*energies*

*Article*

# Assessment of the Progress towards the Management of Renewable Energy Consumption in the Innovativeness Context—A Country Approach

**Monika Sipa * and Iwona Gorzeń-Mitka**

Faculty of Management, Czestochowa University of Technology, 42-201 Częstochowa, Poland; i.gorzen-mitka@pcz.pl
* Correspondence: monika.sipa@pcz.pl

**Abstract:** The fact that European Union (EU) countries have adopted an ambitious plan to achieve zero greenhouse gas emissions by 2050 requires decisive action within the scope of innovation and of the level of energy consumption, especially of the energy from renewable sources. Being directed toward innovation within the scope of renewable energy technology, as well as the proper management of renewable energy consumption, are the main actions aimed at increasing the efficiency of using clean energy, and which also bring the EU closer to the implementation of the assumptions adopted in the European Green Deal. The aim of our study was to assess the progress toward the management of renewable energy consumption in the innovativeness context and the relationship between energy consumption and selected indicators of innovativeness in European Union countries. We present an original ranking assessment of the progress toward the management of renewable energy consumption and identify relationships between the energy consumption of selected energy sources (both renewable and non-renewable) and of selected innovation assessment indicators. The data used to develop the original rating were optimized using the procedures of the MULTIMOORA method, while the relationships between variables were identified through correlation analysis. Our findings provide evidence of significant relationships between the consumption of selected energy sources (in the group of non-renewable sources, e.g., peat and peat products and oil and petroleum products, and in the group of renewable sources, e.g., wind, biofuels, and renewable waste) and of selected indicators of innovation evaluation (e.g., human resources, finance, and support).

**Keywords:** consumption management; renewable energy; innovativeness; multiple-criteria decision making (MCDM)

**Citation:** Sipa, M.; Gorzeń-Mitka, I. Assessment of the Progress towards the Management of Renewable Energy Consumption in the Innovativeness Context—A Country Approach. *Energies* **2021**, *14*, 5064. https://doi.org/10.3390/en14165064

Academic Editor: Jesús Manuel Riquelme-Santos

Received: 7 June 2021
Accepted: 11 August 2021
Published: 17 August 2021

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Copyright:** © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

## 1. Introduction

Energy is an essential element, making it easier for people to function in society, creating the right conditions for work, development, and rest [1,2]. Access to energy is one of the most important aspects of the prosperity and sustainable development of modern societies. Energy is present in all spheres of human life; for example, it is necessary both for the production and distribution of goods and for their use. Thanks to energy, we can travel, as well as build schools, hospitals, and roads, among other things [3,4].

The global energy system is facing challenges related to deregulation, new technologies, governance, policy, and changes in production structure [5]. Before the COVID-19 pandemic crisis, the global energy demand was projected to increase by 45% by 2030 and by more than 300% by the end of the 21st century [3]. Currently, according to the Stated Policies Scenario (STEPS), the global energy demand will reach pre-crisis levels in early 2023, while according to the Delayed Recovery Scenario (DRS), it could be delayed until 2025 if the pandemic prolongs and there is a deeper collapse [6]. According to the "Net Zero by 2050" report, approximately 55% of the cumulative emission reductions are related to consumer choices, such as retrofitting a home with energy-saving technologies, installing a heat pump, or purchasing an electric vehicle [7].

The need for change in the management of energy consumption and production is particularly evident in European countries. According to the Treaty on the Functioning of the European Union (TFEU), there are various measures at the heart of European energy policy aimed at creating an integrated energy market and ensuring the security of energy supply and a stable energy production sector [8].

The EU is obliged to face many challenges in the field of energy production. Despite the decline in energy demand caused by the 2008 crisis and the 2020 COVID-19 pandemic [6], the demand of European Union (EU) economies for energy exceeds their production capacity. An additional EU problem is the lack of local energy resources (in particular, oil and natural gas), which results in a high dependence on energy imports [3,9]. Diversification of energy sources and a greater focus on renewable energy sources (RESs) are therefore necessary. The process of liberalization and consolidation of the European energy production markets is reinforced by the European Union and is reflected in EU legislation, imposing new tasks, powers, and obligations on the regulators of individual countries (e.g., [10–15]). Moreover, the renewable energy market is largely shaped by regulations and legislation (environmental regulations, tax incentives, utility regulations, authorization rules, etc.), which have a huge impact on the market potential, economics, and the use of clean technologies (e.g., [16,17]).

As noted by Alvarez-Herranz et al. [18], the traditional model based mainly on natural and fossil resources has changed in the last decade. This is due to the growth of renewable sources and the implementation of innovations that favor a more sustainable model in the energy sector. Innovation and technological progress are key to finding lasting solutions to today's economic and environmental problems, such as increased resource and energy efficiency [19]. As energy dependency increases, forms of energy with greater flexibility and user-friendly characteristics become more popular [20]. Providing all people with access to stable, sustainable, and modern energy sources at an affordable price and building resilient infrastructure, promoting sustainable industrialization, and fostering innovation are two of the 17 Sustainable Development Goals (SDGs) adopted by the United Nations in the 2030 Agenda for Sustainable Development [19,21]. The European Union has also committed itself to achieving the objectives of the 2030 Agenda by adopting the European Green Deal Action Strategy, which address climate and environmental challenges. It is a set of measures leading to the transition to a circular economy, halting climate change, reversing biodiversity loss, and reducing pollution [22–24]. It is assumed that by 2050, electricity will account for almost 50% of the total energy consumption, and almost 90% of electricity production will come from renewable sources (wind and solar photovoltaic together will account for nearly 70%) [7].

As Schipper et al. [25] pointed out, energy efficiency and energy saving are key to meeting future national and global energy needs. Achieving this requires a comprehensive look at the management of energy consumption and production, as well as the involvement of economies and businesses in innovation activities.

Although numerous studies on energy consumption (e.g., [26–31]) or innovation issues (e.g., [32–38]) can be found in the scientific literature, few of them deal with the evaluation of renewable energy consumption management in the context of specific innovation indicators. Yahya and Rafiq's [39] research can be distinguished among the few current studies that include an analysis of the demand for renewable energy and the level of innovation. However, they identified the relationship between innovativeness and renewable energy consumption in four sub-panels, which were divided based on the state of democracy. They showed that a higher level of innovativeness and regulatory quality can increase the consumption of renewable energy in countries where their democratic system is stronger. Accordingly, we tried to link the level of innovativeness of countries with the consumption of renewable energy, taking into account the type of energy source. This paper seeks to fill this gap and to provide a practical guide for policymakers on how to assess the management of renewable energy consumption by the source type.

To the best of our knowledge, the empirical link between these two variables is not available in prior literature. Therefore, the aim of our study was to assess the progress toward the management of renewable energy consumption in the innovativeness context and the relationship between energy consumption and selected indicators of innovativeness in European Union countries.

Our research questions are:

RQ1: What changes have occurred in the management of renewable energy consumption in EU countries in the period 2015–2019?

In order to obtain the answer to RQ1, we used the MULTIMOORA method, which was introduced by Brauers and Zavadskas [40] and further developed by them in 2010 [41]. These methods have been applied in different studies in many different areas. A comprehensive review of studies using this method was presented by Arian Hafezalkotob et al. [42] in their study "An overview of MULTIMOORA for multi-criteria decision-making: Theory, developments, applications, and challenges." We used the MULTIMOORA method for the assessment of changes in the management of renewable energy consumption in EU countries as suitable for the analysis of problems in which there are several alternatives (in this case, 28 countries) and several objectives (in this case, 14 energy sources and 11 EIS composite indicators). Additionally, as indicated by research—for example, Hafezalkotob et al. [42] and Ijadi Maghsoodi et al. [43]—the MULTIMOORA multicriteria evaluation tool is objective and makes it possible to systematize information and draw impartial conclusions about different phenomena. Since the complexity increases with the increasing choices of alternatives and features, MULTIMOORA is useful for selecting the best alternatives [44].

RQ2: Are there significant relationships between energy consumption by source and innovation evaluation indicators?

RQ3: The consumption of which energy sources is significantly correlated with innovation evaluation indicators?

In order to obtain the answers to RQ2 and RQ3, we used correlation analyses. The purpose of our correlation analyses was to determine whether there is a relationship between the consumption of energy from equal sources (renewable and non-renewable) and the indicators characterizing the innovativeness of the economy.

## 2. Literature Review

Solving energy and climate problems is not easy. In the economies of the European Union countries, around three quarters of energy consumption still comes from non-renewable sources and is used for electricity, heat, transport, and as a material in certain industrial processes, leading to air pollution and carbon dioxide emissions [45]. According to the European Environment Agency (EEA) and the European Environment Information and Observation Network (Eionet), innovative solutions in many sectors can contribute to reducing energy-related greenhouse gas emissions [46,47]. However, Ucala and Xydisb [48] noted that fossil fuels dominate energy production as innovation and changes in production technology take time, and Gareiou et al. [49] pointed out that renewable energy requires the acceptance of citizens, as no new RSE-related technology can be effectively implemented without public acceptance.

The use of energy as an incentive for energy efficiency requires the creation of a number of tools for energy management at the household level [50]. It is necessary to change consumer habits toward more environmentally friendly practices, both at work and at home, and to promote self-consumption facilities in both the industrial and service sectors [51]. Education is key to environmental sustainability; it develops an attitude to comply with environmental regulations, use renewable energy products, and invest in green technology [52].

Modifying consumers' energy demand through various methods, such as financial incentives and behavioral change through education, or demand side management (DSM) [53], is gaining more and more attention due to its potential to control electricity consumption [54]. DSM provides greater demand-side flexibility in the energy system and helps to achieve environmental goals through controlled consumption [55]. Pérez-García and Moral-Carcedo [56] pointed out that managing household electricity demands requires price-fixing measures (taxes, etc.) or subsidizing investments in more efficient technologies, as well as psychology-based incentives or coercive measures.

Renewable energy sources (hydro, solar, biomass, wind, and geothermal energy) are the main drivers increasing the diversification of the energy supply [57]. They contribute, among others, to reducing greenhouse gas emissions, diversifying energy supplies, and reducing dependence on fossil fuel markets (in particular, oil and gas) [50]. The use of renewable energy to protect the environment may be encouraged by legislation promoting this type of energy source [48]. Increased investment in renewable energy sources is the optimal way to reduce the dominance of older fossil fuel power plants and increase the role of local resources [3]. The transition from fossil fuels to renewable energy sources is necessary to achieve a cleaner future [58]. The separation of energy production from fossil fuels creates opportunities for new green industries, technological innovations, and structural changes linked to the transition to a green economy [48]. Technologies based on non-fossil fuels create more jobs per unit of energy than coal and natural gas—and even the entire fossil fuel sector [59,60].

With changes in social needs and lifestyles, economic development and prosperity, and technological innovations, shaped by financial investment and increasing the scale and dissemination of technological applications in society, as well as research and innovation policies, are developing. Innovative solutions are key to ensuring that the storage and transmission of clean energy can be achieved on an appropriate scale. In this area, technological innovation in the private sector plays an important role, as confirmed by the activities of companies such as Tesla, Danfoss, and Siemens. They are the leaders in the implementation of innovative solutions in the areas of energy storage, connection networking, or intelligent energy systems [9,47]. The innovation of economies is determined by the level of research and innovation performance of countries, the strengths and weaknesses of their research and development (R&D) systems [61,62], decisions on financial support at the level of individual EU countries, and bottom-up support for the processes, products, foreign investments, and legal regulations [63]. Wu et al. [64] pointed out that increased funding and multisubject participation will accelerate green technology innovation and the path to green development. According to this, government R&D subsidies can effectively promote renewable energy investment and, furthermore, could attract VC and increase renewable energy investment. The ability of economies to create, implement, and absorb innovations involves actively engaging in and taking action in innovative processes. It also means a commitment to acquire the resources and skills necessary to participate in these processes [65].

The European Commission has proposed the Summary Innovation Index (SII) to measure the competitiveness of European countries in terms of innovation activities. The methodology for calculating the SII distinguishes between eight different steps, and the adopted division makes it possible to identify the degree of modernity and innovation of individual countries [61,66]. The value of this index is included in the research of many authors (e.g., [67–72]).

The SII includes a total of 27 different indicators, divided into four main action groups [73]:

1. Framework conditions, which include the main drivers of innovation outside the company, including three dimensions of innovation—human resources, attractive research systems, and innovation-friendly environment;
2. Investments, which include investments made in both the public and business sectors, including in two dimensions—finance and support and firm investments;

3. Innovation activities, which include innovative efforts at the company level, grouped into three dimensions of innovation—innovator, linkages, and intellectual assets;
4. Impacts, which record the effects of actions at the levels of employment impacts and sales impacts. Employment impacts include indicators that measure employment in knowledge-based activities and employment in fast-growing companies in innovative sectors. Meanwhile, sales impacts measure the economic impact of innovation and include three indicators that measure the exports of mid- and high-tech products, the exports of knowledge-based services, and the sales as a result of innovation.

Identification of the degree of modernity and innovation of individual countries makes it possible to indicate the strengths and weaknesses of national innovation systems and helps economies to point out the areas that they need to address. The European Innovation Scoreboard assesses a country's results in terms of making decisions about innovation policy strategies or decisions regarding innovation, technology, and science in order to achieve the goals of sustainable development, especially in the management of renewable energy consumption. However, as Marinaș et al. [74] pointed out, the transition from an economy based on efficiency to an economy based on innovation depends on increased energy efficiency and increasing the share of renewable energy. It should be noted that renewable energy transition policies differ from region to region due to resource availability [75]. In the years to come, considerable efforts in innovation are needed to ensure that the technologies necessary for zero net emissions reach the markets as quickly as possible.

## 3. Materials and Methods

The aim of our study was to assess the progress toward the management of renewable energy consumption in the innovativeness context and the relationship between energy consumption and selected indicators of innovativeness in European Union countries.

### *3.1. Materials*

The assessment of changes in the management of renewable energy consumption in EU countries in the period 2015–2019 (RQ1) was carried out by creating original rankings based on the MULTIMOORA method. In our approach, we used the MULTIMOORA method as an instrument to assess changes in renewable energy consumption in EU countries over the period 2015–2019. These changes reflect national approaches to managing energy consumption.

The analysis of changes in country positions in the 2015 vs. 2019 ratings allowed us to assess changes in the management of renewable energy consumption. The rationale for the scope of our analysis was as follows: 2015 was taken as the initial period of analysis, because this is the year of publication of "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy" [76], which is, in turn, the last year for which data were available.

The significant relationships (RQ2 and RQ3) between variables (energy sources vs. innovation evaluation indicators) were identified through correlation analyses.

The data were gathered from the energy statistical datasheets for EU countries for the period 2015–2019. These energy statistical datasheets are produced by the European Commission Directorate-General for Energy based on data from Eurostat and from the EU greenhouse gas monitoring mechanism [77]. Based on these data, we analyzed the energy consumption indications of the following energy sources (in relation to non-renewables, such as solid fossil fuels (SFF), peat and peat products (PPP), oil shale and oil sands (OS), oil and petroleum products (OPP), natural gas (NS), and nuclear (N), as well as for renewable ones such as hydro (H), wind (W), solar photovoltaic (SP), solar thermal (ST), tide, wave, and ocean (TWO), biofuels and renewable waste (BRW), geothermal (GEO,) and ambient heat (AH) (heat pumps)). In total, we used 784 variables to verify RQ1.

In the second part of our research, we confronted the previously obtained data on energy consumption by source with indicators defining innovation parameters based on the European Innovation Scoreboard 2020 [61]. To evaluate the relationship between energy consumption by source and innovation, we used the 11 EIS composite indicators (from the European Innovation Scoreboard 2020), such as the Summary Innovation Index (SII), human resources (HR), research systems (RS), innovation-friendly environment (IF-E), finance and support (FS), firm investments (FI), innovators (I), linkages (L), intellectual assets (IA), employment impacts (EI), and sales impacts (SI). In total, we used 795 variables to verify RQ2 and RQ3, and determined 56 correlation coefficients from them.

*3.2. Methods*

The MULTIMOORA method is an extension of the multi-objective optimization by ratio analysis (MOORA) method. This method consists of three parts, namely, a ratio system, a reference point, and a full multiplicative form. The MULTIMOORA method was selected to design the approach for the assessment of the management of renewable energy consumption in EU countries. The approach presents the relationship of 15 combined indicators (types of energy sources). The MULTIMOORA calculation method used in the development of the original rankings of the management of renewable energy consumption in EU countries is presented in Table 1.

The final results of the calculation are presented in Section 4.1 of the results. The relationships between energy consumption by source and innovation evaluation indicators were identified through correlation analyses. The final results of the calculation are presented in Section 4.2 of results. Excel and IBM SPSS Statistics were used to validate the MULTIMOORA algorithm and correlation analyses.

**Table 1.** The Multi-Objective Optimization by Ratio Analysis with the Full Multiplicative Form of Multiple Objectives (MULTIMOORA) procedure.

| Calculation Steps | Methods | Formula | Description of Symbols |
|---|---|---|---|
| Step 1 | Raw data matrix | — | — |
| Step 2 | Data normalization | $x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}}$ | $x_{ij}$ − response of alternative j on objective $i$<br>$j = 1, 2, \ldots, m$   $m$ – number of alternatives<br>$i = 1, 2, \ldots n$   $n$ – number of objectives<br>$x_{ij}^*$ − normalized response of alternative $j$ on objective $i$ |
| Step 3 | The Ratio System (RS) | $y_j^* = \sum_{i=1}^{i=g} x_{ij}^* - \sum_{i=g+1}^{i=n} x_{ij}^*$ | $y_j^*$ − normalized assessment of alternative $j$ with respect to all objectives<br>$i = 1, 2, \ldots, g,$ as the objectives to be maximized<br>$i = g+1, g+2, \ldots n,$ as the objectives to be minimized |
| Step 4 | The Reference Point (RP) | $\underset{(i)}{min}\left\{\underset{(j)}{max} \left\lvert r_j - x_{ij}^* \right\rvert\right\}$ | $r_j$ − $\max x_{ij}^*$ in maximization case |
| Step 5 | Full Multiplicative Form (FMF) | $U_i' = \frac{A_i}{B_i}$<br>$A_i = \prod_{j=1}^{g} x_{ij}$<br>$B_i = \prod_{j=g+1}^{n} x_{ij}$ | $A_i$ − the product of the objectives of the $i$ alternative to be maximized with $g$<br>$n$−the number of objectives to be maximized<br>$B_i$ − the product of the objectives of the $i$ alternative to be minimized with $n$<br>$g$−the number of objectives (indicators) to be minimized |

## 4. Results and Discussion

This section presents the results of the application of the proposed approach to the assessment of the management of renewable energy consumption (15 types of energy sources) in 28 EU countries. Moreover, we indicate the consumption of which energy sources is related to innovation evaluation indicators.

*4.1. Management of the Renewable Energy Consumption in EU Countries (2015 vs. 2019 Ratings)*

Using the decision optimization method presented in the previous section, a decision matrix was created from raw data (for the years 2015 and 2019) on energy consumption in EU countries, analyzed with respect to the type of energy source [77]. Our motivation regarding the selection of the years for the analysis was as follows: 2015—the publication "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy" [76]; 2019—the latest available data on energy consumption. Our approach assumes, based on the 2015 Energy Union's assumptions on increasing the share of energy from renewable sources, that countries should aim to reduce their consumption of energy from non-renewable sources in favor of renewables. Accordingly, in our approach, the consumption of non-renewable energy sources was treated as a non-benefit criterion, while consumption of renewable energy sources was treated as a benefit criterion.

Tables 2 and 3 (normalized decision matrix for 2015, normalized decision matrix for 2019) illustrate the normalized decision matrices according to the formula presented in Step 2 in our procedure.

Next, in Table 4, the values of the ratio system (RS), the reference point (RP), and the utility of the analyses alternatives (in our case, countries) in full multiplicative form of multiple objectives (FMF) are presented.

**Table 2.** Energy consumption in EU countries in 2015—normalization data.

| **Country** | **Energy Source** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Non-Renewables** | | | | | | **Renewables and Biofuels** | | | | | | | |
| | **SFF** | **PPP** | **OS** | **OPP** | **NG** | **N** | **H** | **W** | **SP** | **ST** | **TWO** | **BRW** | **GEO** | **AH** |
| | **Min** | **Min** | **Min** | **Min** | **Min** | **Min** | **Max** | **Max** | **Max** | **Max** | **Max** | **Max** | **Max** | **Max** |
| BE | 0.033 | 0.000 | 0.000 | 0.130 | 0.116 | 0.057 | 0.003 | 0.050 | 0.064 | 0.009 | 0.000 | 0.072 | 0.000 | 0.015 |
| BG | 0.065 | 0.000 | 0.000 | 0.024 | 0.022 | 0.033 | 0.047 | 0.013 | 0.029 | 0.008 | 0.000 | 0.030 | 0.006 | 0.026 |
| CZ | 0.162 | 0.000 | 0.000 | 0.049 | 0.054 | 0.058 | 0.015 | 0.005 | 0.048 | 0.007 | 0.000 | 0.096 | 0.000 | 0.038 |
| DK | 0.018 | 0.000 | 0.000 | 0.037 | 0.024 | 0.000 | 0.000 | 0.128 | 0.013 | 0.014 | 0.000 | 0.088 | 0.001 | 0.068 |
| DE | 0.785 | 0.000 | 0.000 | 0.608 | 0.543 | 0.197 | 0.159 | 0.730 | 0.816 | 0.255 | 0.000 | 0.653 | 0.039 | 0.316 |
| EE | 0.000 | 0.020 | 1.000 | 0.002 | 0.003 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.000 | 0.021 | 0.000 | 0.000 |
| IE | 0.014 | 0.480 | 0.000 | 0.039 | 0.031 | 0.000 | 0.007 | 0.060 | 0.000 | 0.004 | 0.000 | 0.011 | 0.000 | 0.009 |
| EL | 0.055 | 0.000 | 0.000 | 0.067 | 0.022 | 0.000 | 0.051 | 0.042 | 0.082 | 0.100 | 0.000 | 0.033 | 0.002 | 0.000 |
| ES | 0.134 | 0.000 | 0.000 | 0.290 | 0.205 | 0.124 | 0.236 | 0.447 | 0.174 | 0.953 | 0.000 | 0.169 | 0.003 | 0.148 |
| FR | 0.092 | 0.000 | 0.000 | 0.450 | 0.292 | 0.949 | 0.466 | 0.194 | 0.163 | 0.062 | 1.000 | 0.368 | 0.055 | 0.647 |
| HR | 0.006 | 0.000 | 0.000 | 0.018 | 0.017 | 0.000 | 0.054 | 0.007 | 0.001 | 0.004 | 0.000 | 0.033 | 0.002 | 0.005 |
| IT | 0.122 | 0.000 | 0.000 | 0.314 | 0.461 | 0.000 | 0.382 | 0.134 | 0.484 | 0.073 | 0.000 | 0.334 | 0.997 | 0.000 |
| CY | 0.000 | 0.000 | 0.000 | 0.012 | 0.000 | 0.000 | 0.000 | 0.002 | 0.003 | 0.026 | 0.000 | 0.001 | 0.000 | 0.000 |
| LV | 0.000 | 0.000 | 0.000 | 0.008 | 0.009 | 0.000 | 0.016 | 0.001 | 0.000 | 0.000 | 0.000 | 0.034 | 0.000 | 0.000 |
| LT | 0.002 | 0.013 | 0.000 | 0.014 | 0.017 | 0.000 | 0.003 | 0.007 | 0.002 | 0.000 | 0.000 | 0.033 | 0.000 | 0.000 |
| LU | 0.000 | 0.000 | 0.000 | 0.015 | 0.006 | 0.000 | 0.001 | 0.001 | 0.002 | 0.001 | 0.000 | 0.004 | 0.000 | 0.001 |
| HU | 0.023 | 0.000 | 0.000 | 0.039 | 0.062 | 0.033 | 0.002 | 0.006 | 0.003 | 0.004 | 0.000 | 0.070 | 0.019 | 0.000 |
| MT | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| NL | 0.108 | 0.000 | 0.000 | 0.168 | 0.239 | 0.008 | 0.001 | 0.068 | 0.023 | 0.010 | 0.000 | 0.068 | 0.011 | 0.047 |
| AT | 0.032 | 0.000 | 0.000 | 0.066 | 0.057 | 0.000 | 0.312 | 0.044 | 0.020 | 0.071 | 0.000 | 0.146 | 0.006 | 0.089 |
| PL | 0.478 | 0.000 | 0.000 | 0.133 | 0.115 | 0.000 | 0.015 | 0.098 | 0.001 | 0.017 | 0.000 | 0.194 | 0.004 | 0.017 |
| PT | 0.032 | 0.000 | 0.000 | 0.057 | 0.034 | 0.000 | 0.073 | 0.105 | 0.017 | 0.031 | 0.000 | 0.072 | 0.034 | 0.210 |
| RO | 0.058 | 0.005 | 0.000 | 0.048 | 0.074 | 0.024 | 0.140 | 0.064 | 0.042 | 0.000 | 0.000 | 0.093 | 0.005 | 0.000 |
| SI | 0.011 | 0.000 | 0.000 | 0.013 | 0.006 | 0.011 | 0.032 | 0.000 | 0.006 | 0.004 | 0.000 | 0.016 | 0.007 | 0.000 |
| SK | 0.032 | 0.000 | 0.000 | 0.017 | 0.032 | 0.034 | 0.032 | 0.000 | 0.011 | 0.002 | 0.000 | 0.030 | 0.001 | 0.000 |
| FI | 0.027 | 0.873 | 0.000 | 0.047 | 0.019 | 0.047 | 0.141 | 0.021 | 0.000 | 0.001 | 0.000 | 0.220 | 0.000 | 0.000 |
| SE | 0.020 | 0.085 | 0.000 | 0.053 | 0.006 | 0.129 | 0.632 | 0.148 | 0.002 | 0.004 | 0.000 | 0.279 | 0.000 | 0.497 |
| UK | 0.244 | 0.000 | 0.000 | 0.393 | 0.510 | 0.129 | 0.053 | 0.365 | 0.159 | 0.020 | 0.004 | 0.246 | 0.000 | 0.388 |

Source: own compilation.

**Table 3.** Energy consumption in EU countries in 2019—normalization data.

| Country | Energy Source | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Renewables | | | | | Renewables and Biofuels | | | | | | | | |
| | SFF | PPP | OS | OPP | NG | N | H | W | SP | ST | TWO | BRW | GEO | AH |
| | Min | Min | Min | Min | Min | Min | Max | Max | Max | Max | Max | Max | Max | Max |
| BE | 0.042 | 0.000 | 0.122 | 0.113 | 0.103 | 0.003 | 0.060 | 0.075 | 0.010 | 0.000 | 0.070 | 0.001 | 0.023 | 0.015 |
| BG | 0.072 | 0.002 | 0.026 | 0.018 | 0.039 | 0.026 | 0.008 | 0.025 | 0.010 | 0.000 | 0.042 | 0.006 | 0.023 | 0.026 |
| CZ | 0.195 | 0.000 | 0.055 | 0.053 | 0.071 | 0.018 | 0.004 | 0.041 | 0.007 | 0.000 | 0.099 | 0.000 | 0.044 | 0.038 |
| DK | 0.012 | 0.000 | 0.038 | 0.019 | 0.000 | 0.000 | 0.100 | 0.017 | 0.025 | 0.000 | 0.098 | 0.000 | 0.062 | 0.068 |
| DE | 0.737 | 0.000 | 0.609 | 0.561 | 0.175 | 0.174 | 0.776 | 0.820 | 0.268 | 0.000 | 0.619 | 0.061 | 0.273 | 0.316 |
| EE | 0.000 | 1.000 | 0.000 | 0.003 | 0.000 | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 |
| IE | 0.005 | 0.000 | 0.041 | 0.034 | 0.000 | 0.008 | 0.062 | 0.000 | 0.005 | 0.000 | 0.014 | 0.000 | 0.011 | 0.009 |
| EL | 0.071 | 0.000 | 0.065 | 0.033 | 0.000 | 0.035 | 0.045 | 0.078 | 0.105 | 0.000 | 0.027 | 0.002 | 0.075 | 0.000 |
| ES | 0.067 | 0.000 | 0.311 | 0.229 | 0.138 | 0.217 | 0.343 | 0.166 | 0.947 | 0.042 | 0.179 | 0.003 | 0.187 | 0.148 |
| FR | 0.101 | 0.000 | 0.428 | 0.278 | 0.944 | 0.501 | 0.214 | 0.216 | 0.069 | 0.999 | 0.375 | 0.085 | 0.592 | 0.647 |
| HR | 0.006 | 0.000 | 0.018 | 0.018 | 0.000 | 0.051 | 0.009 | 0.001 | 0.006 | 0.000 | 0.033 | 0.009 | 0.003 | 0.005 |
| IT | 0.089 | 0.000 | 0.299 | 0.452 | 0.000 | 0.408 | 0.125 | 0.418 | 0.084 | 0.000 | 0.317 | 0.993 | 0.541 | 0.000 |
| CY | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.027 | 0.000 | 0.002 | 0.000 | 0.011 | 0.000 |
| LV | 0.001 | 0.000 | 0.009 | 0.008 | 0.000 | 0.019 | 0.001 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 |
| LT | 0.002 | 0.000 | 0.017 | 0.014 | 0.000 | 0.003 | 0.009 | 0.002 | 0.000 | 0.000 | 0.032 | 0.000 | 0.006 | 0.000 |
| LU | 0.001 | 0.000 | 0.016 | 0.005 | 0.000 | 0.001 | 0.002 | 0.002 | 0.001 | 0.000 | 0.006 | 0.000 | 0.000 | 0.001 |
| HU | 0.025 | 0.000 | 0.045 | 0.063 | 0.037 | 0.002 | 0.004 | 0.026 | 0.005 | 0.000 | 0.057 | 0.029 | 0.003 | 0.000 |
| MT | 0.000 | 0.000 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.004 | 0.002 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 |
| NL | 0.088 | 0.000 | 0.166 | 0.238 | 0.008 | 0.001 | 0.071 | 0.094 | 0.011 | 0.000 | 0.083 | 0.024 | 0.056 | 0.047 |
| AT | 0.038 | 0.000 | 0.072 | 0.057 | 0.000 | 0.356 | 0.046 | 0.030 | 0.066 | 0.000 | 0.128 | 0.006 | 0.079 | 0.089 |
| PL | 0.600 | 0.000 | 0.173 | 0.125 | 0.000 | 0.017 | 0.093 | 0.013 | 0.026 | 0.000 | 0.187 | 0.005 | 0.055 | 0.017 |
| PT | 0.017 | 0.000 | 0.060 | 0.039 | 0.000 | 0.078 | 0.084 | 0.024 | 0.035 | 0.000 | 0.071 | 0.036 | 0.148 | 0.210 |
| RO | 0.067 | 0.000 | 0.054 | 0.068 | 0.026 | 0.137 | 0.042 | 0.031 | 0.000 | 0.000 | 0.091 | 0.007 | 0.000 | 0.000 |
| SI | 0.015 | 0.000 | 0.013 | 0.005 | 0.012 | 0.039 | 0.000 | 0.005 | 0.004 | 0.000 | 0.015 | 0.003 | 0.009 | 0.000 |
| SK | 0.037 | 0.000 | 0.020 | 0.030 | 0.037 | 0.038 | 0.000 | 0.010 | 0.003 | 0.000 | 0.040 | 0.002 | 0.009 | 0.000 |
| FI | 0.029 | 0.000 | 0.047 | 0.016 | 0.052 | 0.109 | 0.037 | 0.003 | 0.001 | 0.000 | 0.233 | 0.000 | 0.130 | 0.000 |
| SE | 0.025 | 0.000 | 0.059 | 0.007 | 0.147 | 0.575 | 0.122 | 0.012 | 0.004 | 0.000 | 0.285 | 0.000 | 0.354 | 0.497 |
| UK | 0.080 | 0.000 | 0.395 | 0.496 | 0.120 | 0.052 | 0.397 | 0.228 | 0.020 | 0.029 | 0.318 | 0.000 | 0.241 | 0.388 |

Source: own compilation.

**Table 4.** Relations of a selected part of MULTIMOORA procedure-related management of renewable energy consumption in EU countries (2015 vs. 2019).

| Country | | 2015 | | | 2019 | | |
|---|---|---|---|---|---|---|---|
| | | RS | RP | FMF | RS | RF | FMF |
| Austria | AT | 0.532 | 0.065 | 0.018 | −0.079 | 0.356 | 0.000 |
| Belgium | BE | −0.122 | 0.128 | 0.000 | −0.128 | 0.121 | 0.000 |
| Bulgaria | BG | 0.017 | 0.065 | 0.000 | −0.042 | 0.072 | 0.000 |
| Croatia | HR | 0.064 | 0.017 | 0.000 | −0.027 | 0.051 | 0.000 |
| Cyprus | CY | 0.021 | 0.010 | 0.000 | 0.032 | 0.013 | 0.000 |
| Czechia | CZ | −0.115 | 0.162 | 0.000 | −0.159 | 0.195 | 0.000 |
| Denmark | DK | 0.233 | 0.035 | 0.000 | 0.300 | 0.038 | 0.000 |
| Estonia | EE | −0.998 | 1.000 | 0.568 | −0.972 | 1.000 | 0.000 |
| Finland | FI | −0.629 | 0.873 | 0.000 | 0.150 | 0.109 | 0.000 |
| France | FR | 1.173 | 0.949 | 0.000 | 0.945 | 0.944 | 0.000 |
| Germany | DE | 0.837 | 0.785 | 0.000 | 0.879 | 0.737 | 0.000 |
| Greece | EL | 0.165 | 0.065 | 0.000 | 0.127 | 0.071 | 0.000 |
| Hungary | HU | −0.053 | 0.062 | 0.000 | −0.048 | 0.063 | 0.000 |
| Ireland | IE | −0.473 | 0.480 | 0.000 | 0.014 | 0.041 | 0.000 |

**Table 4.** *Cont.*

| Country | | 2015 | | | 2019 | | |
|---|---|---|---|---|---|---|---|
| | | RS | RP | FMF | RS | RF | FMF |
| Italy | IT | 1.508 | 0.461 | 0.004 | 1.231 | 0.452 | 0.002 |
| Latvia | LV | 0.033 | 0.009 | 0.003 | 0.003 | 0.019 | 0.000 |
| Lithuania | LT | −0.001 | 0.017 | 0.000 | 0.013 | 0.016 | 0.047 |
| Luxembourg | LU | −0.011 | 0.013 | 0.000 | −0.010 | 0.016 | 0.000 |
| Malta | MT | 0.000 | 0.002 | 0.000 | 0.004 | 0.002 | 0.000 |
| Netherlands | NL | −0.294 | 0.239 | 0.000 | −0.114 | 0.238 | 0.000 |
| Poland | PL | −0.378 | 0.478 | 0.000 | −0.521 | 0.600 | 0.000 |
| Portugal | PT | 0.418 | 0.055 | 0.000 | 0.414 | 0.078 | 0.000 |
| Romania | RO | 0.134 | 0.074 | 0.000 | −0.181 | 0.137 | 0.000 |
| Slovakia | SK | −0.039 | 0.034 | 0.000 | −0.099 | 0.038 | 0.000 |
| Slovenia | SI | 0.026 | 0.011 | 0.000 | −0.049 | 0.039 | 0.000 |
| Spain | ES | 1.377 | 0.289 | 0.000 | 1.054 | 0.311 | 0.000 |
| Sweden | SE | 1.270 | 0.129 | 0.000 | 0.460 | 0.575 | 0.000 |
| United Kingdom | UK | −0.042 | 0.510 | 0.000 | 0.477 | 0.496 | 0.000 |

Source: own compilation. The ratio system (RS), The reference point (RP), Full multiplicative form of multiple objectives (FMF).

Finally, in Table 5, we present the results of our original rating of the management of renewable energy consumption in EU countries (2015 vs. 2019).

We calculated the original rankings based on the MULTIMOORA method to assess the changes in the management of renewable energy consumption in EU countries in the period 2015–2019 (RQ1). As shown by the results of our analysis, out of 28 countries, 14 improved their starting position in their ranking, two countries did not change their position, and in the case of 12 countries, their ranking deteriorated. Italy (ranked #1 in both rankings), Germany (ranked #2 in both rankings), France (ranked #3 in 2015 and ranked #4 in 2019), and Sweden (ranked #5 in 2015 and ranked #3 in 2019) were the highest ranked countries. The countries that improved their ranking the most over the five-year period were the United Kingdom and the Netherlands (improved their ranking by nine positions), Denmark (improved their ranking by five positions), and Finland and Poland (improved their ranking by four positions). The observed changes in this group of countries indicate that the consumption of energy from non-renewable sources reduced during the period under study. On the contrary, the countries with the worse rankings over five-year period were Romania (down 16 positions), Latvia (down nine positions), and Austria (down six positions). The observed changes in this group of countries indicate that not only was the consumption of non-renewable energy sources not reduced in the period in question, but it actually increased. Thus, the actions taken by these countries in the field of energy consumption management did not bring them closer to achieving the adopted assumptions of the energy union.

The results of our analysis allowed us to identify the changes that occurred in the management of renewable energy consumption in EU countries in the period 2015–2019 (see RQ1). In particular, we identified those countries in which the approach to energy consumption management has reduced their consumption from non-renewable sources and those countries in which the currently implemented energy consumption management policy has not brought about tangible changes in this respect. Moreover, the assessment of changes in the position of a given country in the developed rankings allowed us to determine how strong the changes in energy consumption management in that country have been in comparison to other European Union countries.

**Table 5.** MULTIMOORA ranking of management of renewable energy consumption in EU countries 2015. vs. 2019.

| **Country** | | **Ranking 2015** | | | | | **Ranking 2019** | | | | | **Rating Change 2015 vs. 2019 *** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **RS** | **RP** | **FMF** | **Ranking Sum** | **Final Rank** | **RS** | **RP** | **FMF** | **Ranking Sum** | **Final Rank** | |
| Austria | AT | 6 | 17 | 2 | 25 | **6** | 21 | 8 | 11 | 40 | **12** | **−6** |
| Belgium | BE | 23 | 13 | 26 | 62 | **25** | 24 | 13 | 21 | 58 | **22** | **+3** |
| Bulgaria | BG | 15 | 15 | 16 | 46 | **13** | 18 | 16 | 10 | 44 | **15** | **−2** |
| Croatia | HR | 11 | 22 | 20 | 53 | **18** | 17 | 19 | 23 | 59 | **23** | **−5** |
| Cyprus | CY | 14 | 26 | 12 | 52 | **17** | 11 | 27 | 18 | 56 | **21** | **−4** |
| Czechia | CZ | 22 | 11 | 15 | 48 | **15** | 25 | 11 | 17 | 53 | **19** | **−4** |
| Denmark | DK | 8 | 20 | 18 | 46 | **14** | 8 | 23 | 5 | 36 | **9** | **+5** |
| Estonia | EE | 28 | 1 | 1 | 30 | **7** | 28 | 1 | 1 | 30 | **6** | **+1** |
| Finland | FI | 27 | 3 | 14 | 44 | **12** | 9 | 14 | 12 | 35 | **8** | **+4** |
| France | FR | 4 | 2 | 13 | 19 | **3** | 3 | 2 | 13 | 18 | **4** | **−1** |
| Germany | DE | 5 | 4 | 7 | 16 | **2** | 4 | 3 | 7 | 14 | **2** | – |
| Greece | EL | 9 | 16 | 10 | 35 | **9** | 10 | 17 | 9 | 36 | **10** | **−1** |
| Hungary | HU | 21 | 18 | 19 | 58 | **24** | 19 | 18 | 15 | 52 | **18** | **+6** |
| Ireland | IE | 26 | 6 | 21 | 53 | **19** | 12 | 20 | 16 | 48 | **16** | **+3** |
| Italy | IT | 1 | 8 | 3 | 12 | **1** | 1 | 7 | 3 | 11 | **1** | – |
| Latvia | LV | 12 | 27 | 4 | 43 | **11** | 15 | 24 | 14 | 53 | **20** | **−9** |
| Lithuania | LT | 17 | 23 | 9 | 49 | **16** | 13 | 25 | 2 | 40 | **13** | **+3** |
| Luxembourg | LU | 18 | 24 | 24 | 66 | **26** | 16 | 26 | 22 | 64 | **24** | **+2** |
| Malta | MT | 16 | 28 | 25 | 69 | **28** | 14 | 28 | 27 | 69 | **27** | **+1** |
| Netherlands | NL | 24 | 10 | 22 | 56 | **23** | 23 | 10 | 8 | 41 | **14** | **+9** |
| Poland | PL | 25 | 7 | 23 | 55 | **21** | 27 | 4 | 19 | 50 | **17** | **+4** |
| Portugal | PT | 7 | 19 | 6 | 32 | **8** | 7 | 15 | 6 | 28 | **5** | **+3** |
| Romania | RO | 10 | 14 | 11 | 35 | **10** | 26 | 12 | 28 | 66 | **26** | **−16** |
| Slovakia | SK | 19 | 21 | 27 | 67 | **27** | 22 | 22 | 26 | 70 | **28** | **−1** |
| Slovenia | SI | 13 | 25 | 17 | 55 | **22** | 20 | 21 | 24 | 65 | **25** | **−3** |
| Spain | ES | 2 | 9 | 8 | 19 | **4** | 2 | 9 | 20 | 31 | **7** | **−3** |
| Sweden | SE | 3 | 12 | 5 | 20 | **5** | 6 | 5 | 4 | 15 | **3** | **+2** |
| United Kingdom | UK | 20 | 5 | 28 | 53 | **20** | 5 | 6 | 25 | 36 | **11** | **+9** |

* Green—improvement in the ranking of management of renewable energy consumption 2015 vs. 2019; orange—drop in the ranking of management of renewable energy consumption 2015 vs. 2019. Source: own compilation. The ratio system (RS), The reference point (RP), Full multiplicative form of multiple objectives (FMF).

### *4.2. Energy Consumption by Source vs. Innovativeness Indicators in EU Countries*

The observed changes in the management of energy consumption over the five-year period (2015–2019) led us to ask the question: Are there significant relationships between energy consumption by source and innovation evaluation indicators? In the theoretical background of our research, we indicated that innovativeness is the crucial element for the development of economies, including in the field of energy management. For this purpose, we conducted a correlation analysis between energy consumption by source and key innovation indicators according to the European Innovation Scoreboard. This section presents the results of this correlation analysis. We used data for 2018–2019 to identify the relationships (the latest available data for all variables concerned). The initial data were normalized according to the MULTIMOORA method procedure described in Section 3. The results are presented in Tables 3 and 6 for data on energy consumption by source and in Tables 7 and 8 for key innovation indicators according to the European Innovation Scoreboard.

**Table 6.** Energy consumption in EU countries in 2018—normalization data.

| Country | Energy Source | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Renewables | | | | | | Renewables and Biofuels | | | | | | | |
| | SFF | PPP | OS | OPP | NG | N | H | W | SP | ST | TWO | BRW | GEO | AH |
| | Min | Min | Min | Min | Min | Min | Max | Max | Max | Max | Max | Max | Max | Max |
| BE | 0.034 | 0.000 | 0.000 | 0.126 | 0.113 | 0.066 | 0.003 | 0.052 | 0.071 | 0.011 | 0.000 | 0.074 | 0.001 | 0.014 |
| BG | 0.063 | 0.000 | 0.000 | 0.025 | 0.020 | 0.037 | 0.043 | 0.009 | 0.024 | 0.010 | 0.000 | 0.041 | 0.006 | 0.021 |
| CZ | 0.175 | 0.000 | 0.000 | 0.054 | 0.052 | 0.066 | 0.014 | 0.004 | 0.043 | 0.009 | 0.000 | 0.095 | 0.000 | 0.039 |
| DK | 0.019 | 0.000 | 0.000 | 0.039 | 0.020 | 0.000 | 0.000 | 0.098 | 0.017 | 0.027 | 0.000 | 0.103 | 0.000 | 0.057 |
| DE | 0.775 | 0.000 | 0.000 | 0.600 | 0.557 | 0.173 | 0.150 | 0.773 | 0.835 | 0.317 | 0.000 | 0.620 | 0.052 | 0.263 |
| EE | 0.000 | 0.018 | 1.000 | 0.001 | 0.003 | 0.000 | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 |
| IE | 0.008 | 0.377 | 0.000 | 0.041 | 0.034 | 0.000 | 0.006 | 0.061 | 0.000 | 0.006 | 0.000 | 0.015 | 0.000 | 0.010 |
| EL | 0.051 | 0.000 | 0.000 | 0.063 | 0.031 | 0.000 | 0.048 | 0.044 | 0.069 | 0.115 | 0.000 | 0.028 | 0.002 | 0.073 |
| ES | 0.128 | 0.000 | 0.000 | 0.318 | 0.205 | 0.128 | 0.287 | 0.358 | 0.144 | 0.928 | 0.000 | 0.184 | 0.003 | 0.168 |
| FR | 0.101 | 0.000 | 0.000 | 0.425 | 0.278 | 0.949 | 0.547 | 0.201 | 0.193 | 0.075 | 1.000 | 0.382 | 0.082 | 0.549 |
| HR | 0.004 | 0.000 | 0.000 | 0.019 | 0.017 | 0.000 | 0.064 | 0.009 | 0.001 | 0.006 | 0.000 | 0.033 | 0.002 | 0.003 |
| IT | 0.095 | 0.000 | 0.000 | 0.303 | 0.451 | 0.000 | 0.408 | 0.125 | 0.413 | 0.091 | 0.000 | 0.320 | 0.994 | 0.588 |
| CY | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.030 | 0.000 | 0.002 | 0.000 | 0.010 |
| LV | 0.001 | 0.002 | 0.000 | 0.009 | 0.009 | 0.000 | 0.020 | 0.001 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 |
| LT | 0.002 | 0.023 | 0.000 | 0.017 | 0.013 | 0.000 | 0.004 | 0.008 | 0.002 | 0.000 | 0.000 | 0.033 | 0.000 | 0.006 |
| LU | 0.000 | 0.000 | 0.000 | 0.016 | 0.005 | 0.000 | 0.001 | 0.002 | 0.002 | 0.001 | 0.000 | 0.006 | 0.000 | 0.001 |
| HU | 0.024 | 0.000 | 0.000 | 0.045 | 0.063 | 0.035 | 0.002 | 0.004 | 0.011 | 0.005 | 0.000 | 0.060 | 0.026 | 0.002 |
| MT | 0.000 | 0.000 | 0.000 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.003 |
| NL | 0.091 | 0.000 | 0.000 | 0.176 | 0.233 | 0.007 | 0.001 | 0.074 | 0.067 | 0.011 | 0.000 | 0.073 | 0.016 | 0.049 |
| AT | 0.030 | 0.000 | 0.000 | 0.069 | 0.056 | 0.000 | 0.315 | 0.042 | 0.026 | 0.075 | 0.000 | 0.132 | 0.007 | 0.076 |
| PL | 0.548 | 0.000 | 0.000 | 0.170 | 0.122 | 0.000 | 0.016 | 0.090 | 0.005 | 0.024 | 0.000 | 0.183 | 0.004 | 0.014 |
| PT | 0.030 | 0.000 | 0.000 | 0.056 | 0.038 | 0.000 | 0.104 | 0.089 | 0.018 | 0.039 | 0.000 | 0.071 | 0.039 | 0.147 |
| RO | 0.056 | 0.009 | 0.000 | 0.054 | 0.075 | 0.025 | 0.148 | 0.044 | 0.032 | 0.000 | 0.000 | 0.091 | 0.007 | 0.000 |
| SI | 0.013 | 0.000 | 0.000 | 0.014 | 0.005 | 0.012 | 0.039 | 0.000 | 0.005 | 0.005 | 0.000 | 0.015 | 0.009 | 0.000 |
| SK | 0.037 | 0.000 | 0.000 | 0.021 | 0.031 | 0.033 | 0.030 | 0.000 | 0.011 | 0.003 | 0.000 | 0.029 | 0.002 | 0.000 |
| FI | 0.031 | 0.918 | 0.000 | 0.049 | 0.016 | 0.048 | 0.111 | 0.041 | 0.002 | 0.001 | 0.000 | 0.236 | 0.000 | 0.129 |
| SE | 0.022 | 0.118 | 0.000 | 0.061 | 0.008 | 0.148 | 0.521 | 0.117 | 0.007 | 0.005 | 0.000 | 0.287 | 0.000 | 0.370 |
| UK | 0.090 | 0.000 | 0.000 | 0.400 | 0.513 | 0.124 | 0.046 | 0.400 | 0.234 | 0.022 | 0.019 | 0.298 | 0.000 | 0.246 |

Source: own compilation.

**Table 7.** Key innovation indicators 2018—EU countries—normalization data.

| Country | Composite Indicators of Innovation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SII | Framework Conditions | | | Investments | | Innovation Activities | | | Impacts | |
| | | HR | RS | IFE | FS | FI | I | L | IA | EI | SI |
| BE | 0.238 | 0.289 | 0.173 | 0.231 | 0.262 | 0.308 | 0.245 | 0.180 | 0.141 | 0.248 | 0.231 |
| BG | 0.089 | 0.037 | 0.080 | 0.034 | 0.084 | 0.055 | 0.050 | 0.159 | 0.210 | 0.096 | 0.090 |
| CZ | 0.165 | 0.114 | 0.131 | 0.105 | 0.201 | 0.200 | 0.134 | 0.137 | 0.229 | 0.228 | 0.213 |
| DK | 0.261 | 0.333 | 0.380 | 0.245 | 0.223 | 0.200 | 0.218 | 0.292 | 0.192 | 0.177 | 0.165 |
| DE | 0.235 | 0.153 | 0.181 | 0.231 | 0.308 | 0.282 | 0.204 | 0.268 | 0.185 | 0.295 | 0.275 |
| EE | 0.192 | 0.169 | 0.164 | 0.195 | 0.191 | 0.219 | 0.190 | 0.250 | 0.121 | 0.159 | 0.148 |
| IE | 0.220 | 0.238 | 0.165 | 0.156 | 0.190 | 0.274 | 0.124 | 0.121 | 0.345 | 0.313 | 0.292 |
| EL | 0.150 | 0.106 | 0.053 | 0.100 | 0.138 | 0.302 | 0.176 | 0.085 | 0.158 | 0.160 | 0.149 |
| ES | 0.157 | 0.147 | 0.175 | 0.166 | 0.134 | 0.094 | 0.096 | 0.152 | 0.177 | 0.206 | 0.192 |
| FR | 0.208 | 0.209 | 0.173 | 0.290 | 0.174 | 0.263 | 0.151 | 0.174 | 0.166 | 0.217 | 0.202 |
| HR | 0.112 | 0.074 | 0.059 | 0.067 | 0.199 | 0.198 | 0.107 | 0.076 | 0.113 | 0.087 | 0.081 |
| IT | 0.156 | 0.155 | 0.111 | 0.114 | 0.150 | 0.269 | 0.078 | 0.203 | 0.135 | 0.202 | 0.188 |
| CY | 0.158 | 0.188 | 0.092 | 0.057 | 0.149 | 0.170 | 0.080 | 0.201 | 0.131 | 0.253 | 0.236 |
| LV | 0.121 | 0.071 | 0.159 | 0.223 | 0.095 | 0.082 | 0.079 | 0.116 | 0.179 | 0.132 | 0.124 |
| LT | 0.149 | 0.064 | 0.202 | 0.124 | 0.161 | 0.228 | 0.169 | 0.111 | 0.073 | 0.133 | 0.124 |
| LU | 0.241 | 0.361 | 0.246 | 0.263 | 0.139 | 0.292 | 0.116 | 0.290 | 0.259 | 0.197 | 0.184 |

**Table 7.** *Cont.*

| Country | Composite Indicators of Innovation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SII | Framework Conditions | | | Investments | | Innovation Activities | | | Impacts | |
| | | HR | RS | IFE | FS | FI | I | L | IA | EI | SI |
| HU | 0.128 | 0.088 | 0.151 | 0.093 | 0.172 | 0.070 | 0.089 | 0.102 | 0.252 | 0.201 | 0.188 |
| MT | 0.165 | 0.101 | 0.213 | 0.190 | 0.180 | 0.123 | 0.030 | 0.325 | 0.294 | 0.149 | 0.139 |
| NL | 0.247 | 0.313 | 0.285 | 0.272 | 0.149 | 0.259 | 0.226 | 0.228 | 0.218 | 0.227 | 0.212 |
| AT | 0.230 | 0.235 | 0.145 | 0.185 | 0.244 | 0.311 | 0.257 | 0.271 | 0.119 | 0.203 | 0.189 |
| PL | 0.109 | 0.050 | 0.195 | 0.079 | 0.154 | 0.033 | 0.054 | 0.142 | 0.176 | 0.132 | 0.123 |
| PT | 0.181 | 0.189 | 0.225 | 0.165 | 0.172 | 0.360 | 0.092 | 0.156 | 0.147 | 0.131 | 0.122 |
| RO | 0.060 | 0.039 | 0.121 | 0.058 | 0.013 | 0.000 | 0.064 | 0.056 | 0.082 | 0.148 | 0.138 |
| SI | 0.171 | 0.149 | 0.150 | 0.064 | 0.227 | 0.141 | 0.166 | 0.170 | 0.153 | 0.162 | 0.151 |
| SK | 0.128 | 0.072 | 0.089 | 0.053 | 0.140 | 0.086 | 0.094 | 0.096 | 0.209 | 0.274 | 0.256 |
| FI | 0.266 | 0.242 | 0.308 | 0.249 | 0.277 | 0.353 | 0.243 | 0.256 | 0.149 | 0.216 | 0.201 |
| SE | 0.273 | 0.303 | 0.364 | 0.243 | 0.265 | 0.238 | 0.230 | 0.262 | 0.263 | 0.216 | 0.202 |
| UK | 0.236 | 0.291 | 0.166 | 0.236 | 0.206 | 0.217 | 0.202 | 0.168 | 0.284 | 0.277 | 0.258 |

Source: own compilation.

**Table 8.** Key innovation indicators 2019—EU countries—normalization data.

| Country | Composite Indicators of Innovation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SII | Framework Conditions | | | Investments | | Innovation Activities | | | Impacts | |
| | | HR | RS | IFE | FS | FI | I | L | IA | EI | SI |
| BE | 0.234 | 0.276 | 0.179 | 0.215 | 0.251 | 0.297 | 0.241 | 0.173 | 0.169 | 0.239 | 0.236 |
| BG | 0.088 | 0.043 | 0.084 | 0.022 | 0.084 | 0.053 | 0.051 | 0.164 | 0.212 | 0.093 | 0.091 |
| CZ | 0.163 | 0.121 | 0.138 | 0.110 | 0.192 | 0.193 | 0.133 | 0.109 | 0.263 | 0.218 | 0.215 |
| DK | 0.260 | 0.325 | 0.373 | 0.276 | 0.221 | 0.193 | 0.221 | 0.290 | 0.209 | 0.170 | 0.167 |
| DE | 0.231 | 0.152 | 0.192 | 0.227 | 0.300 | 0.272 | 0.200 | 0.253 | 0.201 | 0.274 | 0.270 |
| EE | 0.191 | 0.176 | 0.156 | 0.172 | 0.195 | 0.212 | 0.191 | 0.238 | 0.140 | 0.153 | 0.151 |
| IE | 0.216 | 0.247 | 0.169 | 0.136 | 0.180 | 0.264 | 0.120 | 0.113 | 0.355 | 0.296 | 0.292 |
| EL | 0.148 | 0.113 | 0.087 | 0.101 | 0.135 | 0.291 | 0.186 | 0.083 | 0.101 | 0.156 | 0.153 |
| ES | 0.164 | 0.152 | 0.223 | 0.148 | 0.132 | 0.091 | 0.097 | 0.148 | 0.203 | 0.193 | 0.190 |
| FR | 0.202 | 0.204 | 0.162 | 0.261 | 0.172 | 0.254 | 0.148 | 0.167 | 0.164 | 0.204 | 0.201 |
| HR | 0.114 | 0.073 | 0.081 | 0.074 | 0.186 | 0.191 | 0.097 | 0.069 | 0.143 | 0.088 | 0.087 |
| IT | 0.160 | 0.161 | 0.137 | 0.107 | 0.150 | 0.260 | 0.099 | 0.203 | 0.154 | 0.185 | 0.182 |
| CY | 0.172 | 0.210 | 0.159 | 0.143 | 0.160 | 0.164 | 0.088 | 0.207 | 0.133 | 0.227 | 0.223 |
| LV | 0.122 | 0.076 | 0.156 | 0.208 | 0.117 | 0.079 | 0.081 | 0.125 | 0.177 | 0.117 | 0.115 |
| LT | 0.154 | 0.078 | 0.212 | 0.160 | 0.160 | 0.220 | 0.156 | 0.111 | 0.114 | 0.122 | 0.121 |
| LU | 0.243 | 0.341 | 0.267 | 0.201 | 0.129 | 0.282 | 0.129 | 0.298 | 0.334 | 0.195 | 0.192 |
| HU | 0.128 | 0.097 | 0.163 | 0.088 | 0.168 | 0.068 | 0.087 | 0.094 | 0.265 | 0.195 | 0.192 |
| MT | 0.162 | 0.127 | 0.264 | 0.176 | 0.167 | 0.118 | 0.024 | 0.272 | 0.330 | 0.136 | 0.134 |
| NL | 0.247 | 0.319 | 0.317 | 0.228 | 0.155 | 0.250 | 0.228 | 0.222 | 0.245 | 0.216 | 0.212 |
| AT | 0.227 | 0.243 | 0.148 | 0.180 | 0.201 | 0.301 | 0.269 | 0.267 | 0.133 | 0.193 | 0.190 |
| PL | 0.114 | 0.053 | 0.239 | 0.077 | 0.152 | 0.032 | 0.058 | 0.139 | 0.187 | 0.128 | 0.126 |
| PT | 0.187 | 0.195 | 0.257 | 0.158 | 0.197 | 0.348 | 0.093 | 0.150 | 0.170 | 0.128 | 0.126 |
| RO | 0.061 | 0.047 | 0.128 | 0.079 | 0.017 | 0.000 | 0.058 | 0.050 | 0.080 | 0.143 | 0.141 |
| SI | 0.164 | 0.146 | 0.162 | 0.060 | 0.213 | 0.137 | 0.166 | 0.173 | 0.186 | 0.156 | 0.154 |
| SK | 0.129 | 0.082 | 0.099 | 0.046 | 0.131 | 0.083 | 0.090 | 0.084 | 0.248 | 0.263 | 0.259 |
| FI | 0.270 | 0.251 | 0.364 | 0.261 | 0.267 | 0.341 | 0.240 | 0.251 | 0.165 | 0.207 | 0.204 |
| SE | 0.272 | 0.305 | 0.351 | 0.232 | 0.277 | 0.230 | 0.222 | 0.259 | 0.296 | 0.205 | 0.202 |
| UK | 0.233 | 0.290 | 0.184 | 0.223 | 0.202 | 0.209 | 0.200 | 0.160 | 0.291 | 0.259 | 0.255 |

Source: own compilation.

The normalized data were subjected to correlation analysis to identify any potential relationships between energy consumption by source and innovation evaluation indicators. The analysis confirmed the existence of relationships between these groups with respect to the selected variables (Table 9). We used correlation analysis to detect significant relationships. Pearson correlation coefficients were determined as a measure of the strength of a linear association between our selected variables. Consistent with Haldun's paper [78], we adopted the following interpretation of the coefficient values when discussing the results of our analysis later in our paper:

- Zero strength of association: 0;
- Negligible strength of association: 0.1 or (−0.1);
- Weak strength of association: 0.2 or (−0.2);
- Moderate strength of association: 0.3 or (−0.3);
- Strong strength of association: [0.4–0.6] or [(−0.4)–(−0.6)];
- Very strong strength of association: [0.7–0.9] or [(−0.7)–(−0.9)];
- Perfect strength of association: 1.0 or (−1.0).

**Table 9.** Energy consumption by source vs. innovativeness indicators in EU countries—correlation matrix (Pearson's correlation coefficient).

| | | Composite Indicators of Innovation | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SII | Framework Conditions | | | Investments | | Innovation Activities | | | Impacts | |
| | | | HR | RS | IFE | FS | FI | I | L | IA | EI | SI |
| Energy source | SFF | 0.030 | −0.150 | 0.004 | 0.052 | 0.268 * | −0.045 | 0.030 | 0.080 | 0.017 | 0.242 | 0.245 |
| | Sig.(2-tailed) | 0.824 | 0.270 | 0.978 | 0.706 | 0.045 | 0.740 | 0.826 | 0.559 | 0.904 | 0.072 | 0.068 |
| | PPP | 0.359 ** | 0.223 | 0.346 ** | 0.234 | 0.320 * | 0.339 * | 0.266 * | 0.137 | 0.112 | 0.244 | 0.246 |
| | Sig.(2-tailed) | 0.007 | 0.098 | 0.009 | 0.083 | 0.016 | 0.011 | 0.047 | 0.313 | 0.411 | 0.069 | 0.067 |
| | OS | 0.038 | −0.001 | −0.061 | 0.066 | 0.052 | 0.035 | 0.141 | 0.180 | −0.176 | −0.115 | −0.116 |
| | Sig.(2-tailed) | 0.780 | 0.993 | 0.654 | 0.627 | 0.703 | 0.797 | 0.299 | 0.185 | 0.194 | 0.397 | 0.395 |
| | OPP | 0.254 | 0.149 | −0.004 | 0.357 ** | 0.269 * | 0.195 | 0.195 | 0.125 | 0.020 | 0.435 ** | 0.436 ** |
| | Sig.(2-tailed) | 0.059 | 0.275 | 0.978 | 0.007 | 0.045 | 0.150 | 0.150 | 0.358 | 0.885 | 0.001 | 0.001 |
| | NG | 0.212 | 0.153 | −0.051 | 0.276 * | 0.200 | 0.173 | 0.167 | 0.102 | 0.054 | 0.438 ** | 0.440 ** |
| | Sig.(2-tailed) | 0.116 | 0.259 | 0.708 | 0.040 | 0.139 | 0.202 | 0.217 | 0.454 | 0.692 | 0.001 | 0.001 |
| | N | 0.170 | 0.112 | 0.004 | 0.371 ** | 0.112 | 0.127 | 0.104 | 0.019 | −0.009 | 0.205 | 0.206 |
| | Sig.(2-tailed) | 0.211 | 0.411 | 0.979 | 0.005 | 0.413 | 0.351 | 0.447 | 0.892 | 0.948 | 0.130 | 0.128 |
| | H | 0.231 | 0.177 | 0.134 | 0.263 | 0.186 | 0.212 | 0.198 | 0.192 | −0.097 | 0.117 | 0.117 |
| | Sig.(2-tailed) | 0.087 | 0.192 | 0.325 | 0.050 | 0.170 | 0.117 | 0.143 | 0.155 | 0.476 | 0.392 | 0.391 |
| | W | 0.291 * | 0.147 | 0.113 | 0.341 * | 0.357 ** | 0.143 | 0.216 | 0.185 | 0.088 | 0.422 ** | 0.424 ** |
| | Sig.(2-tailed) | 0.030 | 0.280 | 0.406 | 0.010 | 0.007 | 0.294 | 0.109 | 0.173 | 0.519 | 0.001 | 0.001 |
| | SP | 0.163 | 0.007 | −0.100 | 0.190 | 0.302 * | 0.218 | 0.131 | 0.181 | −0.052 | 0.377 ** | 0.377 ** |
| | Sig.(2-tailed) | 0.230 | 0.957 | 0.463 | 0.160 | 0.024 | 0.107 | 0.337 | 0.181 | 0.702 | 0.004 | 0.004 |
| | ST | −0.008 | −0.050 | −0.013 | 0.051 | −0.024 | −0.095 | −0.053 | −0.007 | −0.059 | 0.131 | 0.130 |
| | Sig.(2-tailed) | 0.953 | 0.716 | 0.926 | 0.711 | 0.863 | 0.487 | 0.699 | 0.960 | 0.667 | 0.337 | 0.341 |
| | TWO | 0.086 | 0.072 | −0.044 | 0.307 * | −0.011 | 0.121 | 0.024 | −0.019 | −0.075 | 0.076 | 0.076 |
| | Sig.(2-tailed) | 0.527 | 0.597 | 0.748 | 0.021 | 0.937 | 0.376 | 0.862 | 0.892 | 0.580 | 0.577 | 0.576 |
| | BRW | 0.341 * | 0.151 | 0.177 | 0.395 ** | 0.454 ** | 0.250 | 0.297 * | 0.263 * | −0.022 | 0.381 ** | 0.382 ** |
| | Sig.(2-tailed) | 0.010 | 0.268 | 0.192 | 0.003 | 0.000 | 0.063 | 0.026 | 0.050 | 0.874 | 0.004 | 0.004 |
| | GEO | −0.068 | −0.031 | −0.147 | −0.101 | −0.074 | 0.151 | −0.151 | 0.071 | −0.146 | 0.025 | 0.024 |
| | Sig.(2-tailed) | 0.618 | 0.821 | 0.279 | 0.458 | 0.589 | 0.267 | 0.267 | 0.604 | 0.284 | 0.854 | 0.858 |
| | AH | 0.353 ** | 0.285 * | 0.169 | 0.424 ** | 0.297 * | 0.300 * | 0.216 | 0.198 | 0.075 | 0.272 * | 0.271 * |
| | Sig.(2-tailed) | 0.008 | 0.034 | 0.213 | 0.001 | 0.026 | 0.025 | 0.110 | 0.143 | 0.585 | 0.043 | 0.044 |

* correlation is significant at the 0.05 level (two-tailed test); ** correlation is significant at the 0.01 level (two-tailed test); N = 56. Source: own compilation.

We identified 37 statistically significant relationships between the type of energy consumption source and the innovativeness determinants. Of these, 19 correlations were statistically significant at the 0.01 level. All the identified relationships were positive (range from 0 to 1). Most of them were moderate (0.3) or strong (0.4–0.6) relationships.

As our study indicates, the consumption of energy from renewable sources such as wind, biofuel and renewable waste, and ambient heat pumps was dependent on the level of innovativeness of the country (in our study, measured by the SII). In the group of non-renewable energy sources, such regularity was identified only in relation to peat and peat products. Biofuels and renewable waste, ambient heat pumps, and wind were the sources of energy with the most correlations with the indicators of innovation (BRW-7, AH-7, and W-5). Biofuels and renewable waste were the only sources of energy in relation to which the correlations with all group of innovativeness indicators have been identified. Ambient heat pumps were the source of renewable energy in relation to which correlations with all group of innovativeness indicators were identified, excluding factors included in the "innovation activities" (IA) group. Similar relationships were identified for the non-renewable energy sources of peat and peat products. The strongest correlation was identified between the "finance and support" indicator (from the innovation factors group, subsection "investment") and the renewable sources of biofuels and renewable waste. "Finance and support" and "innovation friendly environment" were indicators (components of the country's innovativeness level score) for which correlations with energy consumption from seven sources (out of 14 analyzed) were identified. Among the four subgroups of innovation performance indicators (framework conditions, investments, innovation activities, and impact), the highest number of correlations ($n$ = 12) was identified in the "impact" group. This group of subcriteria of innovation performance illustrates how innovation translates into benefits for the economy as a whole: Employment impacts and sales effects. Thus, we can conclude that changes in the consumption of energy from renewable sources such as wind, solar photovoltaic, biofuels and renewable waste, and ambient heat pumps have a direct impact on the level of benefits in the area of employment impacts and sales effects, which, among other things, captures the country's ability to quickly transform the economy to respond to new needs and to take advantage of emerging demand. Among non-renewable energy sources, similar correctness was found for natural gas and oil and petroleum products. A single relationship was found between the energy source and the level of collaboration between innovative firms, including research collaboration between the private and public sectors and the extent to which the private sector funds public R&D (only for biofuels and renewable waste). Furthermore, a relationship was found between the availability of a high-skilled and educated workforce and energy consumption from ambient heat pumps and between the international competitiveness of the science base and the energy consumption from peat and peat products. Interestingly, no relationship was found between intellectual assets (which captures different forms of intellectual property rights generated in the innovation process) and energy consumption by source.

## 5. Discussion

This study provided an assessment of energy consumption by source in EU countries through an original ranking using a multi-criteria decision analysis, i.e., the MULTIMOORA tool. The analysis of changes in the country's position in the rankings allowed us to determine the directions of energy consumption management by individual countries in the context of the objectives of the energy union. The research results reflect that using the MULTIMOORA multi-criteria evaluation tool makes it possible to systematize information and draw impartial conclusions about the directions of management of renewable energy sources in EU countries. As reported by Jelena Stankevičienė et al. [44], "The complexity increases with increasing choices of alternatives and features, therefore MULTIMOORA is useful in selecting the best alternatives." The use of the MULTIMOORA method by researchers in the study of renewable energy problems is increasing (e.g., [42,43,79,80]). Our research is therefore in line with this research trend.

In the next step, by means of correlation analyses, we identified the relationship between energy consumption by source and the main innovation performance indicators. Among the energy sources whose consumption levels were analyzed, the correlation with innovation performance indicators was mainly shown for renewable energy sources such as biofuels and renewable waste, ambient heat pumps, wind, and solar photovoltaic. Biofuels and renewable waste and ambient heat pumps were the sources of energy in relation to which the most correlations with indicators of innovation were identified. Biofuels are an alternative low-emission fuel for transport, among other things. However, there is currently no large-scale industrial production of biofuels. Converting advanced feedstocks into biofuel is challenging, as each requires new technologies. Many experts have pointed out that the availability and cost of financing are major barriers to investment in advanced biofuels [81,82]. Investment risks are closely linked to the challenges of financing biofuels, and without appropriate risk mitigation strategies, they are an impenetrable barrier to the growth of the sector [83].

Similar to biofuels and renewable waste, ambient heat pumps were the sources of energy in relation to which the most correlations with indicators of innovation were identified. Heat pumps are electrical devices that convert energy from external heat sources (air, groundwater, soil, etc.) into useful heat. They are considered to be one of the most energy-efficient and environmentally friendly technologies that increase the degree of use and effective integration of intermittent renewable energy sources [84].

The results showed that the level of innovativeness can increase energy consumption from heat pumps. Despite wide-range benefits, their global uptake rate remains very low. The potential of heat pumps is highly dependent on the type of technology, the location, and the electricity mix [85]. In the years to come, the driving force behind the reduction in the price of industrial heat pumps may be the rapid growth in technology from manufacturers, suppliers, and research facilities, coupled with increased plant and end-user experience [86].

However, some limitations of this study must be noted. First of all, in our opinion, the fact that we focused on the total parameters of energy consumption in individual countries should be considered as such a limitation. A more detailed analysis, for example, taking into account the sectoral approach, could provide interesting insights. This may provide a direction for future research in this area. The most recent available data used for our study were for the year 2019. The changes that have taken place in the last two years in terms of managing energy consumption in individual countries (especially in the context of the EU's latest energy efficiency targets [87]) may have undoubtedly affected the changes in the ranking. We consider it advisable to update our rankings, as this will allow monitoring of changes in this area. Both the monitoring of changes in the ranking according to our proposed approach and the specification of the analysis with other parameters (e.g., related to legislative changes undertaken in relation to energy management, taking into account the provisions of the national energy and climate plans for 2021–2030, which were prepared by individual EU countries and serve the implementation of the overarching EU objective—the transition to clean energy) could be interesting developments of our findings. Additionally, analysis of the root causes of energy consumption could be an interesting development of our approach.

## 6. Conclusions

Energy production and consumption are particular issues in today's world. The necessity to take into account a sustainable approach to energy management and consumption is a key issue for companies and whole countries. The purpose of this paper was to assess the progress toward the management of renewable energy consumption (by preparing original rankings) and to identify any significant relationships between energy consumption by source and selected indicators of innovativeness in European Union countries.

In terms of methodology, this research paper extended the application of the capabilities of the MULTIMOORA method and applied it to assess the management of energy consumption in the context of innovativeness.

Some of the main findings of our research are:

- Analysis of the original rankings of EU countries showed that the vast majority of them have made changes in their management of energy consumption at the level of the whole economy (out of 28 countries, only two showed no change) (RQ1);
- Fourteen countries have developed their energy consumption management toward renewable energy sources (improved their starting position in the ranking); in the case of 12 countries, energy consumption was mainly from non-renewable energy sources (their ranking deteriorated) (RQ1);
- We found multiple (37 statistically significant correlations; RQ2) relationships between the level of energy consumption by source and the main indicators of innovation performance;

- The relationships mainly concerned renewable energy sources such as biofuels and renewable waste, ambient heat pumps, wind, and solar photovoltaic (RQ3).

The research findings suggest that not all countries have developed their energy consumption management in the direction of renewable energy sources. Moreover, the findings indicate a significant association between the level of innovativeness of the country and the consumption of energy from some types of renewable sources. Thus, to improve environmental performance, economies should put more emphasis on activities that increase the share of RES consumption in the total energy consumption. The involvement of governments to increase the economic innovation and consumption of energy from renewable sources is necessary, especially in economies with high energy shortages.

As for the dependencies indicated in the study, leaders should pay particular attention to the activities aimed at increasing the consumption of energy from renewable sources by boosting economic innovation, especially in the areas mentioned. It is essential to financially support investments in both the public and private sectors. Regulations in pro-innovation policy must take into account the appropriate level of expenditure on R&D in the public sector (at universities and governmental research organizations). In European countries with the highest SII levels, the gross domestic expenditure on R&D is over 3% of GDP (they set 4% of GDP as their target). Regulations supporting the development and availability of venture capital (VC) are important as well. This is frequently the only possible way to finance companies that are growing or develop new (risky) technologies.

It is also advisable to introduce legal and institutional regulations that favor financing public research and development activities by the private sector and establishing and developing research cooperation between the private and public sectors, as well as cooperation between innovative companies. Special attention should be paid to the sector of small- and medium-sized companies and their level of innovation. Entities of this scale require institutional support and appropriate tools to support their innovative activities.

A reasonable regulatory policy should include activities that boost human potential and knowledge resources. Individual economies must focus on increasing the resources of their highly skilled and educated workforce by supporting the process of education at universities and promoting the concept of lifelong learning. It is also crucial to implement legal regulations and institutional solutions for businesses that will encourage entrepreneurs to take action to improve the skills of their employees regarding information and communication technologies (ICT), and invest in both research and development activities, as well as innovations not related to R&D (non-R&D innovation) yet undertaken to generate innovation (e.g., equipment, machinery, acquiring patents and licenses), in order to measure the spread of new production technologies and ideas. Legal and administrative regulations aimed at creating an innovation-friendly environment are required, with the best possible access to broadband and entrepreneurship based on searching/spotting new opportunities. It is also essential to focus on increasing the level of employment in sectors requiring great knowledge (knowledge-intensive) and in rapidly growing companies operating in innovative sectors, as well as increasing the exports of technologically advanced products, services based on knowledge, and innovations introduced to the market and within the company. Having an environment that is perfect for creating new innovations does not translate directly into the ability to introduce new products to the market. Effective participation in global value chains based on knowledge and exporting services with a high level of added value can be facilitated by regulations that increase trade openness or the creation of knowledge exchange networks. There is also necessity for institutions and tools supporting the acquisition of requisite knowledge about foreign markets.

Regulatory policy related to innovation can increase the consumption of clean energy, but the heterogeneity of countries in terms of their natural resources and renewable energy sources means that the implemented internal policies should also have a varied nature.

**Author Contributions:** Conceptualization, M.S. and I.G.-M.; methodology, M.S. and I.G.-M.; validation, M.S. and I.G.-M.; formal analysis, M.S. and I.G.-M.; investigation, M.S. and I.G.-M.; resources, M.S. and I.G.-M.; data curation, M.S. and I.G.-M.; writing—original draft preparation, M.S. and I.G.-M.; writing—review and editing, M.S. and I.G.-M.; visualization, M.S. and I.G.-M.; supervision, M.S. and I.G.-M.; project administration, M.S. and I.G.-M.; funding acquisition, M.S. and I.G.-M. Both authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by Czestochowa University of Technology, Poland, grant number SPB-600/3016/2021.

**Acknowledgments:** We would like to thank the reviewer for their detailed comments and suggestions for developing the manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Martchamadol, J.; Kumar, S. Thailand's energy security indicators. *Renew. Sustain. Energy Rev.* **2012**, *16*, 6103–6122. [CrossRef]
2. Słupizk, S. Świadomy konsument energii w województwie śląskim w świetle badań ankietowych, Studia Ekonomiczne. *Zesyty Naukowe Uniwersytetu Ekonomicznego w Katowicach* **2015**, *232*, 215–224.
3. Chalvatzis, K.J.; Ioannidis, A. Energy supply security in the EU: Benchmarking diversity and dependence of primary energy. *Appl. Energy* **2017**, *207*, 465–476. [CrossRef]
4. Chalvatzis, K.J. Electricity generation development of Eastern Europe: A carbon technology management case study for Poland. *Renew. Sustain. Energy Rev.* **2009**, *13*, 1606–1612. [CrossRef]
5. Broberg, T.; Persson, L. Is our everyday comfort for sale? Preferences for demand management on the electricity market. *Energy Econ.* **2016**, *54*, 24–32. [CrossRef]
6. IEA. World Energy Outlook 2020, Paris. Available online: https://www.iea.org/reports/world-energy-outlook-2020 (accessed on 20 February 2021).
7. IEA. Net Zero by 2050. A Road Map for the Global Energy Sector. Available online: https://iea.blob.core.windows.net/assets/20959e2e-7ab8-4f2a-b1c6-4e63387f03a1/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf (accessed on 15 June 2021).
8. Consolidated Version of the Treaty on the Functioning of the European Union, OJ C 326/49. Available online: http://data.europa.eu/eli/treaty/tfeu_2012/oj] (accessed on 20 April 2021).
9. EEA. *Drivers of Change of Relevance for Europe's Environment and Sustainability*; EEA Report No 25/2019; European Environment Agency: København, Denmark, 2020. [CrossRef]
10. Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on Risk-Preparedness in the Electricity Sector and Repealing Directive 2005/89/EC, PE/73/2018/REV/1. Available online: http://data.europa.eu/eli/reg/2019/941/oj (accessed on 21 December 2020).
11. Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council, PE/55/2018/REV/1, OJ L 328. Available online: http://data.europa.eu/eli/reg/2018/1999/oj (accessed on 21 December 2018).
12. Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the Internal Market for Electricity PE/9/2019/REV/1; OJ L 158. Available online: http://data.europa.eu/eli/reg/2019/943/oj (accessed on 14 June 2019).
13. Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 Establishing a European Union Agency for the Cooperation of Energy Regulators, PE/83/2018/REV/1, OJ L 158, ELI. Available online: http://data.europa.eu/eli/reg/2019/942/oj (accessed on 14 June 2019).
14. Regulation (EU) 2021/783 of the European Parliament and of the Council of 29 April 2021 establishing a Programme for the Environment and Climate Action (LIFE), and repealing Regulation (EU) No 1293/2013 (Text with EEA relevance), PE/14/2021/INIT. Available online: http://data.europa.eu/eli/reg/2021/783/oj (accessed on 20 July 2019).
15. Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on Wholesale Energy Market Integrity and Transparency, OJ L 326. Special Edition in Croatian: Chapter 12, Volume 004. Available online: http://data.europa.eu/eli/reg/2011/1227/oj (accessed on 8 December 2011).
16. Jackson, F. Corporates' venture: Corporate venture capital could prove the vital lifeline for renewable energy developers facing an exodus of private equity investors from the market. *Renew. Energy Focus* **2011**, *12*, 30–33. [CrossRef]
17. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources (Text with EEA relevance.), PE/48/2018/REV/1, OJ L 328. Available online: http://data.europa.eu/eli/dir/2018/2001/oj (accessed on 21 December 2018).
18. Alvarez-Herranz, A.; Balsalobre-Lorente, D.; Shahbaz, M.; Cantos, J.M. Energy innovation and renewable energy consumption in the correction of air pollution levels. *Energy Policy* **2017**, *105*, 386–397. [CrossRef]

19. UN. Sustainable Development Goals. Available online: https://www.un.org/sustainabledevelopment/infrastructure-industrialization/ (accessed on 10 January 2021).
20. Kaldellis, J.K.; Chalvatzis, K.J. *Environment and Industrial Development: Sustainability and Development Air Pollution*; Stamoulis Publications: Athens, Greece, 2005.
21. UN. Transforming Our World: The 2030 Agenda for Sustainable Development, 2015, 70/1. Available online: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (accessed on 15 February 2021).
22. European Commission. The European Green Deal, Brussels 2019 COM 2019, 640. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX:52019DC0640 (accessed on 10 December 2020).
23. European Commission. *Annual Sustainable Growth Strategy 2020*; COM: Brussels, Belgium, 2019.
24. European Commission. *Proposal for a Regulation of the European Parliament and of the Council Establishing the Just Transition Fund*; 22 Final, 2020/0006(COD); COM: Brussels, Belgium, 2020.
25. Schipper, L.; Meyers, S.; Howarth, R.B.; Steiner, R. *Energy Efficiency and Human Activity: Past Trends, Future Prospects*; Cambridge University Press: New York, NY, USA, 1992.
26. Wang, J.-J.; Jing, Y.-Y.; Zhang, C.-F.; Zhao, J.-H. Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renew. Sustain. Energy Rev.* **2009**, *13*, 2263–2278. [CrossRef]
27. Payne, J.E. A survey of the electricity consumption-growth literature. *Appl. Energy* **2010**, *87*, 723–731. [CrossRef]
28. Rennings, K.; Brohmann, B.; Nentwich, J.; Schleich, J.; Traber, T.; Wüstenhagen, R. (Eds.) *Sustainable Energy Consumption in Residential Buildings, 1 Auflage 2013*; Physica-Verlag: Heidelberg, Germany, 2013. [CrossRef]
29. Pham, A.-D.; Ngo, N.-T.; Truong, T.T.H.; Huynh, N.-T.; Truong, N.-S. Predicting energy consumption in multiple buildings using machine learning for improving energy efficiency and sustainability. *J. Clean. Prod.* **2020**, *260*, 121082. [CrossRef]
30. Vakulchuk, R.; Overland, I.; Scholten, D. Renewable energy and geopolitics: A review. *Renew. Sustain. Energy Rev.* **2020**, *122*, 109547. [CrossRef]
31. Howell, M.T. *Energy Centered Management: A Guide to Reducing Energy Consumption and Cost*, 1st ed.; River Publishers: New York, NY, USA, 2015. [CrossRef]
32. Schumpeter, J. *Capitalism, Socialism and Democracy*; Routlege: London, UK; New York, NY, USA, 1954.
33. Freeman, C. *The Economics of Industrial Innovation*; Pinter: London, UK, 1982.
34. Sitek, M.; Tvaronavičienė, M. Innovation Management in Polish Real Estate Developers in the Renewable Energy Sources Context. *Energies* **2021**, *14*, 1702. [CrossRef]
35. Jensen, M.B.; Johnson, B.; Lorenz, E.; Lundvall, B.A. Forms of knowledge and modes of innovation. *Res. Policy* **2007**, *36*, 680–693. [CrossRef]
36. Godin, B. Innovation: The History of a Category, Project on the Intellectual History of Innovation; No.1; Working Paper 2008. Available online: http://www.csiic.ca/PDF/IntellectualNo1.pdf (accessed on 20 May 2021).
37. Fichter, K.; Beucker, S. (Eds.) *Innovation Communities. Teamworking of Key Persons—A Success Factor in Radical Innovation*; Springer: Berlin/Heidelberg, Germany, 2012. [CrossRef]
38. Sipa, M.; Skibiński, A. Innovative Strategies of Small Enterprises in Poland. In Proceedings of the Liberec Economic Forum Conference 2015, Liberec, Czech Republic, 16–17 September 2015; Kocurek, A., Ed.; Technical University of Liberec: Liberec, Czech Republic, 2015; pp. 342–352.
39. Yahya, F.; Rafiq, M. Unraveling the contemporary drivers of renewable energy consumption: Evidence from regime types. *Environ. Prog. Sustain. Energy* **2019**, *38*, 2–7. [CrossRef]
40. Brauers, W.K.M.; Zavadskas, E.K. The MOORA method and its application to privatization in a transition economy. *Control Cybern.* **2006**, *35*, 445–469.
41. Brauers, W.K.M.; Zavadskas, E.K. Project management by Multimoora as an instrument for transition economies. *Technol. Econ. Dev. Econ.* **2010**, *16*, 5–24. [CrossRef]
42. Hafezalkotob, A.; Hafezalkotob, A.; Liao, H.; Herrera, F. An overview of MULTIMOORA for multi-criteria decision-making: Theory, developments, applications, and challenges. *Inf. Fusion* **2019**, *51*, 145–177. [CrossRef]
43. Ijadi Maghsoodi, A.; Mosavi, A.; Rabczuk, T.; Zavadskas, E. Renewable Energy Technology Selection Problem Using Integrated H-SWARA-MULTIMOORA Approach. *Sustainability* **2018**, *10*, 4481. [CrossRef]
44. Stankevičienė, J.; Maditinos, D.I.; Kraujalienė, L. MULTIMOORA as the instrument to evaluate the technology transfer process in higher education institutions. *Econ. Sociol.* **2019**, *12*, 345–360. [CrossRef] [PubMed]
45. Malinauskaite, J.; Jouhara, H.; Ahmad, L.; Milani, M.; Montorsi, L.; Venturelli, M. Energy efficiency in industry: EU and national policies in Italy and the UK. *Energy* **2019**, *172*, 255–269. [CrossRef]
46. EEA. *Sustainability Transitions: Now for the Long Term*; Eionet Report, No 1/2016; European Environment Information: Copenhagen, Denmark, 2016. [CrossRef]
47. EEA. Kształtowanie Przyszłości Energii w Europie: Czysta, Inteligentna i Odnawialna Energia; EEA Report, 2017, No 11/2017. Available online: http://www.zgora.pios.gov.pl/wp-content/uploads/2018/09/Signals-PL-2017.pdf (accessed on 20 December 2020).
48. Ucal, M.; Xydis, G. Multidirectional Relationship between Energy Resources, Climate Changes and Sustainable Development: Technoeconomic Analysis. *Sustain. Cities Soc.* **2020**, *60*, 102210. [CrossRef]
49. Gareiou, Z.; Drimili, E.; Zervas, E. Public acceptance of renewable energy sources. In *Low Carbon Energy Technologies in Sustainable Energy Systems*; Kyriakopoulos, G.L., Ed.; Academic Press: Cambridge, MA, USA, 2021; pp. 309–327. [CrossRef]

50. Elnakat, A.; Gomez, J.D. Energy engenderment: An industrialized perspective assessing the importance of engaging women in residential energy consumption management. *Energy Policy* **2015**, *82*, 166–177. [CrossRef]
51. Santiago, I.; Moreno-Munoz, A.; Quintero-Jiménez, P.; Garcia-Torres, F.; Gonzalez-Redondo, M.J. Electricity demand during pandemic times: The case of the COVID-19 in Spain. *Energy Policy* **2021**, *148*, 111964. [CrossRef] [PubMed]
52. Ahmed, Z.; Wasif, M.; Ali, S. Linking urbanization, human capital, and the ecological footprint in G7 countries: An empirical analysis. *Sustain. Cities Soc.* **2020**, *55*, 102064. [CrossRef]
53. Chiu, W.-Y.; Sun, H.; Poor, H.V. Energy Imbalance Management Using a Robust Pricing Scheme. *IEEE Trans. Smart Grid* **2013**, *4*, 896–904. [CrossRef]
54. Zheng, N.; Guo, J.; Zheng, X. Effects of demand side management on Chinese household electricity consumption: Empirical findings from Chinese household survey. *Energy Policy* **2016**, *95*, 113–125. [CrossRef]
55. Warren, P. A review of demand-side management policy in the UK. *Renew. Sustain. Energy Rev.* **2014**, *29*, 941–951. [CrossRef]
56. Pérez-García, J.; Moral-Carcedo, J. Why Electricity Demand Is Highly Income-Elastic in Spain: A Cross-Country Comparison Based on an Index-Decomposition Analysis. *Energies* **2017**, *10*, 347. [CrossRef]
57. Murty, P.S.R. Chapter 24—Renewable Energy Sources. In *Electrical Power Systems*; Murty, P.S.R., Ed.; Butterworth-Heinemann: Oxford, UK, 2017; pp. 783–800. [CrossRef]
58. Imteyaz, B.; Lawal, D.U.; Tahir, F.; Rehman, S. Prospects of large-scale photovoltaic-based power plants in the Kingdom of Saudi Arabia. *Eng. Rep.* **2021**, e12398. [CrossRef]
59. Wei, M.; Patadia, S.; Kammen, D.M. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy* **2010**, *38*, 919–931. [CrossRef]
60. Engel, D.; Kammen, D.M. Green Jobs and the Clean Energy Economy, Copenhagen Climate Council, Thought Leadership Paper 04. Available online: http://us-cdn.creamermedia.co.za/assets/articles/attachments/21589_greenjobs.pdf (accessed on 22 January 2021).
61. European Commission. European Innovation Scoreboard. Available online: https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en (accessed on 10 March 2021).
62. Sarkar, A.N. Promoting Eco-innovations to Leverage Sustainable Development of Eco-industry and Green Growth. *Eur. J. Sustain. Dev.* **2013**, *2*, 171–224. [CrossRef]
63. Voegtlin, C.; Scherer, A.G. Responsible Innovation and the Innovation of Responsibility: Governing Sustainable Development in a Globalized World. *J. Bus. Ethic* **2017**, *143*, 227–243. [CrossRef]
64. Wu, T.; Yang, S.; Tan, J. Impacts of government R&D subsidies on venture capital and renewable energy investment—An empirical study in China. *Resour. Policy* **2020**, *68*, 101715. [CrossRef]
65. Niedzielski, P. Rodzaje innowacji. In *Innowacje i Transfer Technologii—Słownik Pojęć*; Matusiak, K.B., Ed.; PARP: Warszawa, Poland, 2005.
66. Bielińska-Dusza, E.; Hamerska, M. Methodology for Calculating the European Innovation Scoreboard—Proposition for Modification. *Sustainability* **2021**, *13*, 2199. [CrossRef]
67. Grupp, H.; Mogee, M.E. Indicators for national science and technology policy: How robust are composite indicators? *Res. Policy* **2004**, *33*, 1373–1384. [CrossRef]
68. Szabo, Z.K.; Herman, E. Innovative Entrepreneurship for Economic Development in EU. *Procedia Econ. Financ.* **2012**, *3*, 268–275. [CrossRef]
69. Caird, S.; Hallett, S.; Potter, S. The Open2-Innova8ion Tool—A software tool for rating organisational innovation performance. *Technovation* **2013**, *33*, 381–385. [CrossRef]
70. Fabová, L.; Janáková, H. Impact of the Business Environment on Development of Innovation in Slovak Republic. *Procedia Econ. Financ.* **2015**, *34*, 66–72. [CrossRef]
71. Sipa, M. Diversification of Indexes Determining Innovation of Economies—The Visegrad Group Countries. In *Hradec Economic Days*; Jedlicka, P., Ed.; Gaudeamus: Hradec Kralove, Czech Republic, 2015; pp. 174–181.
72. Trifan, G.; Testai, F.D. Systemic Immune-Inflammation (SII) index predicts poor outcome after spontaneous supratentorial intracerebral hemorrhage. *J. Stroke Cerebrovasc. Dis.* **2020**, *29*, 105057. [CrossRef]
73. European Commission. EIS 2020 Methodology Report. Available online: https://ec.europa.eu/docsroom/documents/41861 (accessed on 5 March 2021).
74. Marinaș, M.-C.; Dinu, M.; Socol, A.-G.; Socol, C. Renewable energy consumption and economic growth. Causality relationship in Central and Eastern European countries. *PLoS ONE* **2018**, *13*, e0202951. [CrossRef]
75. Zhang, D.; Mohsin, M.; Khaliq, A.; Chang, Y.; Taghizadeh-hesary, F. Public spending and green economic growth in BRI region: Mediating role of green finance. *Energy Policy* **2021**, *153*, 112256. [CrossRef]
76. *A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy*; European Commission: Brussels, Belgium, 2015; Available online: https://eur-lex.europa.eu/resource.html?uri=cellar:1bd46c90-bdd4-11e4-bbe1-01aa75ed71a1.0001.03/DOC_1&format=PDF (accessed on 10 March 2021).
77. Energy Statistical Datasheets for the EU Countries. Available online: https://data.europa.eu/data/datasets/information-on-energy-markets-in-eu-countries-with-national-energy-profiles?locale=en (accessed on 10 March 2021).
78. Haldun, A. User's guide to correlation coefficients. *Turk. J. Emerg. Med.* **2018**, *18*, 91–93. [CrossRef]
79. Siksnelyte, I.; Zavadskas, E.K.; Bausys, R.; Streimikiene, D. Implementation of EU energy policy priorities in the Baltic Sea Region countries: Sustainability assessment based on neutrosophic MULTIMOORA method. *Energy Policy* **2019**, *125*, 90–102. [CrossRef]

80. Ossowska, L.J. Consequences of the energy policy in member states of the European Union—The renewable energy sources targets. *Energy Policy J.* **2019**, *22*, 21–32. [CrossRef]
81. De L.T. Oliveira, G.; McKay, B.; Plank, C. How biofuel policies backfire: Misguided goals, inefficient mechanisms, and political-ecological blind spots. *Energy Policy* **2017**, *108*, 765–775. [CrossRef]
82. Banja, M.; Sikkema, R.; Jégard, M.; Motola, V.; Dallemand, J.-F. Biomass for energy in the EU—The support framework. *Energy Policy* **2019**, *131*, 215–228. [CrossRef]
83. Thyfault, C. The Project Finance Market—Is it Open for Biofuels? *Biofuels Finance.* Available online: https://cdn2.hubspot.net/hub/14164/file-13246683-pdf/docs/finance.pdf (accessed on 12 May 2021).
84. Wu, Y.; Xu, R. Green building development in China-based on heat pump demonstration projects. *Renew. Energy* **2013**, *53*, 211–219. [CrossRef]
85. Gaur, A.S.; Fitiwi, D.Z.; Curtis, J. Heat pumps and our low-carbon future: A comprehensive review. *Energy Res. Soc. Sci.* **2021**, *71*, 101764. [CrossRef]
86. Marina, A.; Spoelstra, S.; Zondag, H.A.; Wemmers, A.K. An estimation of the European industrial heat pump market potential. *Renew. Sustain. Energy Rev.* **2021**, *139*, 110545. [CrossRef]
87. European Commission. 2030 Climate & Energy Framework. 2021. Available online: https://ec.europa.eu/clima/policies/strategies/2030_en (accessed on 12 May 2021).