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Assessing the Energy and Climate Sustainability of European Union Member States: An MCDM-Based Approach

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Abstract: Topics related to sustainable economic development are currently important issues in the modern world. However, the implementation of this concept and related operational strategies raises many controversies. On the one hand, it offers hope for ecological, safe, and independent economic development, while on the other hand, it raises public concerns about the costs of such changes. These problems are widely appreciated in the EU, which is the undoubted leader in implementing the concept of sustainable economic development. With regard to this issue, this paper presents the developed methodology for assessing the sustainable energy and climate development of the EU-27 countries. The basis of this assessment is 17 selected indicators characterizing the most important areas related to this development. Their selection was conditioned by the assumptions of the Europe 2020 Strategy and the goals (7 and 13) of the UN Agenda for Sustainable Development 2030. Five widely used methods for multi-criteria analysis supporting management processes (CODAS, EDAS, TOPSIS, VIKOR, and WASPAS) were used for the study. In order to carry out an unambiguous assessment and determine the final ranking of countries in terms of energy and climate sustainability, a methodology was developed to specify the normalized value of the Final Assessment Score (As_{final}). Based on it, the sustainability of individual EU-27 countries in 2010, 2015, and 2020 was assessed, and this assessment formed the basis for dividing these countries into four classes (levels) in terms of sustainability. The results confirmed the high differentiation of the EU-27 countries in terms of sustainability, indicating leaders as well as countries with low levels of sustainability. The countries with the highest and most stable levels of sustainable development of the economy are Sweden and Denmark. The results provide opportunities for their interpretation, both in terms of analyzing changes in individual indicators and in terms of the global assessment of sustainable development in individual countries. These results should be used when developing an energy and climate strategy for the next few years for the EU as a whole and for individual countries.

Keywords: MCDM methods; integrated approach; sustainable energy and climate development; European Union member states

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1. Introduction

The dynamic development of our civilization, mainly through increasing industrialization, has resulted in a huge and ever-increasing demand for energy. In the 19th and 20th centuries, as well as at the beginning of the 21st century, these needs were met by relatively cheap conventional (non-renewable) energy sources [1,2]. Access to these sources has had, and in many cases continues to have, a huge impact on countries' energy security and independence, as well as on their economic development and political importance. Unfortunately, an economy that relies on conventional energy sources on such a huge scale as the world does today has an immensely negative impact on the environment. The scale of changes in our planet's ecosystem, global climate change, and increasing pollution of the air and the environment in general make it necessary to take measures to reduce the degradation of the environment [3–7]. In order to achieve this goal, while maintaining the pace of economic development of the world, it has become necessary to search for and implement solutions that will provide access to adequate amounts of energy, the production of which is not as harmful to the environment as conventional energy.

These conditions are met by renewable energy, based on so-called renewable energy sources (RES) [8–10]. The economic and technological development of the world, ironically based mainly on conventional energy sources, has now made it possible to replace them with renewable energy, which is definitely more beneficial to the environment. First of all, it reduces emissions of harmful substances and greenhouse gases and [11,12], which is particularly important given the current geopolitical situation in Europe, and plays a major role in ensuring the energy security of individual countries and their groups [13,14].

The introduction of a sustainable and closed-circuit economy also makes the processes involved in the production of equipment and machinery for this energy sector increasingly environmentally friendly. This is because at each stage of the product life cycle, solutions related to these concepts are increasingly being applied, reducing the negative impact of these processes on the environment [15]. This issue is particularly noticed and appreciated in the countries of the European Union, which for many years has been promoting and financing activities related to building a green knowledge-based economy [16].

In the EU, the negative impact of the energy sector and, above all, the use of conventional energy sources on the environment was recognized relatively quickly. For this reason, a number of initiatives have been launched to promote energy–climate sustainability and improve environmental quality. Actions in this regard are included in the EU's climate policy goals [17], as evidenced by the inclusion of energy and climate protection among the 17 sustainable development goals of the 2030 Agenda launched by the United Nations (UN) in 2015 (Goals 7 "Affordable and Clean Energy" and 13 "Climate Action") [18,19]. A special role regarding the implementation of Goals 7 and 13 is played by RES, which, on the one hand, enable countries to meet their needs and build energy independence, and on the other hand, help reduce greenhouse gas emissions into the atmosphere.

The role and importance of RES are particularly evident in the case of the energy market turmoil that occurred in connection with the COVID-19 pandemic and now as a result of the armed conflict in Ukraine [20–22]. Indeed, Russia's invasion of Ukraine in February 2022 had a huge impact on global energy markets. Price volatility, energy sources supply shortages, security issues, and economic uncertainty have exacerbated concerns about energy security, i.e., access to sufficient energy at acceptable prices. This event in particular has accelerated discussion and action regarding the EU's achievement of energy independence from fossil fuels even before 2030 [23]. It may therefore turn out that turbulence in the energy market will accelerate the development of RES, which undoubtedly provides an alternative to conventional sources. Currently, achieving energy independence, in addition to improving the quality of the climate, is becoming a key factor in accelerating the development of renewable energy in EU countries.

The issues of climate protection, the development of RES, and increasing energy efficiency while reducing energy consumption and building energy independence are of absolute economic priority for the EU. Of great importance in this regard is the implementation of the idea of sustainable development for the entire EU and its individual countries. These countries have been implementing the provisions of energy strategies for many years, among which Directive 2009/28/EC [24] turned out to be extremely important and influential for the present. This directive formulated for the first time the main goals of EU countries in terms of increasing the share of energy obtained from RES in total energy consumption. The European climate and energy package contained in this directive aimed to increase the share of energy consumption generated from RES to 20% in 2020 and at the same time to reduce greenhouse gas emissions by 20% from 1990 levels, as well as to improve energy efficiency by 20%. Earlier, in 2003, Directive 2003/30/EC [25] was introduced, which promoted the use of biofuels and renewable fuels in transportation. Another important strategy related to sustainable development, including the energy sector and climate protection, is the European climate strategy called the European Green Deal [17]. Its goal is for EU countries to achieve climate neutrality and a "zero-carbon" economy by 2050. The dynamic development of RES and the simultaneous decarbonization of the energy sector of member countries are expected to contribute to the realization of the goals contained in this strategy. The adoption of this strategy and the implementation of previous arrangements for the development of RES clearly indicate that the EU is strongly promoting sustainable economic development, particularly in the energy and climate areas.

However, measures taken over the years have resulted in different levels of renewable energy development in different EU countries. These countries are characterized by significant differences in the implementation of energy and climate goals, included in Agenda 2030, as well as those arising from EU climate strategies. The reason for this state of affairs is, first of all, the considerable socio-economic diversity of individual countries. Historical conditions regarding the level of economic and political development of these countries also have a large impact on the development of a sustainable economy. This, in turn, translates into social consciousness, economic policy, the wealth of societies, and, consequently, the rate of economic development of these countries.

Considering the importance of the topic of sustainable development, this paper presents the results of a study aimed at assessing the level of this development among the EU-27 countries in terms of energy and climate, the most important factors for social development. In order for the research to include the most important factors affecting the level of sustainable development, a set of 17 indicators was selected, describing the state of implementation of the Sustainable Development Goals, indexed in the Eurostat database. As a result of the research, in accordance with the developed methodology, the level of sustainable development of EU-27 countries was assessed and their rankings were determined. The research findings presented in the article are part of the ongoing debate regarding the realization of the EU's energy and climate policy and the two related sustainability goals of the UN's 2030 Agenda, namely Goal 7 ("Ensure access to affordable, reliable, sustainable and modern energy for all") and Goal 13 ("Take urgent action to combat climate change and its impacts"), and their effectiveness. These goals address important issues for the economy and society, namely access to an adequate amount of energy produced in an environmentally neutral way. The study was conducted for three research periods, making it possible to track changes among EU countries in meeting these goals.

It is indisputable that the assessment of energy and climate sustainability is a multi-criteria problem since, as indicated earlier, the number of factors characterizing these issues is significant. Thus, the study of this topic requires the use of methods based on multi-criteria analysis. One such approach is a methodology based on the application of methods from the MCDM group. Despite the large number of such methods available, it is difficult to clearly identify the right one for studying such a complex and multidimensional problem. Therefore, the analysis presented here uses five widely used research methods from the MCDM group (CODAS, EDAS, TOPSIS, VIKOR, and WASPAS) in multi-criteria analysis. For these methods, a research methodology was developed with the aim of applying a new approach to assessing the level of sustainable development of EU countries and determining a clear ranking of these countries in this regard.

The work carried out and the results obtained represent a new approach to the study of sustainable development of the EU-27 countries. The main factors that determine their originality are as follows:

- ➢ Filling of the research gap due to the lack of a multi-criteria price of sustainable energy and climate development of EU countries in the perspective of a decade (2010–2020);
- ➢ Development of a universal approach in the form of a new research methodology for assessing the energy–climate sustainability of EU countries, allowing a transparent and unambiguous comparative assessment of the countries under study, taking into account multiple factors;
- ➢ Development and formulation of recommendations on the use of the MCDM methodology for assessing the energy–climate sustainability of a group of countries.

The presented paper, in addition to a literature review, consists of two main parts. The first presents the developed research methodology regarding the assessment of energy–climate sustainability of the EU-27 countries using the MCDM approach. The second part presents the results of the research on this assessment for the data from 2010, 2015, and 2020. The study ends with conclusions drawn from the results.

The findings should broaden the knowledge regarding the level of sustainable energy and climate development of EU countries, and thus assess the changes being made and identify problems with the implementation of this concept.

2. Literature Studies

Issues related to energy and climate are the subject of numerous scientific studies covering various aspects. One of them is the assessment of energy and climate sustainability, related to the Europe 2020 Strategy and the Sustainable Development Goals of the United Nations (UN) Agenda 2030 [18,19]. In this regard, the choice of the method by which such an assessment is made is important. This is because it is obvious that the selection of such a method, and the algorithm used for the calculations, can have a major impact on the evaluation results.

To date, the literature on energy–climate sustainability in the EU countries has received considerable attention. These works mainly focus on issues related to the achievement of the goals set by Directive 2009/28/WE [24] and the Europe 2020 Strategy [26], and the assessment of whether the assumed values of indicators have been achieved and in which EU countries. This mainly concerns the share of renewable energy in total consumption, transportation, heating and cooling, and electricity generation [27–33], and whether and by how much countries have managed to reduce greenhouse gas emissions compared to 1990 [32–36], as well as whether and how energy efficiency has changed. These works use a variety of approaches to assess the energy–climate sustainability that forms the basis of such analyses.

Kryk and Guzowska [31], using a taxonomic and zero-unitization method, assessed the implementation of the climate and energy goals of the Europe 2020 Strategy by EU member states in 2010 and 2019. Çolak and Ege [37] examined the performance of EU member and candidate countries in achieving the Europe 2020 goals, including energy and climate targets, using a composite indicator methodology. Fura et al. [33] assessed the implementation of the goals contained in the Europe 2020 Strategy in the EU-28 countries using a synthetic linear ordering index at three-time intervals: 2004, 2010, and 2015.

Research to assess the implementation of energy and climate goals on the basis of four indicators, using the kernel-based comprehensive assessment (KerCA) method, was conducted by Siksnelyte-Butkiene et al. [22], and Kryk [38] assessed energy sustainability in the EU. For this study, he used two taxonomic methods: the k-means method and Ward's method. However, the studies cited and the methods used do not provide a ranking of countries, but only a classification of similar objects into clusters. In this regard, of interest is a study by Becker et al. [39], which proposed the creation of an EU2020 index to measure the achievement of the goals of the Europe 2020 Strategy, including energy and climate goals, of EU member states. This index takes into account all eight goals of the Europe 2020 Strategy. Fedajev et al. [40] measured the degree of implementation of the goals of the Europe 2020 Strategy, including energy–climate goals, among EU countries in 2016. They used the MCDM MULTIMOORA technique and the Shannon entropy method for measurement.

The results presented in these works differ, which is influenced by the period studied, the number of indicators included in the study, and the research method used. In the presented papers, the authors used approaches based on only one analytical method to assess the achievement of energy and climate goals. The research and results were interesting from both a scientific and utilitarian point of view. However, the results also showed great variation and so were difficult to compare. Thus, the approach presented in these works does not fully reflect the real situation of the countries studied in terms of energy and climate sustainability.

Obviously, it is difficult to find an ideal solution for this type of analysis, but it would be far more advisable to include more research methods and attempt a broader approach to research.

The selected literature presented here indicates that there is a research gap in the assessment of sustainable energy and climate development due to an overly narrow approach to the study of this development. This is particularly relevant in the EU, which is an amalgamation of 27 countries with different economic, organizational, and social levels.

When taking into account the indicated shortcomings of the existing research, it becomes reasonable to develop a research methodology that takes into account the simultaneous use of several methods and the largest possible number of indicators that characterize the assessed development.

Since the issue under study is multi-level in nature, it was advisable to apply methods for multi-criteria analysis from the group of MCDM methods. Based on selected methods from this group (in this case, five), we developed a universal way of assessing sustainable development in the EU-27 countries and drawing up an unambiguous ranking of these countries. Thus, the methodology presented in the paper represents a new approach to the study of multi-criteria problems and can also be successfully applied to the study of other such issues.

3. Materials and Methods

The section presents data used for the study and the sources of their acquisition, and characterizes the research methodology developed and the methods used.

3.1. Materials

The research used a set of 17 selected indicators to monitor the implementation of the goals of the Europe 2020 Strategy and the 7th and 13th goals of the UN 2030 Agenda for Sustainable Development, which are available in the Eurostat database [41]. The set of indicators adopted for the study met the following necessary criteria for the analysis:

- ➢ Relevance to the objectives of EU energy and climate policy related to the Europe 2020 Strategy and the UN Sustainable Development Goals (Agenda 2030);
- ➢ Simplicity in the construction of indicators;
- ➢ Simplicity of interpretation of the indicators as a basic tool for analysis;
- ➢ Comparability;
- ➢ The potential for use in econometric models, forecasting models and other data analytics issues;
- ➢ Low degree of correlation of variables among themselves;
- ➢ The value of the coefficient of variation above 10%;
- ➢ Accessibility.

The set of indicators characterized by these features and forming the basis of the analysis carried out is shown in Table 1. The values of these indicators adopted for the study were for the years 2010, 2015, and 2020.

Table 1. Variables and units of statistical data.

Indicator	Designation	Stimulant/Destimulant
Primary energy use, tonnes of oil equivalent per capita	X1	D
Primary energy use, 1990 = 100%	X2	S
Energy efficiency (final energy use), tonnes of oil equivalent per capita	X3	D
Energy efficiency (final energy use), 1990 = 100%	X4	S

Table 1. *Cont.*

Indicator	Designation	Stimulant/Destimulant
Final energy use in households per capita, kg of oil equivalent	X5	D
Energy productivity, euros per kilogram of oil equivalent	X6	S
Share of renewable energy in gross final energy use, %	X7	S
Share of renewable energy sources in transport, %	X8	S
Share of renewable energy sources in electricity, %	X9	S
Share of renewable energy sources in heating and cooling, %	X10	S
Energy imports, %	X11	D
Energy poverty, % of population	X12	D
Net greenhouse gas (GHG) emissions, 1990 = 100%	X13	D
Greenhouse gas emissions, tonnes per capita	X14	D
GHG intensity of energy, kg carbon dioxide equivalent/tonnes of oil equivalent	X15	D
Total GHG–GDP intensity, tonnes of carbon dioxide equivalent/million EUR	X16	D
Average carbon dioxide emissions per km from new passenger cars, grams of carbon dioxide per km	X17	D

3.2. Methods

The evaluation of EU countries in terms of energy and climate sustainability is a multi-criteria problem and can be carried out using an approach based on the MCDM method. In MCDM-type problems, a selection of the optimal alternative is made from among all alternatives according to different criteria, which are difficult to compare directly with each other [42–44]. Despite the large number of existing MCDM methods, no single method is considered universal and dedicated to solving a specific decision problem [45]. This results in a situation where the selection of an appropriate method for a given decision-making problem leads to a problem that can be solved by using an MCDM method. Therefore, it is necessary to develop a research methodology to solve the decision problem that has arisen.

The basis of the developed methodology is the adoption of five MCDM methods for analysis, which are widely used and well evaluated from a scientific and practical point of view, which are the CODAS, EDAS, TOPSIS, VIKOR, and WASPAS methods. Each of these methods makes it possible to determine the relative importance of each evaluated alternative, as well as to rank the alternatives against each other (in this case, EU countries). The methods chosen for the study differ in their basic principles, the type of data normalization process, and the way the values and weights of the criteria are combined in the evaluation procedure.

However, the evaluation criteria (indicators) used for the study have different units of measurement, so each method used uses a specific type of indicator normalization to eliminate these units (e.g., percent, tonnes of oil equivalent per capita, tonnes per capita, etc.). The purpose of this process is to obtain dimensionless criteria that can be further analyzed. As Zavadskas and Turskism [46] point out in their study, the process of normalizing indicators is essential for the consistent and correct application of a method.

The use of several methods (of the MCDM type) for analysis can therefore lead to different results from each method when determining the evaluation measure and the ranking of countries made from them.

That is why when assessing the EU-27 countries in terms of energy and climate sustainability, it was proposed to consider the results of all these methods and, as the final result, adopt the arithmetic average of the obtained partial assessments. The scheme of the research procedure for such an adopted method of determining the assessment of sustainable development of EU countries, taking into account the EU climate and energy policy and the UN Agenda 2030, is shown in Figure 1. The research methodology includes a literature search, based on which a research gap was identified, which formed the basis for the formulation of the research objective. To achieve this objective, analytical methods from the group of MCDM methods were used. In order to minimize the error associated with the selection of an inappropriate MCDM method, we decided to use several methods, as presented in the paper, to analyze the problem under consideration.

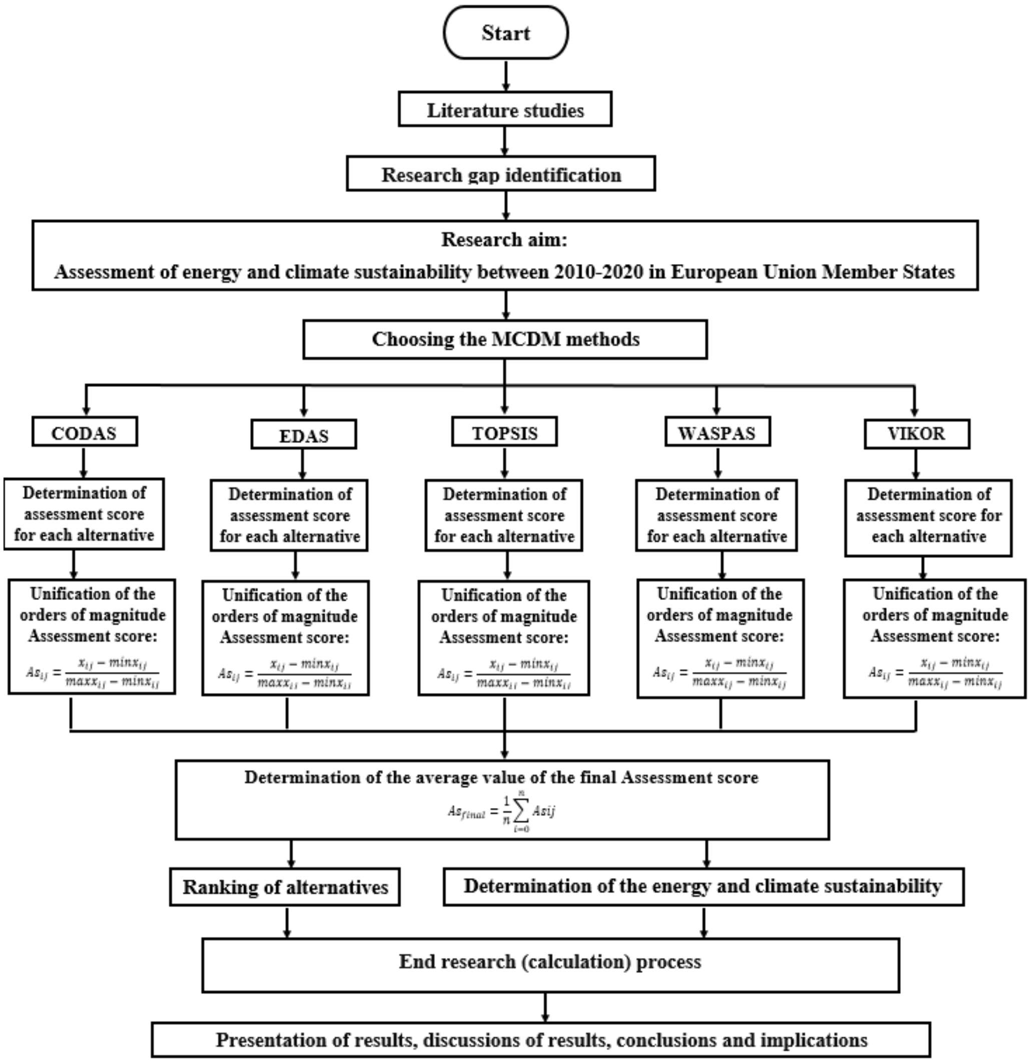


Figure 1. Diagram of the research procedure for the assessment of the EU-27 countries in terms of energy and climate sustainability.

3.2.1. Combinative Distance-Based Assessment (CODAS) Method

In this method, the desirability of alternatives is determined by two measures. Both the main and primary measures are related to the Euclidean distance of the alternatives from the negative ideal. Using this type of distance requires a 12-norm indifference space for the adopted criteria. The secondary measure is the Taxicab distance, which is related to the space of 11-normal differences. The best alternative will be the one that has larger distances from the negative-ideal solution. In this method, if we have two alternatives that are incomparable due to Euclidean distance, Taxicab distance is used as a secondary measure [47,48]. The steps of analysis in this method are as follows:

(1) Create a new decision matrix.
(2) Determine a normalized decision matrix based on the normalization procedure:

$$n_{ij} = \begin{cases} \frac{x_{ij}}{\max\limits_{i} x_{ij}} \; if \; j \in N_b \\ \frac{\min\limits_{i} x_{ij}}{x_{ij}} \; if \; j \in N_c \end{cases} \tag{1}$$

where N_b represents stimulants (benefit), and N_c represents destimulants (cost).

(3) Determine a weighted normalized decision matrix:

$$r_{ij} = n_{ij} \times w_i \tag{2}$$

where w_i represents the weight of the criterion.

(4) Determine a negative-ideal solution from Equations (3) and (4):

$$ns = \left[ns_j\right]_{1 \times m} \tag{3}$$

$$ns_j = \min_i r_{ij} \tag{4}$$

(5) Calculate the Euclidean (E_i) (Equation (5)) and Taxicab (T_i) (Equation (6)) distances of alternatives from the negative-ideal solution:

$$E_i = \sqrt{\sum\nolimits_{j=1}^{m} \left(r_{ij} - ns_j\right)^2} \tag{5}$$

$$T_i = \sum_{j=1}^{m} \left|r_{ij} - ns_j\right| \tag{6}$$

(6) Calculate the relative evaluation matrix of alternatives:

$$R_a = [h_{ik}]_{n \times n} \tag{7}$$

$$h_{ik} = (E_i - E_k) + (\psi(E_i - E_k) \times (T_i - T_k)) \tag{8}$$

where $k \in \{1, 2, \ldots, n\}$ and ψ denotes the threshold function for recognizing the equality of Euclidean distances of two alternatives and is defined as:

$$\psi = \begin{cases} 1 \; if \; |x| \geq \tau \\ 0 \; if \; |x| < \tau \end{cases} \tag{9}$$

where τ is a parameter set by the decision maker and takes a value from 0.01 to 0.05.

(7) Determine the evaluation measure of each alternative:

$$H_i = \sum_{k=1}^{n} h_{ik} \tag{10}$$

(8) Order the alternatives in terms of evaluation value in descending order.

3.2.2. Evaluation Based on Distance from Average Solution (EDAS) Method

The EDAS method is a method of evaluating alternatives and is based on measuring the distance of an alternative from the average solution. This method makes it possible to determine differences between all alternatives and the average solution (AV) and is based on two distance measures which are PDA (positive distance from average) and NDA (negative distance from average). The alternative with higher PDA values and at the same time lower PDA values is the best alternative [49–51]. The steps for proceeding with this method is as follows:

(1) Create a new initial decision-making matrix.
(2) Calculate the value of the average solution based on all evaluation criteria, as follows:

$$AV = \left[AV_j\right]_{1 \times m} \tag{11}$$

$$AV_j = \frac{\sum_{i=1}^{n} x_{ij}}{n} \tag{12}$$

(3) Based on the value of the average solution (AV), determine a positive distance from the average (PDA) and negative distance from the average (NDA) using formulas:

$$PDA = \left[PDA_{ij}\right]_{n\times m} \tag{13}$$

$$NDA = \left[NDA_{ij}\right]_{n\times m} \tag{14}$$

for stimulants:

$$PDA_{ij} = \frac{max\left(0, \left(x_{ij} - AV_j\right)\right)}{AV_j} \tag{15}$$

$$NDA_{ij} = \frac{max\left(0, \left(AV_j - x_{ij}\right)\right)}{AV_j} \tag{16}$$

for destimulants:

$$PDA_{ij} = \frac{max\left(0, \left(AV_j - x_{ij}\right)\right)}{AV_j} \tag{17}$$

$$NDA_{ij} = \frac{max\left(0, \left(x_{ij} - AV_j\right)\right)}{AV_j} \tag{18}$$

(4) To determine weighted sums of PDA and NDA for all alternatives, as follows:

$$SP_i = \sum\nolimits_{j=1}^{m} w_j PDA_{ij} \tag{19}$$

$$SN_i = \sum_{j=1}^{m} w_j NDA_{ij} \tag{20}$$

where w_j represents the weight of the criterion.

(5) Normalize *SP* and *SN* values:

$$NSP_i = \frac{SP_i}{max_i(SP_i)} \tag{21}$$

$$NSN_i = 1 - \frac{SN_i}{max_i(SN_i)} \tag{22}$$

(6) Determine the Appraisal Score (AS_i) index for each alternative:

$$AS_i = 0.5(NSP_i + NSN_i),\ 0 \le AS_i \ge 1 \tag{23}$$

(7) Rank the alternatives according to *ASi* values in descending order. The alternative with the highest *ASi* value is the best choice among all alternatives (the alternative with the largest value of *ASi* index is the best one).

3.2.3. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Method

The basic principle of the TOPSIS method (the method of ordering alternatives according to similarity to the ideal solution) is to define ideal solutions, i.e., positive and negative, based on the shortest path to the ideal solution. The positive and negative ideal solutions are hypothetical solutions in which all index values are similar to the maximum and minimum values, respectively, of a given index in the data matrix [52–55]. The steps of analysis using the TOPSIS method are as follows:

(1) Create a new initial decision-making matrix.
(2) Normalize the new decision matrix according to the equation:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} {x^2}_{ij}}} \tag{24}$$

(3) Determine a weighted normalized decision matrix:

$$v_{ij} = x_{ij} \times w_i \tag{25}$$

where w_i represents the weight of the criterion.

(4) After creating a weighted normalized edit matrix, a positive ideal solution and a negative ideal solution are determined using the equations:

$$v_j^+ = \{v_1^+, v_2^+, \ldots, v_n^+\} = \{max_j(v_{ij})\} \tag{26}$$

$$v_j^- = \{v_1^-, v_2^-, \ldots, v_n^{-+}\} = \{min_j(v_{ij})\} \tag{27}$$

(5) The distance of each alternative from the positive ideal and negative ideal solutions is obtained using the equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2} \tag{28}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2} \tag{29}$$

(6) Determine the relative proximity (P_i) of an alternative to the optimal solution according to Equation (28):

$$P_i = \frac{D_i^-}{D_i^- + D_i^+} \tag{30}$$

(7) Finally, the alternatives are ranked according to the P_i values of the relative proximity (the higher value, the better the alternative).

3.2.4. VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) Method

The VIKOR method is considered a flexible ranking method for determining the best decision-making procedure. The implementation of the VIKOR method focuses on ranking and selecting the best one from a group of alternatives, given the presence of contradictions [56–58]. The procedure for applying the VIKOR method includes the following steps:

(1) Create a new initial decision-making matrix.
(2) Determine the best ($f_i{}^*$) and the worst (f_i^-) values in all the studied criteria based on the equations:

$$f_i{}^* = \max_i f_{ij},\ f_j^- = \min_i f_{ij} \tag{31}$$

$$f_i^- = \min_i f_{ij},\ f_j^- = \max_i f_{ij} \tag{32}$$

(3) Determine the values of Si and Ri using Equations (34) and (35), with w_j being the weight of the criteria, which determines their relative importance:

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_i{}^* - f_j^-\right)}{\left(f_i{}^* - f_j^-\right)} \tag{33}$$

$$R_i = \max_i \left[w_j \frac{\left(f_i{}^* - f_j^-\right)}{\left(f\ {}_i{}^* - f_j^-\right)} \right] \tag{34}$$

where w_j represents the weight of the criterion.

(4) Determine the value of Qi using the equation:

$$Q_i = \frac{v(S_j - S^*)}{(S^- - S^*)} + (1-v)\frac{(R_i - R^*)}{(R^- - R^*)} \tag{35}$$

where $(1 - v)$ is the so-called veto power (where v represents the importance of the weighted sum of criteria, and $(1 - v)$ reflects the importance of the weakest criterion).

(5) The value of v is a weight reflecting the importance of the strategy of most criteria (from Equation (37)):

$$S^* = min_i S_i;\ S^- = max_i S_i \tag{36}$$

$$R^* = min_i SR_i;\ R^- = max_i R_i \tag{37}$$

(6) Create a ranking of alternatives based on Qi values. For this purpose, the determined values are arranged in descending order. The best alternative has the smallest value.

3.2.5. The Weighted Aggregated Sum Product Assessment (WASPAS) Method

The Weighted Aggregates Sum Product Assessment (WASPAS) method was developed by Zavadskas, Turskis, Antucheviciene, and Zakarevicius in 2012. The method is a combination of the Weighted Sum Model (WSM) and the Weighted Product Model (WPM) [59–61]. The workflow for the WASPAS method analysis is as follows:

(1) Create a new initial decision-making matrix.
(2) Determine the normalized decision matrix of positive criteria (stimulants) and negative criteria (destimulants) according to Equations (39)–(40):

$$x_{ij}^* = \frac{x_{ij}}{\max\limits_i x_{ij}},\ i = 1, \ldots,\ m,\ j = 1, \ldots, n \tag{38}$$

$$x_{ij}^* = \frac{\min\limits_i x_{ij}}{x_{ij}},\ i = 1, \ldots,\ m,\ j = 1, \ldots, n \tag{39}$$

(3) Determine the relative additive validity of the normalized values of each alternative:

$$Q_i^{(1)} = \sum_{j=1}^{n} x_{ij}^* w_j,\ i = 1, \ldots,\ m \tag{40}$$

(4) Determine the multiplicative relative additive validity of the normalized values of each alternative:

$$Q_i^{(2)} = \prod\nolimits_{j=1}^{n} \left(x_{ij}^*\right)^{w_j},\ i = 1, \ldots,\ m \tag{41}$$

(5) Determine the generalized evaluation criterion (Q), called the weighted total product evaluation method:

$$Q_i = \lambda \sum_{j=1}^{n} x_{ij}^* w_j + (1 - \lambda) \sum_{j=1}^{n} \left(x_{ij}^*\right)^{w_j},\ \lambda = 0, \ldots\ldots 1. \tag{42}$$

where λ has a value of 0.5.

6) Create a ranking of alternatives based on Qi values.

3.2.6. The New Methodology: Integrated Multiple-Criteria Decision-Making Approach

In order to determine an unambiguous assessment and final ranking position based on the Assessment Score value for each alternative, a calculation algorithm was developed (Figure 2), which includes the following steps:

(1) Unify the orders of magnitude of the Assessment Score values obtained in each MCDM method used for each alternative according to the zero-order unitization equations:

$$As_{ij} = \frac{x_{ij} - minx_{ij}}{maxx_{ij} - minx_{ij}} \tag{43}$$

(if, in the MCDM method, a higher ranking is associated with a higher Assessment Score);

and

$$As_{ij} = \frac{max\ x_{ij} - x_{ij}}{maxx_{ij} - minx_{ij}} \tag{44}$$

(if, in the MCDM method, a higher ranking is associated with a lower Assessment Score);

(2) Determine the average Assessment Score from all used MCDM methods for a given alternative:

$$As_{final} = \frac{1}{n}\sum_{i=0}^{n} Asij \tag{45}$$

(3) Make a ranking of alternatives based on the values of the final Assessment Score (As_{final}) (the highest value of final Assessment Score is position 1, the lowest value-the last position).

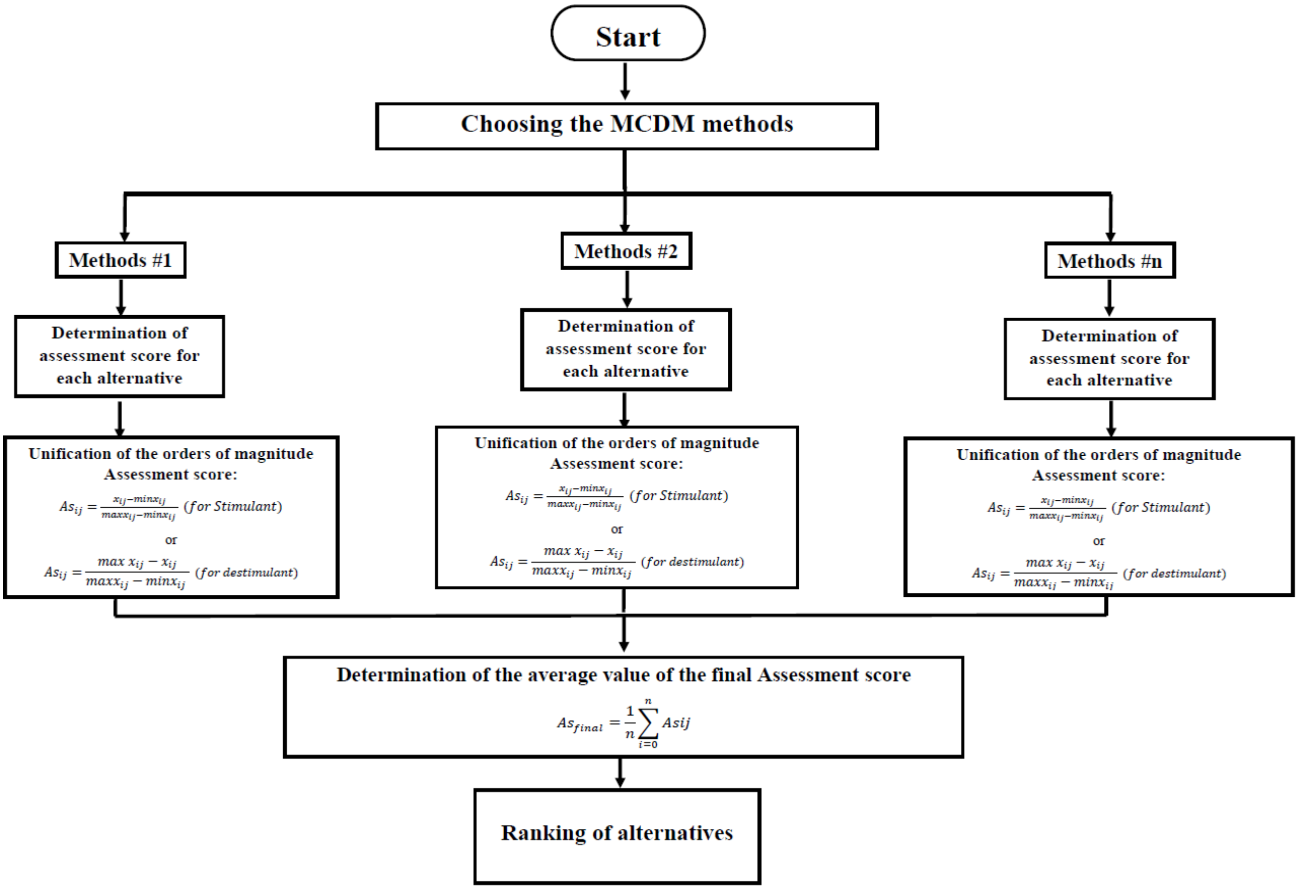


Figure 2. Diagram of the MCDM methods research procedure.

4. Results

This section presents the research results, including an assessment of the level of sustainable development of EU countries and their ranking determined on the basis of these results.

4.1. Descriptive Statistics

A preliminary assessment of the indicators determining the achievement of energy and climate goals in the EU-27 was made by calculating their basic descriptive measures, i.e., maximum, minimum, and mean values, coefficient of variation (CV), and coefficient of asymmetry (CA) in 2010, 2015, and 2020 (Table 2).

The results show that there have been positive changes in the use of renewable energy in the EU-27 in 2020 compared to 2010. This is evident from the maximum as well as mean values of some of the indicators studied (variables X7 to X10). It is noticeable that the average greenhouse gas emissions per capita (X14) and average carbon dioxide emissions per km from new passenger cars (X17) reduced. It is noteworthy that the average and maximum levels of energy poverty, the biggest problem in Bulgaria, also dropped significantly. The mean and maximum values of primary energy consumption per capita, final energy consumption per capita, or final energy consumption in households per capita decreased significantly. By contrast, the value of energy productivity (X6) increased during the period under review.

Table 2. Descriptive statistics of variables in 2010, 2015, and 2020.

Indicator	Mean	Minimum Value	Maximum Value	Coefficient of Variation (CV)	Coefficient of Asymmetry (CA)
			2010		
X1	3.48	1.63 (Romania)	9.09 (Luxembourg)	45.91	1.94
X2	97.80	76.60 (Lithuania)	110.40 (Estonia)	7.34	−0.65
X3	2.55	1.11 (Romania)	8.54 (Luxembourg)	57.55	2.85
X4	99.00	87.10 (Bulgaria)	113.30 (Poland)	5.89	0.15
X5	637.15	167.00 (Malta)	1084.00 (Finland)	36.59	−0.15
X6	5.91	2.13 (Bulgaria)	11.55 (Denmark)	43.44	0.49
X7	16.35	0.98 (Malta)	46.10 (Sweden)	65.77	0.86
X8	4.06	0.00 (Malta)	10.71 (Austria)	65.26	0.66
X9	20.99	0.03 (Malta)	66.36 (Austria)	80.31	1.06
X10	22.16	3.1 (Netherlands)	57.07 (Sweden)	63.85	0.62
X11	55.99	−16.01 (Denmark)	100.64 (Cyprus)	50.38	−0.43
X12	11.98	0.50 (Luxembourg)	66.5 (Bulgaria)	114.40	2.68
X13	87.66	24.5 (Lithuania)	166.90 (Cyprus)	34.09	0.30
X14	9.40	2.50 (Sweden)	26.5 (Luxembourg)	51.57	1.64
X15	143.49	126.2 (Denmark)	162.0 (Latvia)	7.44	−0.06
X16	2967.00	1321.78 (Sweden)	4272.36 (Greece)	23.16	−0.01
X17	544.49	163.05 (Sweden)	1406.11 (Bulgaria)	57.98	1.32
			2015		
X1	3.121	1.55 (Romania)	7.27 (Luxembourg)	40.660	1.600
X2	89.511	72.00 (Greece)	105.90 (Estonia)	7.688	−0.097
X3	2.340	1.10 (Romania)	7.00 (Luxembourg)	50.760	2.614
X4	93.470	78.80 (Greece)	124.60 (Malta)	9.339	1.700
X5	554.963	179.00 (Malta)	904.00 (Finland)	33.689	−0.040
X6	6.930	2.18 (Bulgaria)	16.18 (Ireland)	46.984	1.257
X7	20.350	4.99 (Luxembourg)	52.22 (Sweden)	57.990	0.846
X8	6.576	0.41 (Estonia)	24.56 (Finland)	81.973	2.232
X9	28.463	4.31 (Malta)	71.49 (Austria)	65.221	0.760
X10	27.140	5.28 (Netherlands)	63.24 (Sweden)	59.634	0.541
X11	56.819	11.18 (Estonia)	97.32 (Malta)	44.630	−0.088
X12	11.222	0.90 (Luxembourg)	39.20 (Bulgaria)	93.037	1.313
X13	80.274	29.70 (Lithuania)	145.80 (Cyprus)	34.467	0.387
X14	8.411	1.80 (Sweden)	19.90 (Luxembourg)	44.853	1.076
X15	120.93	101.2 (Netherlands)	137.20 (Estonia)	8.089	−0.326
X16	2948.577	1194.59 (Sweden)	4420.68 (Ireland)	26.181	0.006
X17	465.308	123.38 (Sweden)	1350.58 (Bulgaria)	61.532	1.451
			2020		
X1	2.88	1.44 (Malta)	6.25 (Luxembourg)	37.31	1.60
X2	84.74	65.00 (Greece)	109.80 (Poland)	9.45	0.56
X3	2.21	1.05 (Malta)	6.04 (Luxembourg)	45.81	2.43
X4	91.04	68.20 (Greece)	121.40 (Poland)	13.14	0.84
X5	561.52	204.00 (Malta)	957.00 (Finland)	30.47	−0.05
X6	7.87	2.47 (Bulgaria)	22.61 (Ireland)	54.71	1.91
X7	24.36	10.71 (Malta)	60.12 (Sweden)	47.09	1.41
X8	10.39	5.34 (Greece)	31.85 (Sweden)	46.11	3.59
X9	35.25	9.49 (Malta)	78.20 (Austria)	54.43	0.68
X10	30.96	6.26 (Ireland)	66.38 (Sweden)	55.12	0.52
X11	58.02	10.50 (Estonia)	97.56 (Malta)	36.42	0.00
X12	7.82	1.50 (Austria)	27.50 (Bulgaria)	91.32	1.54

Table 2. *Cont.*

Indicator	Mean	Minimum Value	Maximum Value	Coefficient of Variation (CV)	Coefficient of Asymmetry (CA)
X13	70.09	20.60 (Sweden)	147.60 (Cyprus)	37.85	0.69
X14	7.27	0.70 (Sweden)	16.50 (Luxembourg)	44.89	0.88
X15	111.14	82.3 (Netherlands)	133.0 (Bulgaria)	10.38	−0.53
X16	2751.92	1078.00 (Sweden)	4214.55 (Ireland)	24.49	−0.09
X17	388.73	108.10 (Sweden)	1093.92 (Bulgaria)	56.22	1.44

Notes: X1—primary energy use, tonnes of oil equivalent per capita; X2—primary energy use, 1990 = 100%; X3—energy efficiency (final energy use), tonnes of oil equivalent per capita; X4—energy efficiency (final energy use), 1990 = 100%; X5—final energy use in households per capita, kg of oil equivalent; X6—energy productivity, euros per kilogram of oil equivalent; X7—share of renewable energy in gross final energy use, %; X8—share of renewable energy sources in transport, %; X9—share of renewable energy sources in electricity, %; X10—share of renewable energy sources in heating and cooling; X11—energy imports, %; X12—energy poverty, % of population; X13—net greenhouse gas (GHG) emissions, 1990 = 100%; X14—greenhouse gas emissions, tonnes per capita; X15—GHG intensity of energy, kg carbon dioxide equivalent/tonnes of oil equivalent; X16—total GHG–GDP intensity—tonnes of carbon dioxide equivalent/million EUR; X17—average carbon dioxide emissions per km from new passenger cars, grams of carbon dioxide per km.

In order to assess the changes that have occurred in the values of indicators characterizing energy and climate sustainability in the EU countries between 2010 and 2020, the indices of the dynamics of change of these indicators were determined (Table 3). Determination of the values of these indices makes it possible to identify the magnitude and direction of changes in the studied indicators.

Table 3. Values of indices of the dynamics of change of indicators of sustainable energy and climate development in individual EU member states (2010 = 100%).

Country	Indicator, %																
	X1	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**	**X15**	**X16**	**X17**
Belgium	78	82	83	88	78	127	217	230	343	126	99	73	80	75	81	96	77
Bulgaria	106	99	116	108	114	116	167	608	191	153	94	41	84	91	84	89	78
Czechia	86	88	95	97	94	133	165	180	197	167	153	42	94	92	81	93	71
Denmark	73	77	81	85	82	148	145	844	200	168	−280	158	67	64	76	85	61
Germany	82	83	89	90	89	133	166	155	245	123	106	140	77	76	75	95	75
Estonia	78	78	95	95	92	174	122	2809	275	136	72	87	79	78	75	86	50
Ireland	83	91	86	94	80	205	281	409	250	146	82	49	91	84	80	99	55
Greece	75	72	78	75	95	109	216	279	291	171	119	111	61	64	75	89	87
Spain	84	85	81	82	84	116	154	190	144	144	88	145	74	72	82	92	81
France	78	82	81	85	82	126	151	140	168	145	91	118	80	76	75	93	77
Croatia	93	88	95	90	87	119	124	587	143	112	115	69	87	92	88	93	76
Italy	79	79	80	80	86	115	156	218	190	128	89	72	73	72	82	93	81
Cyprus	77	82	76	82	101	126	274	371	866	197	92	77	88	82	80	101	83
Latvia	103	94	104	94	89	137	139	169	127	140	100	31	110	120	74	95	71
Lithuania	112	101	123	110	100	129	136	145	272	155	95	92	143	156	79	90	71
Luxembourg	69	85	71	88	78	143	410	601	367	268	95	720	77	62	82	95	75
Hungary	100	97	106	103	92	126	109	188	168	98	99	39	90	94	79	97	75
Malta	64	80	87	108	122	125	1094	-	29,653	316	99	50	71	58	77	86	49
Netherlands	78	81	78	82	71	131	357	372	275	260	241	104	77	73	61	98	76
Austria	85	90	87	93	89	115	117	96	118	113	93	39	89	83	78	96	84
Poland	100	100	107	107	96	133	173	99	248	187	135	22	94	94	85	91	69
Portugal	89	86	85	83	104	110	141	175	143	123	87	58	83	86	77	97	89
Romania	98	94	110	104	104	147	107	625	143	93	132	50	81	85	78	101	68
Slovenia	85	87	85	87	77	129	119	350	109	109	93	60	89	87	79	94	73
Slovakia	90	91	88	90	117	130	191	175	130	246	87	130	72	71	82	92	70
Finland	82	84	86	89	88	121	136	306	145	131	86	129	56	55	67	77	66

Table 3. *Cont.*

Country	Indicator, %																
	X1	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**	**X15**	**X16**	**X17**
Sweden	78	87	83	91	79	129	130	331	134	116	88	129	31	28	62	82	66
UE-27 average	85	87	90	92	92	132	211	410	1316	158	91	105	81	80	78	92	72

Notes: X1—primary energy use, tonnes of oil equivalent per capita; X2—primary energy use, 1990 = 100%; X3—energy efficiency (final energy use), tonnes of oil equivalent per capita; X4—energy efficiency (final energy use), 1990 = 100%; X5—final energy use in households per capita, kg of oil equivalent; X6—energy productivity, euros per kilogram of oil equivalent; X7—share of renewable energy in gross final energy use, %; X8—share of renewable energy sources in transport, %; X9—share of renewable energy sources in electricity, %; X10—share of renewable energy sources in heating and cooling; X11—energy imports, %; X12—energy poverty, % of population; X13—net greenhouse gas (GHG) emissions, 1990 = 100%; X14—greenhouse gas emissions, tonnes per capita; X15—GHG intensity of energy, kg carbon dioxide equivalent/tonnes of oil equivalent; X16—total GHG–GDP intensity—tonnes of carbon dioxide equivalent/million EUR; X17—average carbon dioxide emissions per km from new passenger cars, grams of carbon dioxide per km.

4.2. Comparison of Alternative Rankings Using Different MCDM Methods

In the first stage of the primary research, which aimed to assess the energy–climate sustainability of EU countries, using the indices adopted for the study and five MCDM-type methods (CODAS, EDAS, TOPSIS, VIKOR, and WASPAS), the values of the indices specific to each method used were determined. These were the Hi index (in the CODAS method), the As_i index (in the EDAS method), the Pi index (in the TOPSIS method), the Qi index (in the VIKOR method), and the Qi index (in the WASPAS method). Based on the values of these indices, the ranking of the EU-27 countries in terms of energy and climate sustainability, resulting from EU policies and the goals of Agenda 2030, was determined. The calculations were carried out in 3 different years, i.e., 2010, 2015, and 2020. The results of the calculations are shown in Tables 4–6.

Table 4. EU-27 country rankings based on 2010 data.

Country	MCDM Method									
	CODAS		**EDAS**		**TOPSIS**		**VIKOR**		**WASPAS**	
	Assessment Score H_i	**Rank**	**Assessment Score As_i**	**Rank**	**Assessment Score P_i**	**Rank**	**Assessment Score Q_i**	**Rank**	**Assessment Score Q_i**	**Rank**
Belgium	−0.541	23	0.364	23	0.552	19	0.335	22	0.610	20
Bulgaria	−0.139	14	0.227	26	0.433	27	0.319	21	0.608	21
Czechia	−0.972	27	0.427	18	0.559	17	0.308	20	0.568	26
Denmark	1.573	1	0.665	3	0.628	3	0.120	4	0.707	3
Germany	−0.318	19	0.518	15	0.585	10	0.255	16	0.631	16
Estonia	−0.599	25	0.459	17	0.557	18	0.359	24	0.551	27
Ireland	−0.230	16	0.378	22	0.546	21	0.307	19	0.618	19
Greece	−0.320	20	0.426	19	0.545	22	0.255	15	0.620	18
Spain	−0.027	12	0.584	10	0.590	9	0.143	7	0.672	7
France	−0.148	15	0.587	9	0.604	5	0.141	6	0.672	6
Croatia	0.063	10	0.632	6	0.602	6	0.137	5	0.664	10
Italy	−0.073	13	0.542	12	0.580	12	0.160	9	0.666	8
Cyprus	−0.520	22	0.239	25	0.497	26	0.455	26	0.589	24
Latvia	0.190	8	0.647	4	0.593	7	0.197	12	0.665	9
Lithuania	0.784	3	0.521	13	0.549	20	0.180	10	0.682	5
Luxembourg	0.528	5	0.102	27	0.522	25	0.500	27	0.604	22
Hungary	−0.235	17	0.518	14	0.571	14	0.207	13	0.637	13
Malta	0.157	9	0.323	24	0.533	24	0.356	23	0.635	15
Netherlands	−0.893	26	0.415	20	0.571	15	0.298	18	0.601	23
Austria	0.781	4	0.776	2	0.638	2	0.106	3	0.702	4

Table 4. *Cont.*

Country	MCDM Method									
	CODAS		EDAS		TOPSIS		VIKOR		WASPAS	
	Assessment Score H_i	Rank	Assessment Score As_i	Rank	Assessment Score P_i	Rank	Assessment Score Q_i	Rank	Assessment Score Q_i	Rank
Poland	−0.596	24	0.393	21	0.535	23	0.388	25	0.576	25
Portugal	0.436	6	0.635	5	0.562	16	0.071	2	0.710	2
Romania	0.241	7	0.593	8	0.576	13	0.145	8	0.657	11
Slovenia	−0.308	18	0.600	7	0.609	4	0.190	11	0.636	14
Slovakia	−0.381	21	0.514	16	0.581	11	0.238	14	0.622	17
Finland	0.042	11	0.550	11	0.593	8	0.272	17	0.640	12
Sweden	1.553	2	0.932	1	0.714	1	0.000	1	0.781	1

Table 5. EU-27 country rankings based on 2015 data.

Country	MCDM Method									
	CODAS		EDAS		TOPSIS		VIKOR		WASPAS	
	Assessment Score H_i	Rank	Assessment Score As_i	Rank	Assessment Score P_i	Rank	Assessment Score Q_i	Rank	Assessment Score Q_i	Rank
Belgium	−0.911	27	0.312	24	0.528	17	0.369	24	0.612	23
Bulgaria	−0.246	15	0.239	25	0.431	27	0.367	23	0.608	24
Czechia	−0.776	26	0.381	18	0.518	20	0.336	20	0.593	26
Denmark	0.715	4	0.715	2	0.617	2	0.086	2	0.730	2
Germany	−0.573	22	0.462	14	0.551	8	0.311	18	0.629	19
Estonia	0.474	7	0.403	17	0.520	19	0.346	21	0.620	21
Ireland	−0.187	13	0.368	20	0.531	16	0.347	22	0.634	17
Greece	−0.264	16	0.330	23	0.483	24	0.266	15	0.637	16
Spain	−0.290	17	0.468	13	0.540	12	0.235	11	0.657	13
France	−0.361	18	0.538	8	0.573	5	0.218	9	0.672	9
Croatia	0.121	12	0.583	7	0.548	9	0.169	4	0.675	6
Italy	−0.227	14	0.512	9	0.545	10	0.212	7	0.671	10
Cyprus	−0.767	25	0.189	26	0.470	26	0.439	26	0.597	25
Latvia	0.233	10	0.596	6	0.539	13	0.215	8	0.673	7
Lithuania	0.586	5	0.435	16	0.497	23	0.241	13	0.672	8
Luxembourg	0.533	6	0.105	27	0.516	21	0.500	27	0.617	22
Hungary	−0.500	21	0.455	15	0.536	15	0.285	16	0.631	18
Malta	0.186	11	0.359	21	0.524	18	0.332	19	0.670	11
Netherlands	−0.628	23	0.376	19	0.541	11	0.293	17	0.626	20
Austria	0.376	8	0.632	5	0.581	4	0.220	10	0.687	5
Poland	−0.670	24	0.345	22	0.509	22	0.393	25	0.590	27
Portugal	0.323	9	0.492	11	0.474	25	0.200	6	0.663	12
Romania	0.831	2	0.647	4	0.571	6	0.125	3	0.722	3
Slovenia	−0.472	20	0.488	12	0.538	14	0.256	14	0.638	15
Slovakia	−0.385	19	0.507	10	0.553	7	0.240	12	0.638	14
Finland	0.782	3	0.673	3	0.591	3	0.184	5	0.696	4
Sweden	2.156	1	0.925	1	0.702	1	0.000	1	0.828	1

The results show that, depending on the calculation method used, the positions of individual countries in the designated rankings vary. This applies to all the years analyzed. The same ranking position, regardless of the calculation method used, was achieved only in 2015 and 2020 by Sweden, which is the leader in energy and climate sustainability. For some EU countries (considered as alternatives), the differences are small, but for some of them they are more than 15 positions in the ranking (e.g., the highest position of Luxembourg in 2015 in the CODAS method is 6, and the lowest is 27 in the EDAS and VIKOR methods).

Therefore, it can be concluded that the choice of the method of analysis is important for the results obtained.

Table 6. EU-27 country rankings based on 2020 data.

Country	MCDM Method									
	CODAS		EDAS		TOPSIS		VIKOR		WASPAS	
	Assessment Score H_i	Rank	Assessment Score As_i	Rank	Assessment Score P_i	Rank	Assessment Score Q_i	Rank	Assessment Score Q_i	Rank
Belgium	−0.730	27	0.327	21	0.524	19	0.380	22	0.612	23
Bulgaria	−0.308	19	0.180	25	0.426	27	0.403	24	0.608	24
Czechia	−0.297	18	0.304	23	0.504	22	0.400	23	0.593	26
Denmark	0.648	4	0.710	2	0.615	2	0.147	2	0.730	2
Germany	−0.542	22	0.450	14	0.540	10	0.322	17	0.629	19
Estonia	0.626	5	0.505	12	0.529	16	0.281	13	0.620	21
Ireland	0.122	9	0.415	17	0.552	7	0.350	19	0.634	17
Greece	−0.018	11	0.383	20	0.484	24	0.282	14	0.637	16
Spain	−0.195	15	0.499	13	0.536	12	0.252	7	0.657	13
France	−0.347	20	0.529	9	0.562	4	0.239	4	0.672	9
Croatia	−0.090	13	0.552	5	0.536	13	0.250	6	0.675	6
Italy	−0.272	17	0.531	8	0.550	8	0.246	5	0.671	10
Cyprus	−0.614	24	0.145	26	0.442	26	0.462	25	0.597	25
Latvia	0.058	10	0.566	3	0.533	14	0.256	9	0.673	7
Lithuania	−0.130	14	0.316	22	0.477	25	0.353	20	0.672	8
Luxembourg	−0.528	21	0.097	27	0.513	20	0.500	27	0.617	22
Hungary	−0.642	26	0.394	19	0.526	17	0.356	21	0.631	18
Malta	0.427	6	0.399	18	0.525	18	0.332	18	0.670	11
Netherlands	−0.074	12	0.420	16	0.541	9	0.298	15	0.626	20
Austria	0.912	2	0.556	4	0.554	6	0.270	12	0.687	5
Poland	−0.629	25	0.242	24	0.495	23	0.480	26	0.590	27
Portugal	0.253	7	0.544	7	0.511	21	0.196	3	0.663	12
Romania	0.194	8	0.512	11	0.532	15	0.261	10	0.722	3
Slovenia	−0.227	16	0.552	6	0.555	5	0.264	11	0.638	15
Slovakia	−0.588	23	0.445	15	0.537	11	0.320	16	0.638	14
Finland	0.697	3	0.525	10	0.563	3	0.254	8	0.696	4
Sweden	2.351	1	0.928	1	0.686	1	0.000	1	0.828	1

In order to assess the consistency and similarity (variation) between the rankings obtained from each method, Spearman's rank correlation coefficients were determined for these results. The results for the years studied are shown in Tables 7–9.

Table 7. Validation through correlation coefficients among MCDM approaches for 2010.

	CODAS	EDAS	TOPSIS	VIKOR	WASPAS
CODAS	1.000	**0.559**	0.364	**0.605**	**0.803**
EDAS	**0.559**	1.000	**0.893**	**0.910**	**0.831**
TOPSIS	0.364	**0.893**	1.000	**0.786**	**0.683**
VIKOR	**0.605**	**0.910**	**0.786**	1.000	**0.911**
WASPAS	**0.803**	**0.831**	**0.683**	**0.911**	1.000

Note: Statistically significant values are marked in bold.

Based on the analysis of the values of Spearman's rank correlation coefficients, the best fit in terms of country rankings is between the EDAS and VIKOR methods, for which the values of this coefficient range from 0.933 to 0.913 (with a significance level value p less than 0.05). It can also be noted that the results obtained from the EDAS method have the highest values of correlation coefficients with the other methods used in the study. The worst fit for the EDAS method occurs with the results obtained from the CODAS method (correlation coefficient values range from 0.542 to 0.628). On the other hand, the worst fit of the results with the CODAS method is also shown by the results obtained from the TOPSIS (correlation coefficients ranging from 0.336 to 0.439) and VIKOR (correlation coefficients ranging from 0.580 to 0.615) methods.

Table 8. Validation through correlation coefficients among MCDM approaches for 2015.

	CODAS	EDAS	TOPSIS	VIKOR	WASPAS
CODAS	1.000	**0.542**	0.336	**0.580**	**0.743**
EDAS	**0.542**	1.000	**0.832**	**0.933**	**0.871**
TOPSIS	0.336	**0.832**	1.000	**0.701**	**0.709**
VIKOR	**0.580**	**0.933**	**0.701**	1.000	**0.914**
WASPAS	**0.743**	**0.871**	**0.709**	**0.914**	1.000

Note: Statistically significant values are marked in bold.

Table 9. Validation through correlation coefficients among MCDM approaches for 2020.

	CODAS	EDAS	TOPSIS	VIKOR	WASPAS
CODAS	1.000	**0.628**	**0.439**	**0.615**	**0.685**
EDAS	**0.628**	1.000	**0.767**	**0.913**	**0.798**
TOPSIS	**0.439**	**0.767**	1.000	**0.684**	**0.617**
VIKOR	**0.615**	**0.913**	**0.684**	1.000	**0.803**
WASPAS	**0.685**	**0.798**	**0.617**	**0.803**	1.000

Note: Statistically significant values are marked in bold.

Due to the occurrence, on more than one occasion, of large differences in the consistency of the results, as to the actual position in the ranking, it is necessary to apply a solution to determine the unambiguous position of the EU-27 countries in this ranking.

In some works, the authors use the "Mean-rank" method in such a situation, which refers to determining the average value for ranking positions obtained by different methods [62,63]. However, such an approach can lead to a situation in which two or more countries may occupy the same ranking position, which should be avoided in this case.

Based on the presented methodology, the unified values of Assessment Score (As_{final}) for each of the MCDM methods used were determined (Tables 10–12), as well as the final ranking position of the studied alternatives (i.e., EU-27 countries).

Table 10. Unified values of final Assessment Score (As_{final} for the studied EU-27 countries in 2010 and their final ranking position.

Country	MCDM Method					As_{final}	Rank
	CODAS Assessment Score H_i	EDAS Assessment Score As_i	TOPSIS Assessment Score P_i	VIKOR Assessment Score Q_i	WASPAS Assessment Score Q_i		
Belgium	0.169	0.316	0.424	0.330	0.255	0.299	21
Bulgaria	0.327	0.150	0.000	0.362	0.247	0.217	26
Czechia	0.000	0.391	0.447	0.384	0.074	0.259	22
Denmark	1.000	0.678	0.694	0.760	0.678	0.762	2
Germany	0.257	0.501	0.542	0.490	0.346	0.427	15
Estonia	0.146	0.430	0.439	0.281	0.000	0.259	22
Ireland	0.291	0.332	0.401	0.386	0.291	0.340	19
Greece	0.256	0.390	0.399	0.491	0.301	0.367	17
Spain	0.371	0.580	0.560	0.714	0.527	0.550	9
France	0.324	0.584	0.609	0.718	0.527	0.552	8
Croatia	0.407	0.638	0.601	0.725	0.492	0.573	5

Table 10. *Cont.*

Country	CODAS Assessment Score H_i	EDAS Assessment Score As_i	TOPSIS Assessment Score P_i	VIKOR Assessment Score Q_i	WASPAS Assessment Score Q_i	As_{final}	Rank
	MCDM Method						
Italy	0.353	0.530	0.522	0.680	0.500	0.517	11
Cyprus	0.177	0.165	0.228	0.090	0.164	0.165	27
Latvia	0.457	0.656	0.568	0.606	0.496	0.557	7
Lithuania	0.690	0.504	0.413	0.640	0.568	0.563	6
Luxembourg	0.590	0.000	0.315	0.000	0.230	0.227	25
Hungary	0.290	0.501	0.491	0.587	0.374	0.449	14
Malta	0.444	0.266	0.355	0.288	0.365	0.344	18
Netherlands	0.031	0.377	0.491	0.403	0.216	0.304	20
Austria	0.689	0.812	0.730	0.787	0.659	0.735	3
Poland	0.148	0.350	0.361	0.225	0.109	0.239	24
Portugal	0.553	0.642	0.459	0.859	0.692	0.641	4
Romania	0.477	0.592	0.509	0.709	0.461	0.550	10
Slovenia	0.261	0.599	0.625	0.621	0.371	0.495	12
Slovakia	0.232	0.496	0.526	0.523	0.307	0.417	16
Finland	0.399	0.539	0.567	0.455	0.386	0.469	13
Sweden	0.992	1.000	1.000	1.000	1.000	0.998	1

Table 11. Unified values of final Assessment Score (As_{final} for the studied EU-27 countries in 2015 and their final ranking position.

Country	CODAS Assessment Score H_i	EDAS Assessment Score As_i	TOPSIS Assessment Score P_i	VIKOR Assessment Score Q_i	WASPAS Assessment Score Q_i	As_{final}	Rank
	MCDM Method						
Belgium	0.000	0.251	0.359	0.261	0.092	0.193	23
Bulgaria	0.217	0.163	0.000	0.265	0.076	0.144	26
Czechia	0.044	0.335	0.323	0.328	0.013	0.209	22
Denmark	0.530	0.743	0.686	0.828	0.588	0.675	2
Germany	0.110	0.435	0.444	0.378	0.164	0.306	18
Estonia	0.452	0.363	0.328	0.309	0.126	0.316	16
Ireland	0.236	0.321	0.368	0.307	0.185	0.283	19
Greece	0.211	0.274	0.194	0.468	0.197	0.269	21
Spain	0.202	0.443	0.403	0.530	0.282	0.372	12
France	0.179	0.528	0.526	0.564	0.345	0.428	8
Croatia	0.337	0.583	0.431	0.663	0.357	0.474	6
Italy	0.223	0.496	0.420	0.576	0.340	0.411	9
Cyprus	0.047	0.102	0.144	0.121	0.029	0.089	27
Latvia	0.373	0.598	0.401	0.570	0.349	0.458	7
Lithuania	0.488	0.402	0.246	0.517	0.345	0.400	10
Luxembourg	0.471	0.000	0.316	0.000	0.113	0.180	24
Hungary	0.134	0.426	0.386	0.430	0.172	0.310	17
Malta	0.358	0.310	0.344	0.336	0.336	0.337	15
Netherlands	0.092	0.330	0.406	0.415	0.151	0.279	20
Austria	0.420	0.643	0.555	0.560	0.408	0.517	5
Poland	0.079	0.292	0.288	0.215	0.000	0.175	25
Portugal	0.402	0.472	0.161	0.601	0.307	0.389	11
Romania	0.568	0.661	0.518	0.750	0.555	0.610	3
Slovenia	0.143	0.467	0.395	0.489	0.202	0.339	14
Slovakia	0.172	0.489	0.449	0.521	0.202	0.367	13
Finland	0.552	0.692	0.589	0.631	0.445	0.582	4
Sweden	1.000	1.000	1.000	1.000	1.000	1.000	1

Table 12. Unified values of final Assessment Score (As_{final} for the studied EU-27 countries in 2020 and their final ranking position.

Country	MCDM Method					As_{final}	Rank
	CODAS Assessment Score H_i	EDAS Assessment Score As_i	TOPSIS Assessment Score P_i	VIKOR Assessment Score Q_i	WASPAS Assessment Score Q_i		
Belgium	0.000	0.277	0.377	0.240	0.092	0.197	22
Bulgaria	0.137	0.100	0.000	0.194	0.076	0.101	26
Czechia	0.141	0.249	0.300	0.200	0.013	0.181	23
Denmark	0.447	0.738	0.727	0.706	0.588	0.641	2
Germany	0.061	0.425	0.438	0.356	0.164	0.289	18
Estonia	0.440	0.491	0.396	0.438	0.126	0.378	11
Ireland	0.277	0.383	0.485	0.300	0.185	0.326	15
Greece	0.231	0.344	0.223	0.436	0.197	0.286	19
Spain	0.174	0.484	0.423	0.496	0.282	0.372	13
France	0.124	0.520	0.523	0.522	0.345	0.407	9
Croatia	0.208	0.548	0.423	0.500	0.357	0.407	8
Italy	0.149	0.522	0.477	0.508	0.340	0.399	10
Cyprus	0.038	0.058	0.062	0.076	0.029	0.053	27
Latvia	0.256	0.564	0.412	0.488	0.349	0.414	7
Lithuania	0.195	0.264	0.196	0.294	0.345	0.259	20
Luxembourg	0.066	0.000	0.335	0.000	0.113	0.103	24
Hungary	0.029	0.357	0.385	0.288	0.172	0.246	21
Malta	0.376	0.363	0.381	0.336	0.336	0.358	14
Netherlands	0.213	0.389	0.442	0.404	0.151	0.320	16
Austria	0.533	0.552	0.492	0.460	0.408	0.489	3
Poland	0.033	0.174	0.265	0.040	0.000	0.102	25
Portugal	0.319	0.538	0.327	0.608	0.307	0.420	6
Romania	0.300	0.499	0.408	0.478	0.555	0.448	5
Slovenia	0.163	0.548	0.496	0.472	0.202	0.376	12
Slovakia	0.046	0.419	0.427	0.360	0.202	0.291	17
Finland	0.463	0.515	0.527	0.492	0.445	0.488	4
Sweden	1.000	1.000	1.000	1.000	1.000	1.000	1

The designated standardized (unified) ranking of the EU-27 countries in terms of energy–climate sustainability shows that Sweden was the leader throughout the period under review, and Austria was the runner-up. Austria and Finland also achieved good results. By contrast, the last places in the list were occupied by Bulgaria and Cyprus. The results also prove that when it comes to meeting energy and climate goals, there is no decisive division between the countries of the so-called "old EU-14", i.e., those that have mostly performed better in the energy and climate transition, and the poorer performing countries of the so-called "new EU-13".

In order to determine similarities between the results of the rankings obtained from the different methods with the normalized ranking, correlation coefficients were determined for their respective pairs, the results of which are shown in Table 13.

The determined values of the correlation coefficients indicate that the normalized ranking shows the best fit of the results with the EDAS and WASPAS methods, and the worst fit with the CODAS method. However, analysis of these results shows that the normalized ranking method has a strong correlation with all the MCDM methods used (Table 12), which was not the case with the correlation between the individual MCDM methods (Tables 7–9).

Table 13. Validation through correlation coefficients among MCDM approaches and normalized approach to determine ranking positions.

	CODAS	EDAS	TOPSIS	VIKOR	WASPAS
CODAS	**0.714**	**0.687**	**0.791**	**0.731**	**0.714**
EDAS	**0.933**	**0.888**	**0.938**	**0.920**	**0.933**
TOPSIS	**0.802**	**0.811**	**0.744**	**0.786**	**0.802**
VIKOR	**0.949**	**0.824**	**0.906**	**0.893**	**0.949**
WASPAS	**0.951**	**0.840**	**0.883**	**0.891**	**0.951**

Note: Statistically significant values are marked in bold.

Determination of the normalized summed Assessment Score from all methods (Table 12) also made it possible, in the next stage of the study, to assess the level of countries in terms of energy and climate sustainability during the analyzed period. These levels were determined according to the adopted class ranges:

(1) Group 1: High level

$$As_i > \overline{As_i} + s_{As_i} \tag{46}$$

(2) Group 2: Medium-high level

$$\overline{As_i} + s_{As_i} \geq As_i \geq \overline{A_{si}} \tag{47}$$

(3) Group 3: Medium-low level

$$\overline{A_{si}} > As_i \geq \overline{\overline{A_{sii}}} - s_{As_i} \tag{48}$$

(4) Group 4: Low level

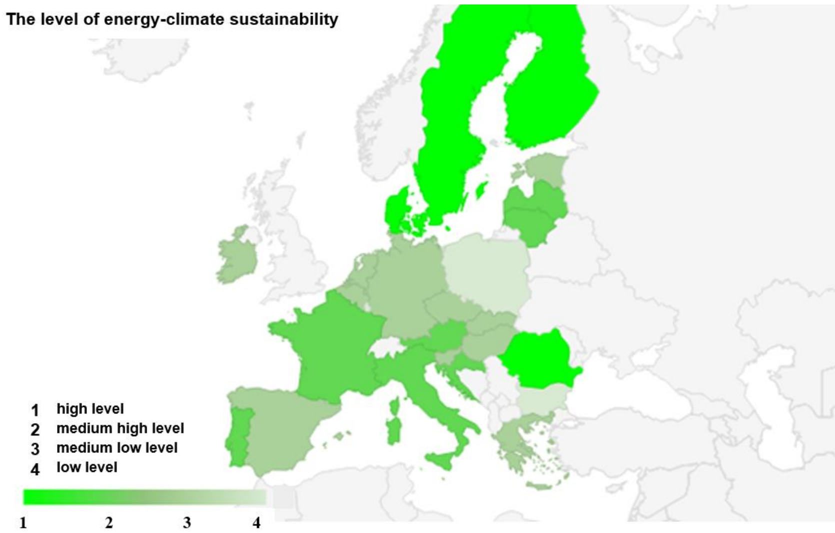
$$As_i < \overline{A_{si}} - s_{As_i} \tag{49}$$

where As_i is the final Assessment Score for the i-th alternative, $\overline{As_i}$ is the average value of final Assessment Score for all alternatives, and s_{As_i} is the standard deviation from the $\overline{As_i}$.

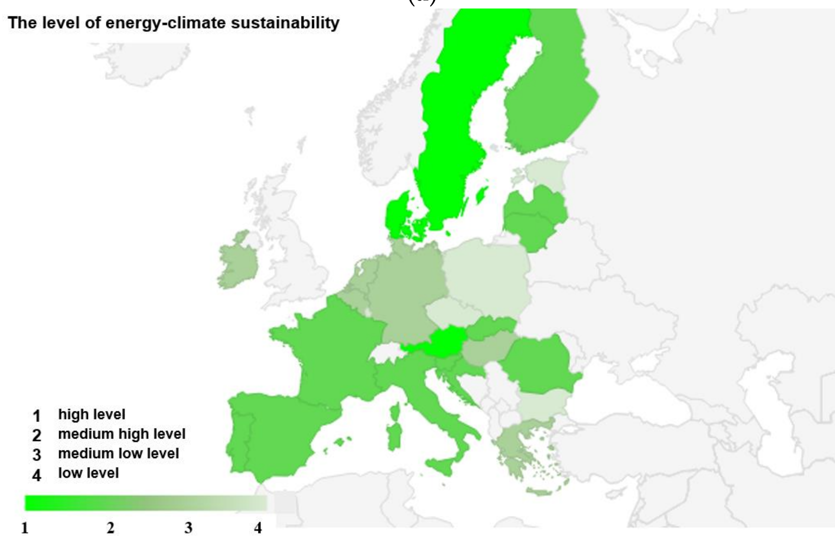
The results of dividing the EU-27 countries into groups according to the level of energy–climate sustainability between 2010 and 2020 are shown in Figure 3.

As already mentioned, the value of the normalized Assessment Score became a measure of the level of energy–climate sustainability, based on which the EU-27 countries were divided into groups. Belonging to a particular group, therefore, reflects the changes that occurred in each country over the years studied (2010–2020).

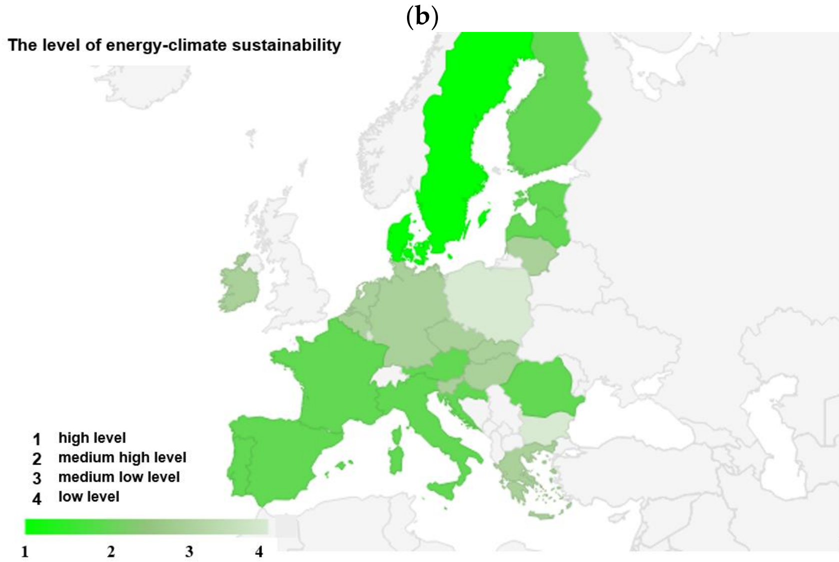
In 2020, the number of countries with a high Assessment Score of energy and climate sustainability was one less than in 2010. Austria dropped out of the group (into the medium-high group), with achievements lower than in the base year, and Sweden and Denmark remained in it, and at the same time also maintained their position in the ranking of countries during the analyzed period (Tables 9 and 11). In 2020, the number of countries with a medium-high level of sustainable development, compared to 2010, did not change and amounted to 11, but the composition of this group changed significantly. In 2010, the group included Portugal, Romania, Slovenia, Slovakia, Finland, Latvia, Lithuania, Spain, France, Croatia, and Italy, and in 2020, Estonia, Spain, France, Croatia, Italy, Latvia, Malta, Austria, Portugal, Romania, and Finland. This means that the level of achievement of energy and climate goals between 2010 and 2020 was improved in Estonia (promoted from 22nd to 11th position and at the same time by two levels: from low to medium-high) and Malta (promoted in 2020 from group 3) and worsened in Austria (down in 2020 from group 1) and Slovenia, Slovakia, and Lithuania (down to group 3 in 2020).



(**a**)



(**b**)



(**c**)

Figure 3. Division of EU member states into groups according to the level of energy–climate sustainability ((**a**) 2010, (**b**) 2015, (**c**) 2020).

In the group of countries with a medium-low level of this development, in 2010 there were seven countries (Belgium, Germany, Ireland, Greece, Hungary, Malta, The Netherlands), and in 2020, nine. This group in 2020 was joined by Slovenia, Slovakia, Lithuania (down from group 2 with a high medium level), and the Czech Republic (up from group 4 with a low level). Malta, on the other hand, left group 3 and was promoted to group 2.

Significant changes, from the point of view of energy–climate sustainability, were reported within group 4, which includes countries with low levels of development. In 2010, six countries belonged to this group, and in 2020, four. Invariably, Bulgaria, Poland, Cyprus, and Luxembourg remained in this weakest group. On the other hand, the Czech Republic (in 2020, medium-low level) and Estonia (in 2020, medium-high level) improved their position.

Thus, it can be concluded that countries that fell into the group of lower levels of energy–climate sustainability, or countries that maintained a low or medium-low level, do not show significant progress in achieving the objectives of this policy.

It should also be noted that during the period under review, some countries, such as Latvia and Lithuania, for example, which fell from the medium-high to medium-low level group, recorded unfavorable changes in indicator values and increased, for example, primary and final energy consumption per capita, final energy consumption in households per capita, and greenhouse gas emissions per capita. These are indicators that are prioritized in the EU, in terms of increasing energy efficiency and climate protection at the same time. A change in their value in a positive direction means no progress in increasing energy efficiency.

During the period under review, virtually all countries recorded an increase in the level of achievement of the energy–climate target related to the development of renewable energy, with considerable differences between countries in this case as well. In general, an increase in the use of RES is noticeable, with the exception of Poland and Austria, where there was a decrease, although small, in the use of renewable energy in transport. From the point of view of the Europe 2020 Strategy and Agenda 2030 (UN), these are negative and undesirable phenomena.

In conclusion, however, during the period under review, almost all EU countries showed progress in the pursuit of energy and climate sustainability, which is a positive finding.

5. Discussion

The results obtained in the study provide ample opportunities for discussion and interpretation. This is facilitated, first of all, by the timeliness and validity of the subject matter undertaken in the work. The recent events related to the SARS-CoV-2 pandemic and the armed conflict in Ukraine further confirm the importance of the development of such a strategically located region in the world as the EU. The multifaceted nature of this problem results, as also shown by the findings, in a wide range of possibilities for their interpretation and reference to the results of other researchers and the state of the economy of EU countries. In the discussion presented here, due to the extensiveness of such analyses, only the most relevant issues related to this are referred to.

The Europe 2020 Strategy [26] launched by the European Commission in 2010 and the UN's Agenda 2030 Goals [18,19], followed by the European Green Deal [17] strategy, are currently the most important pieces of legislation governing sustainable development in the EU. Their common goal is primarily to promote sustainable and smart development to unite this community and build a green knowledge society.

The assumptions of energy and climate policy included in these documents aimed at sustainable development, in the context of the COVID-19 pandemic and the armed conflict in Ukraine, take on a whole new meaning. Independence and, consequently, energy security become the absolute priorities of this policy. It is evident that sustainable development offers opportunities to achieve these goals while limiting negative environmental impacts.

Also related to this is energy poverty, which is becoming a growing social problem, which was already revealed in the second half of 2021, as a result of the coronavirus pandemic, when energy prices began to rise markedly at that time [64]. This process was exacerbated by the armed conflict in Ukraine.

Both of these events, however, show how crucial the development of RES and the building of energy independence are for the existence and economic development of countries, especially in the EU. Despite many voices to the contrary, related to the disruption of the energy market, it is also fully justified to continue the policy of decarbonization of the European economy. Of course, this process may be temporarily slowed down, but the trend must be maintained. Strengthening the assumptions of the Green Deal and sustainable economy should ensure energy security and environmental neutrality in the near future.

With regard to the importance of the topic of energy and climate sustainability, a study was carried out with the aim of assessing the level of this development between 2010 and 2020 in the EU member states. For this purpose, an innovative methodology for assessing energy–climate sustainability based on MCDM methods was developed, and then this assessment was made for individual EU countries. The basis of the conducted research was a set of 17 selected indicators, which, according to the authors, effectively characterize the energy–climate sustainability of the EU. The values of many indicators, such as final energy consumption, primary energy consumption, final energy consumption in households, or greenhouse gas emissions, were also related to the per capita amount, which makes it possible to show their values, considering the demographic factor of these countries.

The methodology developed and applied, as well as the results obtained, on the one hand make it possible to assess the actions taken by individual countries, and on the other hand indicate the directions of possible actions to be taken to improve this development. They should also be used to develop strategies regarding further effective and sustainable energy and climate development.

The results indicate that the countries that perform best in the context of energy and climate sustainability throughout the period from 2010 to 2020 are Sweden and Denmark. These countries are the clear leaders of the analysis carried out. Slightly worse performers are Finland, Austria, Estonia, Spain, France, Croatia, Italy, Latvia, Malta, Portugal, and Romania. On the other hand, the lowest results were achieved by Cyprus, Luxembourg, Poland, and Bulgaria.

An analysis of the energy and climate situation of the Scandinavian countries and Austria shows that they are countries with extensive experience in the energy transition towards green energy sources, initiated as early as the 1970s [65,66]. In addition to a significant share of renewable energy in their overall consumption, this transformation also translates into low greenhouse gas emissions. This is particularly evident in Sweden and Finland, which, despite their significant primary and final energy consumption per capita, have some of the lowest greenhouse gas emissions per capita [67].

An analysis of the situation of countries in southern Europe, such as Greece, Croatia, Portugal, Italy, and Romania, and in the east, such as Estonia and Latvia, shows that they are characterized by significant RES development potential, which at the same time should translate into increased GHG reduction efficiency.

As indicated by the results of studies included in the works, the development of RES in the EU countries can contribute not only to the reduction in greenhouse gas emissions into the atmosphere [68–71], but also improve energy security and increase energy independence, especially with regard to fossil fuel imports [72].

Poland and Bulgaria, two countries of the so-called new EU and post-Communist countries, heavily dependent on fossil fuels with not very modern energy systems, face the greatest difficulties in terms of sustainable development. A major obstacle for these countries in the process of energy transition and energy efficiency improvement are issues related to their low wealth and social problems associated with the transition process. In the case of Bulgaria, however, high potential is noticeable regarding the development of RES, which would have a positive impact on the country's energy independence [73].

Unfortunately, a big problem remains in this case, a high degree of energy poverty [74–76], which, in the case of sustainable development, fits into the seventh and first goals of Agenda 2030 [18,19]. Energy poverty, or the inability to provide households with adequate access to energy services, is a problem that has a significant impact on the quality of life and even the health of individuals or households, which is why it is so important to reduce and eliminate it [77].

This problem translates into many aspects of social life, which often makes it difficult to accept the energy transition process [78]. Without reducing or eliminating this problem, societies will have limited interest in caring about the state of the climate. This is because ensuring that energy needs are met becomes their priority, rather than protecting the climate and the environment. As studies [79] show, climate and environmental policy must go hand in hand with reducing inequality and energy poverty. The most affected by energy poverty in the EU are Eastern European countries, including Bulgaria, as well as some southern EU member states, while countries such as Sweden, Luxembourg, and Austria are least affected by this problem.

When discussing the results, the most prosperous country in the EU-27, which is characterized by a medium-low level of energy and climate sustainability, Luxembourg, should not be overlooked. Although the country has excellent economic conditions (highest GDP per capita), it has the highest primary and final energy consumption per capita, is heavily dependent on imported conventional energy sources, and has the lowest share of renewable energy in total energy consumption. In addition, in the climate dimension, Luxembourg emits the highest amounts of greenhouse gases per capita.

Thus, it can be seen that the EU countries, despite many years of having a common energy and climate policy, are characterized by wide variations in the effectiveness of the implementation of this policy. Thus, the results provide an opportunity to assess the actions taken to date and the effects they have achieved, and should be used to indicate the direction of further work to meet the EU's ambitious plans.

6. Conclusions

The paper presents the results of a study aimed at assessing the level of energy and climate sustainability of EU-27 countries. The assessment covered the period 2010–2020 and was based on 17 selected indicators characterizing the assessment area.

A research methodology based on the MCDM methods approach was developed for the assessment. The methodology included sustainability assessments of individual EU-27 countries made with the help of five well-known and widely used methods to support decision-making processes in multi-criteria issues. This approach also determined further activities, which included the normalization (standardization) of the Assessment Score value obtained for each of the methods used. The normalized Assessment Score values formed the basis for assessing the level of sustainable development of the EU-27 countries and their designated ranking for the years under study (2010, 2015, and 2020). In this case, the normalized and averaged Assessment Score also formed the basis for class (group) division of these countries.

Based on the methodology developed, the research conducted, and the results, the following conclusions can be made:

➢ EU-27 member states between 2010 and 2020 have, for the most part, significantly improved indicators relating to the achievement of energy and climate goals. Of particular note is the improvement in energy efficiency as measured by primary and final energy consumption per capita. Average primary energy consumption in the EU-27 fell by 15%, and final consumption by 10%. By contrast, renewable energy consumption increased to the greatest extent, by 211% overall for the entire community. A particular increase in the use of renewable energy occurred in the transport sector, where, for the EU-27 as a whole, it was 410%. The result of these changes is a 19% reduction in greenhouse gas emissions in 2020 compared to 2010.

- ➢ The EU-27 countries are marked with significant variations in energy and climate sustainability, which, however, did not change significantly during the period under consideration (i.e., 2010, 2015, and 2020). In addition, the compositions of groups with similar levels of sustainability in 2010 and 2020 changed slightly.
- ➢ The highest position in the ranking of EU-27 countries in terms of energy and climate sustainability in the three periods analyzed, i.e., 2010, 2015, and 2020, was achieved by Sweden. Cyprus, on the other hand, was in last place.
- ➢ High levels of energy and climate sustainability throughout the period under review were found in two Scandinavian countries, Sweden and Denmark. These countries should be considered undisputed leaders in the process of implementing a sustainable economy in the EU-27.
- ➢ Low levels of energy and climate sustainability throughout the analyzed period were observed in Cyprus, Luxembourg, Bulgaria, and Poland.
- ➢ It is noticeable that the level of sustainability varies between groups of countries of the so-called "new EU-14" and "old EU-13".

The research and its findings confirm that the problem of assessing the level of sustainability in the energy and climate field using a methodology based on MCDM methods is a complex issue, which consists of the issues of selecting appropriate indicators (consistent with the purpose of the research) and the selection of analytical methods. The example presented shows that the use of MCDM methods provides opportunities to study complex multi-criteria problems, and the results obtained can support the process of managing the phenomena under study (such as EU energy policy).

The research results presented in the paper complement the existing state of knowledge on energy and climate sustainability of the EU-27 countries, in terms of EU and UN policies in these areas. They also exemplify a new approach to analyzing and assessing the sustainable development of a group of countries that make up the community. The versatility of the methodology also provides ample opportunities for its application to the study of other multi-criteria issues related to similar topics. The results obtained by expanding knowledge in the area studied should effectively support decision-making processes.

Based on the results obtained and presented in the paper, it is also possible to identify directions for future research that directly relate to the presented matter. In the current geopolitical situation and the ongoing energy crisis, it is reasonable to examine whether and how the achievement of energy and climate sustainability goals is related to and/or affects the energy security of EU member states. It also seems reasonable to examine whether the pandemic caused by the SARS-CoV-2 coronavirus and the geopolitical turmoil in Europe affect the achievement of energy and climate goals, and how these events will affect Europe's energy security.

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