

DEVELOPMENT OF RENEWABLE ENERGY USE IN POLISH INDUSTRY COMPARED TO EUROPEAN COUNTRIES

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Purpose: The article aims to look at the development of the use of renewable energy sources in industry, in Poland compared to European countries.

Design/methodology/approach: The research was conducted on data from 34 European countries between 2010 and 2021 using dynamic analysis and multivariate analysis in the form of cluster analysis.

Findings: Despite an overall upward trend, eleven countries saw a decline over the explored period. Countries where this development had just begun often increased the share of renewable energy in industry. On the other hand, some countries with slightly higher levels of this indicator initially did not show as much growth or even recorded a decrease.

Originality/value: The value of the article is to present the development of the share of renewable energy in industry in Poland and 34 European countries. A comparison of Poland with other countries showed the existence of uneven growth rates and even declines in the countries studied.

Keywords: renewable energy sources, energy in the industry, development of renewable energy sources.

Category of the paper: Research paper.

1. Introduction

The growing awareness of the need to protect the environment due to global warming is directing countries' efforts to increase the use of renewable energy sources. Traditional, coal-based energy sources have contributed to the increase of pollution through the emission of harmful substances. Renewable energy sources include solar, wind, geothermal, hydropower, tidal and biomass energy. They are considered inexhaustible, and their resources are not depleted in the very long term. Renewable energy sources have great potential as an alternative to traditional energy. An additional aspect, especially since Russia's aggression in Ukraine, is the pursuit of energy independence, which can be provided by renewable energy sources.

Therefore, today, it is increasingly important to ensure energy security toward greater diversification and independence.

The EU's Fit for 55 strategy ("Fit for 55", 2021) aims to reduce emissions by 55 per cent by the end of the decade and achieve climate neutrality by 2050. In Poland, as stated in (PEP2040, 2021) in the perspective of 2040, the aim will be to have about half of the electricity generation coming from renewable sources. It can be achieved - and there is much to be done here - by focusing efforts on many aspects, across national economies: from households to industry (Bogdanov et al., 2021; Dogaru, 2020; Jonek-Kowalska, 2022). This article focuses on aspects of the industry.

There have been many studies in the literature on the development of different renewable energy sources (Banasik, Czupryna-Nowak, 2022; Bórawski et al., 2019; Corrêa da Silva et al., 2016; Kubiak-Wójcicka, Szczęch, 2021; Kumar, Majid, 2020; Lo, 2014; Mularczyk, 2016; Mularczyk, Hysa, 2015; Mularczyk, Zdonek, 2022; Piwowar, Dzikuć, 2019; Tutak, Brodny, 2022; Wolniak, Skotnicka-Zasadzień, 2022).

The use of renewable energy sources also is of great importance in terms of industry, for environmental protection and sustainable development. It can contribute to both environmental protection and lower operating costs for companies thus increasing competitiveness (Amir et al., 2020; Diab et al., 2016; Espinosa et al., 2012; Figueiredo, 2010; Ge et al., 2022; Ghadimi et al., 2015; Giampieri et al., 2020; Hulshof, Mulder, 2020; Lombaerde, 2021; Philbert, 2017). For this reason, it is worth looking into the industry and the use of these energy sources in it.

The purpose of the article is to look at the development of the use of renewable energy sources in industry, in Poland compared to European countries. Accordingly, the following research questions were posed:

- RQ1: What was the rate of growth of the share of renewable energy in the Polish industry between 2010 and 2021?
- RQ2: What was the growth rate of renewable energy in Polish industry between 2010 and 2021 compared to European countries?
- RQ3: What group of European countries does Poland belong to in terms of the development of the share of renewable energy in the industry?

2. Materials and Methods

For the study, data on the volume of renewable energy use in the industry was obtained from the Eurostat database (Database - Eurostat, 2023). The data was collected from 34 European countries. The selection of countries was determined by the availability of data in

the database. It was intended that countries outside the European Union would also participate in the study. The study covered the period from 2010 to 2021.

The collected data values were divided by total energy consumption levels in each country's industry. In this way, an indicator was obtained that denotes the percentage of renewable energy in the total energy consumed in the industry.

Calculations were performed in a spreadsheet and the R environment.

To answer the first and second research questions, methods were used to analyze the dynamics of the phenomena. The results were supplemented with data visualizations in the form of graphs. To answer the third research question, a cluster analysis was conducted. The results were accompanied by data visualizations in the form of box plots.

3. Results and discussion

To find the answer to the question of what the growth rate of renewable energy in the Polish industry in 2010-2021 was, a dynamics analysis was conducted, such as individual single-basis indexes, chain indexes and average rates of change.

Table 1 presents the results of the analysis of the growth rate of the share of renewable energy in total industrial energy for Poland over the 12 years studied.

Table 1.

Analysis of the dynamics of the share of renewable energy in the Polish industry

Year	Share of renewables in total	Year-to-year changes	Changes from 2010	Average annual growth from 2010
2010	6,8%	-	100%	-
2011	7,2%	105%	105%	5,2%
2012	7,6%	106%	112%	5,7%
2013	9,2%	121%	135%	10,6%
2014	9,5%	103%	140%	8,7%
2015	10,0%	105%	147%	8,0%
2016	10,6%	106%	156%	7,7%
2017	10,7%	101%	157%	6,7%
2018	10,5%	98%	154%	5,6%
2019	11,3%	108%	166%	5,8%
2020	12,6%	111%	185%	6,4%
2021	9,9%	78%	145%	3,4%

Source: Own calculations.

There was an almost constant year-on-year increase in the share of renewable energy in the total energy used by the industry. The first of the two exceptions was 2018, with a slight, 2%, decrease in this level compared to 2017. In contrast, the second was 2021. In that year, there was already a significant decrease in the surveyed measure, as much as 22% compared to the previous year. Therefore, considering only the years 2010 to 2020, the share of renewable energy in total energy increased by 85%. However, considering also 2021, the increase was 45%. The former has an average year-on-year increase of about 6.4% and the latter 3.4%.

Further calculations were then carried out to answer the question of how the growth rate of renewable energy in the Polish industry in 2010-2021 was shaped compared to the European economy. Firstly, to examine the dynamics of the share a chart is included in **Figure 1**. To ensure the transparency of the chart, only certain countries were selected for it. A common indicator for the 27 countries of the European Union has also been added.

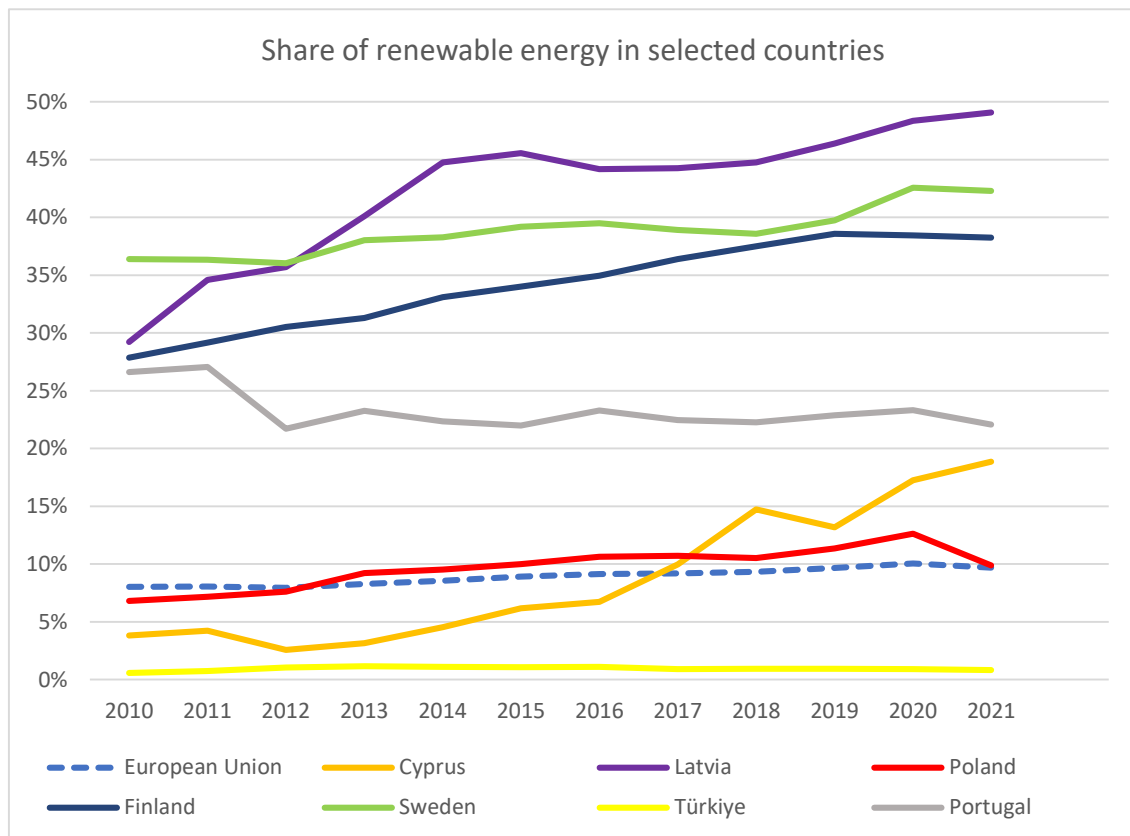


Figure 1. Dynamics of the share of renewable energy in total industry in European countries.

Source: Own calculations.

As the chart shows, the share of renewable energy in industry in Poland was roughly at the European Union average. A rather large decrease in this share in the Portuguese industry and a sharp increase in Cyprus also can be observed.

The graphs in **Figure 2** - **Figure 4** have been added for a better view, showing the states of the studied indicator in 2010, 2016 and 2021 (non-EU countries are yellow). It can be seen on the charts that Poland was initially ranked 13th (among the 34 European countries surveyed), and in 2016 it reached the highest place, 6th, to be ranked 9th in 2021.

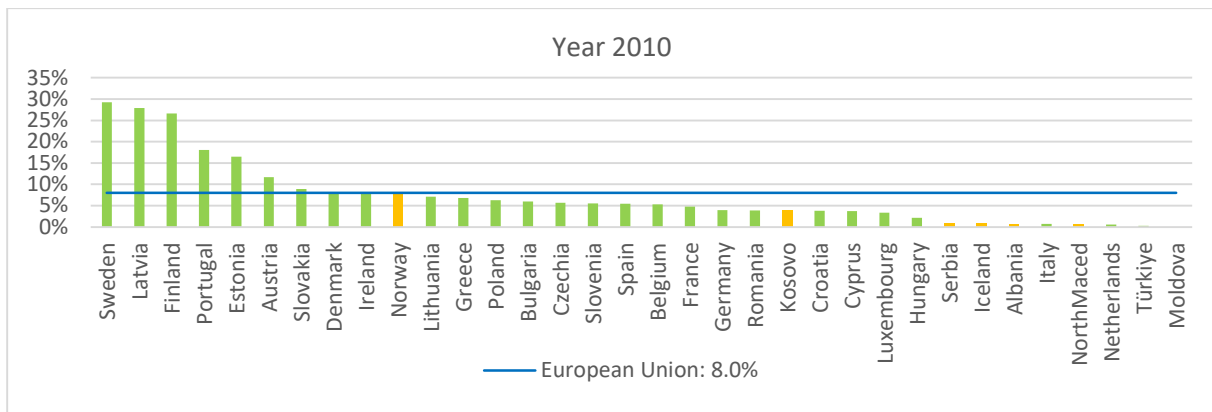


Figure 2. Shares of renewable energy in the total industry in European countries in 2010.

Source: Own calculations.

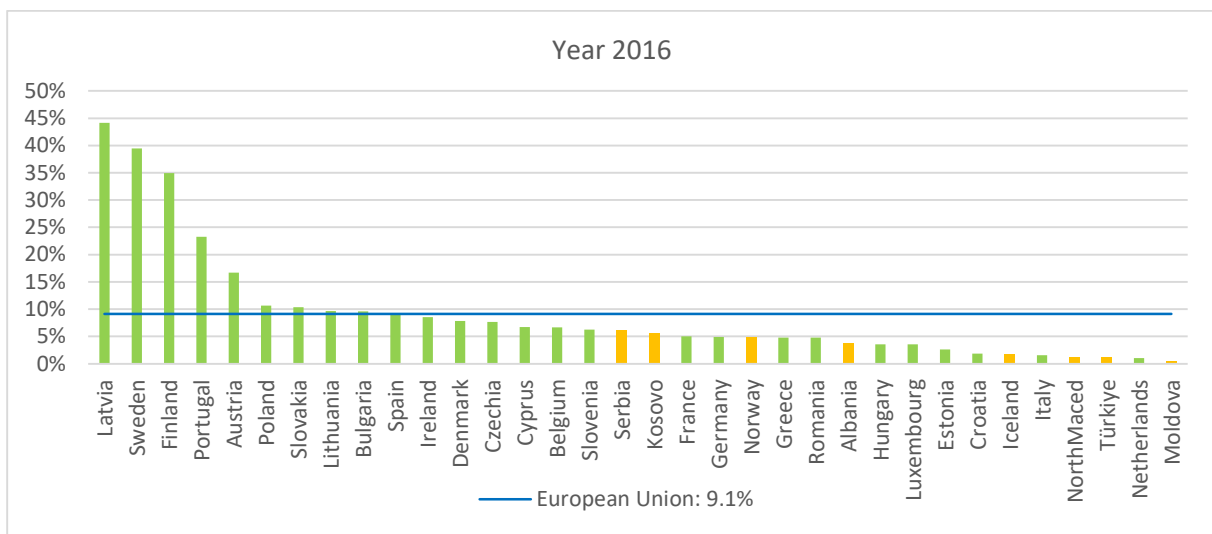


Figure 3. Shares of renewable energy in the total industry in European countries in 2016.

Source: Own calculations.

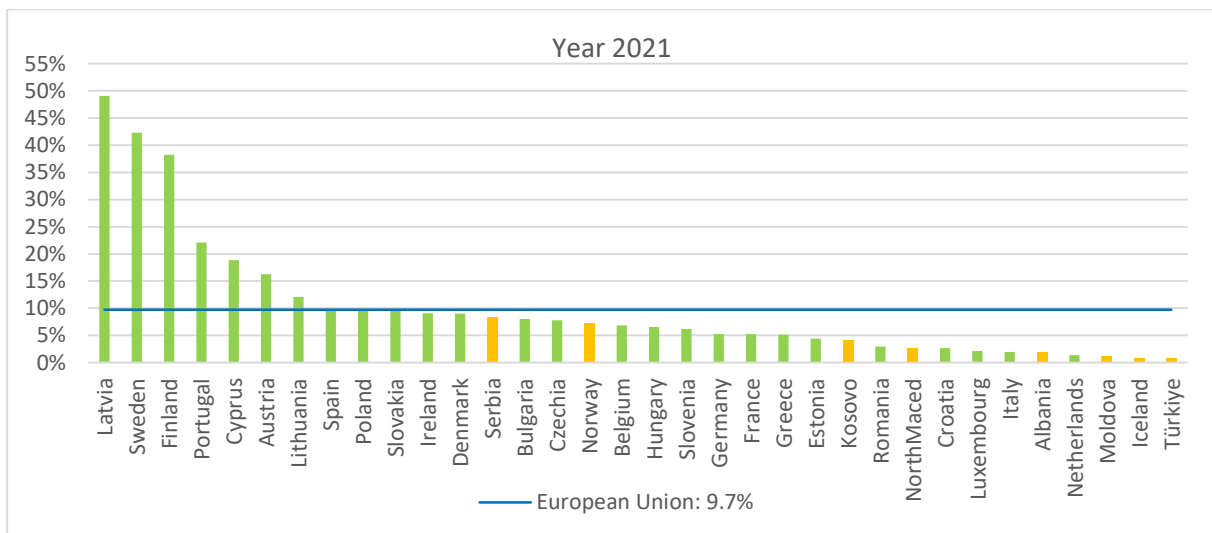


Figure 4. Shares of renewable energy in the total industry in European countries in 2021.

Source: Own calculations.

Analyzing the above four charts, it can be concluded that there are several groups of countries. In the first group are inherent three countries: Latvia, Sweden, and Finland. Their development in the field under study had already taken place before the period analyzed here. Indeed, they have a share of renewable energy at the highest level (from 28-36% in 2010 up to 38-49% in 2021). All three are also European Union countries. The following countries had a share roughly at the level of the average share of European Union countries. This group includes Poland, among others. There is also a group, including e.g., Moldova and Turkey (non-EU countries), with shares well below this value. Comparing the subsequent charts, the different rates of share growth in different countries also become apparent. In general, countries with smaller shares at the beginning are likely to see greater growth. Cyprus is a case in point. However, this is not the rule. There are also countries with negative growth in the share of renewable energy in industry. An example of this is Portugal, which initially ranked close to the group with the highest share (which for them was 27% in 2010). However, in this case, there was not an increase in the share, but a decrease, and the share was as high as 22% in 2021 (which is a 31% decrease compared to 2010). **Figure 5** illustrates, for comparison, the total growth of the examined indicator over the entire period studied. As it turns out, as many as eleven countries met a decrease in the share of renewable energy in the industry in the years studied. Interestingly, only one of them is not a European Union country. Instead, three of the four countries with the highest growth rates (Cyprus, Moldova, Serbia and North Macedonia) were not members of the EU.

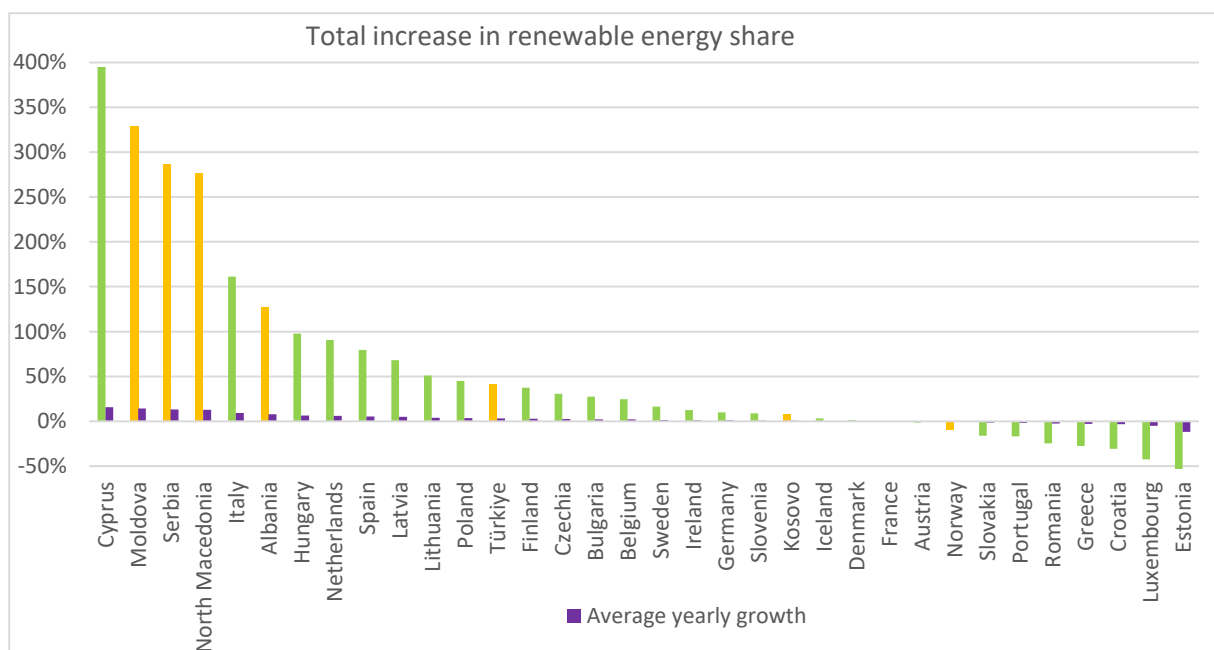


Figure 5. Total growth of renewable energy in the total industry shares in European countries from 2010 to 2021.

Source: Own calculations.

Finally, to answer the third research question of what group of European countries Poland belongs to in terms of the development of the share of renewable energy in the industry cluster analysis was carried out (**Figure 6**).

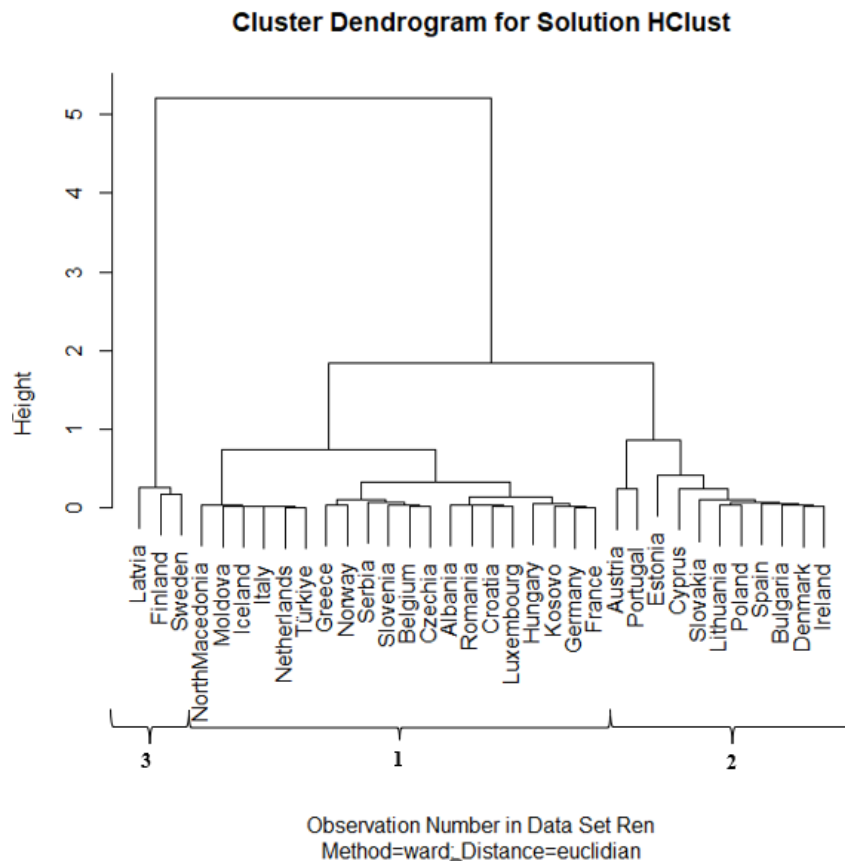


Figure 6. Dendrogram.

Source: Own calculations.

As a result of the cluster analysis, the countries studied can be divided into three groups. The first cluster included countries with the lowest average share of renewable energy in industry over the years studied (at 3.4% in 2010 to 4.1% in 2021). Remarkably, all the non-EU countries surveyed were in this group. Poland was placed in the second cluster, together with countries with a visibly higher level of the factor under study (at an average level of 10.1% in 2010 to 11.8% in 2021). The third cluster includes countries with the highest shares (at an average of 31.2% in 2010 to 43.2% in 2021). The levels of these shares at the beginning and end of the study period are illustrated in the box plots in **Figure 7**. To sum up, Table 2 is included.

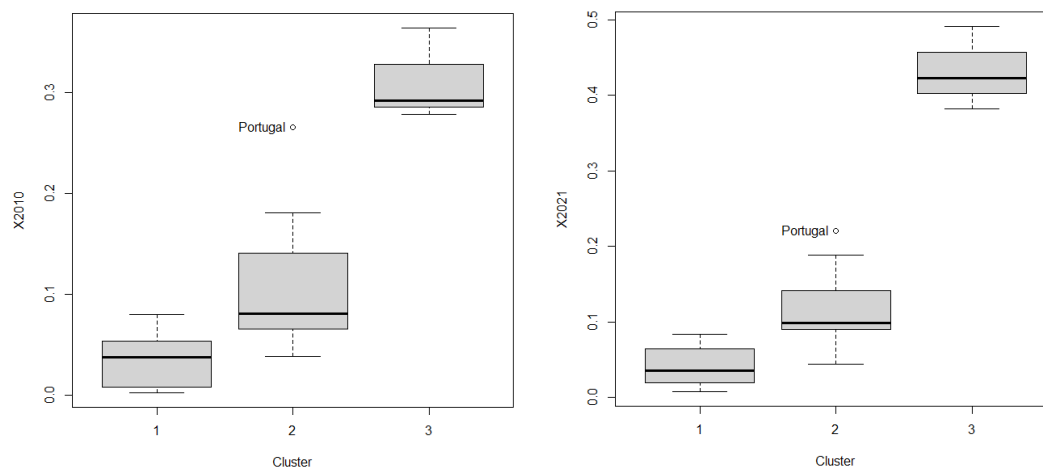


Figure 7. Boxplots of renewable energy shares in the industry by clusters in 2010 (left) and 2021 (right).

Source: Own calculations.

Table 2
Cluster comparison

Cluster No.	Mean share		Standard deviation		Median		Total growth
	2010	2021	2010	2021	2010	2021	
1	0,03395	0,04074	0.02417	0.02502	0.03768	0.03566	20.0%
2	0.10929 (0.09362)*	0.11760 (0.10782)*	0.06838 (0.04684)*	0.05206 (0.04136)*	0.08055 (0.08024)*	0.09881 (0.09827)*	7.6% (14.6%)*
3	0.31158	0.43203	0.04580	0.05472	0.29222	0.42287	38.7%

Note: * without Portugal.

Source: Own calculations.

The highest growth in the average share of renewable energy in the industry during the period under review was in the third group countries, at 38.7%. Also in the first group, the increase in average shares was quite large, at 20%, still, since the countries in this group started from a lower level this is not so evident in the graph. It is apparent that in these countries the development of renewable energy sources is just beginning. In the middle cluster countries, the increase was relatively the smallest at 7.6%. However, after removing Portugal from this group (which, due to the largest decline in the share of renewable energy during the period under review, can be considered an exception to the rule), the value turned out to be twice as large: 14.6%.

4. Summary

Polish industry has seen an almost steady increase in the share of renewable energy in total energy consumed. In 2020, the level increased by 85% compared to the 2010 level. However, in 2021, there was a significant decrease in the measure under study, by as much as

22% compared to the previous year. Considering 2021 as well, the total increase was 45%. Also, the share of renewable energy in industry in Poland was just about at the European Union average. Analyzing the states of the surveyed indicator in 2010, 2016 and 2021 of the 34 European countries surveyed, it was noted that Poland initially ranked 13th, reaching the highest position of 6th in 2016, to be ranked 9th in 2021.

As a result of the cluster analysis, the countries studied were divided into three groups. The first cluster included non-EU and other countries with the lowest average share of renewable energy in industry. This share fluctuated from 3.4% to 4.1% in the years studied, with an average growth rate of 20%. The second is EU countries with a significantly higher level of the studied factor (from 10.1% to 11.8%) but with the lowest relative growth rate (14.6%). The third cluster included EU countries with the highest shares (from 31.2% to 43.2%) and the highest growth rate (37.8%). Poland belonged to the second group.

Research showed, that renewable energy development was at different levels in examined countries. Although a general upward trend can be observed there were eleven countries with a decrease. Countries where this development has just begun have often significantly increased the share of renewable energy in industry. This group often included countries outside the EU, but not exclusively. On the other hand, some countries with slightly higher levels of this indicator did not show as much momentum at first and even declined. These studies show that underneath the studied indicator there is additional information not always disclosed. Not only the European but also the global trend of increasing the share of renewable energy is a fact. On the other hand, the different rates may be the result of different geographic as well as socio-political conditions in each country. Hence uneven growth rates and even declines. This issue certainly requires more extensive analysis in the near future to help understand the phenomenon under study.

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