SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2022
ORGANIZATION AND MANAGEMENT SERIES NO. 166

DIFFERENTIATION OF CLIMATE AND ENERGY POLICY IN THE COUNTRIES OF THE EUROPEAN UNION

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Purpose: The energy policy of the European Union focuses mainly on three areas: renewable energy, reducing the emission of harmful pollutants, in particular CO2, and increasing the efficiency of electricity used. Sustainable energy management, in turn, is undoubtedly associated with the increased use of renewable energy sources ensuring energy security as well as the diversification of energy supplies that support and improve the quality of the environment. The aim of the article is to present the diversity of the European Union countries in terms of actions taken in the field of energy policy resulting from climate and energy goals.
Design/methodology/approach: On the basis of the objectives of the energy policy presented in the EU directives, indicators describing the activities of the Member States in this respect were selected. Then, they were subjected to substantive and statistical verification, leaving 6 variables. The tool of Multidimensional Statistical Analysis, which is a synthetic measure, was used to develop a synthetic measure of the level of achievement of the goals of the climate and energy policy. Two types of analyses were used: static for international comparisons between the European Union countries, conducted for 2021, and dynamic, for the years 2011-2021.
Findings: The most favourable situation in terms of activities aimed at reducing emissions of harmful substances and improving the energy efficiency of countries can be observed in the hitherto leaders of Sweden and Finland. Together with Denmark, these countries have set very ambitious national targets for achieving a share of at least 50% from renewable energy in gross final energy consumption. All countries have increased their energy productivity index. Bulgaria, Italy and Slovakia have made the greatest reductions in pollutant emissions. In the interests of energy independence, countries are trying to increase energy production from domestic resources. The greatest improvements in this field were made in Ireland, Latvia, Portugal and Finland. The division into three groups of countries implementing the energy and climate policy introduced by the EU showed that the indicators that differentiate countries to the greatest extent, among the group of selected variables, are greenhouse gas emissions and the energy dependency ratio.

Keywords: energy and climate policy, EU countries, synthetic measure.

Category of the paper: Research paper.

1. Introduction

The energy sector is recognized by the Member States as a strategic sector of the economy, in which, above all, national interests subject to government regulations are of key importance. Nevertheless, the continuous increase in energy consumption and thus the need to invest in obtaining energy fuels abroad and their transport resulted in the need to introduce Community law (European Union Law, 2002). The main goal of the European energy policy is to take measures aimed at creating an integrated energy market and ensuring the security of energy supplies and a stable energy sector. This provision is particularly important in the context of problems with the purchase of energy resources caused primarily by the dependence of many countries on imports. These problems have been significantly aggravated by the recent war in Ukraine.

2. EU climate and energy policy

The problem of energy security has a global scope, therefore the provisions on energy security were also included in the goals of the United Nations Sustainable Development Agenda, which indicated the need to ensure access to "affordable, reliable, sustainable and modern energy" for all. This goal is to be achieved through "increasing the share of renewable energy in global energy consumption" and "promoting investments in energy infrastructure and clean energy technologies" (Wąs et al., 2020). Actions taken in this area are to increase the effectiveness of the fight against the progressive degradation of the environment and the increasing emission of greenhouse gases, which are a serious threat, increasing pollution and causing unfavourable climate changes (Mahjabeen, Chughtai, Simonetti, 2020).

In order to stop further deterioration of the environment, the UNFCCC (United Nations Framework Convention on Climate Change) was implemented, which describes the basic framework for global cooperation on this issue. This document was supplemented by the provisions of the 2030 Agenda, the Kyoto protocols (1997) and the Copenhagen agreements (2009). The measures included in the climate and energy package were updated on July 14, 2021, when the European Commission announced the "Fit for 55" legislative package. The aim of the package is to reduce greenhouse gas emissions in EU Member States by 55% by 2030 compared to 1990. The aforementioned directives indicate actions aimed at solving the problem of the deteriorating quality of the environment caused, among others, by the use of traditional fossil fuels (Li, 2005).

For the needs of the Member States, the European Union has developed a strategy aimed at fulfilling international obligations in the fight against unfavourable climate change as well as implementing the idea of sustainable energy (Energy Union Package, 2015). This strategy is being implemented gradually, in three main stages, through the implementation of the program objectives set in each of the stages (Gokgoz, Guvercin, 2018), (Chalvatzis, Ioannidis, 2017).

Focusing on the sustainable development strategy, it emphasises the need to promote a modern way of life taking into account appropriate environmental policies and philosophies that will counteract past practices of non-prospective exploitation of the earth's resources (Musiał, Zioło, Luty, Musiał, 2021).

The "20-20-20 package" included the following goals that the EU intended to achieve by 2020:

- 20% reduction in greenhouse gas emissions compared to 1990 levels, which was achieved by reducing emissions by 24%,
- 20% of energy obtained from renewable sources; this target was exceeded with the value of 22.1% in 2020,
- 20% improvement in energy efficiency, which meant savings in energy consumption compared to forecasts (Directive 2009/29/EC, 2009).

In 2020, EU primary energy consumption fell to 1236 million tonnes of oil equivalent (Mtoe), 5.8% above the 2020 target. Final energy consumption reached 907 Mtoe: exceeding the efficiency target by 5.4%.

2030 Green Book states:

- 40% reduction in greenhouse gas emissions compared with 1990 levels,
- 32% of energy obtained from renewable sources,
- 32.5% improvement in energy efficiency (Green Paper, 2013).

This means that by 2030, consumption in the EU countries should not exceed 1128 Mtoe in the case of basic energy and 846 Mtoe in the final energy. In 2020, 9.6% was short of the 2030 target, which means that efforts to improve efficiency must continue in the years to come. In the case of final energy consumption, the distance in 2020 from the target for 2030 was 7.2%.

The "Low Carbon Economy 2050" goal is to achieve EU climate neutrality by 2050 (A Clean Planet for all…, 2018).

The greenhouse gas emissions factor tracks the evolution of emissions for the Kyoto greenhouse gas basket when the EU has committed to reducing them. By 2020, gas emissions have decreased in the vast majority (22) of the EU Member States. The leader in these activities is Sweden, which reached the level of 20.6% compared to 1990. Romania, Estonia and Lithuania reduced the negative environmental impact by more than half. In Poland, the emission of harmful gases was reduced by 20.1%. By contrast, emissions increased in three EU Member States: Austria, Cyprus and Ireland (Key figures on Europe, 2021).

The Paris Agreement (2015) was of key importance for the implementation of the second objective, relating to the development of renewable energy sources in the European Union countries. Its main goals include combating climate change and supporting the development of the economy in order to achieve more sustainable development and lower greenhouse gas emissions. The main postulate of this agreement is to maintain the temperature at a level from 1.5 to 2^{o}C higher than in the pre-industrial period. This agreement, after it entered into force in 2016, has been ratified by 187 countries. The signatories are obliged to prepare their NDC (National Determined Contribution), in which they will present ways to reduce GHG emissions and methods of monitoring the progress of its implementation. In connection with these findings, the EU has adopted a plan under the 2030 Framework for Climate and Energy (European Commission, 2022), which envisages the creation of a sustainable energy system. The elements of the plan include:

- improving energy efficiency;
- ensuring access to affordable energy for all consumers;
- increasing energy independence, which is important in the light of the information that in 2019, 55% of energy consumed in EU countries was produced from raw materials from outside the EU;
- introducing a fully integrated common energy market (Energy Union);
- becoming a world leader in obtaining energy from renewable sources.

Therefore, it is planned that renewable energy sources will play an important role in the future energy system of the EU.

3. Materials and Methods

The statistical material used in the study came from the Eurostat and World Bank databases. In the process of creating a synthetic measure for assessing the level of achieving the goals of climate and energy policy, the tool of Multidimensional Statistical Analysis, which is a synthetic measure, was used. In the first stage of the research, the characteristics describing the studied phenomenon were selected using the Sustainable Development Goals indicators (Table 1), and their character was determined (S - stimulant set, D - destimulant set). The time range of the research covers the years 2011-2020, with the exception of the indicator for which the last analysed year is 2019. Two countries were omitted from the analysis: Cyprus and Malta due to the lack of complete data. The changes in the indicators were found by determining the measures of the dynamics of the phenomena.

Table 1.
Selected variables for the analysis

Area	Variable	Item
Energy	Energy productivity [euro per kilogram of oil equivalent (KGOE]	W_1
	Energy imports dependency [Percentage]	W_2
	Share of renewable energy in gross final energy consumption [Percentage]	W_3
Climate	Share of environmental taxes in total tax revenues [Percentage]	W_4
	Net greenhouse gas emissions [Index, 1990=100]	W_5
	Exposure to air pollution by particulate matter [µg/m3]	W_6

Source: own study on Eurostat.

All the variables in the studied group of objects meet the basic criterion for selecting variables to describe a complex phenomenon (Table 2), i.e. they are not quasi-constant variables (Nermed, 2017).

Table 2.
Numerical characteristics of the indicators in the years

Item	*2011*				*2020*			
	max	***min***	***Me***	***CV***	***max***	***min***	***Me***	***CV***
W_1	12.55	2.03	5.83	0.22	22.61	2.47	6.77	0.19
W_2	97.29	-5.97	53.91	0.25	92.46	10.50	56.33	0.20
W_3	47.63	1.85	13.18	0.23	60.12	10.71	21.75	0.19
W_4	10.56	4.43	7.56	0.15	9.89	3.62	6.81	0.17
W_5	161.50	25.60	86.20	0.18	147.60	20.60	73.20	0.18
W_6	41.30	6.90	17.30	0.18	19.60	4.80	11.80	0.19

Me: Median; CV: Coefficient of Variation.

Source: Own study based on Eurostat.

All the variables showed average differentiation as indicated by the values of the coefficients of variation. The volatility indicators describing the energy policy decreased in 2020 as compared to 2011. This indicates that countries with traditional energy policies with a low share of renewable sources in energy production and low productivity are getting closer to the group of the best countries. In the case of climate policy, the volatility indices have slightly increased (W_4 and W_6) or have not changed (W_5), which may indicate a widening distance between countries. It should be emphasized that the median of indicator 3 increased significantly from 13.18% to 21.75%. The decrease in the median for indicators 5 and 6 should be assessed positively.

In the second stage, the indicators were normalized, according to the formula (Walesiak, 2014; Kukuła, Luty, 2015):

$$z_{ij} = \begin{cases} \dfrac{\max\limits_i w_{ij} - w_{ij}}{\max\limits_i w_{ij} - \min\limits_i w_{ij}}, & W_j \in D \\ \dfrac{w_{ij} - \min\limits_i w_{ij}}{\max\limits_i w_{ij} - \min\limits_i w_{ij}}, & W_j \in S \end{cases} \tag{1}$$

where: w_{ij}, z_{ij} - the actual and standardized values for the implementation of the indicators, respectively W_j for i country, such as: $z_{ij} \in [0,\ 1]$.

In the third stage, the values of the synthetic variable Q_i were determined according to the formula:

$$Q_i = \frac{1}{j}\sum_j z_{ij} \tag{2}$$

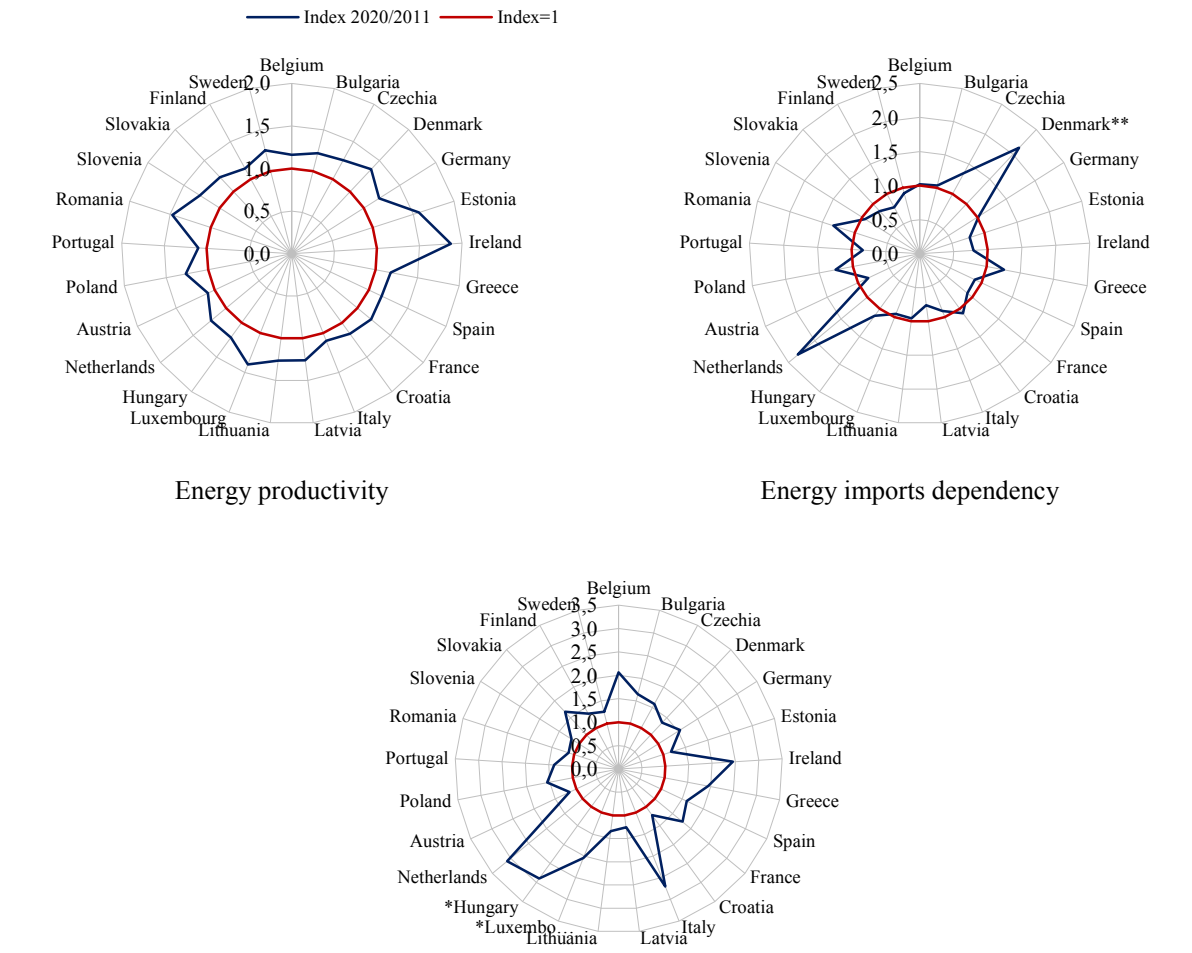
where: Q_i - the level of implementation of the goals of the climate and energy policy and the country, $Q_i \in [0,\ 1]$.

The highest Q_i value indicates the best object.

The analysis of the correlation relationship between the selected rankings was carried out using the Spearman's rank correlation coefficient. The Student's t-test was used to verify it.

4. Results

In 2020, all EU countries increased the size of economic productivity, i.e. the value of goods produced per unit of gross available energy, compared to 2011 (Figure 1). The biggest changes took place in the Irish economy, where productivity increased by EUR 10.25 per kilogram of oil equivalent (KGOE). Large productivity gains were also observed in Denmark, Luxembourg, Sweden and Romania, but were not as significant as in Ireland.



* value doubled.

Figure 1. Changes from 2011 to 2020 in the adopted EU indicators on the level of energy achievement. Source: Own study based on Eurostat.

The dependence on imported energy raw materials is of particular importance in assessing the energy policies of the Member States. In 2020, the figure for the EU as a whole was 57.5%, meaning that the use of imported materials provided almost three-fifths of the available energy. The most important fuel sources in the EU's energy mix in 2020 were mainly crude oil and petroleum products (34.5% of all fuels) and natural gas (23.7% of all fuels). Dependence on imports of crude oil, the primary raw material for the petrochemical industry and the production of fuels used in transport, was the highest among all fuels and only slightly decreased from 94.04% in 2011 to 93.10% in 2020. The second highest rate of import dependency, at 57.49% in 2020, was recorded for natural gas used as a fuel for electricity generation and heating. The share of a country's total energy needs covered by imports from other countries is and has been highly variable across the group of countries analysed. In 2020, the problem of the economy's dependence on imports of energy resources was significant especially in Greece (81%), Belgium (78%), Ireland (71%), Italy (73%) and Lithuania (74%) (Figure 2).

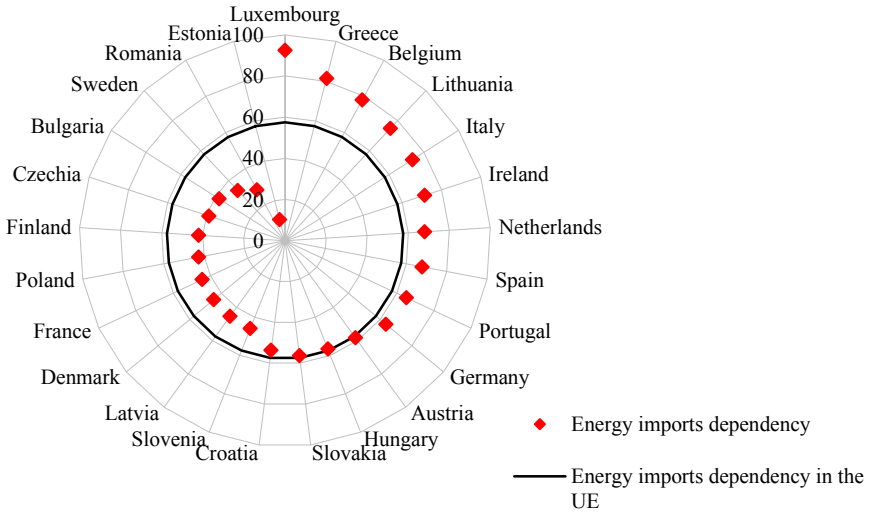


Figure 2. Energy imports dependency (%) in European Union countries in the year 2020.

Source: Own study based on Eurostat.

Largely independent countries include Estonia (10.5%), Romania (28.2%) and Sweden (33.5%). Over the decade (2011-2020), sixteen countries have reduced their energy dependence. Ireland, Latvia, Portugal and Finland have increased the proportion of energy produced from domestic resources to the greatest extent. In contrast, Denmark, the Netherlands, Romania and Poland increased the amount of imported energy resources.

All countries exceeded the goals of the climate and energy policy with regard to the share of energy from renewable sources in the total energy consumption. The most progress has been made in Finland, Sweden and Greece. Hungary, Romania and Slovenia were the least active in this respect.

In 2020, almost all countries exceeded the climate and energy policy targets for the share of renewable energy in total energy consumption (Figure 3).

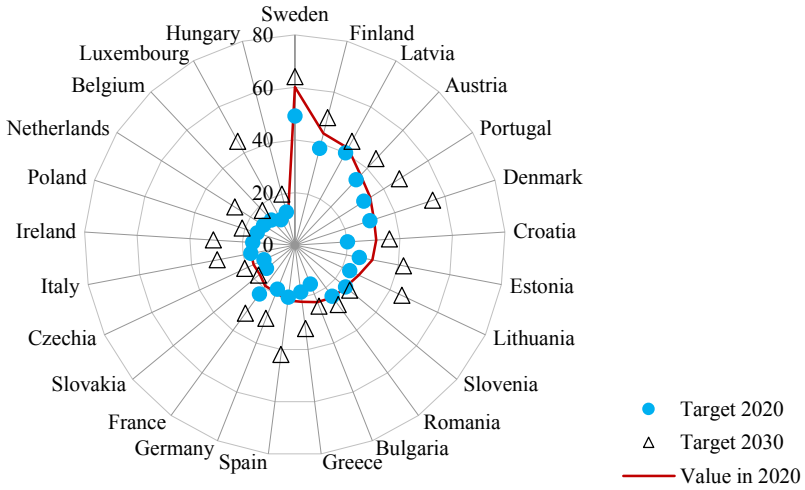


Figure 3. Share of renewable energy in gross final energy consumption in EU countries in 2020 and targets for 2020 and 2030.

Source: Own study based on Eurostat.

Only three countries have set national 2030 targets for the share of renewable energy in gross final energy consumption of at least 50% and these are Sweden (64%), Denmark (55%) and Finland (50%). The share of renewables in EU energy consumption in 2020 was 22.1%, which means that the 2020 target was exceeded by 2.1 percentage points. In 2011, the share of RES in the EU's energy mix was only 13.2%. The undisputed EU leader in terms of the share of renewables in gross energy consumption was Sweden (60.1%), followed by Finland (43.8%), Latvia (42.1%) and Denmark (31, 7%) (Figure 3). At the other extreme in 2019 were: The Netherlands, where the share was only 13.9%, as well as Belgium (13.0%), Malta (10.7%) and Luxembourg (11.7%). Poland (16.1%) was among the countries that set a target below the EU average. The greatest progress between 2011 and 2020 in increasing the share of renewables in energy consumption was made in Finland, Sweden and Greece. The least active in this respect were Hungary, Romania and Slovenia.

Revenue from environmental taxes comes mainly from four types of taxes: energy taxes (approximately three-quarters of the total), transport taxes (approximately one fifth of the total), and taxes on pollution and resources (approximately 4% of the total). In the European Union countries, a decrease in revenues from environmental taxes can be observed, which may indicate an improving situation and limiting the number of harmful factors. Countries where the environmental fee has increased are Greece, Croatia, Romania and France (Figure 4).

In terms of measures to improve the quality of the climate in the area of reducing greenhouse gas emissions, very good results were also observed, as only 4 countries in 2020 exceeded the emission level from 1990. Total domestic greenhouse gas emissions calculated in accordance with the "Kyoto Basket" methodology, i.e. including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the so-called F-gases from all sectors have steadily decreased. With regard to 2011, only Latvia and Lithuania increased gas emissions, while in other countries the measures taken brought the desired effect.

The annual average concentration of particulate matter is especially important for health as it can cause inflammation and worsen the health of people suffering from heart and lung diseases. Fine particles (PM2.5) with a diameter of less than 2.5 micrometres pose a particular risk as they can be more toxic. Countries have made significant progress in reducing pollution from these particles. All member states have reduced the presence of harmful substances in the air. The most favourable changes occurred in Bulgaria, Italy, Hungary and Slovakia.

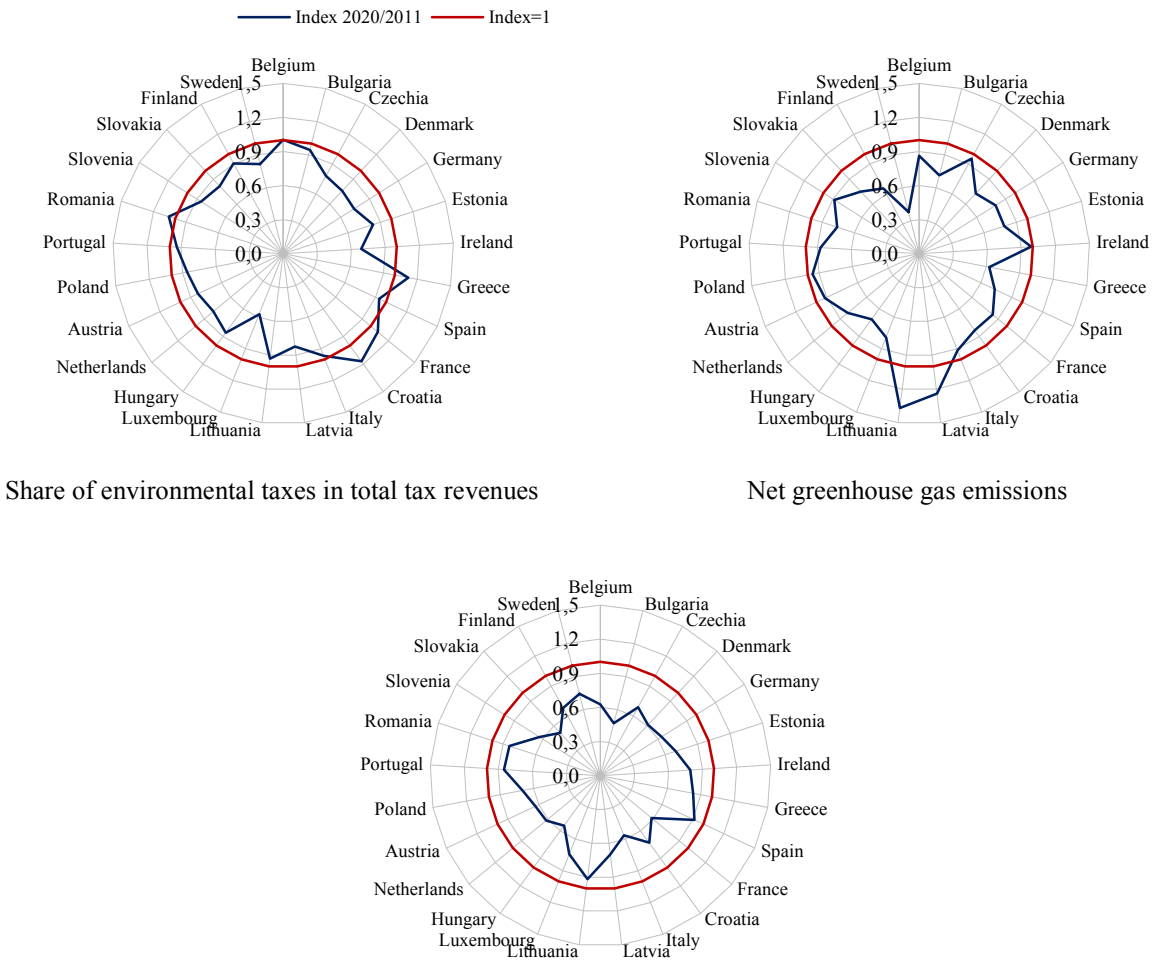


Figure 4. Changes from 2011 to 2020 in the adopted EU indicators on the level climate goals.

Source: Own study based on Eurostat.

Taking into account the aggregated energy targets, most countries in 2020 retained their positions from the 2011 ranking (Figure 5). The greatest progress was made in Ireland, Bulgaria and Latvia, while relatively slow improvement compared to other countries was recorded in the Netherlands, Greece and Croatia.

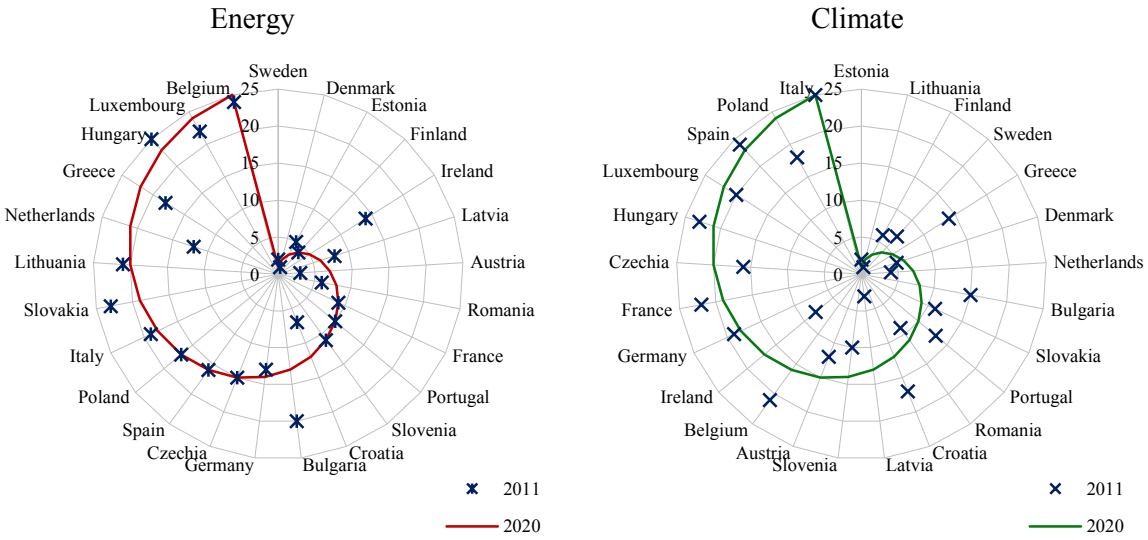


Figure 5. Ranks of EU countries in terms of the level of achievement of energy and climate goals in 2020 and 2011.

Source: Own study based on Eurostat.

For climate targets, the greatest improvement in ranking compared to 2011 can be seen for Greece, Bulgaria and Croatia. On the other hand, the most significant decreases took place in the case of Latvia, Ireland and Poland. It is worth paying attention to the fact that a frequent case is the simultaneous improvement in the ranking of climate targets and deterioration for energy purposes, and vice versa, which is well illustrated by the examples of Greece, Croatia, Ireland and Latvia. This may mean that states tend to place greater emphasis on the implementation of a specific group of goals related to EU policy, ignoring the latter.

The correlation coefficients between the positions of countries in achieving energy goals and the positions of implementing climate policy in 2011 and 2020 are respectively 0.505 (p *value* < 0.05) and 0.378 (non-significant).

5. Conclusions

Energy and climate policy is of particular importance in the modern world. EU countries are making efforts to improve energy efficiency and reduce air pollution. The consequence of actions taken by most countries is the improvement of indicators concerning energy and climate policy. The European Union places great emphasis on obtaining energy from environmentally friendly raw materials. The clear leaders in the EU when it comes to the share of renewable energy sources in gross energy consumption in 2020 were Sweden, Finland, Latvia and Denmark. Only three countries have national targets for the share of renewable energy in gross final energy consumption of at least 50% and these are Sweden, Denmark and Finland.

Countries are trying to use the generated energy more efficiently, hence energy productivity increases in all analysed countries.

Bulgaria, Italy and Slovakia have introduced the most effective measures to reduce the occurrence of harmful substances in the air. Most countries except Latvia and Lithuania have reduced their greenhouse gas emissions. Revenues from taxes on environmental protection decreased in 2020 compared to 2011. More than half of the countries have reduced their energy dependence. In particular, production of energy from domestic resources was increased by Ireland, Latvia, Portugal and Finland. In turn, Denmark, the Netherlands, Romania and Poland increased the volume of imported energy resources.

All Member States have reduced the occurrence of harmful substances in the air. The division into the third group of countries implementing the energy and climate policy introduced by the EU showed that the indicators that differentiate countries to the greatest extent are greenhouse gas emissions and the energy dependency ratio.

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