Energy itself is actually the basis for the development of economies, and the observed energy shortages, excessive exploration of conventional energy resources, and need to care for the natural environment contribute to the change in the direction of energy policy measures and the increasing use of renewable energy sources. At the same time, it has been confirmed that an increased consumption of renewable energy can help accelerate global energy saving and emission reduction [6], but it is also worth exploring its potential impact on reducing energy poverty worldwide [9]. Active transformational climate policy and the promotion of measures related to the development of green energy [6] may bring about positive economic as well as social and environmental effects [10].

The aim of the considerations is to indicate possible scenarios that, with the implementation of the necessary changes and the implementation of the assumed energy transformation, as well as the accompanying changes in general economic indicators, may contribute to reducing the level of energy poverty. At the same time, the indicated scenarios will be supported by the assumptions and the degree of their fulfilment contained in the EU energy policy and selected national policies.

At the same time, it should be pointed out that reducing energy poverty, recognized as a social issue, is part of sectoral policies conducted by states as an element of political interventions. Linking and appropriate use of the scope of political interventions and adequate control of the processes taking place in economies allow for satisfying energy needs [11,12], thus reducing the level of energy poverty. The use of mechanisms and instruments dedicated to energy transformation and their support as part of a consistent energy policy (including, for example, subsidies for improving energy efficiency and tax breaks for energy-saving investments) may affect the implementation of other social policies (environmental costs and health problems of residents related to inadequate access to energy) [13]. At the same time, it should be mentioned that income-based financial assistance allows households to pay their electricity bills, but does not address the root causes of fuel poverty. These are mainly the result of inefficient, old buildings and a lack of adequate heating systems in residential buildings. This means that preventive policy tools should be used to increase energy efficiency. In this way, the measures taken need to be systemic, while at the same time having a long-term effect. In this way, they will make a relatable and real contribution to reducing energy exclusion.

The novelty of the considerations and their added value is the indication of various variants and scenarios of solutions, considering various forecast changes in not only economic indicators (including GDP, fuel prices, and the cost of using renewable energy) and the social and energy poverty indexes, but also the implementation of policy assumptions energy (including the use of renewable energy as an energy source). The novelty of the considerations can be considered from different points of view. The context of research and analysis adopted by the authors allows for the adoption and simultaneous construction of different scenarios that can be considered as part of the topic of energy exclusion. Basing them not only on statistical data, but also on the responses of domain experts is a novelty and an extension of the research in this area. Up until now, the simultaneous use of literature analysis, statistical methods, the Delphi method, and the creation of possible future scenarios on the basis of these has not been linked in scientific deliberations on the topic. Such a linkage gives a more complete picture of the situation and greater possibilities for inference as well as more accurate implications of future solutions and decisions. The reflections and especially the scenarios can have social but also managerial implications, becoming a guide for future actions. The structure of the considerations is as follows: Section 2 is the methodology and research questions; Section 3 is the analysis of the literature on the subject; Section 4 is the data collection and research process; Section 5: Scenarios framework as a basis of the analysis; and Section 6 is the findings, limitations, and discussion. The article ends with a summary.

2. Methodology and Research Questions

Based on a critical review of the literature, the authors indicate various ways of measuring energy poverty, as well as data and forecasts of selected general and general economic indicators (GDP, social poverty index, and RES use), on the basis of statistical data from EU and Eurostat reports. The data were used for empirical research and for creating model scenarios.

The flow chart of the methodology used in the paper is presented in Figure 1.

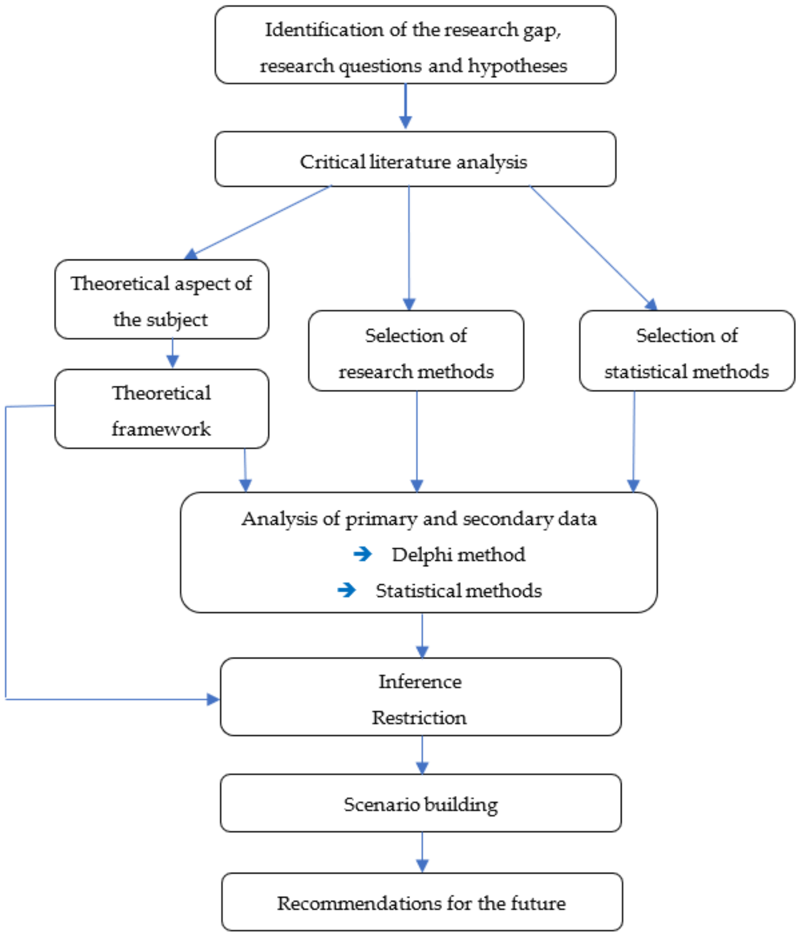


Figure 1. The flow chart of the methodology. Source: own elaborations.

The considerations attempt to answer the following research questions:

RQ 1: Can the energy transition help reduce the energy poverty rate?

Such a formulation of the question is interesting and brings with it a novelty, as currently access to renewable energy sources and their use, especially in households, is very limited. The costs of using this energy are also high, so it is also necessary to answer the question of what conditions should be met for this to happen. This research question should be answered not only in the literature on the subject or in the presented analyses of the statistical data, but also by highlighting and determining which boundary conditions, in the social, economic, and environmental context, should be met in order to reduce energy poverty. In addition, if these conditions are the same for all economies, can these issues be generalized, should the specificity of a given country be adopted?

The context of the first research question allows researchers to ask a second question, referring to typically economic conditions affecting both the level of the energy poverty indicator and the possibility of using renewable energy sources, where the aim will be to eliminate the first element and increase the use of the second.

RQ 2: How the economic changes reflected in the GDP indicator influence the achievement of the selected goals of the energy transition analysis based on scenarios. Will the combination of changes in the amount of GDP and the use of renewable energy sources, as well as the implementation of energy policy assumptions at the level of the EU and individual economies (e.g., Poland) contribute to changes in the rates of energy poverty, including whether it will help to reduce it?

To answer the above questions, we use data on the forecast of the implementation of RES use in comparison with macroeconomic indicators based on the analysis of the EU energy policy assumptions, in various approaches and in connection with the energy poverty indicator. Based on this, we developed scenarios of possible solutions. Finding an answer to the second question is associated with the need to use more renewable energy, which will be associated with greater availability, and this may contribute to price changes, and supporting solutions by governmental instruments, e.g., may contribute to changing the heating system and method, i.e., allowing for the switch to renewable energy and, at the same time, an opportunity for people suffering from energy poverty to get out of it.

Not only the literature on the subject will be used to find answers, but also statistical data and guidelines for energy policies, with particular emphasis on the assumed use of RES.

First, based on the publicly available databases, a comparative analysis of EU countries was carried out, taking into account selected features influencing energy poverty.

Then, in order to try answer the research questions presented in the article, seven EU countries were selected (three with the largest and three with the lowest GDP per capita, and Poland), and then the relationship analysis was conducted. For this purpose, the Statistica program was used. In order to check the correlations between the variables, Pearson correlation was used.

The statistical significance of the Pearson's correlation coefficient we assessed using Student's *t*-test at the significance level = 0.05, for which the null hypothesis (H0) was verified that Pearson's r correlation coefficient = 0 (no relationship), with the alternative hypothesis (H1) that Pearson's correlation coefficient $\neq 0$ (there is a relationship between the variables).

The next step in our analyses was to use the Delphi method to determine the trends, their impact and assess the probability of the occurrence of individual factors influencing the development of the RES market in the near future. Twelve experts were invited to participate in the study.

A simplified algorithm of the expert study carried out is presented in Figure 2.

The purposeful selection of experts was used, thanks to which efforts were made to obtain the knowledge, experience, and opinions of the most competent people from the point of view of the study. The experts included experts in the field of energy, experts in the field of economics, entrepreneurs, and a representative of a local government unit. According to the methodology, two series of questionnaires were conducted. The survey presented groups of factors influencing the development of energy from renewable sources along with the Likert scale. Based on the results from the first round, after comparing the responses, a second questionnaire was prepared, in which experts could read the forecasts of other specialists (anonymously), and change or maintain their previous opinions. The purpose of repeating the study was to reduce the scope of the divergence of opinion and to obtain the best possible consensus opinion of the majority of experts.

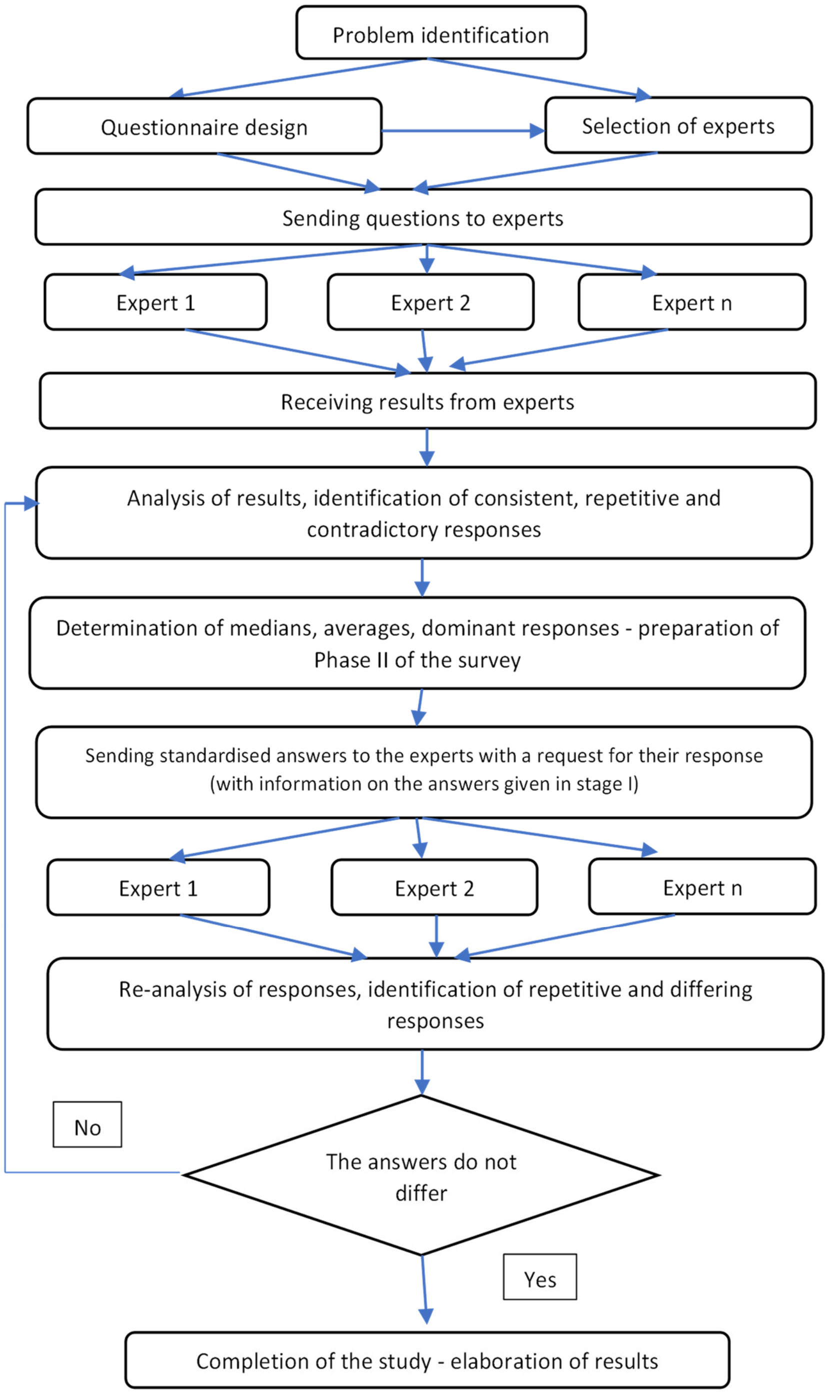


Figure 2. Simplified algorithm of the expert study carried out. Source: own elaborations.

Because there was no unanimity among researchers when assessing which of the concordance coefficients was the best when the application conditions allowed for the use of several available coefficients, the authors decided to use the Kendall's *W* coefficient. It was used to determine the coefficient of concordance between the experts' answers. The values of this coefficient ranged from 0 (complete disagreement) to 1 (complete compliance). This coefficient was calculated according to the following formula [14]:

$$W = \frac{12S^2}{m^2(k^3 - k)} - \frac{3(k+1)}{k-1} \quad (1)$$

which is the number of items to be rated.

The significance of the W coefficient was assessed using the χ^2 statistic with $k-1$ degrees of freedom:

$$\chi^2 = m(k-1)W \quad (2)$$

for which the null hypothesis (H0) that the experts do not agree is verified against the alternative hypothesis (H1), which states that the experts agree. In the absence of grounds for rejecting the null hypothesis, it can be concluded that the experts' answers were random, and thus they did not agree.

The next step in the analyses was to use the scenario method. The scenario method was used to formulate conclusions and possible recommendations for the future, which presents the predicted picture of the situation in the future. The created scenarios aim to present possible behaviours that result from appropriately adjusted factors as well as external factors taken into account. Their advantage is the strategic approach and the possibility of presenting the issue from various points of view, and thanks to this method, it is possible to predict various types of phenomena that may occur in a changing environment, and thus in the scope of decisions made; for example, take corrective actions or confirm well-conducted actions. A characteristic feature of the scenario method is the analysis of discontinuous changes, i.e., changes that are not an extrapolative continuation of the processes taking place in the environment in the past at a given time. The constant changes taking place in economies require the use of tools to increase their resilience and reduce risk to the currently identified phenomena. Scenario methods support activities in the field of strategic planning in the conditions of a changing and unstructured environment. They do not answer the question of what will happen in the future, but they can stimulate stakeholders to predict various phenomena and study their impact, using the identified phenomena. Scenario building allows for a company or state to cope with uncertainty and a rapidly changing environment [15]. It stimulates the management of enterprises or governments to consider variant thinking, i.e., a certain readiness to consider the phenomena that may turn out differently from the predictions [16]. The scenarios provide a comprehensive, multi-component description of the future behaviour of the system. They provide a conceptual description of the future based on the cause and effect relationships identified by the participants. Scenarios are often used to study complex situations, such as the future of a given industry or the world economy [17]. This means they perfectly fit into the assumptions presented in the article. Adding to this the index measurement being a quantitative reflection of the phenomena studied, these methods and results may support the postulates presented as a result of the analyses, diagnoses, and syntheses of the phenomena studied.

3. Literature Review

3.1. Definition and Measurement of Energy Poverty

Energy poverty is a phenomenon that occurs when individuals, families, or groups of a population lack the resources to provide sufficiently warm and well-lit homes, in line with socially acceptable levels [18]. It is a situation in which people do not have access to appropriate, economical, reliable, safe, or environmentally sustainable modern energy services [19]. Energy poverty is the inability of people to obtain and maintain an adequate level of heat in their homes, measured by the percentage of energy expenditure above the 10 % threshold of the national average, because the residual income places the household below the official poverty line [20–22]. Energy poor persons or households are those where the energy costs incurred to maintain indoor temperatures exceed 10% of the household income [23]. The inhabitants of households with difficulties in meeting various types of energy needs are considered energy poor. This applies not only to problems with access to electricity, but also to heating and hot water [24]. Energy poverty means that households cannot afford to buy enough energy to meet their household needs [25]. The broad definition and different scope of the components of the energy poverty indicators contribute to the fact that it is not only a problem faced by developing or poor countries [26], but one faced by all world economies. The reasons for energy poverty are presented in

Figure 3. The turbulence of the environment and the speed of economic changes, as well as the constant economic crises, affect the occurrence of energy poverty to a different extent. Therefore, it should be pointed out that this is a fairly common problem that should be prevented, as the consequences of its occurrence are not only economic, but also social and environmental (e.g., heating with materials that are not adapted and are thus harmful to the natural environment).

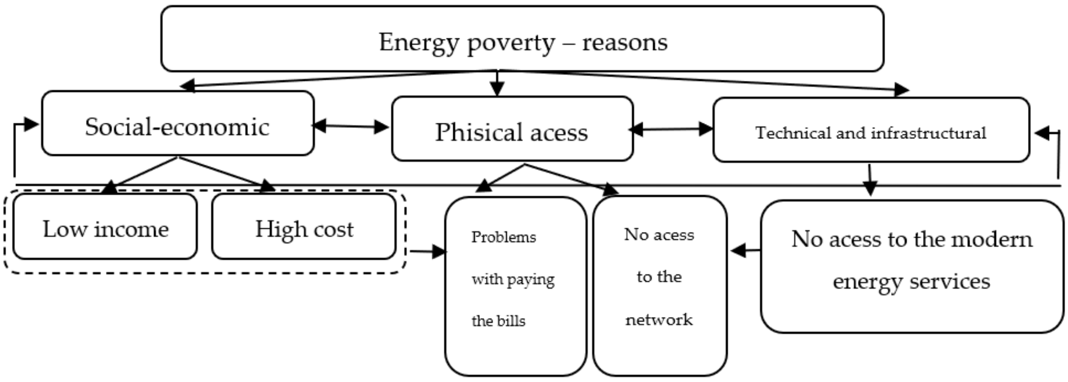


Figure 3. Reasons for energy poverty. Source: own elaborations.

As a result of the wide scope of understanding the concept of energy poverty, it is worth mentioning the measurement systems used to quantify the scope and amount of energy poverty. There are too many definitions and measurement systems in the literature to discuss in detail. To better illustrate the measurement system, the most important indicators used in the literature are presented in Figure 4.

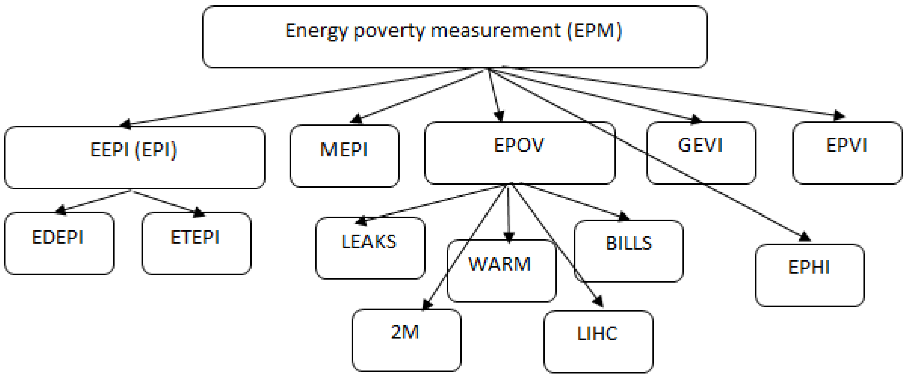


Figure 4. Energy poverty measurement system—framework and selected elements. Source: own elaborations.

EPI (EEPI)—The Energy Poverty Index is used to analyse the effects of macro-level drivers on energy poverty in the EU member states, and to provide a basis for the theoretical interpretations of questions related to unequal development and material deprivation of energy transition [11,27–29].

The above EEPI indicator [29] is used to measure energy poverty, and the solutions created allow for assessment of the activities that were taken by Member States to alleviate energy poverty. These are broken down into two components—transport poverty and the overall response to national energy poverty. This aspect is important because it can be used to compare how countries of the European Union correlate variables related to the implementation of the energy policy, the elements and indicators of which also relate to the above data. The quantitative aspect of the indicator is used to assess the alleviation of the causes of energy poverty through an assessment of the alleviation of its symptoms.

MEPI—the Multidimensional Energy Poverty Index defines energy poverty as a lack of access to adequate energy services (e.g., electricity, modern cooking fuels, entertainment, education, telecommunications, and other electrical appliances [30], as well as high levels of indoor pollution) [31]. Energy poverty is treated in a similar way in the EPHI Energy Poverty in Households Index [32], while at the same time, it refers to the possibilities of households in terms of their social situation, related to the availability and affordability of the supplied energy, or to thermal efficiency in relation to financial criteria and possibilities, infrastructure quality, and comfort, as defined in the Statistics of the European Union on Income and Living Conditions (EU-SILC) [13]. In a similar context, the Energy Poverty in Households Index is calculated [32].

EPOV is the European Energy Poverty Observatory, and is the most widely used index to measure energy poverty in Europe. It includes primary and secondary indicators, which include energy prices and housing data [24]. The index identifies the following four elements. Two are linked to the income and expenditure approach: a high share of energy expenditure in income (2M) and a low absolute energy expenditure (M/2), both of which are based on the European Union Statistics on Income and Living Conditions (EU-SILC). In addition, it considers arrears on utility bills and an inability to keep the home adequately warm [33]. When interpreting this indicator, it should be pointed out that households affected by energy poverty experience inadequate satisfaction of basic energy services, which results from a combination of high energy expenditure, low household income, inefficient buildings and equipment, and the specific energy needs of households [33].

GEVI, the global energy vulnerability index, is an approach to global energy vulnerability, which is a universal measure. Its components refer to electricity access, energy intensity, energy imports, renewable energy consumption, energy consumption, fuel export, and renewable electricity output [34,35]. It is a very universal approach and is generally not complicated to use.

EPVI, the Energy Poverty Vulnerability Index, is related to the GEVI index, focusing on heating and cooling in order to identify energy-poor regions and hotspots for local action [36,37].

There are many other methodologies that are more or less related to the indicated methodologies. Some of them try to include issues of quality and access to energy in the measurement (e.g., the multi-tier framework for measuring energy access, the energy supply index, the minimum standards of domestic energy services, and the structural energy poverty vulnerability (SEPV) index, and analysing political and socio-economic conditions in EU countries, as well as exploring the relationship between the indexes and energy poverty and winter mortality) [37].

The indicated measurement system differs in terms of both the scope and the possibilities of its use. The approaches differ depending on the region, the adopted methodology, or the scope of the data sets adopted for the assumptions [19,22,31,38,39]. Most measurement systems are based on guidelines or previously proposed methodologies, and are not always able and sensitive enough to take into account different territorial or socio-cultural contexts [30], which limits their use or their ability to draw conclusions about larger geographic areas, which would be useful for economically developed or developing countries, and at the same time become a very universal tool.

3.2. Main Assumptions of the Energy Transformation

The assumptions of the energy transformation include, above all, decarbonisation and abandoning non-renewable energy sources and replacing them with sustainable renewable energy. Changing the types of energy used requires the use of new technologies and the development of so-called green technologies [40]. These processes are inherently related to the use of technologies, both traditional and innovative/modern, and the connection with other sectors of the economy, including ICT or blockchain, allowing for cost-effectiveness, or influencing the acceleration of renewable energy production processes, thus providing energy networks with new resources and greater stability [41,42].

The scope, area, and pace of energy transformation depends on the energy policy of a given country, which defines the appropriate framework for these changes and their directions. In this context, many factors should be taken into account, including the supply and energy demand, in order to use the appropriate instruments and make the transformation effects beneficial for all stakeholders, as well as to meet environmental, social, and economic goals [43].

Changes in the ways and types of energy used require policy measures to stimulate the development of sustainable technologies that support the use of renewable energy sources. Energy transformation is not an easy and one-stage process, it requires, especially in the early stages of political interventions, searching for market niches in which a new energy system of a given country can be developed [44].

Energy transformation contributes not only to changes in the energy system itself, but it also affects the social sphere. Therefore, transformation and the creation of a zero-emission economy cannot be approached only as an element related to fuels and the implementation of modern technologies [45]. Changes in the energy system may also occur when a large number of consumers become energy producers, which is the case with the use of renewable energy in households.

Analysing the scientific literature, it can be concluded that the link between renewable energy and poverty reduction focuses mainly on the reduction of energy poverty thanks to the use of solar energy [46]. The impact of other renewable energy sources, including the use of wind, water, and biomass energy, has been very rarely studied.

4. Data Collection and Research Process

When analysing the problem of energy poverty, several variables were taken into account. One of them was the inability to maintain the right temperature in the house. The analysed data in this regard showed that in 2015–2020, this problem gradually decreased. Moreover, there were very big differences between European countries. In 2020, the highest percentage of people in the total population who were unable to maintain an adequate temperature in their home was in Albania (35.8%), Bulgaria (27.5%), and North Macedonia (23.8%). Countries such as Switzerland (0.2% of the population), Norway (0.8%), and Austria (1.5%) were the least affected by this problem. At the same time, the average for EU-27 was 7.5%. The percentage of the population unable to keep their homes adequately warm is presented in Figure 5.

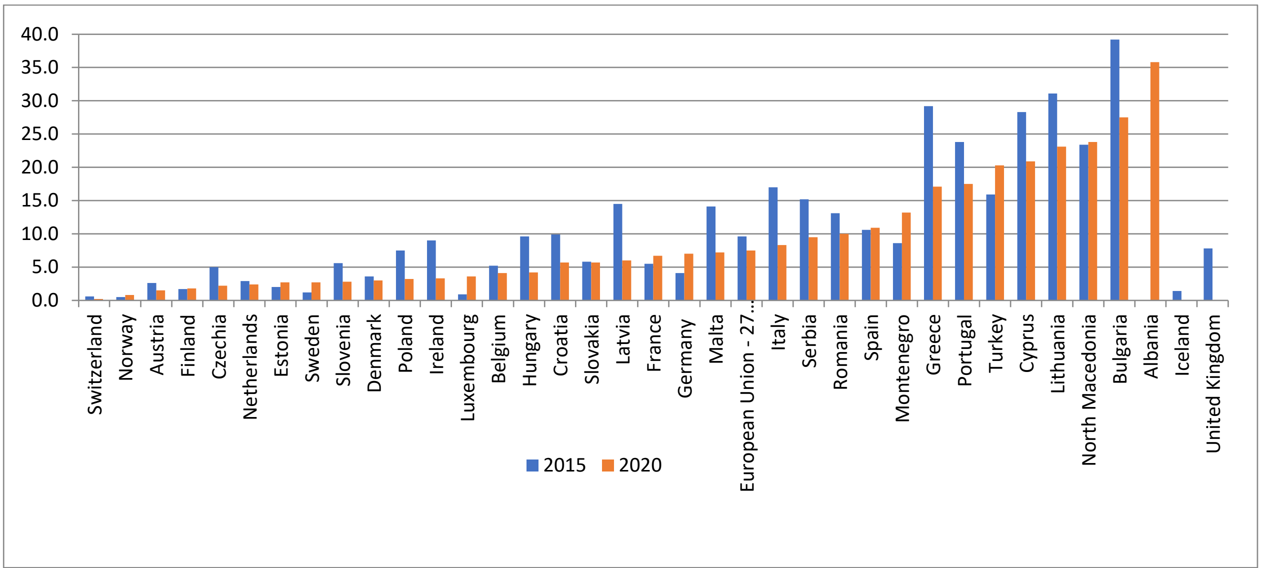


Figure 5. Percentage of the population that is unable to keep home adequately warm in European countries during 2015 and 2020. Source: own preparation based on Eurostat database [47].

An important measure illustrating the level of energy poverty is, inter alia, the indicator showing the share of citizens living in houses with leaking roofs and damp walls. When analysing the data presented in the figure, it can be seen that the highest percentage of people living in poor conditions occurred in countries such as Cyprus, Turkey, and Portugal. The share of citizens living in houses with leaking roofs and damp walls was the lowest in Finland, Slovakia, and Poland, in turn. The percentage of the population living in houses with damp walls and leaking roofs is presented in Figure 6.

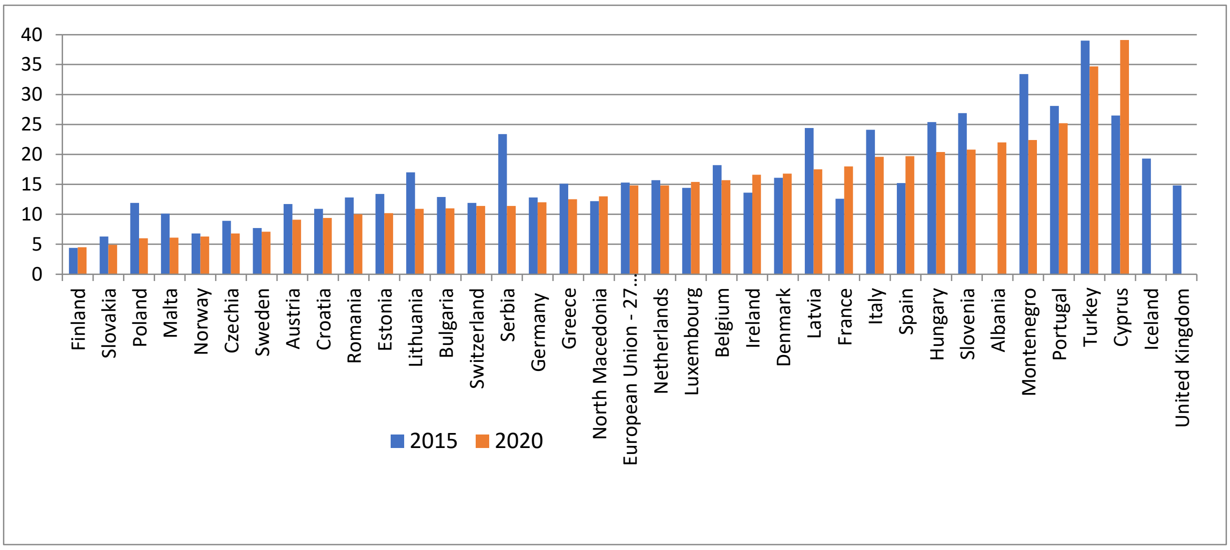


Figure 6. Percentage of the population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames or the floor in 2015 and 2020. Source: own preparation based on the Eurostat database [47].

Electricity prices are significant factor influencing the level of energy poverty. Their levels in 2015 and 2021 are presented in the Figure 7.

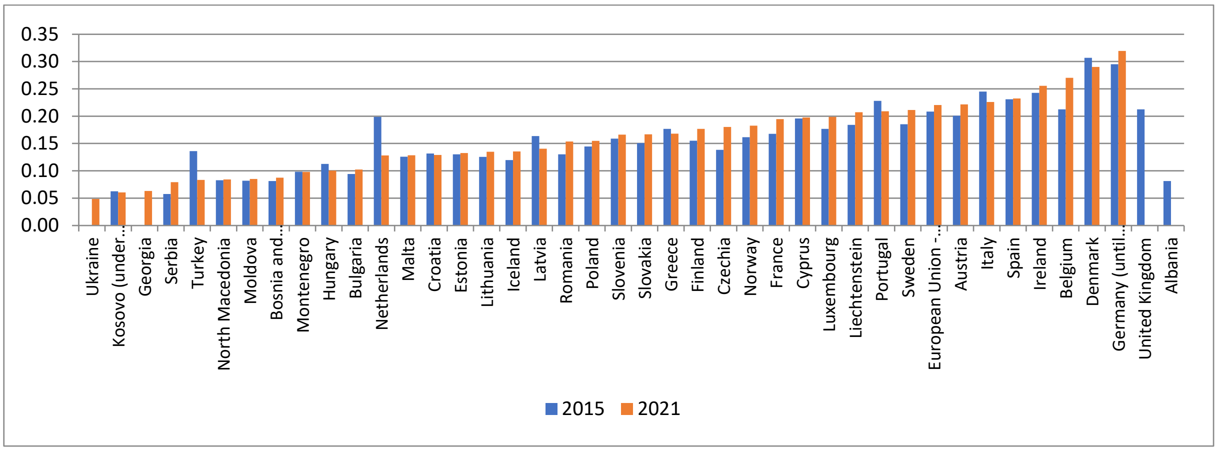


Figure 7. Average electricity prices (without taxes) for household consumers in 2020 (in EUR, per kWh). Source: own preparation based on Eurostat database [47].

When analysing electricity prices, it can be noticed that in 2021, the highest prices were recorded in countries such as Germany (EUR 0.3193 per kWh), Denmark (EUR 0.29), and Belgium (0.2702). We can observe that the lowest electricity prices were usually paid by households in countries with the highest percentage of people affected by the problem of inability to maintain adequate temperature at home. Therefore, in order to better illustrate the factors influencing the problem of energy poverty, apart from the price, it is also worth paying attention to the share of household expenses for electricity, gas, and other fuels.

The analysis of the data contained in the Figure 8 shows that in most European countries, the share of expenditure on electricity, gas, and other fuels in the total consumption expenditure decreased. On the one hand, the largest share of expenditure on these goods was incurred by the citizens of Slovakia (in 2020, these expenses accounted for 9.1% of all expenditure), followed by Poland (7.9%) and Serbia (6.9%). On the other hand, household budgets were the least burdened in this respect in Malta (2%), Luxembourg (2.2%), and Iceland (2.3%). Moreover, the average household in the European Union spends around 4.3% of its expenditure on these purposes.

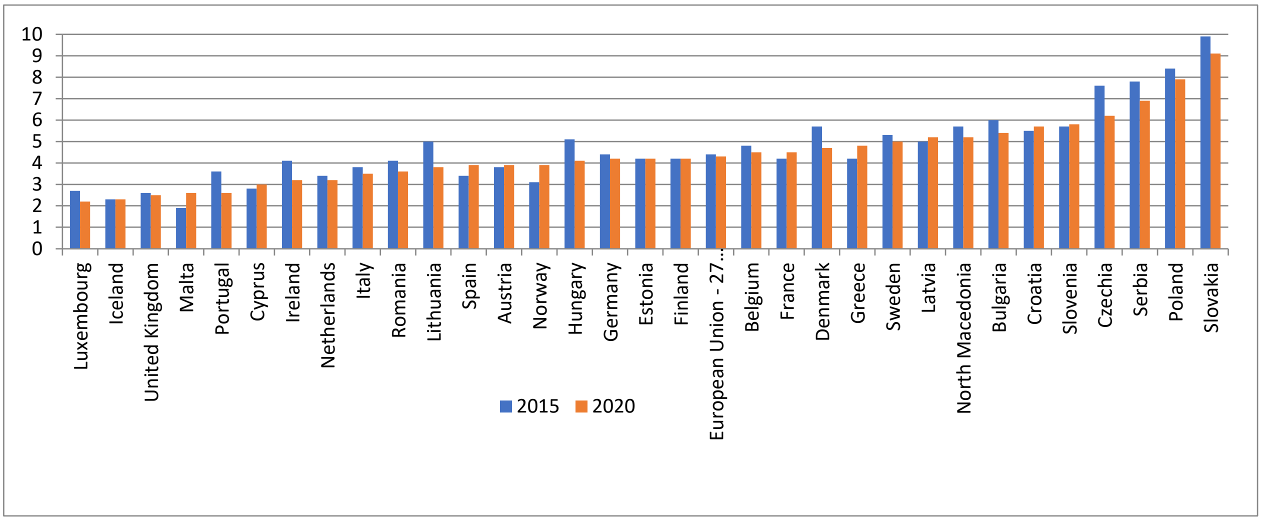


Figure 8. Electricity, gas. and other fuel expenditure for households in 2015 and 2020 in European countries (in%). Source: own preparation based on Eurostat database [47].

An extremely important fact when considering issues related to both the transformation of energy policy and the way to influence energy poverty is the use of renewable energy in various areas of social and economic life. The share of RES in gross energy consumption measures the degree of renewable energy use and hence the extent to which renewable fuels have replaced fossil and/or nuclear fuels. The share of RES in the gross final energy consumption is presented in Figure 9.

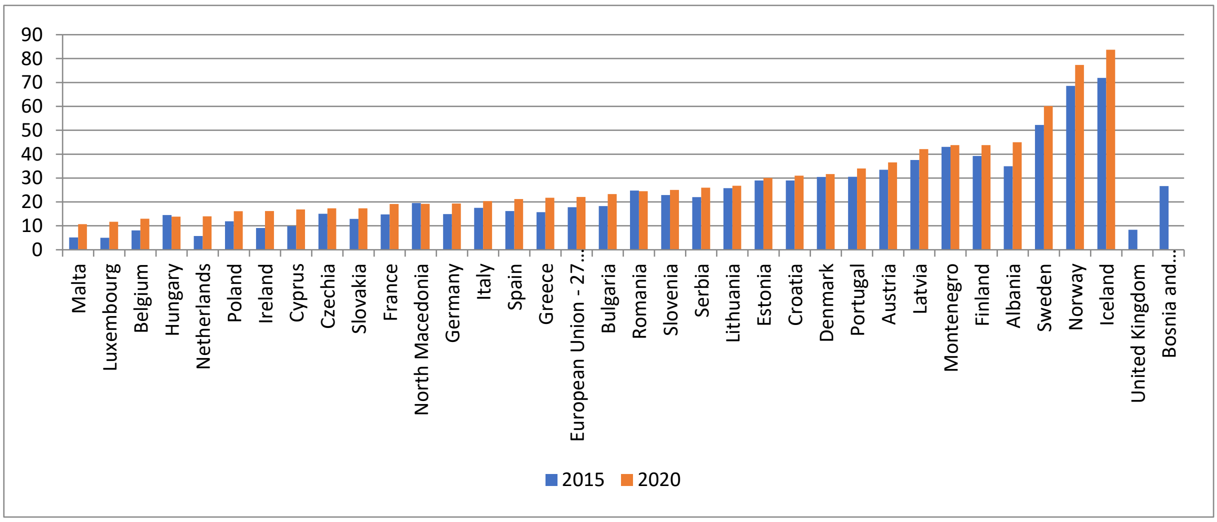


Figure 9. Share of renewable energy in the gross final energy consumption in European countries in 2015 and 2020 (in%). Source: own preparation based on the Eurostat database [47].

It can be noticed that in the analysed years, in almost every European country, there was an increase in the share of renewable energy in the gross energy consumption. The largest increase in the share of renewable energy took place in the Netherlands (an increase of over 144%), Malta (109%), and Luxembourg (133%). In addition, the largest share of renewable energy in gross energy consumption was observed in the Scandinavian countries—namely Iceland (as much as 83.7% in 2020), Norway (77.3%), and Sweden (60.1%). In turn, the lowest rate of energy use was in countries such as Malta (10.7%), Luxembourg (11.7%), and Belgium (13%). The average share of energy from renewable sources in gross energy consumption for EU countries was 22.1% in 2020.

In order to provide a more detailed answer to the research questions presented in the article, using the Statistica program, seven EU countries were selected—three with the largest and three with the lowest GDP per capita, and Poland. The justification for choosing three countries with the largest and three countries with the smallest GDP was dictated by an attempt to check whether there were differences in the study area between these countries, and, if so, how large they were. In turn, the choice of Poland resulted from both of the authors' research interests and the fact that it is a country that is still undergoing transformation and, moreover, certain issues regarding the use of renewable energy are currently controversial, for both society and government, in this country. Then, an analysis of the relationship was carried out:

- Between household expenses for electricity, gas, and other fuels and the share of RES in gross energy consumption (RQ1).
- Between the index of being unable to heat the house and the share of RES in gross energy consumption (RQ1).
- Between GDP per capita and the share of RES in gross energy consumption (RQ2).
- The level of inability to keep the house adequately warm and the level of GDP per capita (RQ2).
- Between the level of inability to keep the house adequately warm and household expenses for electricity, gas, and other fuels (RQ2).
- Between household expenses for electricity, gas, and other fuels and the level of GDP (RQ2).

The value of the statistical significance level was not arbitrarily imposed; however, the frequently accepted significance threshold is $\alpha = 0.05$. This value for the significance level was also adopted in our study. This is why, in order to statistically verify the relationship between the analysed variables, using Student's t-test at the significance level of alpha = 0.05, the null and alternative hypotheses were formulated to determine whether it was possible to reject the null hypotheses. The null hypothesis was tested:

Hypothesis 0 (H0). *Pearson's correlation coefficient = 0 (there was a lack of dependence of the analysed variables),*

Against the alternative hypothesis.

Hypothesis 1 (H1). *Pearson's correlation coefficient r is $\neq 0$ (there was a dependence between the studied variables).*

The level of statistical significance of the obtained results was verified by performing the statistical significance test (Student's t-test). Its effect was the value of statistical significance (p-value), which was then compared with the assumed value of the significance level. The results of the analysis of correlation are presented in Table 1.

It can be noted that in most of the studied countries there was a statistically significant positive correlation between the increase in GDP per capita and the degree of RES consumption.

Table 1. Correlation analysis.

	Variable	Mean	St. Dev.	Var.1	Var.2	Var.3	Var.4
Bulgaria	Var.1	18.05	2.847	1,000,000	**0.859183**	**−0.945871**	0.596454
	Var.2	19,669.81	1,839,048	**0.859183**	1,000,000	**−0.967970**	0.335723
	Var.3	38.44	6.577	**−0.945871**	**−0.967970**	1,000,000	−0.513872
	Var.4	5.25	0.477	0.596454	0.335723	−0.513872	1,000,000
Greece	Var.1	16.38	2.9939	1,000,000	−0.376552	−0.371983	0.521750
	Var.2	28,600.47	917.0344	−0.376552	1,000,000	−0.444462	**−0.752510**
	Var.3	24.88	5.5551	−0.371983	−0.444462	1,000,000	−0.052349
	Var.4	4.24	0.2797	0.521750	**−0.752510**	−0.052349	1,000,000
Romania	Var.1	23.97	1.166	1,000,000	0.514785	−0.491281	−0.180660
	Var.2	25,076.36	3322.471	0.514785	1,000,000	**−0.966799**	**−0.698139**
	Var.3	12.53	2.339	−0.491281	**−0.966799**	1,000,000	0.620363
	Var.4	3.90	0.403	−0.180660	**−0.698139**	0.620363	1,000,000
Poland	Var.1	11.85	1.573	1,000,000	0.572454	**−0.636649**	−0.434855
	Var.2	28,656.75	2976.146	0.572454	1,000,000	**−0.949406**	**−0.946888**
	Var.3	8.03	3.680	**−0.636649**	**−0.949406**	1,000,000	**0.915136**
	Var.4	8.35	0.536	−0.434855	**−0.946888**	**0.915136**	1,000,000
Norway	Var.1	69.36	4.381	1,000,000	**0.840089**	−0.044578	0.122253
	Var.2	62,993.94	1126.004	**0.840089**	1,000,000	−0.091488	−0.064782
	Var.3	0.83	0.200	−0.044578	−0.091488	1,000,000	**0.856459**
	Var.4	3.61	0.348	0.122253	−0.064782	**0.856459**	1,000,000
Denamrk	Var.1	30.72	4.451	1,000,000	**0.926902**	0.122558	**−0.906264**
	Var.2	53,836.91	2370.259	**0.926902**	1,000,000	−0.051902	**−0.955180**
	Var.3	2.93	0.462	0.122558	−0.051902	1,000,000	0.043694
	Var.4	5.62	0.738	**−0.906264**	**−0.955180**	0.043694	1,000,000
Ireland	Var.1	9.74	2.84	1,000,000	**0.885648**	**−0.765053**	**−0.785243**
	Var.2	70,531.04	14,590.65	**0.885648**	1,000,000	**−0.829324**	**−0.912069**
	Var.3	6.60	2.35	**−0.765053**	**−0.829324**	1,000,000	**0.922716**
	Var.4	3.74	0.53	**−0.785243**	**−0.912069**	**0.922716**	1,000,000

Var.1: Share of RES in gross final energy consumption (in%); Var.2—GDP per capita, PPP, international $; Var.3—Inability to maintain adequately temperature in the house (in%); Var.4—Expenses of households for electricity, gas, and other fuel in selected EU countries (in%). The correlation coefficients are significant with $p < 0.05000$. The strongest relationships are marked in bold. Source: Authors' calculations.

In the analysed countries, there was also a negative correlation between the degree of use of RES and the problem of the inability to keep a house adequately warm. Such a relationship was especially noticed in countries with a relatively lower level of GDP per capita. In these countries, the more the use of RES increased, the more the level of energy poverty, measured as the inability to adequately heat the house, decreased.

The analysis of the correlation between household expenditure on electricity, gas, and other fuels and the share of RES in gross energy consumption showed a negative relationship between these variables.

The conducted analyses also showed the existence of a statistically significant positive correlation between the share of household expenses on electricity, gas, and other fuels for the total consumption expenses and the level of inability to maintain adequate heating in the house. The larger part of the budget these expenses were, the greater the problem of keeping an appropriate temperature in the house.

5. Scenarios Framework As a Basis of the Analysis Delphi Study

The scenario methodology was used in the next stage. The methodology of environmental scenarios was used for the considerations, which determined the strength of the impact of the processes occurring in the environment on the organization, society, or other examined factors, as well as the assessment of the probability of these phenomena occurring in the future. Within the adopted methodology, the following scenarios were distinguished: optimistic, pessimistic, surprise, and the most probable. When creating scenarios, measurable and immeasurable processes, as well as those that can be illustrated by a mathematical model, are considered. The most objective and probable analysis will be obtained when several types of scenarios are created. Their basis is probability. They require periodic control and correction [48]. The starting point for considerations is the identification of the most important factors from the environment that affect the studied phenomenon. When building the scenarios, one should take into account the rating scale regarding the negative strength of the influence (from −5 to −1) and the positive strength of the influence (from +1 to +5). In the context of the probability of the occurrence of a given factor, they are considered in three tendencies: an upward tendency of the process in the future, a stabilizing tendency of the process in the future, and a downward tendency. Based on the analyses, the scenarios were created. For the optimistic scenario, in particular spheres we selected the trend that had the greatest positive impact on the studied phenomenon. In the pessimistic scenario, we chose the trend that had the greatest negative impact on the studied phenomenon. For the surprise scenario, we selected the trends that had the least probability occurrence. For the most probable scenario, we used the sum of the trends with the highest probability of occurrence.

The starting point for considering and creating scenarios was the identification of the most important factors that influenced the development of energy from renewable sources. The following were distinguished:

- Economic factors—GDP growth rate (due to changes in the level of investments, innovativeness of enterprises, changes in the level of government purchases, especially to improve the competitiveness and innovation of the economy, fiscal and monetary policies, the level of consumer spending, and the level of exports and imports).
- Political factors—including government policy regarding investments in renewable energy.
- Administrative and legal factors—including structure of legal acts.
- Procedural and informational factors—including environmental awareness of the society, as well as access to information on possible sources of financing,
- Economic and financial factors—including economic mechanisms, in particular tax, incentives to invest in renewable energy, and investment costs in renewable energy.
- The scenario framework is presented in Figure 10.

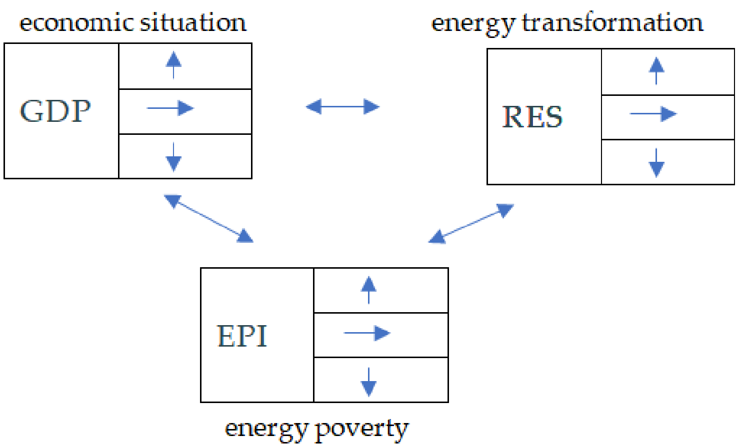


Figure 10. Scenario framework. Source: own prepared.

The characteristics of the possible renewable energy development scenarios are presented in Table 2.

The next step in our research was the selection of 12 experts. The experts were people dealing with energy and economy issues, but also entrepreneurs and a representative of a local government unit. The purposeful selection was used to obtain the most competent opinions. Surveys questionnaire containing factors influencing the development of energy from renewable sources along with the Likert scale were addressed to the experts.

After comparing the responses, a second questionnaire was prepared, in which experts could read the forecasts of other specialists (anonymously), and change or maintain their previous opinions.

To determine the coefficient of concordance between the experts' answers, the Kendall's W coefficient was calculated.

The result of Kendall's W = 0.77. This means that the experts agreed with each other to a reasonable (but not super high) extent.

Table 2. Renewable energy development scenarios.

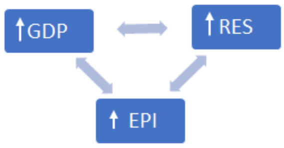
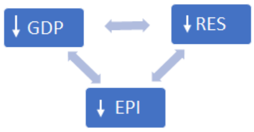
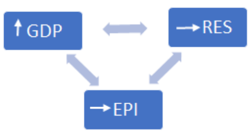
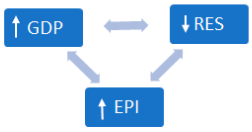
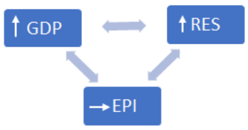
<table>
<tr><td>
</td><td>Optimistic scenario
In the optimistic scenario, taking into account three areas, a good economic situation favours energy transformation and reducing energy poverty. Namely, a good economic situation, manifested by an increase in GDP (thanks to investment growth, increase in the innovation of enterprises, increase in government purchases, especially for purposes related to/to improve the competitiveness and innovation of the economy, stable fiscal and monetary policy, and increase in consumer spending) with the simultaneous lack (or minor) of political, administrative and legal, procedural, informational, economic, and financial barriers, will contribute to energy transformation and the development of the RES market. At the same time, the increase in GDP may probably translate into an increase in the income of the society, which in turn will reduce energy poverty (increase in the EPI index), i.e.,
• decrease in the share of energy expenditure in the total expenditure,
• decrease in the share of citizens who are not able to maintain an appropriate temperature at home in winter/summer,
• a decrease in the share of citizens living in houses with leaking roofs and damp walls
• a decline in the share of citizens who cannot afford or who have limited access to public transport.
Energy transformation will also contribute to reducing energy poverty, e.g., through, inter alia, ensuring the usually fixed cost of electricity and thus reducing household expenses related to it.</td></tr>
<tr><td>
</td><td>Pessimistic scenario
In the pessimistic scenario, we take into account three areas, namely the bad economic situation makes it difficult, the energy transformation, and the increase in energy poverty. An unfavourable economic situation, manifested by a decline in GDP, will have great barriers at the same time:
• Political,
• Administrative and legal barriers, manifested, inter alia, in an improper structure of legal acts related to renewable energy sources,
• Procedural and information, manifested, inter alia, in a lack of knowledge about social, economic, and environmental benefits related to the implementation of investments using renewable energy sources, lack or difficulties with accessing information about possible sources of financing, an insufficient level of ecological awareness of the society, and a lack of access to equipment and new technologies,
• Economic and financial, manifested by the occurrence of unfavourable economic mechanisms (e.g., tax), which would enable obtaining appropriate financial benefits in relation to the amount of expenditure incurred for the development of investments in the production of energy from renewable sources; high costs for the development of technologies using energy from renewable sources will reduce energy transformation and the development of the RES market.
At the same time, a decline in GDP may likely translate into a decline in the society's income, which in turn will increase energy poverty, i.e.,
• An increase in the share of energy expenditure in the total expenditure,
• An increase in the share of citizens unable to maintain an appropriate temperature at home in winter/summer,
• An increase in the share of citizens living in houses with leaking roofs and damp walls
• Increasing the share of citizens who cannot afford or have limited access to public transport.
In this scenario, the decline in the energy transformation will also contribute to increasing energy poverty, e.g., through, inter alia, a lack of access to alternative, cheaper energy sources and thus dependence on large suppliers.</td></tr>
<tr><td>
</td><td>Scenario status quo
The status quo scenario takes into account three areas, namely that a favourable economic situation does not favour the energy transformation and does not change the level of energy poverty. In this scenario, despite the good economic situation manifested by GDP growth (thanks to: investment growth, an increase in government purchases, stable fiscal and monetary policy, and an increase in consumer spending), energy transformation is halted. This may happen as a result of numerous information, education, financial, and economic barriers (lack of incentives and other economic mechanisms, e.g., in the form of tax preferences for investments in renewable energy and high costs of works related to obtaining energy from renewable sources), political and administrative legal barriers. At the same time, in this scenario, GDP growth will not translate into an increase in society's income (mainly enterprises will benefit from a higher GDP in this scenario), which, in turn, will not reduce the energy poverty of the society. In addition, halting energy transformation will contribute to maintaining the level of energy poverty at the same level, e.g., through, inter alia, lack of access to alternative, cheaper energy sources and thus dependence on large suppliers.</td></tr>
</table>

Table 2. *Cont.*

	Surprise scenario 1 In Surprise Scenario 1, three areas were taken into account: the favourable economic situation is not conducive to energy transformation, but the level of energy poverty is decreasing. The good economic situation due to the presence of numerous barriers (informational and educational, financial and economic, administrative and legal, inappropriate government policy discouraging domestic and foreign investors from investing in renewable energy sources, inappropriate political and economic mechanisms blocking and the operation and development of renewable energy investments) may cause a decline in energy transformation. At the same time, despite the decline in energy transformation, a growing GDP may translate into an increase in society's income, thus reducing the level of energy poverty. In addition, the government, despite the lack of beneficial measures to support investments in renewable energy, but wishing to reduce energy poverty, may conduct other activities. These mainly consist of the use of instruments such as specific benefits, housing and energy allowances, freezing or reducing electricity prices, thermo-modernization of residential buildings, or consulting in the field of energy saving. In such a scenario, it should be kept in mind that the first three instruments are intended only to alleviate the problem of poverty (they do not remove its problem). At the same time, these instruments are a heavy burden for the state budget, and their use may have negative consequences for the state of this budget in the future (a deepening budget deficit due to rising government spending) and, thus for the government's fiscal policy.
	Surprise scenario 2 In Surprise Scenario 2, three areas are taken into account, namely a good economic situation favours energy transformation, but does not change the level of energy poverty. Such a scenario will be possible in a situation of high information and education barriers in society, i.e., lack of knowledge about the possibility of using energy from sources other than traditional ones, lack of knowledge about social, economic, and environmental benefits related to the use of renewable energy sources, and a lack of government actions encouraging the use of this type of installations using renewable energy sources.

Source: own elaboration.

The statistical significance of the calculated Kendall's W coefficient was also examined using χ^2 statistic with $k-1$ degrees of freedom. The obtained result indicated that the null hypothesis should be rejected in favour of the alternative hypothesis, in which the experts agreed in their opinions.

The obtained answers allowed us to conduct the next stage of our analyses, i.e., to identify trends, their impact, and to assess the likelihood of individual factors influencing the development of the RES market in the near future. An assessment of the factors influencing the development of energy from renewable sources is presented in Table 3.

Table 3. Assessment of the factors influencing the development of energy from renewable sources.

	Trend	Influence	Probability of Changes Occurring
GDP growth rate	growth constant declining	+4 +3 −3	0.4 0.3 0.3
Political factors	growth constant declining	+4 +2 −2	0.4 0.3 0.2
Administrative and legal factors	growth constant declining	+5 +2 −4	0.3 0.4 0.3
Procedural and informational factors	growth constant declining	+3 +2 −3	0.3 0.4 0.3
Economic and financial factors	growth constant declining	+5 +2 −4	0.6 0.1 0.3

Source: own elaboration.

The next stage was the development of three scenarios of factor changes: optimistic, pessimistic, and the most probable (Table 4).

Table 4. Scenarios of changes affecting the development of RES.

	The Strength of the Impact of the Scenario		
	Optimistic	**Pessimistic**	**Most Probable**
GDP growth rate	+4	−3	+4
Political factors	+4	−2	+4
Administrative and legal factors	+5	−4	+2
Procedural and informational factors	+3	−3	+2
Economic and financial factors	+5	−4	+5
Average strength of influence	4.2	−3.2	3.4

Source: own elaboration.

The above analyses show that the greatest threat to the development of the RES market are economic and financial, as well as administrative and legal factors. At the same time, these areas have the greatest opportunities. Appropriate design of legal provisions, defining the rules for the use of renewable energy sources in an appropriate and unambiguous manner, is of great importance in this respect. In particular, it is about the construction of legal regulations (concerning, for example, spatial planning, standards related to the location of power plants) so that they do not raise any doubts and do not allow for various interpretations. In the most probable scenario, the leading processes, i.e., the ones that can have the greatest impact on the RES market, are economic and financial improvement, as well as better state policy in this respect.

6. Findings, Limitations, and Discussion

The great importance in the context of the use of renewable energy and the reduction in energy poverty [49] has the impact of policy actions, as well as the widest possible use of renewable energy and not focusing on only one of its elements (e.g., solar energy). Extensive scientific research should be carried out on the widest possible use of various types of energy, as the specific geographical location of countries contributes to the fact that different types of energy can be used to a different extent [50]. Legal solutions should be promoted, as well as appropriate funds prepared for the implementation of the undertaken actions.

A novelty in the considerations is the indication of various scenarios that may occur in the economy and that have an impact on the occurrence of energy poverty. As can be seen from the conducted research, various factors influence the level of energy poverty [51] in different ways. The actions taken to limit them must be coherent and carried out consistently. The current situation related to energy supplies to European countries may contribute to unexpected changes and an increase in energy poverty, despite many years of efforts to reduce it and comply with the principles of sustainable development. The scenarios show the consequences of the actions taken by politicians, but also by households. The current political and economic situation is a limitation when considering and implementing the scenarios. The war in Ukraine and the departure from cheap energy purchased from Russia (for Europe) have become critical risk factors that could cause significant energy problems. The consequence may be the abandonment of investments in renewable energy (and the use or at least further testing of conventional energy). Unfortunately, further use of non-renewable energy could be much more expensive, less ecological, and not conducive to meeting the social goals of sustainable development (such as fair and free access to such energy resources as needed).

The novelty of our considerations is the application and use of different research methodologies to investigate the problem of energy exclusion and the possible consequences of such a condition, namely descriptive and mathematical statistics combined with the results of the Delphi method. Such an approach has not yet been used for the topic indicated. By linking expert knowledge with statistical data and theoretical assumptions in the literature, it was possible to systematise and create possible scenarios, as well as by linking the global energy poverty rate with the rapid development of the renewable energy industry in the context of energy poverty alleviation. Novelties include the exploration of regional heterogeneity and the mediating role of energy efficiency in linking renewable energy to poverty alleviation. Through a turbulent environment and rapid change, the looming energy crisis may contribute to an increased risk of energy poverty, even more so than today. This could particularly affect European Union countries. The main novelty of our assessment is the presentation of a new theoretical framework in the context of scenario building for the factors and indicators influencing the incidence of fuel poverty. Based on quantitative and qualitative research, we present a qualitative approach to analyses related to the impact of macroeconomic indicators on the economy, fuel poverty, and energy transition, on the basis of which scenarios of possible actions and events are built.

A limitation of the reflections is that they have relied on traditional approaches for the study of fuel poverty and exclusion, without, for example, addressing aspects of the so-called Hidden Face of Fuel Poverty and how to deal with it [52]. Another limitation is the limited use of statistical analyses, which will be deepened in subsequent studies. However, this is related to the scenario approach and reliance on the Delphi method in the context of solution development.

7. Conclusions

Energy poverty and its various forms is a phenomenon that affects most countries in the world [53]. A better understanding of both the phenomenon and its magnitude, using knowledge of possible scenarios for the development of economies using modern energy management and implementing the energy transition, could become the panacea that solves the problem. Climate variability, climate differences in a local context [54], and socio-demographic factors are important for the occurrence (increase or levelling) of fuel poverty. The geographical area and degree of urbanisation of municipalities can be critical factors in the context of analysing and addressing energy poverty [52].

The development of renewable energy is an important factor in the development of countries, with a particular focus on the development of so-called green civilisation. Thus, in order to empirically investigate the primary impact of renewable energy consumption on global energy poverty alleviation, it is first necessary to assess the global energy poverty index, and then to consider whether the rapid development of the renewable energy industry can help alleviate energy poverty. If the answer is yes, action needs to be taken and the appropriate tools need to be implemented to achieve energy transformation as soon as possible. Regional heterogeneity and the mediating role of energy efficiency in linking renewable energy to poverty alleviation are also discussed in the deliberations. We conclude, on this basis, that (1) global energy poverty shows a significant alleviating trend over the period studied, and the rapid development of the renewable energy industry can help alleviate energy poverty. (2) There is considerable regional heterogeneity in the relationship between renewable energy and poverty reduction. In European countries, increasing the share of renewable energy can significantly reduce energy poverty. (3) The role of energy efficiency in conjunction with renewable energy along with poverty reduction is significant. Renewable energy not only directly alleviates energy poverty globally, but also has a significant energy poverty inhibiting effect by improving energy efficiency. Following these three conclusions, we propose appropriate policies to alleviate energy poverty and improve energy efficiency.

It should be taken into account that many countries in the current geopolitical situation may face a shortage of energy, regardless of whether they are developed or developing countries, thus cooperation in the field of research and development, as well as the promotion and availability of renewable energy should be expanded, and cooperation mechanisms, measurements, and methods should be used for a reduction of energy exclusion, while increasing the use of renewable energy from various sources.

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