Using SSP-VIKOR in Sustainable Share of Renewable Energy Sources Assessment

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Abstract. Multi-Criteria Decision Analysis (MCDA) methods are widely applied in decision-making across various fields, including sustainability, social and environmental issues, and energy management. Despite their popularity, many commonly used MCDA methods, such as the Analytical Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and Multi-Attribute Utility Theory (MAUT) show compensatory features. This means that strong performance in some criteria can compensate for weaker performance in others, which contradicts the principles of strong sustainability. In contrast, non-compensatory MCDA methods, such as Preference Ranking Organization METHod for Enrichment of Evaluation (PROMETHEE) and ELimination and Choice Expressing the Reality (ELECTRE), align more closely with the principles of strong sustainability. However, these methods often lack numerical ranking capabilities and can be computationally complex, limiting their broader adoption.

This paper addresses this gap by introducing the Strong Sustainability Paradigm based VIKOR (SSP-VIKOR) method, an extension of the traditional VIKOR approach. The SSP-VIKOR method incorporates compensation reduction modeling by adjusting the sustainability coefficient, enabling a more accurate evaluation of sustainability-related decision problems. The effectiveness of SSP-VIKOR is demonstrated through an assessment of the sustainable share of renewable energy sources (RES) in selected European countries. Given the European Union's commitment to reducing greenhouse gas emissions, improving energy security, and promoting economic development, it is crucial to accurately evaluate the sustainability contributions of RES. The findings highlight the potential of SSP-VIKOR as a practical tool for policymakers and stakeholders seeking to balance the environmental, economic, and social dimensions of sustainability.

Keywords: SSP-VIKOR · Multi-criteria decision analysis · Renewable energy sources assessment · Strong sustainability paradigm.

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1 Introduction

The use of multi-criteria decision analysis (MCDA) methods is increasingly common in decision-making across various fields, including sustainable development, social and environmental issues, production management, healthcare, and more [8]. The popularity and versatility of MCDA methods stem from their ability to consider multiple evaluation criteria simultaneously, even when these criteria may conflict with one another and are expressed in different units. Additionally, the widespread adoption of MCDA methods is largely due to their user-friendly nature, particularly those derived from the American school, such as the Analytical Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and Multi-Attribute Utility Theory (MAUT) [21]. The methods mentioned earlier are compensatory, meaning that favorable outcomes in certain criteria can compensate for weaker outcomes in others. This characteristic is a significant limitation when applying these methods to decision-making problems in the field of sustainability, as compensability conflicts with the principles of the strong sustainability paradigm [27]. There are, however, multi-criteria decision analysis (MCDA) methods that are in line with the strong sustainability paradigm and allow for limited compensation. Methods from the Preference Ranking Organization METHod for Enrichment of Evaluation (PROMETHEE) and ELimination and Choice Expressing the Reality (ELECTRE) families fall into this category [15]. Nonetheless, not all of these methods provide a numerical ranking, which is a drawback. Additionally, these methods tend to be more algorithmically complex than compensatory methods, making them harder to apply. As a result, they are less popular compared to compensatory methods. This highlights a research gap that requires enhancing existing multi-criteria methods by incorporating compensation reduction modeling to broaden their application to sustainability problems [22].

This paper aims to introduce the Strong Sustainability Paradigm based VIKOR (SSP-VIKOR) method, which is an enhancement of the classic VIKOR method. The SSP-VIKOR method improves upon its predecessor by incorporating the ability to model the degree of compensation reduction. In SSP-VIKOR, the degree of compensation can be effectively modeled by adjusting the value of the sustainability coefficient. In this paper, the SSP-VIKOR method is applied to assess the sustainable share of renewable energy sources in selected European countries. The sustainable contribution of renewable energy sources (RES) to the European economy is crucial to the European Union's energy policy for several reasons. Key among them are the goals of reducing greenhouse gas emissions and improving air quality to slow climate change, enhancing energy security by increasing countries' independence, diversifying energy sources, and stabilizing energy prices. Additionally, this contribution supports public health, boosts economic development, and fosters innovation.

The rest of the paper is organized as follows. In section 2 a review of the literature on the application of multi-criteria methods in the problem of sustainable development was made. Section 3 provides basic assumptions and mathematical

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formulas of the presented method SSP-VIKOR. This section also reviews the multi-criteria model used in this research work. In section 4 research results are presented, while in section 5 they are discussed. The last section 6 summarizes the results of the survey and draws conclusions.

2 Literature review

Multi-criteria decision analysis (MCDA) methods have consistently demonstrated their effectiveness in addressing decision-making challenges across various fields. These methods are especially useful in situations where decisions must consider multiple, often conflicting criteria. One significant area where MCDA is applied is in energy-related decisions [28]. MCDA methods are effectively used to evaluate the energy mix by considering different energy sources. Among the most commonly used methods are AHP, ELECTRE, and TOPSIS [21]. In research works, methods such as AHP [27], and PROMETHEE [15] are used to select wind farm sites. AHP or ANP are often used in site selection of photovoltaic farms [16, 20]. MCDA methods are also effective in assessing the efficiency of renewable energy technologies, with TOPSIS being a suitable option [17, 23]. MCDA methods are also used in solving problems in the area of environmental [2], for example, in the analysis of the impact of investments on the environment, the choice of waste management strategies involving AHP, TOPSIS [6, 11], VIKOR [13], and PROMETHEE [14]. Another area where Multi-Criteria Decision Analysis methods are useful is in transportation, particularly for selecting solutions in logistics systems, where the PROMETHEE method can be applied [26]. MCDA methods are utilized in management as they support strategic decision-making and supplier selection, exemplified by the successful application of the COmplex Proportional Assessment (COPRAS) method in the oil and gas industry [29]. The next useful application of MCDA is in healthcare, where it supports the evaluation of treatment effectiveness and the development of healthcare systems, particularly utilizing AHP [1]. Another application area of MCDA is water [10] and forest [7] resources management, where AHP is applicable [12].

A review of the literature concludes that compensatory methods, such as AHP, TOPSIS, VIKOR, and COPRAS, dominate the MCDA methods used in sustainability decision-making research. Compensatory methods evaluate alternatives in a holistic manner, allowing for weaker performance in one area to be compensated by better performance in another. This means that an alternative can receive a high rating if it excels in one criterion, even if it performs poorly in another area. While compensatory methods can be applied to sustainability assessments, their effectiveness depends on how the concept of sustainability is defined. However, these methods have limitations. They can lead to compensation for poor performance and may result in misinterpretation of the results. A high weighted sum score could blur significant issues in certain aspects of sustainability [9].

Alternatives to compensatory methods include non-compensatory methods, which do not allow good performance in one criterion to compensate for poor per-

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formance in another. Another option is setting critical thresholds, which are limits for individual criteria that cannot be exceeded. Additionally, multi-criteria hybrid approaches combine features of both compensatory and non-compensatory methods. One example is the Strong Sustainability Paradigm based Technique for Order Preference by Similarity to Ideal Solution (SSP-TOPSIS) method, where the classic Multi-Criteria Decision Analysis (MCDA) approach is modified to minimize compensation [3]. The SSP-TOPSIS method developed by the author has been effectively applied to evaluate the sustainable share of renewable energy sources (RES) across various sectors of the economies of European countries [3] and to assess photovoltaic systems [5]. In a subsequent research effort, the author developed a new multi-criteria approach that incorporates criteria compensation reduction modeling based on the VIKOR method. This approach, called SSP-VIKOR, was utilized to evaluate the progress of selected European countries towards achieving the targets of Sustainable Development Goal 7 (SDG 7) [4].

The successful application of the SSP-VIKOR method in the area of energy, considering the achievement of intended goals related to RES, inspired the author to adopt this approach for a multi-criteria assessment of the sustainable share of RES in various sectors of the economy across European countries. This assessment takes into account the populations of these countries. As a country's population increases, it faces greater challenges in energy provision, costs, and environmental impact [18]. Developing sustainable RES enables countries to improve their quality of life, achieve economic stability, and enhance energy security, resulting in advantages for both society and the economy [24].

3 Methodology

3.1 Multi-criteria assessment model

The model used for the multi-criteria evaluation of countries regarding the sustainable share of renewable energy sources (RES) across different sectors of the economy was developed based on indicators from the Eurostat database. These indicators are accessible through a tool known as the Short Assessment of Renewable Energy Sources (SHARES). The data can be found at the following link `https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20(SHARES)`.

The model's criteria are divided into four groups. Group G_1 consists of five criteria related to the contribution of various renewable energy sources (RES) to electricity generation. Group G_2 includes four criteria that represent the consumption of RES in different modes of transportation. Group G_3 contains six criteria addressing RES consumption in heating and cooling. Finally, Group G_4 includes three criteria related to the gross final consumption of energy from RES. The criteria included in the described model are shown in Table 1. This model considers data in kilotonnes of oil equivalent (KTOE) per 100 000 inhabitants.

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All criteria are designed to enhance the value of RES participation in every considered aspect.

Table 1: Criteria for evaluation model of sustainable RES share based on SHARES.

C_j	Criteria names
	Group G_1 - Electricity generation from RES (RES-E)
C_1	Annual electricity generation from Hydro
C_2	Annual electricity generation from Wind
C_3	Annual electricity generation from Solar
C_4	Annual electricity generation from Solid biofuels
C_5	Annual electricity generation from All other renewables
	Group G_2 - Electricity consumption in Transport from RES (RES-T)
C_6	Annual consumption of renewable electricity in road transport
C_7	Annual consumption of renewable electricity in rail transport
C_8	Annual consumption of renewable electricity in all other transport modes
C_9	Annual consumption of renewable electricity compliant biofuels in transport
	Group G_3 - Electricity consumption in Heating and Cooling from RES (RES H&C)
C_{10}	Annual final energy consumption in heating and cooling
C_{11}	Annual derived RES based heat
C_{12}	Annual derived RES based heat for heat pumps
C_{13}	Annual derived RES based heat for heat pumps of which from aerothermal and hydrothermal heat pumps
C_{14}	Annual derived RES based heat for heat pumps of which from geothermal energy using heat pumps
C_{15}	Annual RES based energy consumption in renewable cooling
	Group G_4 - Gross final consumption of energy from RES (RES)
C_{16}	Gross final consumption of energy from RES in electricity generation
C_{17}	Gross final consumption of energy from RES in heating and cooling
C_{18}	Gross final consumption of energy from RES in transport

3.2 The SSP-VIKOR method

In this section, subsequent stages of the novel multi-criteria method called Strong Sustainability Paradigm based VIKOR (SSP-VIKOR) are given. The author implemented the SSP-VIKOR in Python 3, and it is available in the open source GitHub repository at link `https://github.com/energyinpython/SSP-VIKOR-for-sustainability-assessment`. In this work, 29 European countries were assessed in relation to the sustainable share of renewable energy sources in different branches regarding electricity generation and consumption.

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3.3 The SSP-VIKOR Method

Step 1. Build the decision matrix including performance values x_{ij} gained for m alternatives positioned in rows in relation to n criteria positioned in columns, as Equation (1) shows,

$$X = [x_{ij}]_{m \times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

where $i = 1, 2, \ldots, m$ denote i-th alternative and $j = 1, 2, \ldots, n$ define j-th criterion. C_{+j} represents profit criteria and C_{-j} indicates cost criteria. This step corresponds to the first step of popular MCDA methods.
Step 2. Calculate the Mean Deviation values represented by MD_{ij} for each performance value included in the decision matrix x_{ij} subtracting the mean value $\overline{x}_j$ from performance values x_{ij} for each C_j criterion. Then, multiply the outcome by the s_j coefficient value. The coefficient denoted by s_j defines the sustainability coefficient, which is an adjustable parameter of SSP-VIKOR. It represents the level of criteria compensation reduction. Values of the s coefficient are assigned by the decision-maker to each j-th criterion. The s coefficient may have assigned real numbers from 0 to 1. High values of s_j approaching 1 represent a considerable reduction of compensation of j-th criterion performance value. In contrast, low values of s_j represent a low degree of criteria compensation reduction. The whole procedure of Mean Deviation computation is performed according to Equation (2).

$$MD_{ij} = (x_{ij} - \overline{x}_j)s_j \tag{2}$$

Step 3. Assign 0 values to these MD_{+ij} for profit criteria C_{+j} that are lower than 0. If MD_{+ij} is lower than 0 it denotes that x_{+ij} is lower than $\overline{x}_{+j}$. Attach 0 values for these MD_{-ij} for cost criteria C_{-j} which are higher than 0. It means that x_{-ij} are higher than $\overline{x}_{-j}$. Described procedure is demonstrated in Equation (3),

$$MD_{ij} = 0 \, \forall \, MD_{+ij} < 0 \; \vee \; MD_{-ij} > 0 \tag{3}$$

where MD_{+ij} represents Mean Deviation values for profit criteria C_{+j} and MD_{-ij} defines Mean Deviation values for cost criteria C_{-j}. This step is intended to prevent undesirable improvement of performance values that are outliers from the mean toward the worse.
Step 4. Subtract MD_{ij} values from performance values x_{ij} included in decision matrix as Equation (4) presents. The outcome is a compensated decision matrix.

$$t_{ij} = x_{ij} - MD_{ij} \tag{4}$$

The rest of the steps are analogous to the classic VIKOR method.

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Step 5. determine the best f_j^* and the worst f_j^- values for each criteria functions. Use Equation (5) for profit criteria and Equation (6) for cost criteria.

$$f_j^* = t_j^{max}, \quad f_j^- = t_j^{min} \tag{5}$$

$$f_j^* = t_j^{min}, \quad f_j^- = t_j^{max} \tag{6}$$

Step 6. Calculate the S_i and R_i values using Equations (7) and (8). Criteria weights are denoted by w_j, and they were determined using an objective weighting method called Criteria Importance Through Inter-criteria Correlation (CRITIC) method [19].

$$S_i = \sum_{j=1}^{n} w_j(f_j^* - f_{ij})/(f_j^* - f_j^-) \tag{7}$$

$$R_i = \max_j [w_j(f_j^* - f_{ij})/(f_j^* - f_j^-)] \tag{8}$$

Step 7. Calculate the Q_i values with Equation (9)

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1 - v)(R_i - R^*)/(R^- - R^*) \tag{9}$$

where
$S^* = S_i^{min}, \quad S^- = S_i^{max}$
$R^* = R_i^{min}, \quad R^- = R_i^{max}$
v denotes the weight assigned for the strategy of "most criteria". For computations in this research, $v = 0.5$ was set.
Step 8. The rankings of alternatives are built by sorting S, R, and Q values in ascending order. The result of this stage includes three ranking lists.
Step 9. A compromise solution is reached regarding the conditions of good advantage and acceptable stability within the three vectors obtained in the previous step. The alternative with the lowest value is the best assessed.

4 Results

The first stage of the research involved evaluating countries that were considered for potential compensation reductions based on specific criteria groups. Table 2 presents the results of the analysis, indicating the sustainability coefficients derived from the standard deviation values of the normalized decision matrix for each criterion group in the decision model. The columns titled "None" present the results and rankings for scenarios with no compensation reduction across any group of criteria, which aligns with the traditional VIKOR compensation method.

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Table 2: Comparison of SSP-VIKOR results for compensation reduction in particular criteria groups.

Country	None	G_1	G_2	G_3	G_4	All groups	None	G_1	G_2	G_3	G_4	All groups
Belgium	0.5465	0.5525	0.5441	0.5420	0.5452	0.5445	15	14	15	15	15	14
Bulgaria	0.6348	0.6433	0.6357	0.6289	0.6352	0.6385	21	21	21	21	21	21
Czechia	0.6009	0.6100	0.6005	0.5913	0.5999	0.5990	18	18	19	18	18	18
Denmark	0.4303	0.4388	0.4276	0.4232	0.4276	0.4264	5	4	5	6	5	4
Germany	0.4697	0.4806	0.4681	0.4503	0.4684	0.4590	7	7	7	7	7	7
Estonia	0.4800	0.4865	0.4810	0.4752	0.4790	0.4819	8	8	8	8	8	8
Greece	0.5535	0.5616	0.5554	0.5473	0.5543	0.5581	16	16	16	16	16	16
Spain	0.5440	0.5531	0.5429	0.5388	0.5438	0.5466	14	15	14	14	14	15
France	0.5026	0.5105	0.5004	0.4841	0.5011	0.4887	10	11	10	9	10	9
Croatia	0.9322	0.9220	0.9323	0.9308	0.9327	0.9212	28	28	28	28	28	28
Ireland	0.9044	0.8997	0.9047	0.9008	0.9036	0.8956	27	27	27	27	27	27
Italy	0.4468	0.4584	0.4449	0.4195	0.4466	0.4298	6	6	6	5	6	5
Cyprus	0.3115	0.3115	0.3131	0.3062	0.3115	0.3078	2	2	2	2	2	2
Latvia	0.9478	0.9443	0.9491	0.9479	0.9481	0.9460	29	29	29	29	29	29
Lithuania	0.7753	0.7454	0.7761	0.7686	0.7735	0.7376	24	24	24	24	24	24
Luxembourg	0.5188	0.5242	0.5191	0.5190	0.5199	0.5258	13	12	13	13	13	13
Hungary	0.6291	0.6386	0.6297	0.6273	0.6290	0.6372	20	20	20	20	20	20
Malta	0.4232	0.4391	0.4250	0.4177	0.4241	0.4363	4	5	4	4	4	6
Netherlands	0.5159	0.5265	0.5144	0.5114	0.5154	0.5200	12	13	12	12	12	12
Austria	0.4061	0.4102	0.4053	0.4019	0.4033	0.4024	3	3	3	3	3	3
Poland	0.6474	0.6471	0.6479	0.6438	0.6470	0.6438	22	22	22	22	22	22
Portugal	0.4992	0.5018	0.4985	0.4987	0.4981	0.4996	9	10	9	10	9	11
Romania	0.8543	0.8311	0.8543	0.8543	0.8543	0.8311	26	26	26	26	26	26
Slovenia	0.6021	0.6108	0.6003	0.5939	0.6007	0.5996	19	19	18	19	19	19
Slovakia	0.8076	0.7817	0.8070	0.8030	0.8072	0.7762	25	25	25	25	25	25
Finland	0.5091	0.4948	0.5064	0.5103	0.5078	0.4919	11	9	11	11	11	10
Sweden	0.2356	0.1936	0.2356	0.2356	0.2356	0.1936	1	1	1	1	1	1
Iceland	0.7256	0.7314	0.7257	0.7279	0.7254	0.7334	23	23	23	23	23	23
Norway	0.5820	0.5783	0.5806	0.5813	0.5809	0.5752	17	17	17	17	17	17

The three highest-rated countries, namely Sweden, Cyprus, and Austria, consistently maintain their positions across all groups, regardless of the criteria used for compensation reductions. This indicates that these countries demonstrate favorable and balanced performance values in every criterion group. Denmark ranks fifth in VIKOR's compensation ranking, but it rises to fourth place when compensation reductions are applied within the G_1 and all criteria groups. On the other hand, Denmark drops to sixth place when compensation reductions are applied within the G_3 criteria group. This indicates that strong performance in the G_3 group helps Denmark achieve a better overall score, compensating for weaker results in other groups. In contrast, Italy, which is sixth in the VIKOR compensation ranking, improves its position to fifth when compensation is reduced within the G_3 criterion group and across all criteria groups. This suggests that Italy maintains good performance across all criterion groups, reflecting a sustainable share of Renewable Energy Sources (RES) in all sectors considered.

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The second stage of the investigation focused on analyzing how sensitive the SSP-VIKOR scores were to increasing reductions in compensation across all criterion groups, which were modeled by progressively increasing an incremental sustainability coefficient. The results of this analysis displaying changes in rankings are presented in Figure 1.

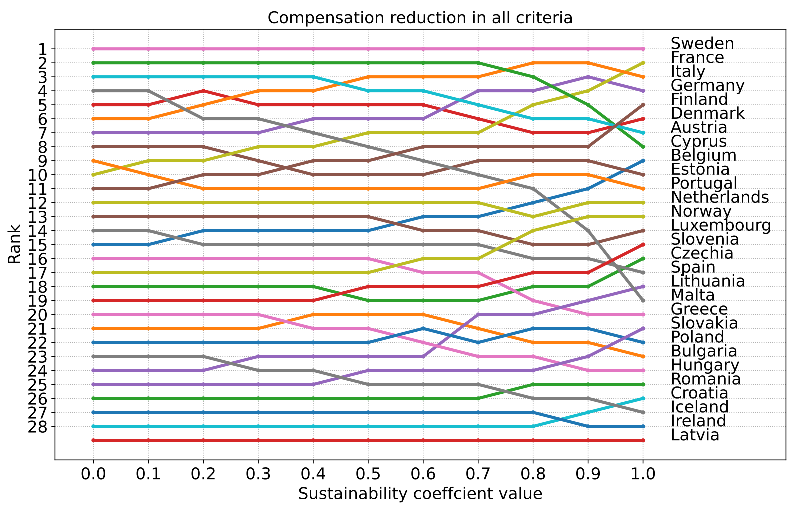

Fig. 1: SSP-VIKOR ranks for rising compensation reduction in all criteria.

It can be observed that Sweden, despite gradually reducing compensation across all criteria, maintains its leadership position. This reflects the country's high and balanced share of renewable energy sources (RES) in all examined sectors of the economy. Countries that demonstrate favorable performance with a well-balanced distribution across all criteria include France, Italy, Germany, and Finland. These nations either maintain stable positions or even improve their rankings despite increasing reductions in the possibility of compensation. In contrast, countries such as Cyprus, Malta, Iceland, and Hungary have experienced significant declines in their rankings due to compensation reductions. This indicates that for these countries, while they may have some favorable scores in certain criteria that enable them to compensate for the weak performances in other areas, their overall sustainability is insufficient to provide good scores regardless of compensation reduction.

In the third and final stage of the investigation, the author conducted a sensitivity analysis of the rankings by gradually reducing compensation for each group of model criteria: G_1, G_2, G_3, and G_4. Notably, the changes in rankings demonstrated a larger range for groups G_1 and G_3, as illustrated in Figures 2 and 3, compared to groups G_2 and G_4, which are represented in Figures 4 and 5.

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One possible explanation for this observation is that groups G_1 and G_3 contain a greater number of criteria.

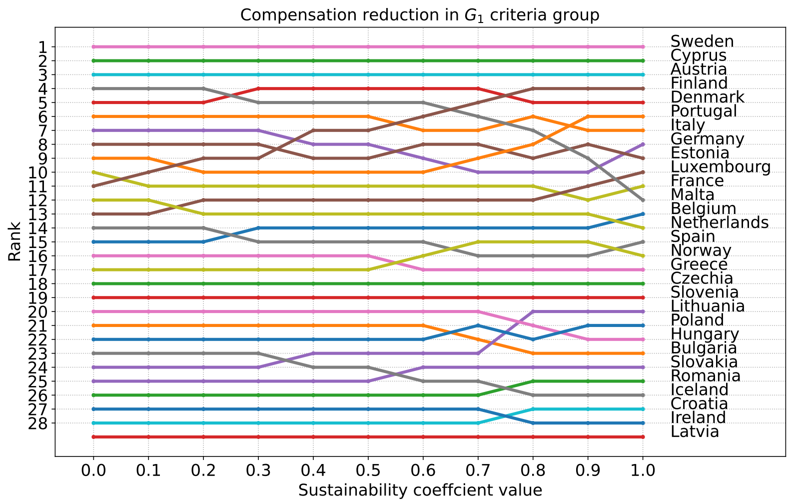

Fig. 2: SSP-VIKOR ranks for rising compensation reduction in G_1 criteria group.

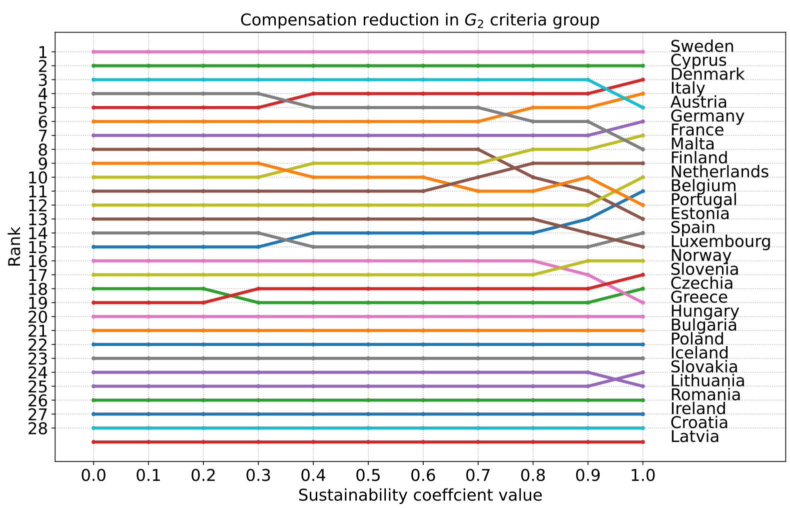

Fig. 3: SSP-VIKOR ranks for rising compensation reduction in G_2 criteria group.

The results obtained confirm that Sweden achieved the most favorable and balanced performance values regarding the share of renewable energy sources (RES) in the analyzed sectors of the economy.

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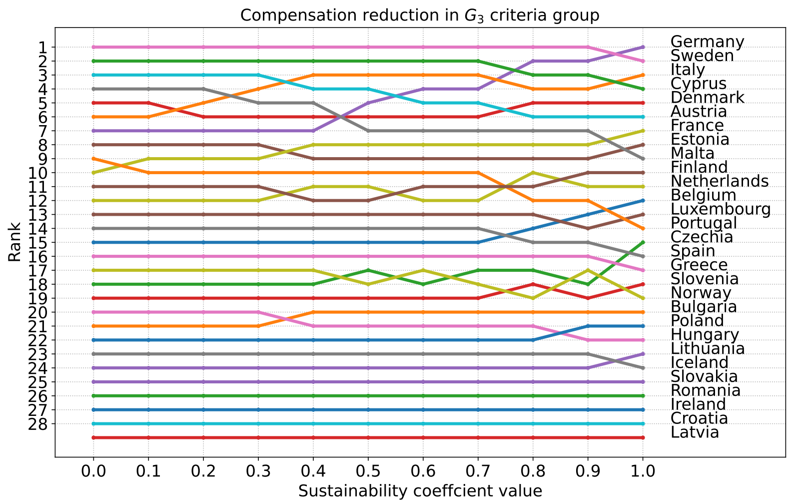

Fig. 4: SSP-VIKOR ranks for rising compensation reduction in G_3 criteria group.

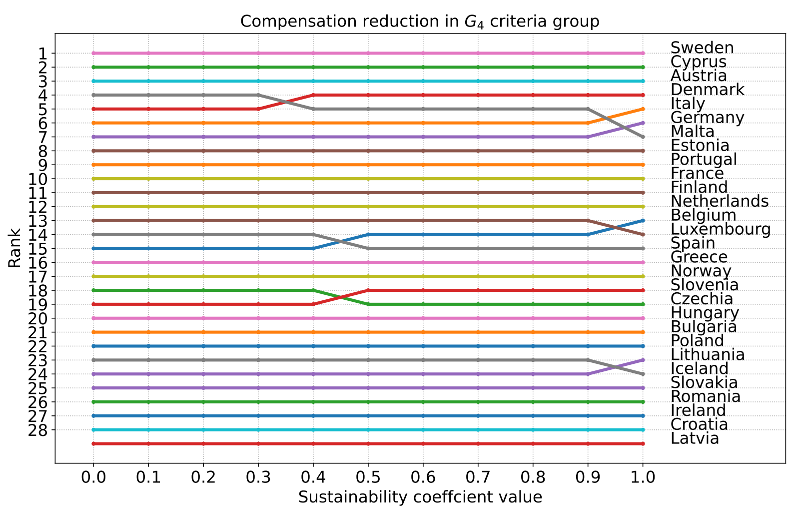

Fig. 5: SSP-VIKOR ranks for rising compensation reduction in G_4 criteria group.

The data shown in Figure 4 suggest that Cyprus and Austria exhibit positive performance values within the G_3 criteria group, as their rankings drop when compensation reductions are applied. Among the well-rated countries in all conducted analyses, Sweden, Denmark, Austria, and Cyprus stand out. These countries consistently rank at the top regardless of the degree of compensation reduction or the criteria group being evaluated. Conversely, the countries with

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the poorest performance across all analyses include Romania, Croatia, Iceland, Ireland, and Latvia.

5 Discussion

The results indicate that the SSP-VIKOR method enhances analytical capabilities compared to the traditional compensation VIKOR method. By adjusting the level of compensation reduction, it becomes possible to assess whether the alternatives exhibit strong and balanced performance across all considered aspects.

The results indicate that Sweden has the highest and most balanced share of renewable energy sources (RES) among the analyzed industries, giving the country a leading position despite any reductions in compensation. An analysis of data from the Eurostat database confirms this, as Sweden received favorable ratings across all criteria and did not exhibit weaknesses in any area. This approach is influenced by Sweden's policy, with the Swedish government's objective to achieve 100% renewable electricity generation by 2040, primarily relying on hydro and wind power [30].

Alongside Sweden, Austria and Denmark also showed strong results, emphasizing their high and sustainable participation in RES. Austria is a country with ambitious targets for the share of renewable energy sources (RES) in its energy consumption. Bioenergy is the main renewable energy source in Austria. Additionally, it has the highest use of hydropower among EU countries, and many companies in this sector are focusing on innovations that promote a vibrant business environment. Denmark has made significant progress in the consumption of renewable energy sources, primarily through the use of wind power [25].

In contrast, Malta experienced the most significant decline, dropping from fourth to nineteenth place due to increased compensation reductions across all criteria. Eurostat evaluation data reveals that Malta recorded zero values for six of the model's criteria: C_1, C_4, C_7, C_8, C_{11}, and C_{14}. With limited opportunities to compensate for these deficiencies through better scores in other areas, the country's ranking deteriorated significantly. The penetration of renewable energy sources in Malta remains low, despite ongoing efforts to promote their consumption [25].

A similar situation applies to Iceland, which showed zero values for eight of the model's criteria: C_3, C_4, C_7, C_8, C_{12}, C_{13}, C_{14}, and C_{15}. This resulted in Iceland's poor 23rd position in all analyses, which has not improved and has predominantly worsened.

6 Conclusions

This paper presents the new SSP-VIKOR method for evaluating the sustainable share of renewable energy sources (RES) in European countries. The SSP-VIKOR method expands upon the compensatory VIKOR method and serves

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as an alternative to non-compensatory methods for multi-criteria assessments, particularly addressing the principles of a strong sustainability paradigm.

The results of the investigation indicate that Sweden ranks highest among all countries when analyzing the reduction of criteria compensation using the SSP-VIKOR method across all groups of criteria. This reflects Sweden's strong and balanced participation in RES. Denmark and Austria also deserve recognition as they rank well in this analysis. The SSP-VIKOR method serves as a sustainability assessment tool that broadens the range of analytical options available for modeling criteria compensation reduction. This approach highlights new possibilities that arise from adapting well-established compensatory MCDA methods originating from the American school.

Future work will include benchmarking studies of the SSP-VIKOR method in relation to other non-compensatory approaches, as well as expanding classical compensation methods to incorporate the capability to model compensation reduction.

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