

Greening the Future: Europe's Renewable Energy Landscape in 2030

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Abstract. *The increased price of energy and the limited resources of the planet have increased the worldwide attention to renewable energy resources. The purpose of this paper is to present the European context regarding these renewable sources. In addition, the evolution over time of some indicators relevant to this field is described for better shaping the general audience's understanding of the current status on the renewable sources. Using a statistical approach, the paper ranks the member states in terms of the consumption of renewable resources in areas such as transport and electricity. Throughout the research, it has been noted that there are significant differences between member states. An example to reinforce what was previously described is the fact that, for the share of renewable energy in gross final energy consumption, the minimum value is approximately eight times lower than the maximum. Additionally, forecasting methods of indicators analysed based on historical data were applied to establish the course of EU27 countries for the year 2030, when the implementation period of the Sustainable Development Goals ends.*

Keywords: Renewable Energy, Green Economy, Descriptive Statistics, Sustainable Development.

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Introduction

The limited resources of the planet do not cope with the advanced technological processes necessary for the comfort of human life. To avoid depleting the planet of its precious resources, in the field of energy, efforts are being made to integrate a percentage of renewable sources as high as possible. In this sense, within the seventh Sustainable Development Goal entitled "Affordable and clean energy", a target is integrated for the substantial increase in the percentage of energy from renewable sources worldwide (United Nations, 2015).

Moving from the global plan to a narrower framework, that of the European Union, it is noted that in 2009, European leaders proposed that by 2020, 20% of energy consumption at the level of the Union should come from renewable sources. Continuing this approach, in 2018 they set a new goal, according to which, by 2030, 32% of the proportion of energy sources should come from renewable sources. In July 2021, this percentage increased to 40%, and as a result of the war between Russia and Ukraine, the EU leaders proposed to reduce the dependence on Russian energy sources by increasing the percentages of clean energy (Ciucci, 2022). According to data provided by Eurostat, the percentage of renewable energy resources at the level of the European Union for 2020 was 22.1%, 2.1% above the target they proposed in 2009 (Eurostat, 2023).

Three-quarters of greenhouse gas emissions come from the energy sector. Therefore, by increasing the percentage of energy from renewable sources, these emissions will be considerably reduced (European Parliament, 2023). For this reason, but also to reduce imports and the dependencies caused by them, the European Commission proposed in May 2022, through the REPowerEU plan, to increase the percentage of renewable sources to 45% (European Commission, 2023).

The current paper described the context of the EU in 2021 (this being the last data available on Eurostat) regarding the percentage of energy sources coming from renewable sources, and the three main sectors in which these resources are used were also discussed. Among the information provided is the EU ranking of the percentage of renewable resources for each member state. Thus, it is possible to note those countries for which the percentage of 20% related to the objective proposed in 2009 was not reached, but also the states that exceeded the percentage of 40-45% related to the target proposed for 2030. Using data forecasting methods based on historical information about them, an attempt was made to determine the course of the EU27 countries for the year 2030 - this year symbolizing the end of the period of implementation of the 17 Sustainable Development Goals. Among the models used are the Autoregressive Integrated Moving Average (ARIMA), Holt-Winters Trend methods and Double Moving Average, and their accuracy testing was carried out by applying Theil's U, Durbin-Watson and Root Mean Square Error (RMSE) tests.

Problem Statement

Increasing the percentage of energy produced from renewable sources helps both to slow down the rate of depletion of the planet's resources, but also to reduce pollution by reducing greenhouse effects, thus to positive changes in the climate sense. Thanks to the investments made in the energy sector, there is an increase in the percentage of energy from renewable sources, obviously, at the same time as the decrease in the percentage of energy from non-renewable sources, the differences between the two becoming smaller, especially for the EU15 countries, for which in 2015 the two percentages approached the 1:1 ratio (Halicioglu & Ketenci, 2018). Returning to the 27-member states of the European Union, significant increases in the consumption of energy from renewable sources were observed. Thus, in the time interval 2000-2019, the increase in this consumption (expressed in thousand tonnes of oil equivalent) was approximately 200%. The highest growth was registered in the field of transport (over 2200%), and the lowest in the field of industry (approximately 140%) (Tutak & Brodny, 2022).

Investments were and are needed to increase the percentage of renewable sources in total energy sources. In this sense, in a study carried out by Alsagr (2023), it was found that Financial Development (being divided into financial institution's efficiency and financial market's efficiency) has a significant impact on investments for renewable energy. In this sense, the long-term impact of financial efficiency on renewable energy investment was positive both for advanced and emerging economies. Another important element discovered by the author is the fact that in all four models he made, the long-term relationship between carbon emissions and renewable energy investment was negative. Another example of supporting investments in the field of green energy can be found in the study carried out by Bakry et al. (2023) in which 76 developing economies are analysed in the period 2010-2019. Among the results obtained, it is noted that green finance is expected to help reduce CO₂ emissions. Regarding the effect of renewable energy on these emissions, the authors mentioned that although the impact is negative (an increase in this indicator leads to a reduction in emissions), it is significant only in the long term.

While investments in green energy are encouraged, the same cannot be said for taxes. Thus, according to the article made by Nchofoung et al. (2023), environmental taxes (which would aim to make people responsible, but also to bring additional money to the state budget to increase investments in green energy) would lead to an increase in the consumption of renewable energy only in developed countries, and for developing countries the effect would be to diminish green energy technologies.

The perception of European citizens on the transition to renewable energy is also very important because they must be convinced to apply the greenest possible methods to reduce pollution and not limit the resources offered by the planet to the extreme. According to a study carried out by Panarello & Gatto (2023), the countries of the north and west of the EU have similar views on policies regarding the transition to green energy. The same cannot be said for countries in the East as the citizens of this region do not seem to be so eager to accept the adaptation to green energy. According to the same study, citizens from the south, but also from the non-EU-15, believe that it is the responsibility of the EU to reduce energy poverty, as these are the poorer countries of the Union. In addition, countries with a high level of transition to renewable energy believe that it is the responsibility of the EU to encourage investments for these energy sources (Dima & Vasilache, 2009; Panarello & Gatto, 2023).

The green economy is a topic for which the interest of researchers is growing. According to the bibliometric analysis carried out by Zhu et al. (2023) in the period 2016-2022, 1022 papers were written, the number of articles in 2022 being more than 14 times higher compared to 2016. Another bibliometric analysis was carried out on renewable energy sources and their production (Seminario-Córdova & Rojas-Ortega, 2023), noting that for the period 2019-2023, at the time of writing the paper, the authors identified a number of 2340 documents, of which 1408 were articles.

Furthermore, at the EU level, there is an interest in the ability of these states to manage renewable energy sources (Simionescu et al., 2020; Włodarczyk et al., 2021; Suhanyiova et al., 2023). Additionally, the interest of researchers is not limited to the Union, but to the regions (central and eastern Europe (Rokicki et al., 2022), Baltic states (Streimikiene & Mikalauskiene, 2016)) and countries (Croatia (Denona Bogovic & Grdic, 2020), France (Ya, 2016) , Poland (Paska et al., 2020) that make it up.

Research Questions/Aims of the Research

The present study aims to determine the ability of countries to achieve the objectives proposed by the European Union for the year 2030. To determine this, some preliminary steps are necessary. First of all, it is necessary to determine the percentage in which the member states managed to achieve the 20% target proposed in 2009 for the year 2020. Then, it is desired to determine the progress registered by the member states from the level of 2015 (when the 2030 Agenda was signed) to the last year with available data (in this case, 2021). In addition, the percentages of energy from renewable sources consumed by the member states in the three important sectors are determined: electricity, transport, heating, and cooling. In this sense, it will be possible to identify the levels at which the states are with regard to these values, observing if there are significant differences in terms of the analysed sectors.

Research Methods

Statistics are used to describe certain characteristics of a group of observations. The utility of statistical analysis refers to the ability to reduce the collected data in the form of a summary that allows providing a meaning to these data. The most common descriptive statistics terms refer to indicators for measuring central tendency and dispersion. The first category includes the mean, median and mode, and the second category includes elements such as standard deviation, frequency distribution, range and interquartile range (Fisher & Marshall, 2009).

The form of visual representation of the described elements for this study is the histogram. By the shape provided by the data distribution, it can be noted if they are placed symmetrically with respect to the mean, median, mode (Gaussian distribution), or if the data have a positive or negative asymmetry (Kaur et al., 2018).

Another way that data will be easier to visualize is represented by maps. In the current study they were used to help geographically determine the areas that consume the highest or lowest percentages of renewable energy sources.

For the first part of the research, the data provided by Eurostat for the year 2021 were used regarding the share of renewable energy in gross final energy consumption, both in total and structured by the main sectors that use these resources. For the forecast proposed for the year 2030, data from 2004 to 2021 were exploited, this time only for the total share of renewable energy in gross final energy consumption.

In order to determine whether the proposed target for 2030, namely to have a percentage of 45% of the total energy made up of renewable sources, can be reached, data forecasting methods based on historical values will be used: Autoregressive Integrated Moving Average (Ho & Xie, 1998), Double Exponential Smoothing (Nazim & Afthanorhan, 2014), Damped Trend Non-Seasonal (McKenzie & Jr., 2010) and Double Moving Average (Hyndman, 2009).

The program that has helped to create these forecasts is Crystal Ball, presenting in increasing order of RMSE the best models that can foresee the data and shows the values of Theil's U and Durbin-Watson tests for each of the methods. Theil's U test is used to determine if the forecast is better than guessing (Small & Wong, 2001), while Durbin-Watson (Durbin & Watson, 1950) is applied to establish if the model errors are autocorrelated at lag 1.

Findings

In this section, the progress made by EU member states from the moment of signing the 2030 Agenda to now is discussed, and indicators in the field of energy from renewable sources are analysed.

Share of energy from renewable sources

In this subsection, the indicator regarding the share of renewable energy in gross final energy consumption is analysed.

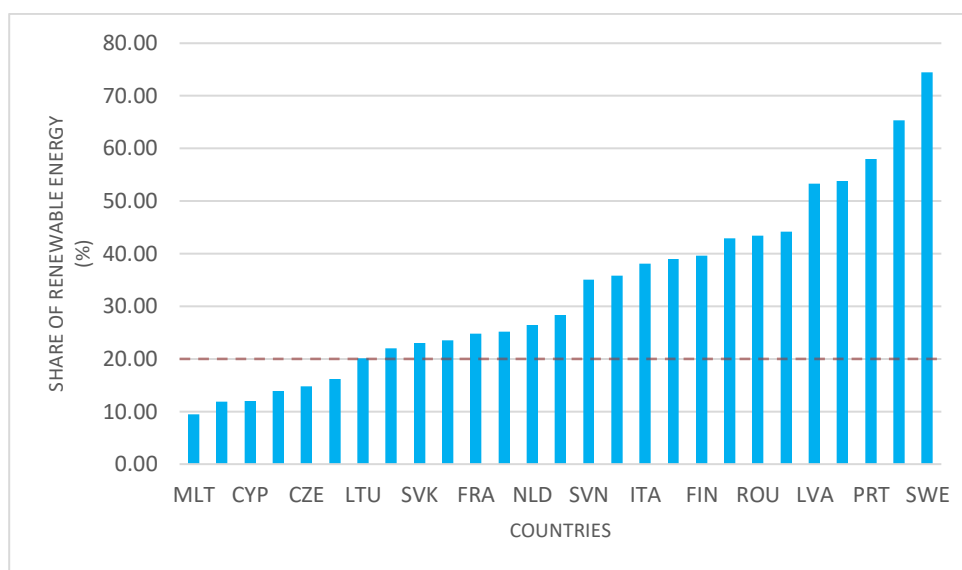


Figure 1. The share of renewable energy in gross final energy consumption (2020)

Source: Own research using data from Eurostat.

From Figure 1 it can be seen, as mentioned in the Introduction, that in terms of the EU average for the year 2020, the target proposed in 2009, 20%, has been exceeded. According to the first step discussed in the third section of this paper, it was desired to determine the states that did not reach the 20% threshold planned for 2020. In this sense, it is noted that most states have percentages of this indicator that exceed the established value; the countries which failed to reach this value are Malta, Hungary, Cyprus, Luxembourg, the Czech Republic, and Poland (see Appendix A).

Table 1. Descriptive statistics - Share of energy from renewable sources (2021)

	Mean	Q1	Median	Q3	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum
<i>sr_2021</i>	24.49	16.32	19.34	32.66	12.26	2.05	1.37	11.74	62.57

Source: Own research using Excel.

According to the information provided in Table 1, the average at the level of the 27 EU member states for the share of renewable energy in gross final energy consumption was 24.49%. Furthermore, the median value is lower than the average, with 50% of the states having values lower than 19.34%. The minimum value is approximately six times lower compared to the maximum value, having a positive asymmetry, most of the data recorded by

the countries have low percentages for this indicator. The values deviate, on average, from the value of 24.49% by 12.26%, and three-quarters of the countries have values that reach a maximum of 32.66%.

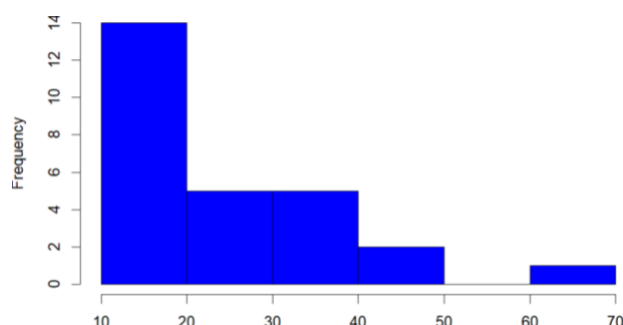


Figure 2. Graphical analysis of renewable energy sources (2021)

Source: Own research using RStudio.

In Figure 2, the indicator discussed histogram related to the previously is presented. The positive asymmetry and the fact that approximately half of the member states present values that do not reach 20%. As an exception, it can be noted that only two countries have values that exceed 40% (Latvia and Finland) and only one country has a percentage that reaches over 60%.

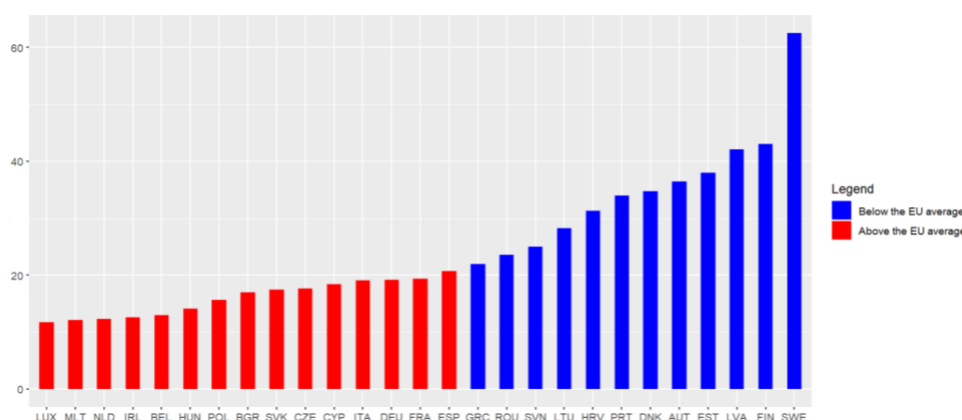


Figure 3. The share of renewable energy in gross final energy consumption (2021)

Source: Own research using RStudio.

According to the European ranking that can be seen in Figure 3, more than half of the member states have lower values compared to the EU average. The countries with the lowest values of this indicator are Luxembourg, Malta and the Netherlands, while the highest values are found in countries such as Latvia, Finland and Sweden.

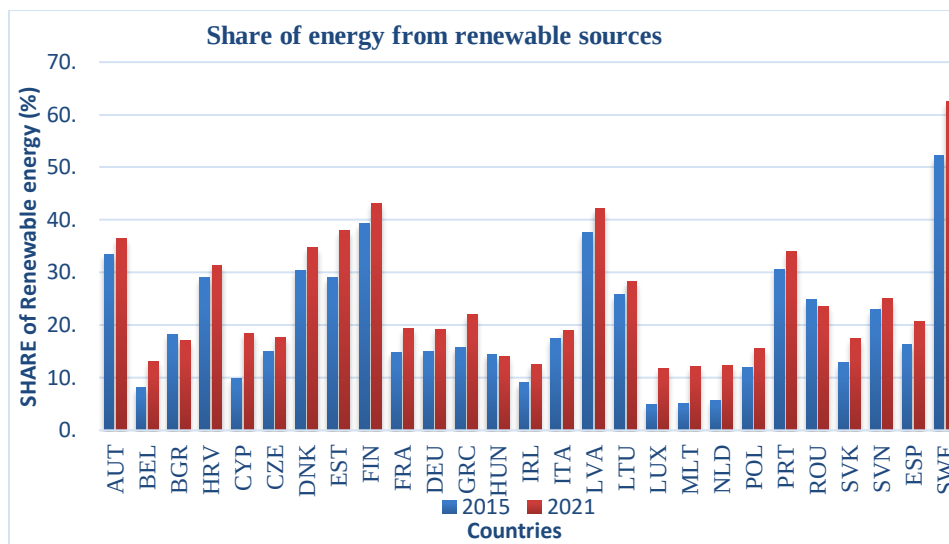


Figure 4. The comparative evolution of renewable energy resources

Source: Own research using data from Eurostat.

Objective 7 "Affordable and clean energy" proposes through its second target that "by 2030, increase substantially the share of renewable energy in the global energy mix" (United Nations, 2015). Therefore, since the signing of the 2030 Agenda in 2015 to date, the situation appears to have improved for most member states, although the differences do not seem so significant. According to Figure 4, the countries for which the values in 2021 are lower compared to 2015 are Bulgaria, Hungary and Romania, while the countries with significant developments are Cyprus, Estonia and Sweden. Although Luxembourg, Malta and the Netherlands still have the lowest values of this indicator, notable differences are observed between the two analysed time points.

Share of renewable energy in gross final energy consumption by sector (electricity, transport, heating and cooling)

For this subsection, data on the share of renewable resources used in areas such as electricity, transport or heating and cooling are described.

Table 2. Descriptive statistics - renewable energy by sector

	Mean	Q1	Median	Q3	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum
<i>el_2021</i>	35.19	20.03	34.98	44.82	18.68	-0.18	0.71	9.66	76.19
<i>tr_2021</i>	9.39	7.09	8.21	10.13	5.17	11.05	3.08	4.30	30.43
<i>hc_2021</i>	30.74	18.73	25.63	41.44	16.85	-0.37	0.57	5.17	68.64

Source: Own research using Excel.

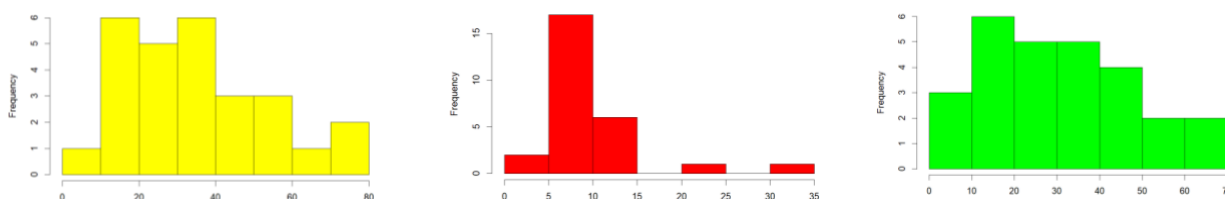
In Table 2 it can be easily seen that the transport sector has the lowest percentages for the share of renewable energy in the gross final energy consumption. If for the other two fields the averages are between 30% and 35%, the average for transport is only 9.39%.

Analysed individually, it is noted that for the electricity sector half of the countries have values that exceed 35% (in this case the mean and median being almost equal), the

percentages deviating on average by 18.68% from this value. In this case, the minimum value is approximately eight times lower than the maximum value, and there is a slight positive asymmetry, a sign that low values for this indicator predominate.

Returning to transports, it can be observed that 75% of the countries have values lower than 10.13%, with a significant positive skewness and a leptokurtic distribution.

For heating and cooling, the difference between the minimum and maximum values is vast, being more than 13 times lower than the maximum, almost double compared to the field of transport. However, the value of 0.57 for the asymmetry coefficient shows that the asymmetry is moderate and positive, identifying several small values for this indicator.



*Figure 5. Graphical analysis of renewable energy sources by sector
(electricity, transport, heating and cooling)*

Source: Own research using RStudio.

Although in all three cases presented in Figure 5 one can observe the predominant presence of small values, the strong positive asymmetry in the transport sector and its two outliers are highlighted. For electricity, it is noted that more than half of the member states have values of renewable resources consumed between 10% and 40%. A third of these have values exceeding 40% and only one country has a consumption lower than 10%. In transport, most countries consume between 5% and 10% of renewable resources. There are two states where the percentages exceed 20% and 30%, respectively. For the heating and cooling sector, it is noted that the median is closer to the first quartile, a sign that there are more low values of this indicator, 14 having values that do not exceed 30%.

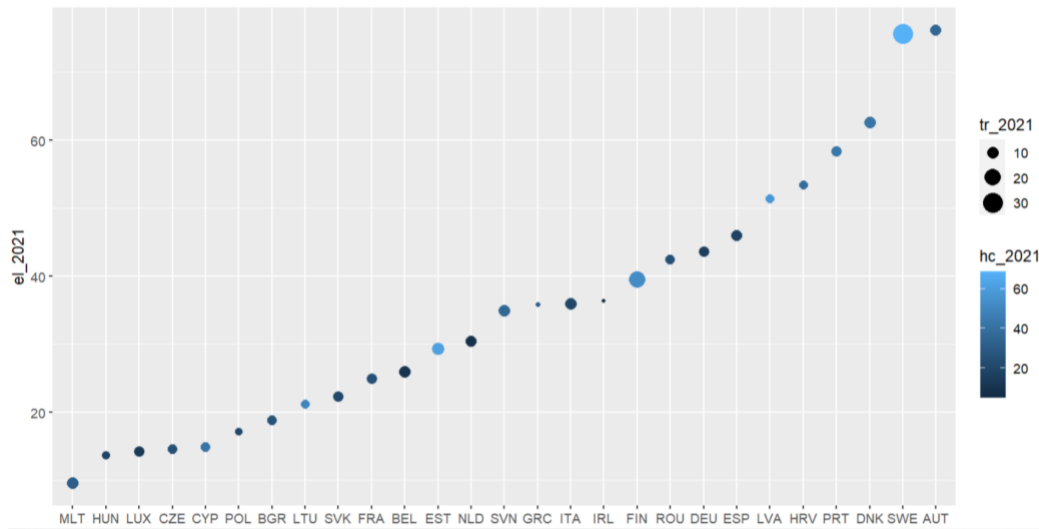


Figure 6. Share of renewable energy in gross final energy consumption by sector (2021)

Source: Own research using RStudio.

Figure 6 shows the summarized presentation of the member states through the lens of the three analysed sectors. Thus, it is noted that in the field of electricity, the lowest value is recorded for Malta, which has average values for the other two sectors. The highest values (over 70%) are present in Sweden (which also has very high values for the other two sectors) and Austria (with average values for the other two analysed sectors). Very low values for the transport sector are recorded in Greece and Ireland, the latter having a small percentage also attributed to the heating and cooling sector. A thorough analysis of each sector is carried out in Figure 7 – Figure 12.

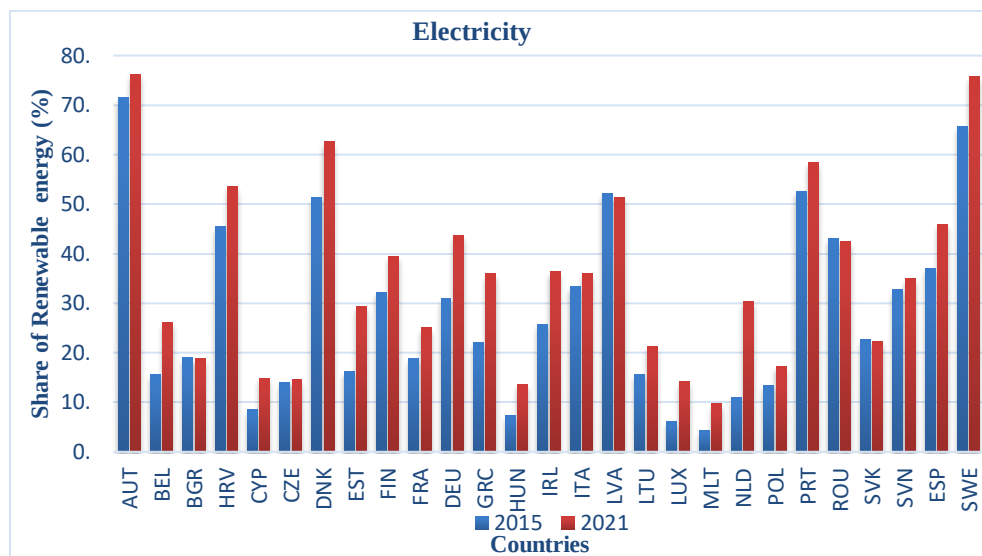


Figure 7. The comparative evolution of renewable energy resources (electricity)

Source: Own research using data from Eurostat.

As mentioned above, according to Figure 7, the countries with the highest values for the share of renewable resources in the electricity sector are Austria and Sweden, which have the same positions in the European ranking in 2015. The most significant increase can be seen in Malta, followed by Greece, Estonia and Germany. Between these years, most states registered an increased value of the percentages in this field, with the exception of Bulgaria, Slovakia, Romania and Latvia, where a decrease in values has been identified.

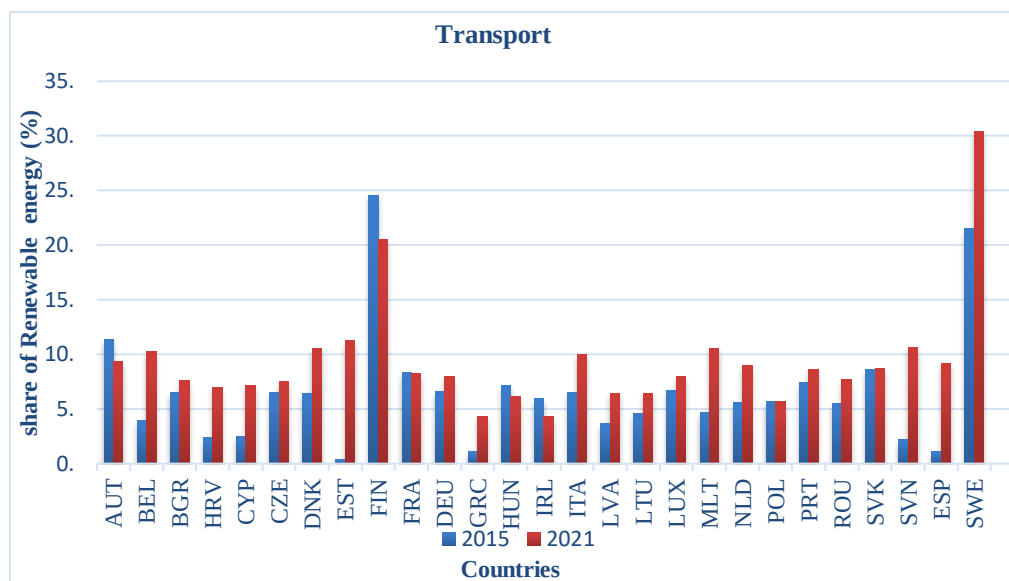


Figure 8. The comparative evolution of renewable energy resources (transport)

Source: Own research using data from Eurostat.

In the transport sector, it can be seen in Figure 8 that Sweden maintains its leading position, with the second highest recorded progress after Estonia. For this indicator, there are several countries that could not rise to the level of 2015, among them being Poland, France, Hungary, Ireland, Austria and Finland.

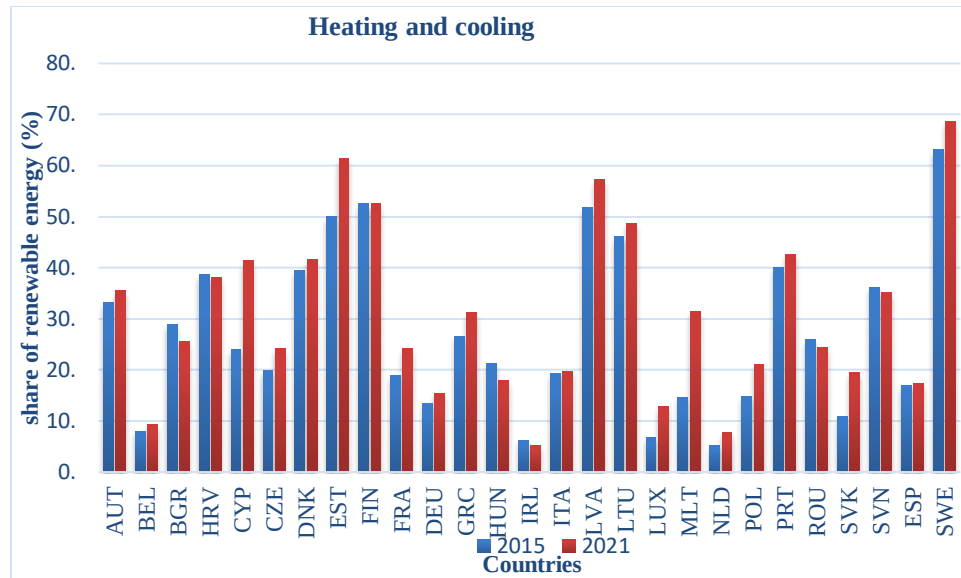


Figure 9. The comparative evolution of renewable energy resources (heating and cooling)

Source: Own research using data from Eurostat.

As in the previous cases, Estonia and Malta have some of the highest increases recorded for the time periods analysed. The same cannot be said about Croatia, Slovenia, Ireland, Romania, Bulgaria and Hungary which recorded lower values by 0.59% to 3.40% compared to 2015 (Figure 9).

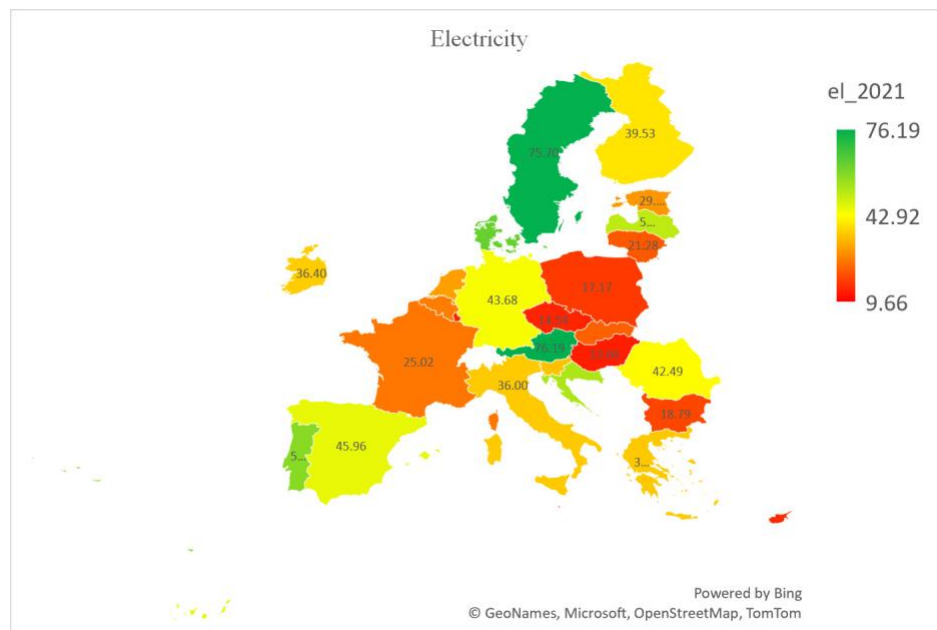


Figure 10. Renewable energy - electricity 2021

Source: Own research using Excel and data from Eurostat.

For a clearer and visual representation of the values recorded by the EU member states of the proportion of renewable resources used in the electricity sector, it can be noted in Figure 10, the EU map, the coloring of the countries depending on the values of this indicator. Thus, it can be observed that the presence of colors seems balanced, with very low values (such as Hungary, the Czech Republic, Poland), medium values (Romania, Germany and Spain), but also very high values (recorded in Sweden and Austria).

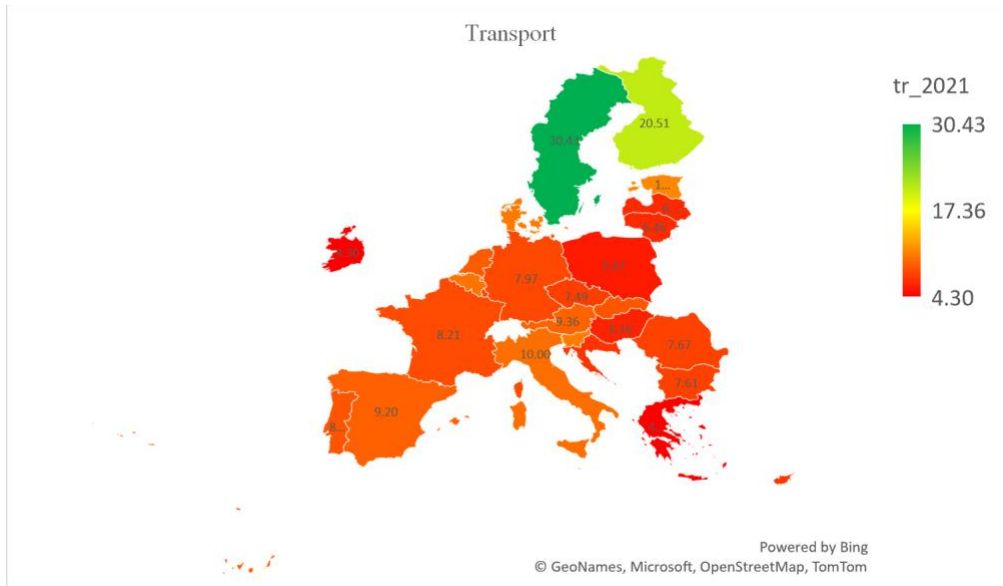


Figure 11. Renewable energy - transport 2021

Source: Own research using Excel and data from Eurostat.

Figure 11 shows the predominant presence of low values (most states with values that do not exceed 10%), with the exception of Italy, Estonia, and obviously Finland and Sweden, where the highest values are found.

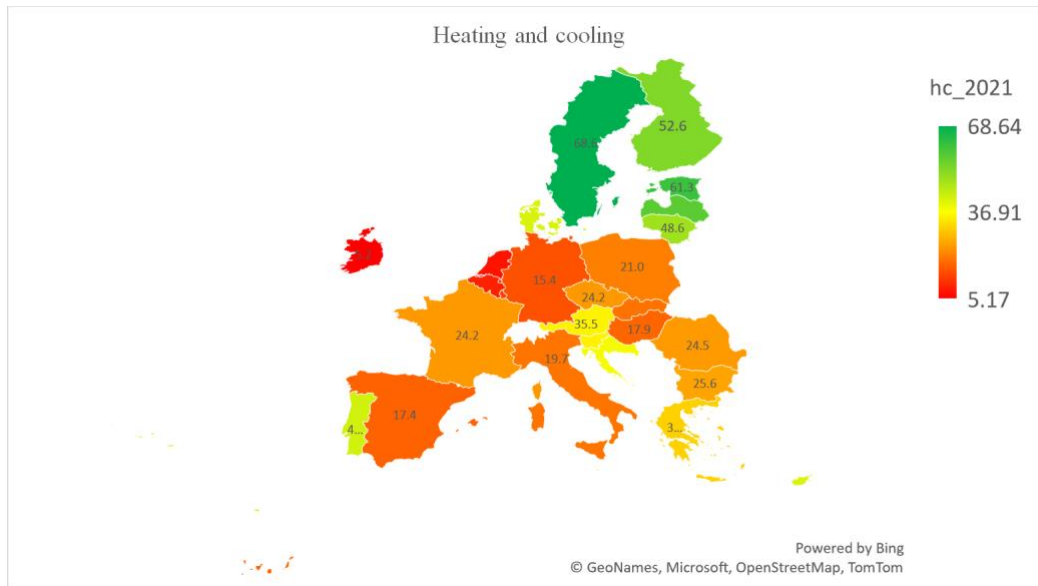


Figure 12. Renewable energy - heating and cooling 2021

Source: Own research using Excel and data from Eurostat.

In Figure 12 it can be seen that the heating and cooling sector registered many high values, which can be identified in the northern part of Europe. However, most values fall between the minimum and average values.

According to the analysis carried out for these sectors that consume energy supplied from renewable sources, transport can be considered the most deficient, with the lowest percentages attributed to these resources.

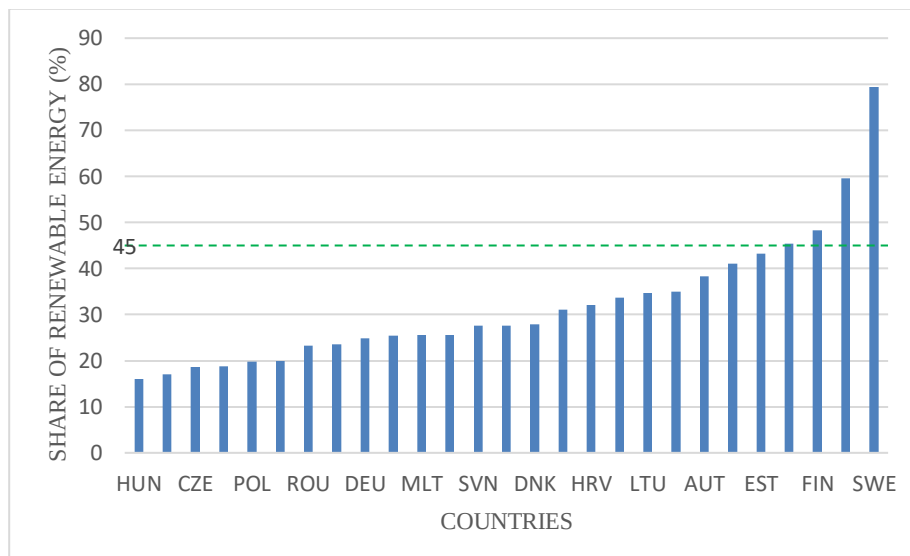


Figure 13. Share of renewable energy 2030

Source: Own research using CrystalBall.

Figure 13 shows that based on the data forecast for 2030, only four countries (Latvia, Finland, Cyprus and Sweden) seem to reach the proposed target. The historical data that allowed the creation of these forecasts dates from 2004 to 2021, the predictions being made for the time horizon 2022-2030.

The forecasting methods used to determine these values are Autoregressive Integrated Moving Average (Belgium, Czech, Denmark, Ireland, Croatia, Luxembourg, Hungary, Malta, Poland, Slovenia, Slovakia, Sweden), Double Exponential Smoothing (Spain, Italy, Cyprus, Latvia, Portugal), Double Moving Average (Germany, Romania), Damped Trend (Bulgaria, Estonia, Greece, French, Lithuania, Netherlands, Austria) and Single Exponential Smoothing (Finland). For these, the Theil's U test values did not exceed 1, while for Durbin-Watson the values were between 1.54 and 2.15, with the exception of Romania, where the rate was 1.3.

As it can be noted, the information provided is not exactly encouraging, so more importance should be given to investments in this area because both the pandemic we went through and the Russian-Ukrainian war showed us how unpredictable life is, but also the fact that we have to be ready for anything.

The article contributes to a better understanding of trends in the EU regarding green energy, as well as future ones, through the forecast based on historical data.

Conclusion

The objective proposed by the European Commission for the year 2030, namely that 45% of the total energy produced to come from renewable resources, is a bold one. The same can be said for the 2009 objective, which was successfully reached in 2020. To achieve this, the investments that will be made in the field of research and technology, as well as the adopted policies, will be the path to accomplish it.

According to the analysis carried out in this paper, it was noted that from the point of view of the EU average, a series of important steps have been taken in most countries, with only six countries having a percentage of renewable energy below 20% of total consumption. However, three of these states (Cyprus, Malta, Luxembourg) had some of the largest increases recorded during the period 2015-2021 (see Figure 4). The highest values recorded for this indicator were achieved by the Nordic countries (Sweden, Finland, Denmark, Estonia, Latvia) and Austria; a similar situation was recorded for the heating and cooling sector. In the electricity sector, Austria recorded the highest value of 76.19%, immediately followed by Sweden. At the opposite pole were countries such as Malta, Hungary and the Czech Republic. The lowest percentages were recorded in the transport sector, where the values ranged from 4.30% to 30.43%, with Sweden maintaining the lead position in the EU ranking, followed by Finland. In this case, the lowest percentages were identified in Ireland, Greece and Poland.

The discrepancies identified between the percentages registered by the EU member states of these indicators are significant, especially for the heating and cooling sector, where the minimum value is more than 13 times lower compared to the maximum. Although the ranking of countries differs from one analysed sector to another, some aspects remain constant: in all cases presented, Sweden and Finland were always in the top positions, while countries such as Hungary, Malta and Luxembourg were at the opposite pole.

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Appendix A: The labels attributed to the countries

Country	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Denmark	Estonia	Finland	France	Germany	Greece	Hungary
Label	AUT	BEL	BGR	HRV	CYP	CZE	DNK	EST	FIN	FRA	DEU	GRC	HUN
Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden
IRL	ITA	LVA	LTU	LUX	MLT	NLD	POL	PRT	ROU	SVK	SVN	ESP	SWE