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IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT GOAL 7 IN EUROPEAN UNION COUNTRIES – A MULTIDIMENSIONAL COMPARATIVE ANALYSIS

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ABSTRACT: The essence of Sustainable Development Goal 7 is to: "Ensure access to affordable, reliable, sustainable, and modern energy for all." Its implementation, given the current geopolitical situation in the world, presents a significant challenge for many countries, including members of the European Union. The aim of this article is to conduct a multidimensional comparative analysis of European Union countries in terms of their progress towards achieving Sustainable Development Goal 7. The research is based on statistical data sourced from the Eurostat database for 2013, 2018 and 2022. The research methods used include Hellwig's Synthetic Measure of Development, the TOPSIS method, and the Simple Additive Weighting (SAW) method. The results of the study confirm that in the years studied, European Union countries varied in their achievement of Sustainable Development Goal 7. The best situation was in Denmark, Sweden, Ireland and Romania. The worst situation was in Malta, Germany, Bulgaria and Belgium.

KEYWORDS: SDG 7, Hellwig method, TOPSIS method, Simple Additive Weighting (SAW) method

Introduction

The concept of sustainable development, although known for many years, remains relevant today. The latest goals for sustainable development are outlined in the 2030 Agenda, which was adopted by 193 countries at the UN level in New York from September 25-27, 2015. The 2030 Agenda for Sustainable Development (Transforming Our World: the 2030 Agenda for Sustainable Development) is an action plan that defines a model for sustainable development on a global scale.

The Agenda contains 17 Sustainable Development Goals (SDGs), divided into 169 tasks and 304 indicators, aimed at ensuring that by 2030, people live better, healthier, and safer lives in social, environmental, and economic aspects. Many authors emphasise that all SDGs are equally important, should be integrated, and must be achieved together (Chen et al., 2018; Kostetckaia & Hametner, 2022; Kudelko, 2025).

Since 2016, the Sustainable Development Goals have replaced the previous 8 Millennium Development Goals (MDGs), which contributed to lifting over 1 billion people out of extreme poverty, eliminating gender inequality in access to education, and providing 91% of the world's population with access to drinking water. The current SDGs have a more universal scope and focus more on developed countries, whereas the MDGs primarily addressed the poorest parts of the globe (Pondel, 2021).

The 2030 Agenda (Article 21) recognises the responsibility of each country to implement it at the global, national, and regional levels, taking into account realities, capabilities, and levels of development, while respecting national policies and development priorities (Błasiak-Nowak & Rajczewska, 2018).

Achieving these goals faces significant challenges, such as rapid climate change and the uncertain international situation caused by, for example, the war in Ukraine. Russia's invasion of Ukraine has triggered a severe energy crisis, leading to rising energy prices. The current geopolitical situation makes access to energy one of the most serious challenges of the modern world. Gas supply disruptions caused by the war have forced an increase in fossil fuel production, which dominates global energy production, delaying the transition to renewable energy. Nevertheless, the development of renewable energy sources (RES) remains a key direction for energy development in many countries around the world (Dmytrów et al., 2022), and the technologies already exist (e.g., 17% of electricity comes from hydroelectric power plants) (Kuriqi et al., 2021).

According to the report. "Tracking SDG 7" (The World Bank, 2024) the world is making progress in achieving the Sustainable Development Goals (including Goal 7, which encompasses "Ensure access to affordable, reliable, sustainable, and modern energy for all"), but reaching these goals by 2030 will be quite challenging. The report's authors highlight that in 2021, 675 million people worldwide still lacked access to electricity, and 2.3 billion people used environmentally harmful fuels to meet their basic needs, including cooking. The report also states that rising energy prices are worsening the prospects of achieving universal access to clean and affordable electricity. Projections suggest that by 2030, 1.9 billion people worldwide will still lack access to clean cooking fuels, and 660 million (primarily in Sub-Saharan Africa) will remain without access to electricity.

Given these challenges, humanity is now compelled to seek new, unconventional energy sources (Latkowska et al., 2011). The continuous increase in global energy demand and the prospect of depleting fossil fuel reserves have significantly heightened interest in renewable energy sources and methods for utilising them. The search for and subsequent use of ecological energy sources align with the global trend of discovering and diversifying new energy sources. This is also an important direction for the European Union.

To ensure the sustainable and secure development of each country, a successful energy transition must be based on effective policies and technological innovations combined with the large-scale mobilisation of investment capital. The international community must utilise all these tools to achieve the desired outcome (Lup et al., 2023). An important aspect of many contemporary studies is demonstrating the level of implementation of the Sustainable Development Goals (SDGs) in individual countries (Fura, 2015).

The aim of this article is to assess the implementation of Sustainable Development Goal 7 by the European Union countries in selected years, namely 2013, 2018, and 2022. This goal was pursued by determining the value of a synthetic measure using seven variables through three selected linear ordering methods: the Z. Hellwig's Synthetic Measure of Development, the TOPSIS method, and the Simple Additive Weighting (SAW) method.

The added value of this article lies in the construction of rankings for European countries based on their level of implementation of Sustainable Development Goal 7 and in comparing the results obtained through different methods. The article poses the following research questions:

- Do EU countries have a similar level of achievement of Sustainable Development Goal 7 in the years studied?
- Which countries are the leaders, and which occupy the lowest positions in the rankings produced by the three research methods?
- What is the consistency of the rankings over time and across the different methods used?
- Do the rankings of EU countries in terms of achieving Sustainable Development Goal 7 tend to show greater differentiation as the time intervals between assessments increase?

The significance of the research problem and the achievement of the article's objective required a comprehensive analysis of the literature on the subject, including strategic documents, as well as the application of descriptive statistics and multidimensional comparative analysis.

As Chirambo (2018) notes, it is very important to constantly monitor SDG 7, emphasising that better access to energy can potentially alleviate poverty, promote industrialisation, facilitate gender equality, and reduce regions' vulnerability to climate change. Detailed knowledge about the implementation of each specific sustainable development goal should be a strategic priority (Firoiu et al., 2021).

This article fills a research gap concerning the implementation of SDG 7 across all 27 European Union countries within a specified time frame. The literature includes new studies on this topic, but they often focus on individual countries (Vela-Cobos et al., 2021) or selected regions of the world (Lup et al., 2023; Müller et al., 2021). All these authors emphasise the importance of identifying and implementing best practice models, thereby accelerating the achievement of previously established goals.

The research objectives led to the division of the article into several sections. It begins with an introduction that justifies the choice of the research topic, followed by a literature review, a presentation of the research methods used, and the results of empirical research. The final section presents a discussion of the results and the concluding remarks.

An overview of the literature

The principles of sustainable development have been recognised as fundamental in the development process of all European Union member states (Grzebyk & Stec, 2015; Kiselakova et al., 2020), despite their varying levels of socio-economic development. Sustainable development appears to be an attractive alternative to traditional development concepts because it considers the social, economic, and environmental aspects of activities, addresses the needs of both present and future generations, integrates the actions of various entities, and ensures equal opportunities to meet the needs of different communities (Pondel, 2021). The need to implement the principles of sustainable and durable development arises, among other things, from factors such as the limited and depleting natural resources and the growing economic and social losses caused by environmental pollution (Górka, 2007).

To achieve the Sustainable Development Goals (SDGs), countries must address environmental and energy challenges (Chirambo, 2018; Pandey & Asif, 2022). As noted by the authors (Carvalho & Santos, 2024; Gebara & Laurent, 2023), the energy sector plays a key role in achieving SDGs such as affordable and clean energy (SDG 7), SDG 13 ("tackling climate change"), and SDG 3 ("good health and well-being"). In a world marked by increasing concerns about environmental degradation, climate change, and socio-economic inequalities, understanding the multifaceted contribution of the energy sector to sustainable development has become essential. With the global population growing, the demand for energy is rising sharply.

Energy is fundamental in eliminating poverty and hunger, facilitating access to basic services such as healthcare, education, and water, as well as sustaining economic growth and environmental protection (Santika et al., 2019). In modern times, energy plays a decisive role in increasing industrial

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production, fostering innovation and job creation, and developing society (Niedziółka, 2011; Ściążko & Kubica, 2002). Electricity generation is also a significant factor in promoting a circular economy (Santos et al., 2023).

Energy serves as a central axis for numerous development goals, providing essential input for transforming materials in economic processes to ensure the material well-being of society (Burke & Melgar, 2022). It impacts sectors ranging from health and education to economic growth and environmental sustainability (United Nations, 2021).

As many authors emphasise, achieving SDG 7 requires an increased use of alternative, including renewable, energy sources in the energy mix (Marks-Bielska et al., 2020; Dhali et al., 2023). Many middle- and high-income countries are diversifying their national energy portfolios by increasing the share of wind, solar, hydro, and geothermal energy (Ellabban et al., 2014).

The gradual increase in the share of renewable energy, as highlighted by successive United Nations reports (UN-DESA, 2018; United Nations, 2021), requires intensified efforts to achieve these goals and a deeper understanding of the causes of delays in their implementation (Estevão & Lopes, 2024).

Another key approach to achieving SDG 7 is enhancing energy efficiency, which is crucial for meeting the EU's climate goals (Bukarica & Tomšić, 2017; Bertoldi & Mosconi, 2020; Yu et al., 2022) and for reducing greenhouse gas emissions and air pollution (Kanemoto et al., 2016; Lu et al., 2020).

As suggested by authors like He et al. (2022), achieving SDG 7 can also benefit many other SDGs. Priorities should include expanding electrification in rural areas, increasing investment in decentralised energy infrastructure and clean technology, planning for the phase-out of fossil fuels, smartly deploying renewable energy, and expanding tools like cap-and-trade systems and carbon taxes.

Research methods

To evaluate the achievement of SDG 7 among EU countries in 2013, 2018 and 2022, three selected linear ordering methods were employed: Hellwig's Synthetic Measure of Development, the TOPSIS method, and the Simple Additive Weighting (SAW) method.

The application of linear ordering methods in assessing complex phenomena involves several stages:

I. Selection of Diagnostic Variables.

In this stage, the variability of the initially proposed variables and their correlations are examined. The assessment of variability typically uses the classical coefficient of variation v_j, defined by the formula (Nowak, 1990):

$$v_j = \frac{s_j}{\bar{x}_j} \quad (j=1,2,...,m), \tag{1}$$

where:
s_j – the standard deviation of the characteristic X_j,
$\bar{x}_j$ – the arithmetic mean of the characteristic X_j,

Variables that meet the following condition are removed from the set of potential diagnostic variables:

$$|v_j| \leq v*, \tag{2}$$

where:
$v*$ – the critical value of the coefficient of variation (commonly set at 0.10).

Examining the correlation among variables to eliminate those that provide redundant information. A commonly used method in this case is the reversed correlation matrix method by Malina and Zeliaś (1997, 1998), which includes the following stages:

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1. Calculating the matrix $\boldsymbol{R}$ of Pearson linear correlation coefficients between the variables:

$$\boldsymbol{R} = \begin{bmatrix} 1 & r_{12} & \cdots & r_{1m} \\ r_{21} & 1 & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & 1 \end{bmatrix}, \tag{3}$$

where:
r_{jk} – the Pearson linear correlation coefficient between the variables X_j and X_k.

2. Determining the inverse matrix of matrix $\boldsymbol{R}$

$$\boldsymbol{R^{-1}} = \left[r^{(ij)}\right], \tag{4}$$

where:
$r^{(ij)}(i, j = 1,2, ...,m)$ – elements of the inverse matrix R^{-1}.

In the case of excessive correlation of a variable with the other variables, the diagonal elements of the inverse matrix $\boldsymbol{R}^{-1}$ are significantly larger than one, which is an indicator of poor numerical conditioning of the matrix $\boldsymbol{R}$.

3. Applying the criterion for eliminating variables that meet the condition:

$$\left|r^{(jj)}\right| > r*, \tag{5}$$

where:
$r^{(ij)}$ – diagonal element of the matrix $\boldsymbol{R}^{-1}$,
r^* – the critical value for the diagonal elements of the matrix $\boldsymbol{R}^{-1}$, often set at a value of 10.

After statistical verification of the variables, the set of variables retains what are known as diagnostic variables.

II. Discussion of the assumptions of selected linear ordering methods.

Three selected linear ordering methods were used in the study: Z. Hellwig's Synthetic Measure of Development, the TOPSIS method, and the Simple Additive Weighting method. It should be noted that these methods are quite frequently used in comparative studies of objects related to complex phenomena. They involve the following procedural steps:

1. Presentation of the values of variables X_j (j = 1, 2, ..., m) for each object O_i (i = 1, 2, ..., n) in the form of an observation matrix:

$$\boldsymbol{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}, \tag{6}$$

2. Determining the nature of variables, which may be stimulants or destimulants. Stimulants are attributes where high values are considered desirable from a certain perspective, while low values are undesirable. Destimulants, on the other hand, are attributes where low values are considered desirable from the perspective of the phenomenon under study, and high values are undesirable (Hellwig, 1968).
3. Performing normalisation of the variable values using the formulas:

   For stimulants:

$$z_{ij} = \frac{x_{ij} - \min_i\{x_{ij}\}}{R_j}. \tag{7}$$

For destimulants:

$$z_{ij} = \frac{\max_i\{x_{ij}\} - x_{ij}}{R_j}. \tag{8}$$

It should be noted that in studies conducted over multiple periods, normalisation is performed in such a way that the minimum value, maximum value, and range are calculated simultaneously for all years included in the study.

4. Determining the value of the synthetic measure

Due to the complexity of the concept of sustainable development, comparing the level and assessing individual European Union countries in implementing its goals is a rather challenging task, and, due to the large number of goals and the tasks involved, it is also very labour-intensive. Such activities require defining the measurement method and developing one or more indicators for this measurement (Kiselakova et al., 2020).

As mentioned, three methods were used in the study to develop synthetic indicators based on these methods, which show the level of implementation of Sustainable Development Goal 7 in EU countries and subsequently enable their comparison in selected years.

4.1. Hellwig's (1968) Synthetic Measure of Development

After normalising the variables according to formulas 7 and 8, and determining the value of the abstract object P_0 with coordinates ($z_{01}, z_{02},...,z_{0m}$), the following steps are carried out:

$$\begin{cases} z_{0j} = \max_i z_{ij}\ , \quad \text{when } X_j \text{ is a stimulant} \\ \qquad\qquad \text{or} \\ z_{0j} = \min_i z_{ij}\ , \quad \text{when } X_j \text{ is destimulant} \end{cases} \qquad j = 1,2,\cdots,m \tag{9}$$

which is considered as the development pattern.

Next, the Euclidean distances of the selected objects from the pattern established in the above manner are calculated using the formula:

$$D_{io} = \sqrt{\sum_{j=1}^{m}\left(z_{ij} - z_{oj}\right)^2}. \tag{10}$$

This way, a sequence of distance values $D_{10}, D_{20},...,D_{n0}$ is obtained. Based on this sequence, we calculate the average.

$$\overline{D}_o = n^{-1}\sum_{i=1}^{n} D_{io}, \tag{11}$$

and

$$S_o = \sqrt{n^{-1}\sum_{i=1}^{n}(D_{io} - \bar{D}_o)^2}. \tag{12}$$

Next, we determine the value of:

$$D_0 = \overline{D}_0 + 2S_0. \tag{13}$$

In the final stage, the value of the development measure is calculated:

$$d_i = 1 - \frac{D_{io}}{D_o}, \tag{14}$$

resulting in the sequence $d_1, d_2, ..., d_n$.

The higher the value of the measure did_idi for an object, the more developed it is in terms of the implementation of the studied complex phenomenon.

4.2. The TOPSIS Method (Technique for Order Preference by Similarity to an Ideal Solution) (Hwang & Yoon, 1981) is, like the Hellwig method, one of the pattern-based methods. It involves determining the Euclidean distances from both the ideal solution and the anti-ideal solution.

After normalising the variables according to formulas 7 and 8, the coordinates of the model units – ideal solution (A^+) and anti-ideal solution (A^-) are determined as follows:

$$A^+ = (\max_i(z_{i1}), \max_i(z_{i2}), \cdots, \max_i(z_{im}) = (z_1^+, z_2^+, \cdots, z_m^+). \tag{15}$$

$$A^- = (\min_i(z_{i1}), \min_i(z_{i2}), \cdots, \min_i(z_{im}) = (z_1^-, z_2^{-+}, \cdots, z_m^-). \tag{16}$$

Next, the Euclidean distances of each object from the ideal solution z^+ and the anti-ideal solution z^- are calculated using the formulas:

$$d_i^+ = \sqrt{\sum_{j=1}^m \left(z_{ij} - z_m^+\right)^2}, \qquad d_i^- = \sqrt{\sum_{j=1}^m \left(z_{ij} - z_m^-\right)^2}. \tag{17}$$

In the final stage, the values of the synthetic measure are determined:

$$S_i = \frac{d_i^-}{d_i^+ + d_i^-}. \tag{18}$$

The measure S_i takes values in the range [0,1]. The smaller the distance of a given object from the ideal solution and, consequently, the larger its distance from the anti-ideal solution, the closer the value of the synthetic measure is to one. This means that an object (or country) is more developed in terms of the studied complex phenomenon if it has a synthetic measure value closer to one.

4.3. Simple Additive Weighting (SAW) method (Kukuła, 2000)

This method is one of the patternless methods. After normalising the variables according to formulas 7 and 8, the values of the synthetic measure are calculated using the formula:

$$MS_i = \frac{1}{m}\sum_{j=1}^m z_{ij}, \tag{19}$$

where:
MS_i – synthetic measure for the i-th object,
z_{ij} – normalized values of the variables.
m – number of variables.

Results of the research

For some time, there has been ongoing discussion in the literature about measuring sustainable development, as well as its individual goals and the selection of widely accepted synthetic indicators (Bova & Śleszyński, 2020; Jędrzejczak-Gas et al., 2021) by identifying a range of preliminary assumptions concerning the chosen variables. Variables should be relevant to the research goal, measurable, independent of each other, and non-redundant in terms of the information they convey. They should also be reliable, readily accessible, and regularly updated (Van de Kerk & Manuel, 2008).

The assessment of EU countries in terms of the implementation of Sustainable Development Goal 7 in 2013, 2018 and 2022 was based on the following variables:
X1 – Primary energy consumption [sdg_07_10],
X2 – Final energy consumption [sdg_07_11],
X3 – Final energy consumption in households per capita [sdg_07_20],
X4 – Energy productivity [sdg_07_30],
X5 – Share of renewable energy in gross final energy consumption by sector [sdg_07_40],
X6 – Energy import dependency by products [sdg_07_50],
X7 – Population unable to keep home adequately warm by poverty status [sdg_07_60].

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Variables X4 and X5 are stimulants, while the remaining variables are destimulants. The values of variables X1 to X7 were obtained from the Eurostat website (https://ec.europa.eu/eurostat/data/database).

The variables defining Sustainable Development Goal 7 in 2022 were subjected to statistical verification. Due to the level of variability, no reduction of variables was performed. The coefficients of variation ranged from 0.303 for variable X3 – Final energy consumption in households per capita, to 1.353 for variable X2 – Final energy consumption.

To assess the correlation of variables, the reversed correlation matrix method by Malina and Zeliaś (1997, 1998) was used. Only one variable, X1 – Primary energy consumption, showed excessive correlation and was removed from the initial set of variables. Therefore, the diagnostic variables remaining were X2 to X7. The same set of diagnostic variables was adopted for the years 2013 and 2018.

The diagnostic variables were used to calculate the values of synthetic measures using the three proposed methods: Z. Hellwig's Synthetic Measure of Development, the TOPSIS method, and the Simple Additive Weighting (SAW) method for selected years, namely 2013, 2018, and 2022.

According to Śleszyński (2002), computed indicators that operate with a single number should fulfil at least two functions. They should provide clear and accessible information about the progress in policy implementation and serve as a source of information for ongoing social control, thus enabling the assessment of whether contemporary socio-economic changes are indeed aligned with sustainable development guidelines.

The obtained results are presented in Table 1.

Table 1. Values of the synthetic measure for EU countries regarding the achievement of Sustainable Development Goal 7 in 2013, 2018, and 2022 according to the applied methods

Countries	Hellwig method			TOPSIS method			SAW method		
	2013	2018	2022	2013	2018	2022	2013	2018	2022
Austria	0.249	0.285	0.280	0.593	0.620	0.611	0.619	0.651	0.643
Belgium	0.051	0.082	0.153	0.453	0.473	0.523	0.435	0.464	0.529
Bulgaria	0.016	0.090	0.136	0.483	0.516	0.542	0.473	0.523	0.559
Croatia	0.225	0.237	0.241	0.589	0.600	0.598	0.608	0.620	0.617
Cyprus	0.049	0.118	0.178	0.470	0.507	0.547	0.456	0.510	0.561
Czechia	0.129	0.151	0.166	0.534	0.547	0.553	0.549	0.565	0.570
Denmark	0.360	0.436	0.507	0.680	0.711	0.719	0.763	0.812	0.849
Estonia	0.165	0.199	0.248	0.577	0.607	0.633	0.622	0.674	0.705
Finland	0.172	0.165	0.203	0.555	0.556	0.584	0.582	0.588	0.636
France	0.118	0.177	0.227	0.474	0.525	0.550	0.469	0.529	0.555
Germany	0.026	0.085	0.124	0.417	0.465	0.477	0.389	0.453	0.470
Greece	0.147	0.177	0.212	0.528	0.544	0.563	0.534	0.553	0.575
Hungary	0.132	0.130	0.149	0.510	0.521	0.532	0.512	0.528	0.542
Ireland	0.163	0.313	0.357	0.536	0.618	0.608	0.555	0.723	0.844
Italy	0.150	0.184	0.215	0.470	0.507	0.541	0.468	0.508	0.549
Latvia	0.187	0.256	0.298	0.549	0.617	0.655	0.561	0.651	0.695
Lithuania	0.098	0.112	0.194	0.480	0.486	0.549	0.475	0.482	0.558
Luxembourg	0.039	0.109	0.222	0.484	0.516	0.578	0.471	0.526	0.632
Malta	-0.022	0.048	0.085	0.463	0.511	0.525	0.435	0.518	0.541
Netherlands	0.144	0.181	0.213	0.547	0.556	0.567	0.567	0.573	0.584
Poland	0.133	0.140	0.172	0.522	0.516	0.538	0.529	0.520	0.546

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Countries	Hellwig method			TOPSIS method			SAW method		
	2013	2018	2022	2013	2018	2022	2013	2018	2022
Portugal	0.193	0.245	0.298	0.566	0.603	0.645	0.581	0.622	0.668
Romania	0.229	0.255	0.255	0.612	0.632	0.619	0.645	0.663	0.638
Slovakia	0.118	0.145	0.166	0.525	0.544	0.547	0.534	0.560	0.560
Slovenia	0.206	0.224	0.269	0.583	0.601	0.636	0.607	0.629	0.665
Spain	0.200	0.208	0.232	0.560	0.560	0.570	0.571	0.570	0.578
Sweden	0.312	0.362	0.432	0.656	0.692	0.730	0.718	0.761	0.844

In the studied years, the values of the synthetic measure indicating the level of achievement of Sustainable Development Goal 7, calculated using the Hellwig method, TOPSIS method, and SAW method, generally increased for most EU countries. This indicates positive changes occurring in EU countries regarding access to affordable, reliable, sustainable, and modern energy. By comparing the values of the synthetic measure for 2022 and 2013, countries with the greatest increases can be identified. The best results were achieved by:

- according to Z. Hellwig's method: Ireland (0.194), Luxembourg (0.183), Denmark (0.147),
- according to the TOPSIS method: Latvia (0.106), Luxembourg (0.094), Portugal (0.079),
- according to the SAW method, Ireland (0.289), Luxembourg (0.161), Latvia (0.134).

Table 2 presents the rankings of individual EU countries in terms of the achievement of Sustainable Development Goal 7 in 2013, 2018, and 2022 according to the applied methods.

Table 2. Positions of EU countries based on the values of the synthetic measure for the achievement of Sustainable Development Goal 7 in 2013, 2018, and 2022 according to the applied methods

Countries	Hellwig method			TOPSIS method			SAW method		
	2013	2018	2022	2013	2018	2022	2013	2018	2022
Austria	3	4	6	4	4	8	5	6	8
Belgium	22	26	23	26	26	26	25	26	26
Bulgaria	26	24	25	20	21	21	20	20	19
Croatia	5	8	10	5	10	10	6	10	12
Cyprus	23	21	19	24	24	20	24	23	17
Czechia	18	17	22	14	14	16	14	14	16
Denmark	1	1	1	1	1	2	1	1	1
Estonia	11	11	9	7	7	6	4	4	4
Finland	10	16	17	10	13	11	8	11	10
France	20	15	12	22	17	17	22	17	21
Germany	25	25	26	27	27	27	27	27	27
Greece	14	14	16	15	15	15	16	16	15
Hungary	17	20	24	18	18	24	18	18	24
Ireland	12	3	3	13	5	9	13	3	3
Italy	13	12	14	23	23	22	23	24	22
Latvia	9	5	4	11	6	3	12	7	5
Lithuania	21	22	18	21	25	18	19	25	20
Luxembourg	24	23	13	19	20	12	21	19	11
Malta	27	27	27	25	22	25	26	22	25

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Countries	Hellwig method			TOPSIS method			SAW method		
	2013	2018	2022	2013	2018	2022	2013	2018	2022
Netherlands	15	13	15	12	12	14	11	12	13
Poland	16	19	20	17	19	23	17	21	23
Portugal	8	7	5	8	8	4	9	9	6
Romania	4	6	8	3	3	7	3	5	9
Slovakia	19	18	21	16	16	19	15	15	18
Slovenia	6	9	7	6	9	5	7	8	7
Spain	7	10	11	9	11	13	10	13	14
Sweden	2	2	2	2	2	1	2	2	2

Analysing the data presented in Table 2, it can be observed that according to Z. Hellwig's method, the leaders in the achievement of Sustainable Development Goal 7 in 2013 were Denmark, Sweden, and Austria, while in 2018 and 2022, Denmark, Sweden, and Ireland were the leaders.

According to the TOPSIS method, in 2013 and 2018, the top-ranking countries in the EU were Denmark, Sweden, and Romania, while in 2022, Sweden, Denmark, and Latvia were the leaders.

The leaders of the EU country ranking, based on the results of the Simple Additive Weighting method in 2013, were Denmark, Sweden, and Romania, while in 2018 and 2022, Denmark, Sweden, and Ireland led the rankings.

On the other hand, the last three positions in the achievement of Sustainable Development Goal 7, according to the results of the Hellwig method, in 2013 were occupied by Malta, Bulgaria, and Germany, in 2018 by Malta, Belgium, and Germany, and in 2022 by Malta, Germany, and Bulgaria.

According to the TOPSIS method, the bottom positions were occupied in 2013 and 2022 by Germany, Belgium, and Malta, while in 2018, they were occupied by Germany, Belgium, and Lithuania.

The country ranking built using the Simple Additive Weighting method was closed in 2013 and 2022 by Germany, Malta, and Belgium, and in 2018 by Germany, Belgium, and Lithuania.

In general, there is a notable consistency in the ranking of EU countries in terms of the achievement of Sustainable Development Goal 7 in the studied years, although there are some deviations in the positions of certain countries, depending on the applied research methods.

It is worth emphasising that between 2013 and 2022, Denmark and Sweden were the leaders in the achievement of Sustainable Development Goal 7, occupying 1st and 2nd place in the EU country rankings obtained through the three methods.

It should be noted that the rankings of EU countries in terms of the achievement of Sustainable Development Goal 7 obtained using the proposed methods are similar, but not the same, in the studied years. Therefore, it is useful to assess the consistency of the obtained results using Kendall's tau correlation coefficient. However, the Spearman rank correlation coefficient was not used in the study, as it cannot be applied to assess the similarity of object rankings over time (Walesiak, 2011).

The values of the Kendall's tau correlation coefficient calculated between the ranking results obtained by different methods are presented in Table 3.

Table 3. Consistency of rankings measured using the Kendall's tau correlation coefficient across the studied years and applied methods

Method	2013			2018			2022		
	Hellwig	TOPSIS	SAW	Hellwig	TOPSIS	SAW	Hellwig	TOPSIS	SAW
Hellwig	1.000	0.789	0.761	1.000	0.801	0.749	1.000	0.766	0.744
TOPSIS	0.789	1.000	0.937	0.801	1.000	0.926	0.766	1.000	0.875
SAW	0.761	0.937	1.000	0.749	0.926	1.000	0.744	0.875	1.000

The obtained values of the Kendall's tau correlation coefficient confirm a high degree of consistency in the rankings of EU countries regarding the achievement of Sustainable Development Goal 7.

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The values ranged from 0.744 to as high as 0.937. The highest consistency of results in 2013, 2018, and 2022 was achieved using the TOPSIS and SAW methods (Kendall's tau correlation coefficient was 0.937, 0.926, and 0.875, respectively). In the case of the Hellwig method and SAW, the consistency was at the level of 0.761, 0.749, and 0.744. Meanwhile, between the Hellwig and TOPSIS methods, the consistency was at 0.789, 0.801, and 0.766.

It is also interesting to check whether the rankings of EU countries in terms of achieving Sustainable Development Goal 7 tend to show greater differentiation as the time interval between them increases.

Table 4. Consistency of EU country rankings in selected years and according to the methods applied

Years	Hellwig method	TOPSIS method	SAW method
2013-2018	0.789	0.823	0.778
2018-2022	0.801	0.744	0.795
2013-2022	0.647	0.715	0.664

Analysing the data presented in Table 4, it can be observed that the comparison of 5-year periods (2013-2018 and 2018-2022) yields higher consistency in the rankings than the 10-year period (2013-2022). Over a longer time period, greater changes in the positions of EU countries in terms of achieving Sustainable Development Goal 7 can be observed.

Discussions and Conclusions

Goal 7 is one of the 17 Sustainable Development Goals, and as noted by the authors (Jędrzejczak-Gas et al., 2021), its achievement by 2030 will be possible through the development of renewable energy sources. In the context of the war in Ukraine and other macroeconomic changes, these sources offer an alternative not only to coal but also to gas and oil. This will promote global energy security and support sustainable development.

The importance of renewable energy for global sustainable development, including Goal 7, has been highlighted by Trinh and Chung (2023). They argue that renewable energy is key to sustainable green energy for daily human life and the natural environment, with non-pollutant gas emissions to mitigate climate change. They discussed current results and techniques in converting renewable energy into electrical energy for sustainable electricity production, integration, industrial application, and green energy globalisation.

Further review of the literature reveals that researchers also address other issues related to the implementation of Sustainable Development Goal 7. Some researchers (Gebara & Laurent, 2023) focus on factors that enable the assessment of national SDG-7 performance using 29 indicators, which encompass environmental, social, and techno-economic aspects particularly relevant to the sustainable development of the energy sector. Their study covers 176 countries, comparing results to evaluate how current energy systems are far from achieving truly sustainable levels. This holistic approach allows policymakers at the national level to identify issues, set priorities, and direct actions to achieve SDG-7.

The article presented the level of implementation of Sustainable Development Goal 7 in EU countries in selected years, 2013, 2018, and 2022. Considering this criterion, it aimed to highlight some research findings.

The article (Firoiu et al., 2021) analyses the dynamics of implementing the specific targets of SDG 7 in EU member states from 2015 to 2019, five years after the adoption of the Paris Agreement. The European Union, with the adoption of the European Green Deal, has set itself an extraordinarily ambitious goal of achieving climate neutrality by 2050. This goal entails a massive investment plan aimed at reducing disparities among EU member states and supporting their transformative efforts to turn the Union into a modern, resource-efficient, and competitive economy. The authors focused on developing clusters (from A to D), dividing countries into groups based on their levels of SDG 7 achievement from 2015 to 2019. In 2015, the best-performing countries were grouped in Cluster C, including Denmark, Finland, Romania, and Sweden, while the worst-performing countries were grouped in Cluster D - Cyprus, Ireland, Lithuania, Luxembourg, and Malta. By 2019, there were only slight changes, with countries in Cluster C remaining the most committed to achieving SDG 7.

Countries with more modest results were grouped in Cluster D. The results highlighted a group of high-performance countries as well as countries that require increased attention and support to facilitate the transition to a greener economy. It is noticeable that the group of top-performing countries is growing, which indicates genuine concern and commitment to achieving SDG 7.

Another study by Dmytrów et al. (2022) aimed to compare selected European countries in terms of the degree of implementation of SDG 7 using the COPRAS method and to compare the relative dynamics of SDG 7 achievement from 2005 to 2020. The top-performing countries were Norway, Denmark, Estonia, Croatia, Latvia, Sweden, and the United Kingdom, while Belgium, Bulgaria, Cyprus, Lithuania, and Finland were the lowest performers. Romania improved its position the most, while Greece and Iceland performed the worst.

Both articles conclude that the achievements of the most advanced countries should serve as an incentive for those at a lower level of development, and changes in the rankings of these countries should reflect their path toward sustainable development.

Summary of Findings

The results of the research indicate that the level of implementation of SDG 7 was not uniform. Evidence shows a higher level of achievement in the northern EU member states and a lower level in the southern countries of Europe. The results are consistent with those achieved by other authors, despite the use of different research methods.

Referring to the research questions posed in the article, it can be concluded that:

- EU countries have a varied level of achievement of Sustainable Development Goal 7 in the studied years.
- According to Z. Hellwig's method, the leaders in the achievement of Sustainable Development Goal 7 in 2013 were Denmark, Sweden, and Austria, while in 2018 and 2022, Denmark, Sweden, and Ireland were the leaders. According to the TOPSIS method, the top-ranking countries in 2013 and 2018 were Denmark, Sweden, and Romania, and in 2022, Sweden, Denmark, and Latvia. The leaders in the EU country ranking according to the Simple Additive Weighting (SAW) method in 2013 were Denmark, Sweden, and Romania, and in 2018 and 2022, Denmark, Sweden, and Ireland. The last three positions in the achievement of Sustainable Development Goal 7, according to the results of the applied methods, were mostly occupied by Malta, Bulgaria, and Germany or Lithuania.
- The obtained values of the Kendall's tau correlation coefficient confirm a high degree of consistency in the rankings of EU countries regarding the achievement of Sustainable Development Goal 7, obtained using the Hellwig, TOPSIS, and SAW methods. The values ranged from 0.744 to as high as 0.937. The highest consistency of results in 2013, 2018, and 2022 was achieved using the TOPSIS and SAW methods.
- It was confirmed that the rankings of EU countries in terms of achieving Sustainable Development Goal 7 tend to show greater differentiation as the time interval between them increases.

The results obtained can serve as a starting point or foundation for further analyses using other statistical methods, including different partial indicators. Such analyses can be conducted at the level of individual countries or the European Union as a whole. It is important to note that the studies are not without limitations, which may affect the results and conclusions drawn. These limitations mainly involve issues related to access to necessary data, the choice of research methods, and the variables used in the studies.

Research, including that presented in this article, allows for tracking and evaluating the degree of achievement of SDG 7, assessing the effectiveness of implemented public policies or development strategies adopted by the analysed countries, and providing scientists and policymakers with the knowledge needed to shape a better and more responsible future. The importance of identifying best practice patterns and replicating them on a regional, national, or international scale is also emphasised, as this facilitates the dissemination of knowledge that will accelerate the achievement of established goals, including SDG 7.

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The contribution of the authors

Conceptualisation, M.G. and M.S.; literature review, M.G.; methodology, M.S.; writing, M.G., M.S. and W.C.; discussion and conclusions, writing, M.G., M.S. and W.C.

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Mariola GRZEBYK • Małgorzata STEC • Wiesława CAPUTA

REALIZACJA 7 CELU ZRÓWNOWAŻONEGO ROZWOJU W KRAJACH UNII EUROPEJSKIEJ – WIELOWYMIAROWA ANALIZA PORÓWNAWCZA

STRESZCZENIE: Istotą 7 celu zrównoważonego rozwoju jest zapewnienie wszystkim dostępu do źródeł stabilnej, zrównoważonej i nowoczesnej energii po przystępnej cenie. Jego realizacja w obecnej sytuacji geopolitycznej świata stanowi bardzo poważne wyzwanie dla wielu krajów, w tym członków Unii Europejskiej.
Celem artykułu była wielowymiarowa analiza porównawcza krajów Unii Europejskiej pod względem realizacji celu 7 zrównoważonego rozwoju. Podstawę badań stanowiły dane statystyczne zaczerpnięte z bazy Eurostatu za 2013, 2018 i 2022 rok. Zastosowanymi metodami badawczymi były: metoda wzorca rozwoju Z. Hellwiga, metoda TOPSIS oraz metoda Simple Additive Weighting (SAW). Wyniki przeprowadzonych badań potwierdzają, że w badanych latach kraje Unii Europejskiej były zróżnicowane pod względem realizacji 7 celu zrównoważonego rozwoju. Najlepszą sytuację posiadały: Dania, Szwecja, Irlandia i Rumunia. Najgorszą natomiast Malta, Niemcy, Bułgaria i Belgia. Dość duża zgodność wyników porządkowania krajów UE w zakresie realizacji celu 7 zrównoważonego rozwoju uzyskanych zaproponowanymi metodami, potwierdziła dużą ich przydatność w badaniach zjawisk złożonych.

SŁOWA KLUCZOWE: cel 7 zrównoważonego rozwoju, metoda Hellwiga, metoda TOPSIS, metoda Simple Additive Weighting (SAW)