

## SHARE OF RENEWABLE ENERGY IN POLAND COMPARED TO EU COUNTRIES

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**Abstract:** The paper analyses changes that occurred in production of renewable energy in EU countries in 2004-2017 with special focus on Poland. Forecasts of renewable energy shares in total gross energy consumption for 2020 were calculated for EU and individual member states to verify whether it is possible to achieve the goals determined in Europe 2020 strategy. It is probable that the goal for EU will be achieved, however, a lot of countries will face difficulties in meeting it, and some other countries simply have no chances to meet the goal. Unfortunately, Poland is among the last group of countries. There are also states that have achieved the goal determined for 2020 much earlier, for example Bulgaria, Estonia or Sweden. In the next step, development of the renewable energy share in final consumption in power industry, in heating and cooling, as well as in transport is analysed. Based on this, using the method of k-means, a group of countries that in 2004 and in 2017 were leaders in this sphere, but still have a lot to do to reach high level of share of renewable energy is identified. The group of leaders in 2004 and 2017 slightly changed. Estonia and Lithuania joined Denmark, Croatia, Latvia, Austria, Portugal, Romania, Slovenia, Finland and Sweden. Poland still has a lot to do to reach the European level of renewable energy share, however the trend of renewable energy share that has been observed since 2012 is really alarming.

**Keywords:** Europe 2020, renewable energy, forecasts.

### 1. Introduction

Continuously warming climate forced state governments to implement actions for environment protection, especially to decrease emission of greenhouse gasses. For many years, the trends of actions in the sphere of the environment protection have been determined by UN, OECD and EU. Conference in Stockholm (1972) was a turning point in international policy concerning environment protection. After 1972 the most important documents concerning environment protection included:

- the report entitled *Our Common Future* (1987) which comprises the issues of sustainable development,
- Agenda 21,
- *Europe 2020*,
- *declaration: The Future We Want*,
- *Development 2030 Agenda: Transforming Our World*.

While trying to adapt to trends observed in the world and to requirements specified by European Commission, Poland has also been implementing numerous actions and conducting, for example, a Clean Air – healthy choice campaign [Czyste Powietrze – zdrowy wybór [Clean Air – healthy choice], 2019].

In Poland the share of coal in electricity production has been continuously declining – in 1990, the share was 98%, in 2010 – 90% and in 2017 around 77%, including bituminous coal – 46.4%, which represents the lowest total share of coal in electricity production in Polish history (Wysokie napięcie, 2019). This confirms the thesis formulated by M. Turek and I. Jonek-Kowalska (Turek, and Jonek-Kowalska, 2015), that bituminous coal mining will face considerable reduction in the next few years in Poland. There are many reasons for this situation as the authors state. The decline of coal mines represents greater opportunities for development of renewable energy sources.

The purpose of the article is to forecast renewable energy share in final gross energy consumption for the entire EU and individual member states until 2020. The author compared the calculated forecasts with goals determined in 2020 strategy. The share of renewable energy consumption in power industry, heating and cooling sector as well as transport in individual EU countries was also compared.

All statistical data come from Eurostat webpage. Data from 2004-2017 were used for the analysis.

The forecasts were calculated with the use of linear or polynomial trends of the second degree, whereas the method of the least squares or Cochran-Orcutt's method was applied to estimate the parameters if autocorrelation of random element occurred. All calculations were made in the GRETLE program.

## 2. Literature review

The issue of environment protection and greenhouse gas emission occurs very frequently in the literature; both individual researchers as well as government organisations and international organisations address the issue.

The approach to environment protection can be really diverse, from presentation of legal aspects (Jakubowska, 2018) through management of environment protection (Wyrębek, 2010),

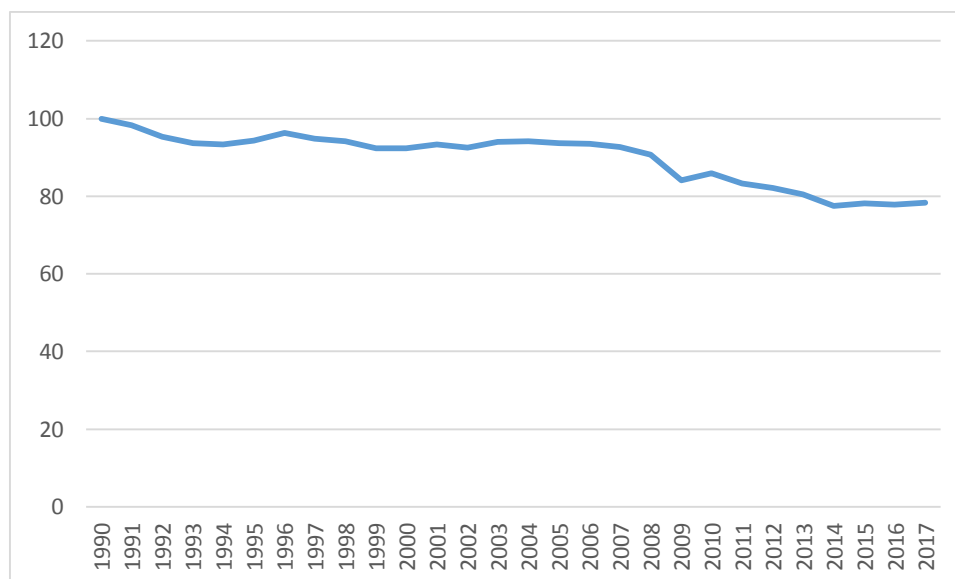
description of the possibilities of development of renewable energy resources (Ignarska, 2013) to statistical and econometric analyses. These analyses are regularly conducted by statistical offices (GUS [*Central Statistical Office*], 2018), international organisations (Ecofys, 2014) and individual researchers (Graczyk, 2017).

Statistical and econometric analyses are necessary not only to control progress concerning environment protection, but also to control implementation of all goals of Europe 2020 strategy, related not only to the share of renewable energy in final gross energy consumption. Other goals are also the subject of many case studies (Warzecha, 2019). Considering the goals of Europe 2020 strategy, attention must be paid to more far-reaching goals, and thus concerning the strategy of Sustainable Europe 2030 (Wójcik, 2018; McKinsey, & Company, 2009).

### 3. Development of energy from renewable sources in EU in 2004-2017

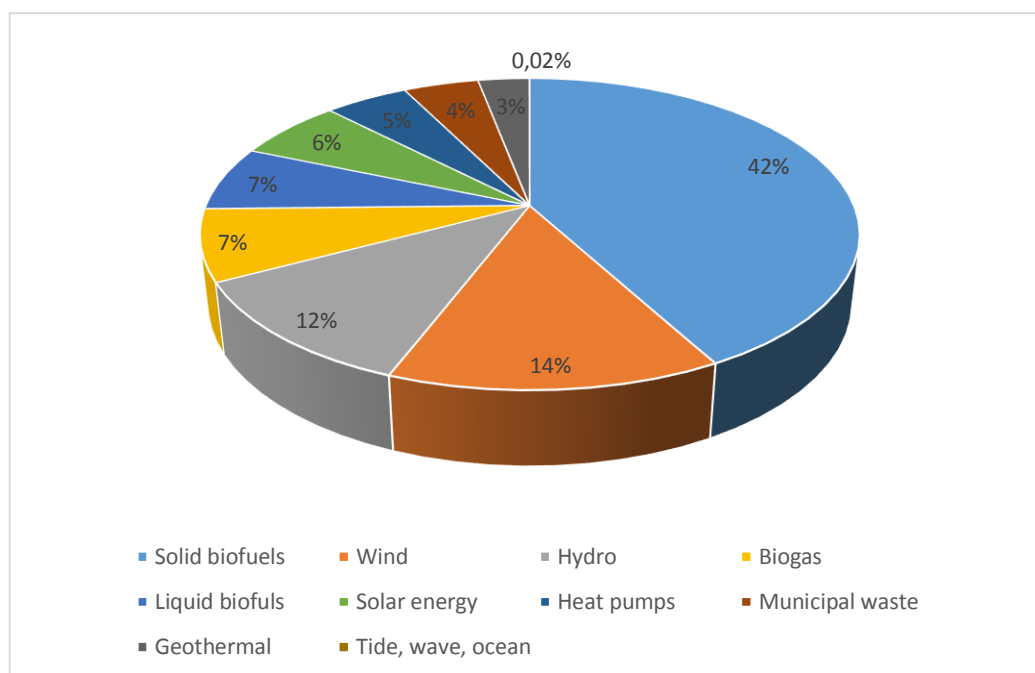
Europe 2020 strategy assumes that until 2020, emission of greenhouse gasses will decrease in comparison to 1990 by 20%. This goal is to be achieved through reduction of energy intensity in EU economy by 20% as compared to 1990, and thanks to increase in the share of energy gained from renewable sources to 20% in total gross energy consumption.

Emission of greenhouse gasses (Fig. 1) in EU already in 2014 decreased by over 20% in comparison to 1990, whereas the share of energy form renewable sources still did not reach 20%, i.e. the assumed goal (Fig. 4).

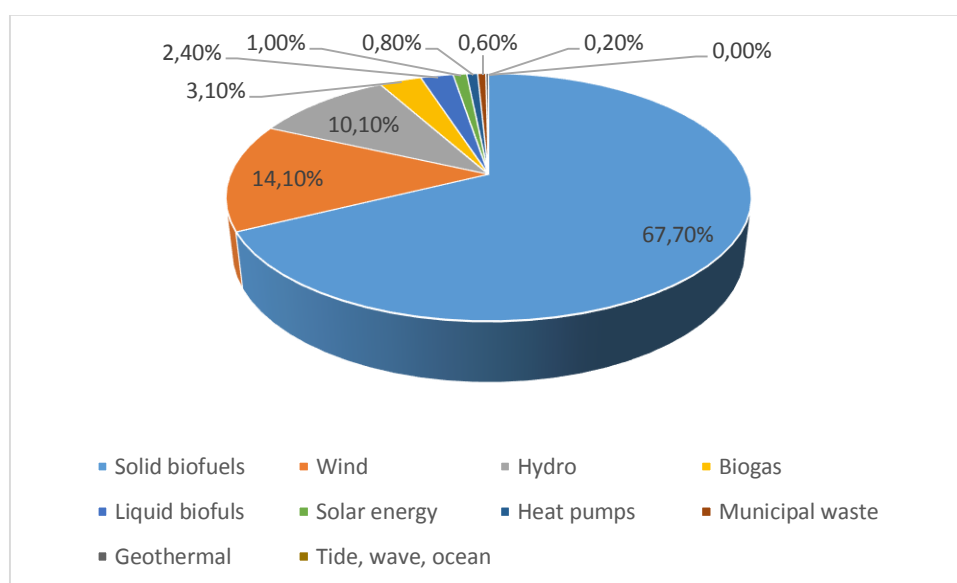


**Figure 1.** Emission of greenhouse gasses in EU (1990 = 100).

These goals concern EU, as a whole – individual countries have their own determined national goals. The structure of energy production from renewable resources is diverse in certain countries. Figure 2 and 3 show the structure of energy production from primary sources in 2017 in the entire EU and in Poland.

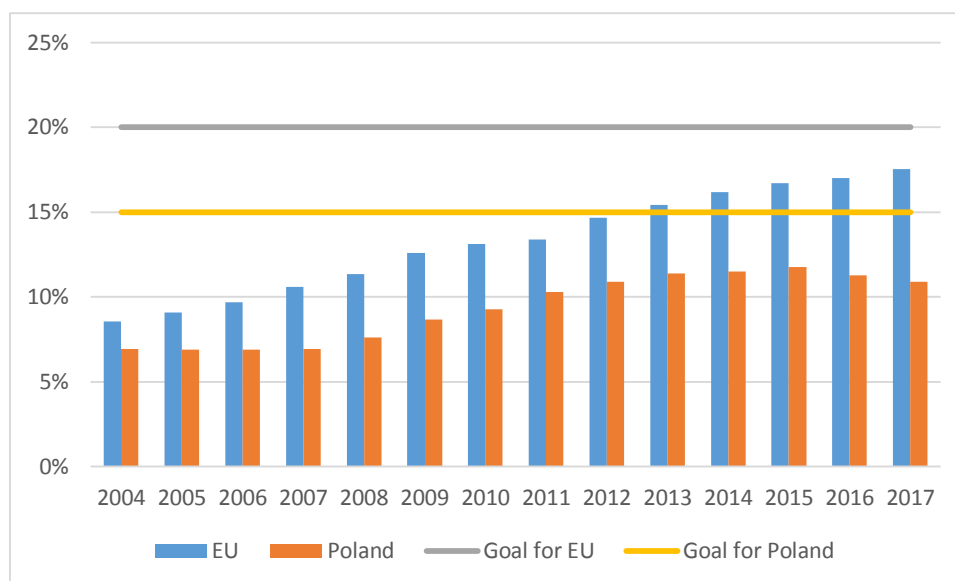


**Figure 2.** Structure of primary energy production from renewable sources in EU in 2017 from: <https://stat.gov.pl/obszary-tematyczne/srodowisko-energia/energia/energia-2019-folder,1,7.html>.



**Figure 3.** Structure of primary energy production from renewable sources in Poland in 2017 from: <https://stat.gov.pl/obszary-tematyczne/srodowisko-energia/energia/energia-2019-folder,1,7.html>.

The structure of energy production from primary sources in certain countries depends on many determinants, firstly on geographical location. Despite diverse structures, each state that is a member of the EU is obliged to increase the share of energy produced from renewable sources. Fig. 4 shows the share of energy produced from renewable sources in EU and in Poland over 2004-2017 and the goals assumed in Europe 2020 strategy.



**Figure 4.** Share of energy produced from renewable sources in EU and Poland in 2004-2017.

Both in the EU and in Poland increase in the share of energy produced from renewable sources is observed. The difference is that in the EU continuous growth of this share is noticed, whereas in Poland it can be seen that the graph takes the shape of sinusoid. Both EU as a whole and Poland, have not achieved the determined goal yet. Table 1 shows projections of the shares of energy produced from renewable sources calculated on the basis of trends for the whole EU and for individual member states. The forecasts were calculated with the use of linear or polynomial trends of the second degree, whereas the method of the least squares or Cochran-Orcutt's method was applied to estimate the parameters if autocorrelation of random element occurred (Maddala, 2006).

**Table 1.**

*Forecasts of renewable energy shares for 2020*

	Goal (%)	Forecast for 2020 (%)	Average prediction error	Estimation method
<b>EU</b>	20	20.2	0.37	OLS
<b>Belgium</b>	13	10.9	0.41	C-O method
<b>Bulgaria</b>	16	22.8	1.12	C-O method
<b>Czech Republic</b>	13	17.5	0.76	C-O method
<b>Denmark</b>	30	43.3	0.78	OLS
<b>Germany</b>	18	15.9	0.52	OLS
<b>Estonia</b>	25	33.8	1.42	C-O method
<b>Ireland</b>	16	12.2	0.37	OLS
<b>Greece</b>	18	19.6	0.91	C-O method
<b>Spain</b>	20	20.4	0.72	OLS
<b>France*</b>	23	18.2	0.43	OLS
<b>Croatia</b>	20	30.0	1.13	C-O method
<b>Italy</b>	17	19.5	1.08	C-O method
<b>Cyprus</b>	13	11.8	0.49	OLS
<b>Latvia</b>	40	40.4	2.36	OLS
<b>Lithuania</b>	23	31.1	1.40	OLS
<b>Luxembourg</b>	11	7.4	0.52	C-O method
<b>Hungary</b>	13	11.3	1.87	OLS
<b>Malta**</b>	10	9.7	0.19	OLS

Cont. table 1.

<b>Netherlands</b>	14	7.4	0.26	OLS
<b>Austria</b>	34	32.3	0.83	OLS
<b>Poland***</b>	15	9.3	0.52	OLS
<b>Portugal</b>	31	31.1	0.74	OLS
<b>Romania</b>	24	24.6	1.67	OLS
<b>Slovenia</b>	25	24.7	1.74	OLS
<b>Slovakia</b>	14	14.2	0.79	OLS
<b>Finland</b>	38	46.8	1.50	OLS
<b>Sweden</b>	49	55.7	1.09	OLS
<b>United Kingdom</b>	15	14.7	0.68	OLS

All models successively passed the verification process – the random element does not show autocorrelation, heteroscedasticity and has normal distribution.

\* in 2001, 0-1 variable was introduced to the model.

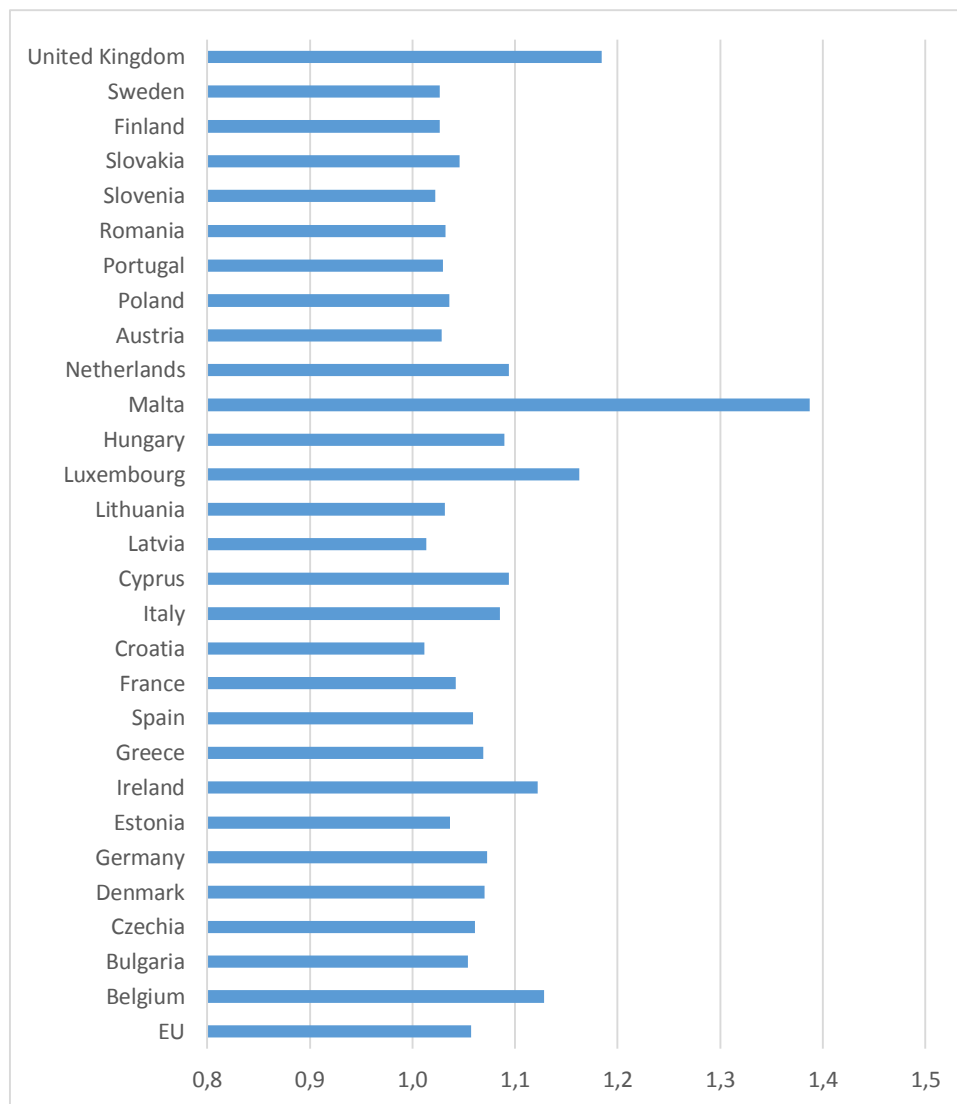
\*\* the model was estimated for data from 2009.

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On the basis of forecasts presented in Table 1, it can be stated that the share of renewable energy in EU will most probably reach 20%, and thus the determined goal will be achieved. In the case of individual countries, 13 of them will not reach the determined goal. They will be Belgium, Germany, France, Cyprus, Luxembourg, Hungary, Malta, Holland, Austria, Poland, Slovenia and Great Britain. Some of these countries will miss the goal only a little, but there are also countries such as Luxembourg, Poland and Holland that will significantly miss the target. On the other hand, there are also countries that already reached the goal and in 2020 they will significantly exceed it. They are Bulgaria, Estonia and Sweden.

The smallest share of energy produced from renewable sources in 2017 was in Luxembourg, Holland and Malta (around 7%) and the largest in Latvia, Finland and Sweden. In Sweden, the share reached 54.4% which is certainly the best result. Swedish achievements in modernisation of energy industry was emphasised already several years ago (Frączek, 2012) and it can be a model for the countries that still face a lot of problems with restructuring this sector.

The speed with which certain countries increase the share of energy produced from renewable sources is also important. Certainly, the countries that had very little share of energy from renewable sources at the beginning of the studied period can achieve better results in this sphere. Fig. 5 shows the average rate of changes in the share of renewable energy in 2004-2017 for individual EU countries.



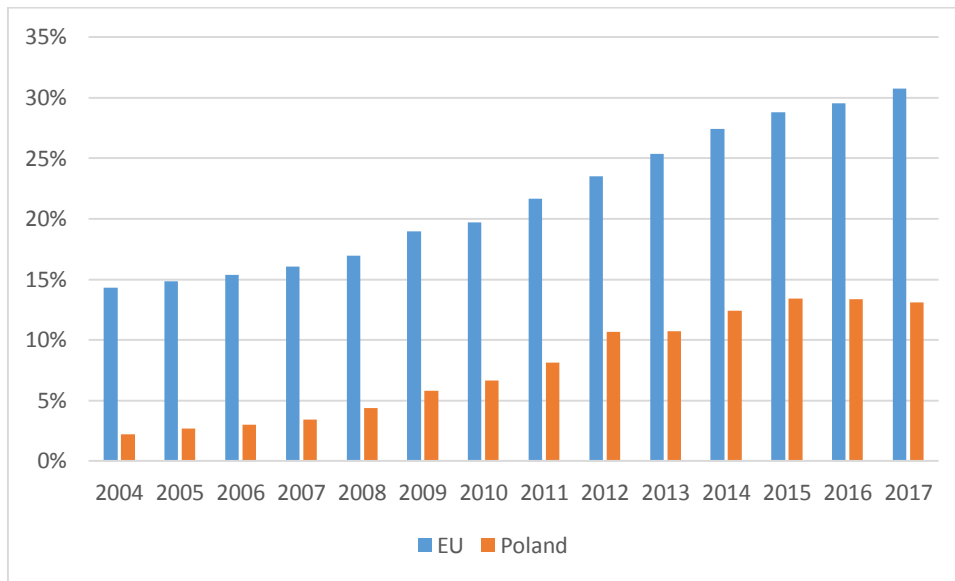
**Figure 5.** Average rate of changes in the share of renewable energy in 2004-2017.

Average rate of changes in the share of renewable energy in 2004-2017 in EU reached 1.057 which means that year after year, the share of renewable energy was increasing, annually by 5.7% on average. The share was growing the fastest in Malta, but it has to be noticed that in 2004 it was only 0.1%. The share of energy from renewable sources in 2004-2017 was growing the most slowly in Latvia and Croatia, but the share in these countries in 2004 was respectively 32.8% and 23.4%.

#### 4. Renewable energy in selected sectors

Energy from renewable sources can also be approached through the prism of energy consumption in specific sectors. This chapter presents shaping of the share of energy from renewable sources in final energy consumption in energy sector, heating and cooling sector and in transport.

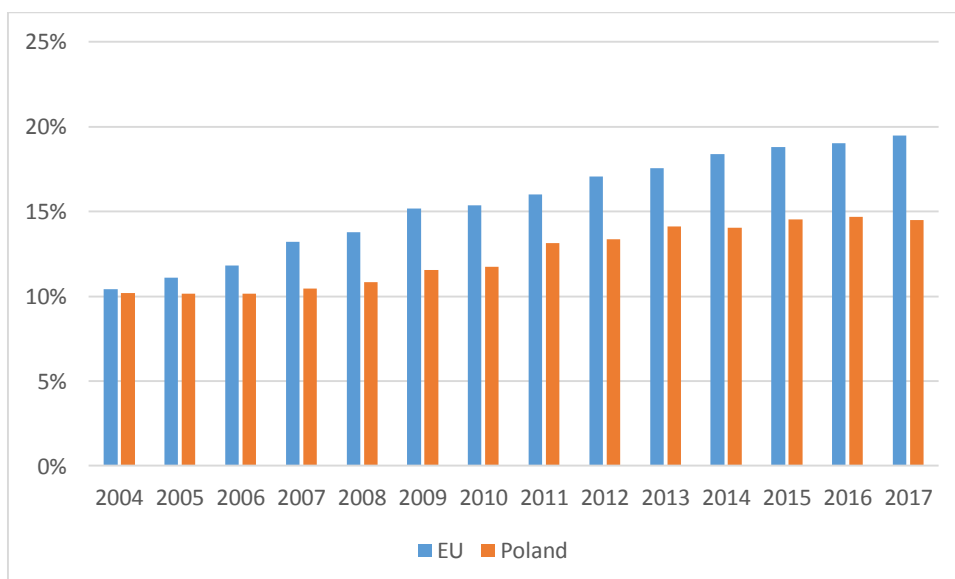
Fig. 6 shows shaping of renewable energy share in final energy consumption in EU and Poland in 2004-2017.



**Figure 6.** Renewable energy share in final consumption in energy sector.

Both in the whole EU and in Poland, the share of renewable energy in final consumption in energy sector in 2017 is considerably greater than in 2004. The largest growth of the share has been observed since 2008, however from 2015 in EU decrease of the growth rate can be observed, and in Poland the decline in the share of renewable energy in final consumption in energy sector has been noticed.

The situation in Poland seems much better in heating and cooling sector (Fig. 7). Here, the differences between EU and Poland are significantly smaller, but also in this sector seriously alarming tendencies are observed. While in 2004 the share of renewable energy in final consumption in heating and cooling was almost on EU level, in 2017 this difference was considerably bigger (5 pp) and is still growing.

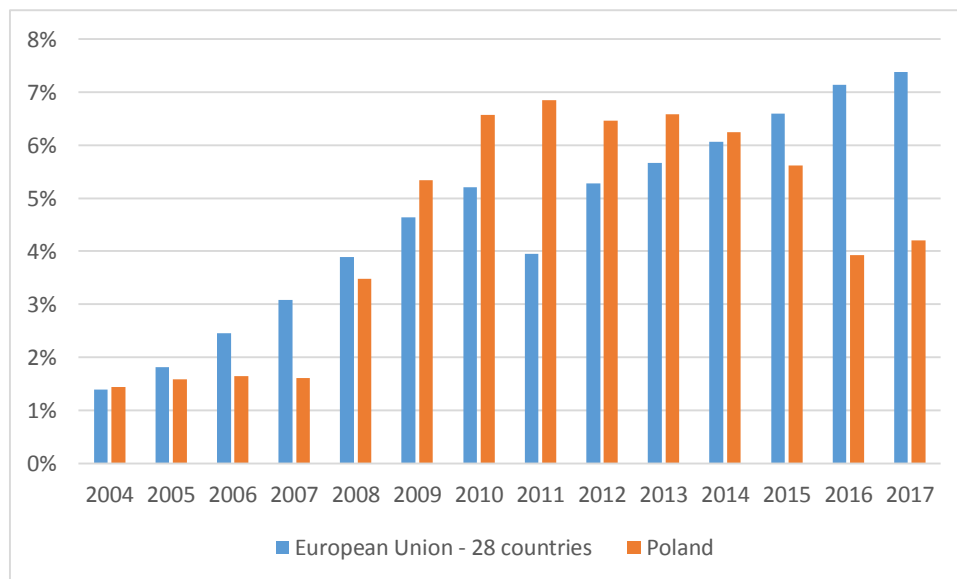


**Figure 7.** Renewable energy share in final consumption in heating and cooling sector.



The share of renewable energy in transport (Fig. 8) in 2004 was slightly bigger than in EU, but until 2007 it was on almost the same level, whereas in EU it was constantly growing. From 2008 there was a sudden growth of the share of renewable energy in transport in Poland and it lasted until 2011. After that, the share was continuously decreasing until 2016. In 2017 there was a slight growth but the share of renewable energy in transport in Poland is much smaller than in EU. In EU there was also a breakdown in growth of renewable energy in transport in 2011, but after that a continuous growth of the share is observed.

Attention must also be paid to the fact that the share of energy from renewable sources in transport is on a very low level – in EU in 2017 it was only around 7%.



**Figure 8.** Renewable energy share in final consumption in transport.

In the next stage, EU countries were clustered with the use of k-means method according to the share of renewable energy consumption in heating, cooling and transport sector to identify the states that are leaders in implementation of changes beneficial for the natural environment and those in which there is still a lot to do. The analysis was conducted separately for 2004 and 2017, which will help notice the changes that occurred.

As a result of conducted analysis for 2004, 2 clusters were identified. Group 1 includes the following states: Denmark, Croatia, Lithuania, Austria, Portugal, Romania, Slovenia, Finland and Sweden. Group 2 includes remaining countries. Table 2 shows descriptive statistics of specific groups.

**Table 2.**

*Result of clustering of the countries with the use of k-means method – 2004*

		Group 1	Group 2
Electricity	mean*	36.209	6.38
	standard deviation	13.529	5.872
Heating and cooling	mean*	29.674	9.359
	standard deviation	11.228	8.945
Transport	mean*	2.031	0.756
	standard deviation	2.037	0.661

\* share of renewable energy in final consumption in individual sectors in %.

Group 1 includes the states that have considerably bigger shares of energy produced from renewable sources in each sector. In group 1 there is also a remarkably greater diversity between the states which results from the fact that the averages for individual sectors are significantly bigger.

In 2017 the composition of the groups slightly changed. Estonia and Lithuania, i.e. two Baltic countries joined the first group. Table 3 shows descriptive statistics of the groups in 2017.

**Table 3.**  
*Result of clustering of states with k-means method – 2017*

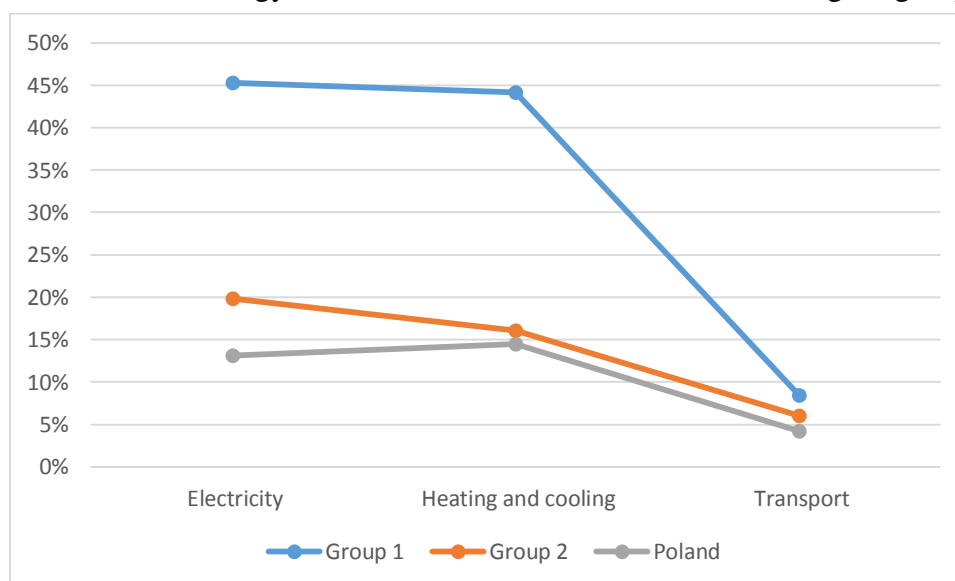
		<b>Group 1</b>	<b>Group 2</b>
Electricity	mean*	45.265	19.806
	standard deviation	18.292	9.998
Heating and cooling	mean*	44.182	16.069
	standard deviation	12.801	7.485
Transport	mean*	8.416	6.06
	standard deviation	9.399	1.793

\* share of renewable energy in final consumption in individual sectors in %.

In both groups significant progress in the use of energy from renewable sources in all sectors can be noticed. Considering heating and cooling, as well as transport, the difference in averages increased for both groups, thus in these sectors more progress was achieved by the countries from group 1, whereas in the case of energy sector the difference between means declined, but this change was not considerable.

One can easily notice the group that Estonia and Lithuania joined. They are countries that are the leaders in the use of renewable energy. In group 1 the countries of northern part of Europe are predominant. Portugal is the only exception from southern European countries.

Poland ranks poorly even in comparison with the countries from the second group. In 2017, in all sectors the share of energy from renewable sources is below the average in group 2 (Fig.9).



**Figure 8.** Share of energy from renewable sources in final energy consumption – means for group 1 and 2 and the values for Poland in 2017.

## 5. Summary

Environment protection is a global issue, especially air protection that has no borders. EU determines specific goals in this sphere and aims to achieve them. The goal determined in strategy Europe 2020, representing production of 20% of energy from renewable sources was very ambitious, however EU can achieve it if the rate of changes remains the same. Also the goal determined for 2030 (30% of energy should be produced from renewable sources) seems to be attainable by many EU member states.

Unfortunately, Poland ranks poorly in this respect in comparison with EU member states. Even though the goal determined for Poland is by 5 percentage points lower than for the EU, Poland will not achieve the assumed goal. It is alarming that the share of renewable energy in 2017 in Poland was on the level of 2012, and since 2015 the share has been declining.

Also the share of energy from renewable sources in energy sector, in heating and cooling, as well as in transport in Poland is on very low level. Poland is an outsider of changes in production of energy from renewable sources, and as data of the Ministry of Energy from 2018 show, there was another dramatic decline in the amount of energy produced from renewable sources (Tab. 4).

**Table 3.**

*The amount of electricity produced from renewable sources in renewable energy source installations determined on the basis of certificates of origin and certificates of biogas origin issued by the President of the Energy Regulatory Office with the division into types of renewable energy source installation*

Type of renewable energy installation	Amount of energy [MWh] produced from renewable sources confirmed by certificate of origin	
	Time of production:	
	2017	2018
Installations using biogas (including agricultural gas)	1 032 724.096	782 734.634
Installations using biomass	3 514 789.021	2 406 797.934
Installations using solar energy	84 436.477	76 270.786
Installations using wind energy	14 948 873.696	9 685 970.309
Installations using water energy	790 752.220	456 007.351
Installations using the technology of co-combustion of biomass, biofluids, biogas or agricultural biogas with other fuels	1 000 565.525	448 567.879
<b>Total</b>	<b>21 372 141.306</b>	<b>13 856 348.893</b>
<b>Total for 2017 and 2018:</b>	<b>35 228 490.199</b>	

Source: data to be published on webpages of the Public Information Bulletin of the Ministry of Energy: [www.me.gov.pl](http://www.me.gov.pl).

Denmark, Croatia, Latvia, Austria, Portugal, Romania, Slovenia, Finland, Sweden, Estonia and Lithuania are absolute leaders in production of energy from renewable sources. Due to similar geographical location Poland should follow the example of Baltic countries.

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