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Progress and Disparity: A Decade of Renewable Energy Development in Europe

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Abstract:

Purpose: *This article investigates the economic environment for renewable energy development using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method for ranking renewable energy projects in various countries.*
Design/Methodology/Approach: *This work constructs a framework for economic landscape assessment by picking out diagnostic variables reflecting key variables driving renewable energy development, environmental tax revenues, import dependence, energy usage, and environmental impacts. The TOPSIS method allows a multidimensional analysis of renewable energy, enabling a hierarchy of countries based on synthetic indicators.*
Findings: *The study covers all regions with available data for the selected years, relying on comprehensive and accessible variables essential for the analysis. Data describing the economic indicators relevant to renewable energy development in each region for 2012 and 2020, which were sourced from EUROSTAT, ensure a robust foundation for the analysis.*
Practical Implications: *Findings will help policymakers, investors, and developers make sound choices to promote sustainable and renewable energy projects.*
Originality/Value: *Since it is challenging to represent the potential for renewable energy development through a single characteristic, this study employs a multidimensional statistical analysis based on a TOPSIS synthetic index to quantify this potential.*

Keywords: *Penewable energy, economic evaluation, TOPSIS, strategic planning, synthetic indicators.*

JEL classification: *Q42, C44, R11.*

Paper type*: Research article.*

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1. Introduction

The economic landscape for renewable energy development is marked by spatial variability, closely tied to the uneven socio-economic development of different regions. This variability underlines the importance of a comprehensive and balanced approach to socio-economic growth, which, as outlined in various national and international development strategies, aims to enhance the quality of life and foster sustainability.

Analyzing economic factors influencing renewable energy development becomes crucial in formulating regional and local development policies, thereby increasing the demand for detailed investigations into this problem (Zhang *et al.*, 2019; Chen *et al.*, 2023; Kosfeld and Gückelhorn, 2012).

Renewable energy development is a topic of significant interest within socio-economic research. Despite numerous studies, there has been a relatively limited empirical examination of the spatial relationships between economic variables and the success of renewable energy initiatives at the regional and multiregional levels. This gap justifies a study on the spatial autocorrelation of economic factors relevant to renewable energy development across different countries (Nowak, 2011; Szaruga *et al.*, 2022).

The article aims to provide a linear ordering of regions based on their potential for renewable energy development and to analyze the spatial autocorrelation of these potentials using synthetic indicators, which requires comparing many countries characterized by a diverse set of variables.

Since it is challenging to represent the potential for renewable energy development through a single characteristic, this study employs a multidimensional statistical analysis based on a TOPSIS synthetic index to quantify this potential.

The first part of the article discusses theoretical aspects of the economic landscape affecting renewable energy development. Subsequently, a linear ordering of the analyzed countries is conducted using the TOPSIS method. A synthetic indicator of renewable energy development potential is constructed to perform a spatial autocorrelation analysis, aiming to identify the strength of relationships between regions in terms of their renewable energy development potential (Peng *et al.*, 2019; Elyoussoufi and Bousfoul, 2021).

The study covers all regions with available data for the selected years, relying on comprehensive and accessible variables essential for the analysis. Data describing the economic indicators relevant to renewable energy development in each region for 2012 and 2020, which were sourced from EUROSTAT, ensure a robust foundation for the analysis.

2. Development of Renewable Energy Concept and Literature Review

Renewable energy development encompasses expanding and implementing renewable energy sources within a human lifespan. Unlike limited fossil fuels, which cause environmental degradation, renewable energy sources like solar, wind, hydro, and biomass have much less environmental impact (IRENA 2020).

The development of renewable energy is a crucial step toward reducing climate change and ensuring economic growth and energy security in every country (Thalassinos *et al.,* 2022; Damu *et al.,* 2023; Sharma *et al.,* 2023; Demessinova *et al.,* 2018; Jacobson *et al.,* 2017; Pociovalisteanu *et al.,* 2010).

From an economic perspective, switching to renewable energy creates specific economic opportunities by creating jobs, rural development, and diversifying power supplies to decrease import dependency on imported fuels (Wei *et al.,* 2010). The significant downsides are the high investment costs and the intermittent generation capacities of several renewable sources.

Policy support frameworks, technological advancements, and market conditions for feed-in tariffs, tax incentives, and renewable portfolio standards drive economic development sustainably (Tóth and Bencs, 2023; Johnstone *et al.,* 2010). From an environmental point of view, it is essential to develop renewable energy sources because of the environmental impact of their activities: renewable energy plays a critical role in reducing greenhouse gas emissions and addressing climate change.

Renewable energy technologies decrease air and water pollution, which causes multiple health problems and reduces external costs (Markandya *et al.,* 2009; Medvedkina aand Khodochenko, 2020; Omer, 2010).

Order preference by similarity to ideal solution technique TOPSIS is a decision-making method that identifies the best alternatives based on their distance from an ideal solution. In the area of renewable energy development, TOPSIS could be utilized to assess and prioritize renewable energy projects on several fronts, including cost-effectiveness, environmental impact, social acceptance, and technological feasibility (Hwang and Yoon, 1981). Such multicriteria decision-making helps policymakers and investors consider both the advantages and risks of renewable energy projects (Algarni *et al.,* 2023).

Despite the benefits, renewable energy development has technological barriers, grid integration problems, and social acceptance issues. To meet these challenges, countries must continue research and development in this area and invest in grid infrastructure, public engagement, and education (Ackermann *et al.,* 2001).

Additionally, the future advancement of renewable energy depends upon new energy storage solutions to deal with sun and wind energy intermittency problems and on a worldwide work for sustainability and global warming mitigation. Global cooperation and knowledge transfer are vital for a move to a reduced-carbon energy future (IEA, 2020).

3. Research Methodology

The ranking method for renewable energy development is of central significance in empirical research domains, especially when analyzing the economic environment for developing renewable energy initiatives. The development path of renewable energy projects has historically been shaped by economic, ecological, and social factors that have produced a matrix that involves an organized evaluation method.

This study has adapted a multicriteria evaluation procedure to the intricacy of renewable energy development. The first step was compiling a suite of variables covering the multiple factors driving renewable energy development. They were then analyzed further to extract a subset of the most pertinent diagnostic variables fundamental to the viability and possible success of renewable energy development across countries.

This transformation starts with standardizing selected variables to remove differences in units and scales, to make each variable dimensionless, and to allow comparability across indicators. The values are normalized to a standard scale to form a standardized decision matrix for multicriteria analysis. This aggregation helps to synthesize composite indicators for every country based on its overall conformity to the ideal model of renewable power development.

The last step is calculating a set of synthetic variables, merging all criteria into a single coherent metric. These synthetic measures are the basis for rankings based upon relative proximity to an idealized development model of renewable power instead of directly evaluating support for renewable development in their present economic environment.

This methodology also considers that countries with a weak renewable energy sector might have economic circumstances enabling renewable power growth. This way of analysis ensures that it is confined to the development potential and its conformity with ideal benchmarks rather than to presumptive evaluation of the quality of existing economic circumstances for renewable energy development.

To assess the economic environment for renewable energy development in various countries, we used the TOPSIS technique. This technique is ideal for multidimensional analysis dealing with a set of vital economic factors influencing renewable energy sector development in different countries. It features 29 indicators covering everything from environmental tax revenues to energy consumption patterns.

To determine the economic environment for renewable energy development in different countries, we applied the classical technique for order of preference by similarity to the ideal solution (TOPSIS). Unlike Hellwig's method of development pattern, frequently used by scientists, TOPSIS constructs a synthetic measure by considering the Euclidean distance to an ideal and an anti-ideal solution.

A higher synthetic variable value signifies closer proximity to the ideal solution and a greater distance from the anti-ideal solution. The construction phases of the synthetic indicator, as defined by Hwang and Yoon (1981), are as follows:

1) creation of a normalized decision matrix, standardizing variables to eliminate unit discrepancies and bring them onto a comparable scale;
2) construction of a weight matrix, followed by the generation of a weighted normalized decision matrix, should variable weighting be requisite; this reflects the relative importance of each criterion in the evaluation process.
3) the determination of the coordinates for the ‘ideal’ (A+) and ‘anti-ideal’ (A–) solutions, based on the normalized characteristics:

$$A^{+} = (\max_i(v_{i1}), \max_i(v_{i2}), \ldots, \max_i(v_{\mathrm{iN}})) = (v_1^{+}, v_2^{+}, \ldots, v_N^{+}), \tag{1}$$

$$A^{-} = (\min_i(v_{i1}), \min_i(v_{i2}), \ldots, \min_i(v_{\mathrm{iN}})) = (v_1^{-}, v_2^{-}, \ldots, v_N^{-}), \tag{2}$$

4) calculation of the Euclidean distance for each entity from both the ideal and anti-ideal solutions:

$$s_i^{+} = \sqrt{\sum_{j=1}^{N}(v_{\mathrm{ij}} - v_j^{+})^2}, s_i^{-} = \sqrt{\sum_{j=1}^{N}(v_{\mathrm{ij}} - v_j^{-})^2}, i = 1,2,\ldots,M, j = 1,2,\ldots,N \tag{3}$$

5) calculation of the synthetic value, which encapsulates the multidimensional assessment into a singular score, facilitating a straightforward ranking of countries based on their renewable energy development prospects:

$$C_i = \frac{s_i^{-}}{s_i^{+} + s_i^{-}}, \text{ where } 0 \leq C_i \leq 1. \tag{4}$$

The use of a synthetic indicator of renewable energy sources status (SIRESS) is justified by replacing the characterizations of the studied entities, which are described by several characteristics of renewable energy development, with a description based on a single aggregated value. This allows for analyzing similarities between studied entities since we have a point of reference instead of a ranking based on non-pattern measures.

In our study, the distilled essence of complex multidimensional data is presented in the SIRESS as one metric that simplifies the comparative analyses of countries concerning renewable energy development. We aggregate diverse indicators in one composite index to present a far more succinct representation of the economic landscape of renewable energy in each country.

This method offers a standardized benchmark versus non-pattern measures that lack a point for comparison, enabling a straightforward ranking of the entities under review. The SIRESS thus makes the study's findings more straightforward and assists stakeholders in making decisions based on relative standings suggested by one broad indicator.

In choosing variables for our analysis, the degree of variability and degree of correlation were considered, employing the inverse of a correlation matrix method for this purpose. This allowed us to capture extensive dimensions applicable to renewable energy development while keeping interdependencies among variables.

Importantly, we did not exclude any variable based on these criteria - correlation and variability. This was based upon the project's objective to keep a holistic view of the renewable energy arena to enable a nuanced evaluation of the elements affecting renewable power development.

With all variables retained, we sought to capture the complete range of influences on the renewable energy sector so that our synthetic indicator SIRESS reflects a holistic assessment of renewable sources of energy status across countries. This approach bolsters our findings' reliability and validity and provides stakeholders with a more detailed picture of the renewable energy landscape.

4. Characteristics of the Accepted Factors

The dataset contains variables EUROSTAT offers on economic, environmental, social, and energy issues associated with renewable energy development. The data is structured to identify stimulants that encourage renewable energy development and destimulants that could hinder it.

To systematically evaluate the multifaceted economic and environmental landscape for renewable energy development, the analysis encapsulates various variables presented in Table 1. These variables represent the essence of four key realms: economic factors, energy usage/sources, environmental impact, and social and human factors.

Economic factors (X_3, X_4, X_5, X_6, X_7) are vital to understanding the fiscal dynamics underlying renewable energy development. These factors range from the nuanced environmental tax revenues indicating a country's dedication to environmentally friendly stewardship to the GDP per capita indicating financial robustness and potential investment capabilities in green energy technologies.

Moreover, government expenditure on research and development proves the strategic importance of innovating in this sector.

For electricity consumption sources (X_1, X_2, X_8), the existing energy matrix for every country was analyzed, and import dependence was compared with renewable energy usage. These variables highlight present dependencies and shifts towards much more sustainable energy practices.

Environmental impact variables (X_9, X_{10}, X_{11}) are precursors to the ecological footprint of previous and current energy policies and practices. They reveal the extent of emissions attributable to conventional energy usage, water resource exploitation, and transportation's carbon efficiency.

Finally, human and social factors (X_{12}, X_{13}, X_{14}, X_{15}, X_{16}) give clues on social readiness and human capital to allow for the renewable energy sector growth.

Healthcare expenditure as a proxy for social well-being, unemployment rates, adult education levels, and human resources in sciences and technology form a socio-economic basis for renewable energy development. The early leavers from education, captured by the X_{16} variable, could also reflect on the potential challenges in attracting a skilled workforce required to develop the renewable energy market.

Each of the variables presented in Table 1 gives us the picture needed to assess and prioritize renewable energy development within the complex mix of national economic and environmental strategies.

Table 1. *The list of factors that describe the desired area accepted for testing*

Category	**Variable Description**	**Variable character**
Economic Factors	X_3 - Environmental tax revenues (% of GDP) X_4 - Taxes on production and imports (% of GDP) X_5 - Gross domestic product at market prices (EUR per capita) X_6 - Gross domestic expenditure on RandD by sector of performance (EUR per inhabitant) X_7 - Government budget allocations for RandD in total government expenditure (%)	Stimulant Stimulant Stimulant Stimulant Stimulant
Energy Consumption and Sources	X_1 - Energy imports dependency (%) X_2 - Primary energy consumption (tonnes of oil equivalent per capita) X_8 - Primary energy consumption from renewables (TWh – equivalent)	Destimulant Destimulant Stimulant
Environmental Impact	X_9 - Air emissions account totals (kilograms per capita) X_{10} - Water exploitation index, plus (WEI+) (%) X_{11} - Average CO2 emissions per km from new passenger cars	Destimulant Destimulant Destimulant

Social and Human Factors	X_{12} - Total health care expenditure (% of GDP) X_{13} - Total unemployment rate (% of the population in the labor force) X_{14} - Adult participation in learning by sex (%) X_{15} - Human resources in science and technology (% of the total population) X_{16} - Early leavers from education and training by sex (%)	Stimulant Destimulant Stimulant Stimulant Destimulant

Source: *Author's research.*

Researchers often argue whether weights should be assigned to variables in spatial data; this article thus has not assigned fractional weight coefficients for the variables. This was done because of the concern that diagnostic variables inadvertently overlooked would be automatically assigned zero weights. This may skew the analysis as it assumes no unconsidered variable is essential - a stance that might not be realistic.

The unweighted approach treated all variables equally in the initial analysis to avoid subjective bias from the weighting (Młodak, 2006; Balicki, 2009). This methodological choice seeks to provide a more objective and equitable assessment of the spatial data.

The variables had been chosen primarily according to the availability, timeliness, and completeness of data for all analyzed units. The included variables are indicative rather than absolute values. This has allowed for the reduction of disturbances associated with some objects having certain characteristic features.

5. Stimulants vs Destimulants

The initial analysis provides an overview of each variable, categorizing them based on their roles within the context of this research. In particular, variables were defined as stimulants or destimulants based on the expected effect on renewable energy development.

With this analytical framework, nine variables were classified as drivers and catalysts for developing renewable energy and seven as destimulants - variables that could be detrimental to the sector. Selecting variables as destimulants or stimulants of renewable energy development is based on the intrinsic qualities of each variable and the perceived effect on the renewable energy industry.

Each variable is categorized as a stimulant or destimulant based on its conceptual relevance and empirical information showing its impact on the evolution of the energy sector, particularly in renewable energy sources.

This approach provides a comprehensive understanding of how each variable can drive or hinder the development of renewable energy, highlighting the multi-faceted nature of the energy sector and the complex interaction of various factors that influence its direction. By identifying the variables in this way, the study provides the basis for a more focused and insightful analysis to clarify how renewable energy can be most effectively developed and the barriers that need to be overcome or mitigated.

6. Results and Discussion

In taxonomic methods, one of the main requirements for the final diagnostic variables is their comparability (the principle of additivity). Normalization was carried out through classical standardization of variable values to compare characteristics with different units and magnitudes.

This means that a process of normalization should be applied to make various characteristics or variables directly comparable within the framework of taxonomic analysis, mainly when these characteristics differ significantly in their scales, units, or magnitudes. Classical standardization, which often involves subtracting the mean and dividing by the standard deviation for each variable, is a common method used in this context.

This process transforms the data so that the variables have a mean of zero and a standard deviation of one, ensuring that differences in scale or units do not distort comparisons or analyses. This step is crucial in taxonomic methods as it facilitates a fair and objective comparison across different variables, allowing for more accurate classification or assessment based on standardized data.

Implementing TOPSIS analysis has helped arrange countries according to the array of determinants driving the growth of renewable energy sources. This methodological choice has been vital in the analytical process, navigating the complicated, complex set of variables that drive the development of the renewable energy landscape.

Using synthetic indicators, a comparative measure was calculated that ranks each country relative to others in the same context. These indicators comprise a hierarchy in which higher synthetic measures suggest better engagement in and advancement of renewable energy initiatives.

This assessment is not one-dimensional but captures the financial incentives, regulatory frameworks, technological advances, and environmental commitments involved in renewable energy development. The final rankings thus provide an understanding of the country's position in renewable energy development, offering a clearer insight into global trends, policy, and strategic decision-making in pursuing a sustainable energy future.

Table 2. *Synthetic meter of the development of renewable energy sources in 2012 and 2020 by country*

2012			2020		
Position in the ranking	Country	Synthetic meter	Position in the ranking	Country	Synthetic meter
1	Luxembourg	0.876956	1	Luxembourg	0.892363
2	Norway	0.868984	2	Ireland	0.694739
3	Sweden	0.491519	3	Norway	0.541785
4	Denmark	0.478379	4	Denmark	0.472085
5	Netherlands	0.406009	5	Iceland	0.453732
6	Austria	0.399683	6	Sweden	0.410568
7	Ireland	0.393719	7	Netherlands	0.393506
8	Finland	0.385117	8	Finland	0.368152
9	Iceland	0.362116	9	Austria	0.367036
10	Belgium	0.359115	10	Germany	0.346049
11	Germany	0.349089	11	Belgium	0.334311
12	France	0.3331	12	France	0.28187
13	Italy	0.27563	13	Italy	0.220306
14	Spain	0.224724	14	Malta	0.206514
15	Cyprus	0.218753	15	Spain	0.182874
16	Malta	0.176693	16	Cyprus	0.176796
17	Slovenia	0.174715	17	Slovenia	0.162722
18	Portugal	0.173211	18	Portugal	0.148515
19	Greece	0.155525	19	Estonia	0.142005
20	Slovakia	0.143702	20	Czechia	0.134187
21	Latvia	0.140365	21	Slovakia	0.124076
22	Croatia	0.136841	22	Latvia	0.120587
23	Czechia	0.134187	23	Lithuania	0.11241
24	Hungary	0.131331	24	Hungary	0.105006
25	Lithuania	0.126327	25	Croatia	0.10355
26	Romania	0.1191	26	Greece	0.101446
27	Bulgaria	0.1002	27	Romania	0.098983
28	Estonia	0.095857	28	Bulgaria	0.082165
29	Poland	0.091527	29	Poland	0.074679
Characteristics of distributions:			Characteristics of distributions:		
MED:	0.218753		MED:	0.182874	
AV:	0.286982		MN:	0.270794	
V_s:	0.712110		V_s:	0.738125	
SD:	0.204363		SD:	0.199879	
Q1:	0.136841		Q1:	0.120587	
Q3:	0.385117		Q3:	0.368152	

Note: *MED – median; AV – average; Vs — coefficient of variation; SD — standard deviation; Q1 — first quartile; Q3 — third quartile.*

Source: *Author's research.*

Notable is Luxembourg's continual top position in the ranking from 2012 to 2020; this microstate has shown an incremental increase of its synthetic meter score from 0.876 to 0.892, which, when seen in the context of TOPSIS analysis, signifies sustained excellence in addition to an improvement in renewable energy sources development.

This represents a solid and holistic national energy strategy Luxembourg has maintained and optimized. The reasons behind this sustained leadership are worth examining as they might offer best practices for other countries trying to enhance their renewable energy development.

The rise of the Republic of Ireland to second position marks a significant change in the energy landscape in a European context. Previously ranked seventh with a synthetic meter score of 0.393, Ireland moved to 0.694 for 2020. This impressive upsurge is attributed to a mix of policy steps and investment in renewable energy solutions - particularly wind and biomass energy sectors - areas of specific development in Ireland.

The dynamics of such a transition are of particular interest to stakeholders in the renewable energy sector as they encapsulate the effects of governmental policy, social commitment, and economic incentives in catalyzing a transition towards sustainable energy practices.

Norway and Denmark's eight years of top rankings demonstrate a dedication to renewable energy sector growth. Norway's slight decline from the second to the third rank and a synthetic meter drop from 0.868 to 0.541 may indicate emerging challenges in the renewable energy sector.

In contrast, Denmark's marginal decline with a relatively steady synthetic meter reading (0.478 to 0.472) suggests that while Denmark continues to be one of the leading countries in renewable energy development (particularly in wind energy), it must continue to introduce innovations and possibly increase investment to maintain its position.

The high rankings for Denmark and Norway verify their long-standing place as leaders in renewable energy based on their investments and usage, primarily in wind energy and hydropower. In the face of both external market forces and internal policy shifts, the resilience of their renewable energy development strategies and infrastructure could serve as a compelling model for other countries wishing to increase their renewable energy share in gross final energy consumption.

Upon closer examination of the progression in rankings and synthetic meter scores for 2012 and 2020, several countries have demonstrated substantial progress in producing and implementing renewable energy sources in their energy mix. For instance, Iceland has moved up the rankings, rising from ninth to fifth position.

This is backed by a rise in the synthetic meter to 0.453 from 0.362, indicating the nation's interest in geothermal and hydroelectric energy solutions. Iceland possesses distinctive geothermal power generation abilities, making it possible to use these natural resources better than some other European countries. The data reflect this particular usage.

Malta's rise from 16th to 14th place and a synthetic meter increment from 0.176 to 0.206 suggests considerable progress in renewable energy efforts. Given Malta's limited natural resources and geographic limitations, this progress may reflect practical policy implementations and investments in solar and wind energy sectors, aligning with the European Union's targets for sustainable energy development.

Estonia's rise from 28th to 19th position with its synthetic meter from 0.095 to 0.142 demonstrates an upward trend in renewable energy development. This Baltic state historically relied on oil shale.

However, the TOPSIS analysis demonstrates a shift to renewable energy sources - primarily biomass, wind, and solar. Estonia's policy shifts towards renewables are likely driven by environmental considerations and the EU's renewable energy directives.

The quantitative assessment of the synthetic meter suggests that these countries are enhancing their renewable energy profiles in reaction to global environmental problems and EU policy frameworks for sustainable development and reduction of greenhouse gas emissions. All these shifts also imply an effective alignment of national energy strategies with the broader objectives of energy security, economic competitiveness, and environmental stewardship.

Delving deeper into the data from the second half of the rankings reveals more nuanced renewable energy development dynamics within European countries: Slovakia, Lithuania, Latvia, Croatia, and Hungary continue to be at the bottom of the rankings for the observed time - with slight modifications when it comes to the synthetic meter.

These countries have shown relatively slow progress in renewable energy development. The data point to infrastructural, economic, and policy hurdles that have restricted their growth rate in renewable energy. Additionally, weaker synthetic meter readings reflect previous fossil fuel dependency and transitional problems to economic sustainability.

Poland continues to be at the bottom of the rankings - an obvious indication of a lengthy path to renewable energy transition. Even though the synthetic meter value decreased modestly from 0.091 to 0.074 - Poland is behind other European countries in renewable energy development. This is because of the higher dependence on coal and its associated socio-economic strengthening, making it hard to diversify the countries' energy mix.

Although the share of coal in the country's energy mix decreased from almost 90% in 2012 to 75% in 2020 (Wichliński *et al.*, 2023), coal remains a significant energy source for the Polish economy. The data indicate that intense policy interventions and investments might be required for Poland to boost its renewable energy capacities.

The overall trend in the dataset suggests progress toward improved renewable energy sources, albeit at various rates across the mentioned countries. Enhancements in the synthetic meter between 2012 and 2020 in various countries demonstrate a general dedication to the European Union's renewable energy goals and the transition to renewable energy systems. Technological advancements and policy work on carbon dioxide footprint reductions, international agreements, and energy security improvements characterize it.

These findings illustrate the complicated interaction of countries' capacities, policy frameworks, and economic problems determining the speed and scale of renewable energy development. The heterogeneity of progress among countries calls for tailored strategies addressing regional challenges and opportunities in the context of the broader energy transition throughout Europe.

7. Conclusions

A taxonomic study on the development of renewable energy sources from 2012 to 2020 provided insights into the energy transition dynamics of the area. Luxembourg's sustained leadership and Irish's quick increase in rankings point to the benefit of robust policy frameworks and investments in renewable energy in those countries.

Similarly, the upward trend in the case of Iceland and Malta is an outcome of their successful exploitation of natural resources combined with the implementation of new technology and innovative energy solutions, respectively.

However, the data also demonstrate a dispersed unevenness in renewable energy progress throughout the continent, with Eastern and Central European countries displaying the slowest growth for various economic, infrastructural, and historical reasons. Poland's position at the base of the rankings for both years particularly highlights the challenges faced by countries reliant on fossil fuels and the need for more decisive policy action to improve energy transformation.

The general trend of improvement in most countries suggests a convergence of technical, socio-political, and economic factors aiming for EU renewable energy objectives. This progression is not only a response to the imperatives of climate change mitigation but also a strategic alignment with energy security goals and economic viability.

It is crucial to understand that renewable energy advancement is more than an economic or technical problem but an intricate process requiring nationally tailored strategies. Supporting innovation, knowledge transfer, and investments in renewable energy development are crucial to future uniform European renewable energy sector development. Differences in the pace require continuous support for those behind for a genuinely inclusive energy transition across the region.

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