

European Research Studies Journal  
Volume XXIII, Issue 3, 2020

pp. 185-198

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## Energy Consumption Versus Greenhouse Gas Emissions in EU

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Submitted 25/03/20, 1<sup>st</sup> revision 16/04/20/, 2<sup>nd</sup> revision 19/05/20, accepted 01/06/20/

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### **Abstract:**

**Purpose:** The article aims to trace out the interplay of the share of individual energy sources in the total consumption and greenhouse gas emissions from the European Union countries.

**Approach/Methodology/Design:** By taking into account the share of individual energy sources in consumption in 2015, the EU countries were divided into 5 clusters. For each cluster, the values of the indicators for 2005 were determined to assess the changes. Additionally, energy dependence and greenhouse gas emissions factors were included.

**Findings:** During the 2005-2015 period, the consumption of renewable energy increased, while the carbon dioxide emissions fell. It is difficult to say unequivocally whether limiting CO<sub>2</sub> emissions through increased renewable energy sources consumption can be considered sufficient. It should also be pointed out that there was no clear link between the increase in the share of renewable energy sources and the decrease in energy dependence in EU countries.

**Practical Implications:** The study directly refers to ongoing political debate on CO<sub>2</sub> emissions at both the community and national levels in EU countries.

**Originality/Value:** The study offers the first of its kind examination of the interplay of the share of individual energy sources in the total consumption and greenhouse gas emissions from the European Union countries.

**Keywords:** Sustainable development, energy consumption, renewable energy, energy dependence, greenhouse gas emissions, European Union countries.

**JEL classification:** O13, P18, Q42

**Paper Type:** Research study.

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## **1. Introduction**

There is nothing permanent except change. All-natural elements are subject to transformation, including climatic conditions. The rapid development of industry as well as the dynamic growth of the world's population has caused a strong increase in anthropogenic pressure on the environment. The overexploitation of natural resources and the associated carbon dioxide emissions warrants an immediate political response at the global level (Dong *et al.*, 2018; Ijadi *et al.*, 2018). The current attempts to mitigate climate change, however, seem to be slow and insufficient, which have been reflected in the more radical forms of protest and environmental conflicts worldwide (Christensen and Olhoff, 2019).

Reducing anthropogenic pressure requires the reconfiguration of existing political and managerial principles. In this context, the sustainable development paradigm seems to be of key value. Positive examples of European Union actions towards the promotion of renewable energy solutions are the best examples that wide changes are possible. For example, the “3x20 targets” were accepted by the European Union countries (reduction in CO<sub>2</sub> emissions, reduction in total primary energy consumption, and increase in the share of renewable energy sources in energy consumption) and are already used as advanced propositions in many political debates and contexts (European Commission, 2010; 2011).

This paper was motivated by significant climate changes on the one hand and attempts to mitigate its scale and dynamics on the other hand. In particular, this article aims to trace the interplay of the share of individual energy sources in the total consumption in and greenhouse gas emissions from the European Union countries. The research questions guiding this analysis are as follows:

- Does an increase in renewable energy consumption in the EU reduce CO<sub>2</sub> emissions sufficiently?
- Does the increase in renewable energy consumption actually contribute to the increase in the independence of EU markets?

The analysis was conducted for two years, i.e., 2015 (base year) and 2005 (comparative year). This study built upon a secondary data from Eurostat. The paper is structured as follows. First, it briefly summarizes the academic and political debate on climate change. Second, the data and methods applied in the paper are presented. Third, it presents the results, and finally, the discussion and political recommendations are formulated.

## **2. Literature Review**

As climate change worsens and anthropogenic pressure threatens the living environment of all species on the planet, sustainable development has become a priority (Lin and Chiu, 2018). Sustainable development is considered and discussed

in a wide approach. Sustainable development is usually presented as a common part of the environment, society and economy (Gericke *et al.*, 2019; Purvis *et al.*, 2019), but the division into three pillars, which are only partly connected, does not result in an integrated or principles-based approach (Giddings, *et al.*, 2009). Generally, sustainable development should be implemented in an integrated way with regard to the mutual interactions of spheres (Stafford-Smith, 2017). Sustainability results need goal-oriented assessment frameworks (Cohen, 2017). In addition, the understanding of sustainable development in terms of these three dimensions has become a global reference point and a common ground for most global initiatives (Smith *et al.*, 2018, Weitz *et al.*, 2018).

The discussions on climate change and sustainable development are dominated by national and international politics. Sustainability transitions involve both the private and public sectors (Ottens and Edelenbos, 2019). To support actions for sustainable development, the dialogue between the scientific and policy communities should be strengthened (Fritzsche *et al.*, 2018). The issue of sustainable development is discussed at both the national and global levels. In many countries, much effort has been put into reducing CO<sub>2</sub> emissions – among others, in the OECD countries (Churchill *et al.*, 2018) and European Union countries (Lu and Lu, 2018).

Although a high level of socioeconomic development facilitates or even causes environmentally friendly activities, developing countries are aware of the importance of sustainable development and the related objectives to be achieved. Many developing countries demonstrate a commitment to combating climate change (Bartniczak and Raszkowski, 2019).

Sustainable development covers various spheres of socioeconomic activity – from households (Sheng, *et al.*, 2018; Ropuszyńska-Surma and Węglarz, 2018) through the labor market (Ruesga-Benito *et al.*, 2018) to business (Ruiz-Real *et al.*, 2019) and from agriculture (Snyder *et al.*, 2014, Campbell *et al.*, 2014) and forestry (Johansson, 2018) in rural areas through industry (Fritzsche *et al.*, 2018) to services in urban areas (Cohen, 2011).

Sustainable development is particularly important in the context of the socioeconomic aspects directly related to the use of natural resources and CO<sub>2</sub> emissions. The energy sector is undoubtedly such an area. If the environment is to serve future generations as it serves the present generations, humanity must give up dirty fuels in favor of environmentally friendly energy. Moreover, the global community must continue to improve energy efficiency and rational energy management. Therefore, the global community must act in accordance with the principles of sustainable development (Acelandu *et al.*, 2017; Akar, 2016; Spaiser *et al.*, 2017; Wu *et al.*, 2017). The intention of most energy-related policies is to lead to more efficient or cautious use of resources and more sustainable behavior to benefit the environment (Si *et al.*, 2018). At the global level, 17 Sustainable Development Goals have recently been defined and adopted. Two of the SDGs refer directly to

energy and climate change (SDG 7 reads “ensure access to affordable, reliable sustainable and modern energy for all,” and SDG 13 reads “take urgent action to combat climate change and its impacts”) (United Nations, 2019). The necessity of measuring progress towards sustainable development has resulted in specific targets and indicators (Reyers *et al.*, 2017).

One of the directions for reducing anthropogenic pressure is the use of renewable energy sources, also called alternative energy resources (Fridleifsson, 2008). In recent years, many renewable energy technologies have been developed, such as wind energy, hydropower, solar radiation and geothermal energy (Ijadi, 2018). Sustainable development and renewable energy sources combine into the concept of “sustainable energy development”. This concept means ensuring access to sufficient energy not only to the present but also to future generations and ensuring the reduction of the negative impact of energy production and consumption on the environment (Spaiser, 2017). At the global level, increased renewable energy intensity can lead to a decline in CO<sub>2</sub> emissions (Dong *et al.*, 2018). Some countries have already enacted or are considering implementing significant changes to reduce greenhouse emissions, especially in energy production and consumption (Bergen and Muñoz, 2018). Climate change and the need to reduce greenhouse gas emissions contribute to the transition from nonrenewable sources to renewable energy sources. Other events contribute to this process: concerns over energy security, high and volatile oil prices and high dependency on foreign energy sources (Ozcan and Ozturk, 2019).

## **2. Materials and Methods**

The time range included 2015 (base year) and 2005 (comparative year). The data used originated from the Eurostat publication and database. The diversity of European Union countries was examined using cluster analysis based on 2015 data. The studies used the so-called Euclidean metric, which is understood as a function of similarity (Madhulatha, 2012).

Standardized variables were used for the calculations. The J.H. Ward method was applied, which involves connecting those clusters that together provide the minimum sum of squared distance from the centroid of a new focus, which they form (Murtagh and Legendre, 2014).

The analysis included five diagnostic features, i.e., the share of solid fuels in energy consumption (%), share of oil in energy consumption (%), natural gas share in energy consumption (%), share of renewable energy sources in energy consumption (%), and nuclear energy share in energy consumption (%). The choice of indicators was based on substantive and statistical criteria as well as the availability of complete data.

For each cluster, the values of the indicators for 2005 were determined to assess changes. Additionally, the energy dependence (% of imports in the total energy consumption) was determined. Furthermore, the greenhouse gas emissions factors were included, i.e., the greenhouse gas emissions (in CO<sub>2</sub> equivalent, 1990=100), greenhouse gas emissions per capita (tons of CO<sub>2</sub> equivalent per capita), greenhouse gas emissions intensity from energy consumption (2000=100). All indicator values were analyzed for 2005 and 2015.

### 3. Results

Based on the indicator values for the share of the individual energy sources in the total consumption, it was observed that in the majority of the analyzed countries, the share of solid fuels and crude oil prevailed. The smallest share was characterized by nuclear energy, which in thirteen analyzed countries, both 2005 and 2015 were not used at all (Table 1).

**Table 1.** Individual sources of energy consumption share (%) in 2005 and 2015

Specified	Solid fuels		Natural gas		Nuclear energy		Renewable energy sources		Oil	
	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
Belgium	8.8	5.9	25.0	25.8	20.8	12.4	2.3	7.9	41.8	44.7
Bulgaria	34.6	30.4	14.3	14.0	23.0	21.5	9.4	18.2	23.0	22.7
Czechia	44.6	39.1	17.0	15.3	11.9	16.4	7.1	15.1	21.8	19.2
Denmark	19.0	10.3	22.6	17.1	0.0	0.0	16.0	30.8	41.2	38.6
Germany	24.0	25.3	22.7	20.7	12.3	7.5	6.7	14.6	35.5	34.2
Estonia	56.8	61.6	14.2	6.2	0.0	0.0	17.5	28.6	18.8	17.9
Ireland	17.5	15.5	22.7	26.5	0.0	0.0	2.9	9.2	56.3	49.7
Greece	28.5	22.9	7.5	10.9	0.0	0.0	7.0	15.4	57.7	51.0
Spain	14.3	10.9	20.7	20.2	10.3	12.2	8.4	16.2	48.9	42.8
France	5.2	3.3	14.8	13.9	40.0	44.2	9.5	15.2	33.7	30.5
Croatia	7.0	7.1	24.2	24.4	0.0	0.0	23.8	29.0	45.9	38.5
Italy	8.7	7.9	37.2	35.4	0.0	0.0	7.5	17.5	44.2	36.6
Cyprus	1.4	0.2	0.0	0.0	0.0	0.0	3.1	9.4	96.4	92.8
Latvia	1.8	1.1	29.6	25.1	0.0	0.0	32.3	37.6	32.4	33.9
Lithuania	2.1	2.7	27.3	29.9	30.0	0.0	16.8	25.8	30.0	37.6
Luxembourg	1.6	1.2	24.5	18.5	0.0	0.0	1.4	5.0	65.8	63.1
Hungary	11.0	9.4	43.8	29.7	13.0	16.3	4.5	14.5	25.8	27.5
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.0	99.9	85.4
Netherlands	9.6	14.1	42.0	37.6	1.2	1.4	2.5	5.8	41.7	40.2
Austria	11.7	9.6	23.7	20.7	0.0	0.0	23.9	33.0	42.2	36.0
Poland	59.2	50.6	13.3	14.4	0.0	0.0	6.9	11.8	22.4	25.1
Portugal	12.2	13.9	13.7	17.7	0.0	0.0	19.5	28.0	58.9	45.2
Romania	22.4	18.2	35.5	27.5	3.7	9.3	17.3	24.8	26.2	28.1
Slovenia	21.0	16.3	12.7	10.1	20.7	19.1	16.0	22.0	35.2	34.8
Slovakia	22.2	19.9	30.4	23.6	23.8	24.1	6.4	12.9	19.5	20.4
Finland	14.2	12.1	10.5	6.8	17.4	18.1	28.8	39.3	30.0	26.4
Sweden	5.2	4.7	1.7	1.6	36.6	28.9	40.6	53.9	27.7	22.2
United Kingdom	16.2	12.5	36.5	32.1	9.0	9.5	1.3	8.2	36.1	36.7

*Source:* Eurostat, 2017; Eurostat Database; 2019.

The highest share of solid fuels in energy consumption, both in 2005 and in 2015, was recorded in Estonia and Poland. This share was more than half of the total consumption. The largest amount of gas was used in the Netherlands and Italy out of the total energy consumption, which were 37.6% and 35.4%, respectively, in 2015. The use of nuclear energy was primarily in France, which has 58 nuclear reactors. In this country, in 2005, 40% of the energy consumed came from nuclear energy, while in 2015, that share increased to 44.2%. Europe has insignificant oil deposits, which is why all EU countries import oil from abroad. Cyprus and Malta had the largest share of oil in energy consumption; in these countries, almost all consumption came from this source. According to energy dependence (Table 2), the highest shares of imports in total energy consumption were noticed in Cyprus and Malta, which had rates of 100% in 2005 and almost 100% in 2015. Denmark was the most energy-independent country in 2005, and Estonia was the most independent in 2015.

**Table 2.** *The energy dependence and greenhouse gas emission factors in 2005 and 2015*

Specified	Energy dependence (% of imports in total energy consumption)		Greenhouse gas emissions (in CO <sub>2</sub> equivalent, 1990=100)		Greenhouse gas emissions per capita (tons of CO <sub>2</sub> equivalent per capita)		Greenhouse gas emissions intensity from energy consumption (2000=100)	
	2005	2015	2005	2015	2005	2015	2005	2015
Belgium	80.1	83.9	99.5	81.5	14.2	10.8	100.3	89.9
Bulgaria	47.3	36.5	61.6	59.5	8.4	8.7	104.0	111.6
Czechia	27.8	31.9	74.5	64.6	14.6	12.3	89.4	79.1
Denmark	-50.9	13.0	95.5	70.9	12.7	9.0	93.3	72.6
Germany	60.9	62.2	80.4	73.7	12.3	11.4	94.9	95.5
Estonia	28.2	9.6	47.6	44.7	14.2	13.8	100.7	92.4
Ireland	89.6	88.9	127.4	109.6	17.3	13.2	99.9	87.4
Greece	68.2	71.0	131.5	93.0	12.6	9.1	99.6	85.4
Spain	81.6	72.9	154.1	119.7	10.3	7.5	101.7	88.5
France	51.7	46.0	102.5	85.7	9.0	7.1	94.3	80.2
Croatia	52.6	48.9	93.2	75.8	7.0	5.8	101.9	90.7
Italy	83.3	77.0	112.8	84.7	10.2	7.3	96.4	86.1
Cyprus	100.0	97.7	159.3	143.9	13.6	10.7	106.8	101.3
Latvia	63.8	51.2	43.6	43.7	5.2	5.9	92.6	86.6
Lithuania	56.6	78.4	47.3	42.1	6.9	7.0	99.0	106.6
Luxembourg	97.4	95.9	108.5	88.3	30.7	20.4	109.0	96.1
Hungary	62.2	53.9	81.2	65.3	7.6	6.3	90.5	79.4
Malta	100.0	97.0	141.2	112.0	8.0	5.8	89.6	72.3
Netherlands	37.8	48.4	99.8	91.3	13.8	12.2	96.8	99.3
Austria	72.1	60.6	118.9	101.8	11.5	9.4	103.6	84.1
Poland	17.7	29.9	85.2	82.7	10.4	10.2	99.1	91.9
Portugal	88.6	78.2	145.3	118.3	8.5	7.0	97.4	87.8
Romania	27.2	16.4	59.9	47.2	7.0	5.9	96.6	93.2
Slovenia	52.5	49.7	110.4	90.7	10.3	8.2	95.5	87.9
Slovakia	66.0	60.1	69.3	55.4	9.5	7.6	95.4	82.0
Finland	54.7	48.2	98.3	79.3	13.5	10.5	94.0	76.4
Sweden	37.1	28.9	94.3	76.8	7.6	5.7	89.7	77.9
United Kingdom	13.4	37.5	89.7	66.7	12.1	8.3	98.8	89.4

*Source: Eurostat, 2017; Eurostat Database; 2019.*

Generally, in European Union countries, the greenhouse gas emissions decreased during the research period (Table 2). Compared to 1990 and the Kyoto Protocol, the worst situation was observed in Southern European countries (Spain, Portugal, Cyprus, and Malta) in both analyzed years. The largest positive changes were noticed in Baltic countries (Estonia, Latvia, and Lithuania). In both 2005 and 2015, Luxembourg was characterized as having the highest greenhouse gas emissions, which repeatedly exceeding the smallest value (recorded in Latvia in 2005 and in Sweden in 2015). In terms of the greenhouse gas emission intensity of the energy consumption in 2005, eight countries exceeded 100 (2000=100), while three countries did not exceed 90%. In 2015, only three countries exceeded 100, and six countries did not reach 80%.

By comparing the shares of individual sources in the energy consumption based on the 2015 values, the countries were divided into five clusters (figure 1, table 3, table 4). The first cluster included two countries, namely, Cyprus and Malta. These countries were characterized by the smallest area and the smallest number of inhabitants in the European Union. No significant energy resources were located in these countries. In 2015, the energy consumption in these countries was based almost entirely on crude oil (93% on average), which they imported mainly from Russia and Norway. In 2015, a small amount of energy from renewable energy sources was used in Malta, and in Cyprus, it was also used from solid fuels. In these countries, the share of crude oil in energy consumption decreased by 5.1 pp and solid fuels by 0.5 pp. The renewable energy share increased by 5.6 pp. The shares gas and nuclear energy did not change, and in 2015, the countries in the first group did not produce energy from these sources. In the first cluster, greenhouse gas emissions decreased by 22,3 pp in 2015 compared to those in 2005. Although this was the largest decrease, the level of greenhouse gas emissions was still the highest in the first group in comparison with all analyzed clusters. This situation was caused by the dominance of crude oil in the energy consumption. In 2015, the level of greenhouse gas emissions (in CO<sub>2</sub> equivalent) still exceeded the value from 1990.

**Table 3.** *The share of individual sources in energy consumption in 2005 and 2015 by clusters.*

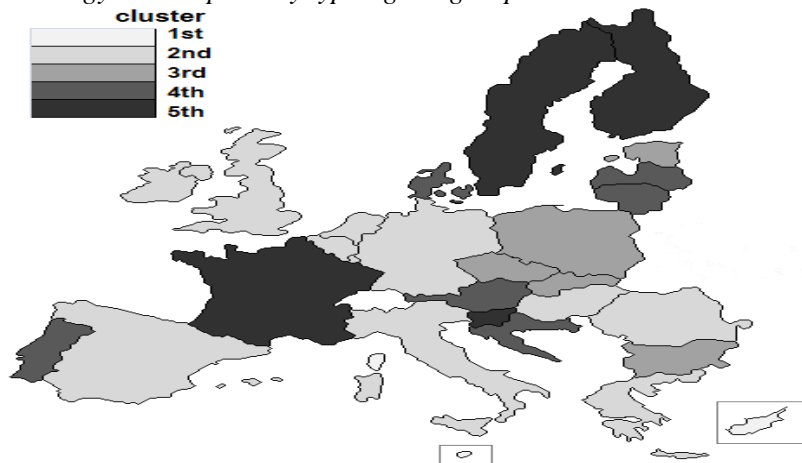
Specified	Solid fuels %		Natural gas %		Nuclear energy %		Renewable energy sources %		Oil %	
	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
1 <sup>st</sup> cluster	0.6	0.1	0.0	0.0	0.0	0.0	1.7	7.2	97.8	92.7
2 <sup>nd</sup> cluster	14.6	12.9	29.1	26.2	6.4	6.3	5.6	12.6	44.3	41.9
3 <sup>rd</sup> cluster	41.8	37.1	17.0	13.4	11.4	12.1	9.5	17.3	20.4	20.1
4 <sup>th</sup> cluster	8.7	7.5	22.9	22.7	4.7	0.0	22.1	30.6	41.6	39.2
5 <sup>th</sup> cluster	10.6	9.0	9.5	7.5	27.0	24.3	23.7	32.6	29.1	26.6

**Source:** *Own study based on Eurostat data (Eurostat, 2017; Eurostat Database; 2019).*

The second cluster was the largest, including eleven countries. This cluster was characterized by the largest share of gas in the energy consumption, but this share

decreased by 2.9 pp compared to that in 2005. The share of renewable energy in the total consumption doubled and amounted to 12.6% in 2015. The energy consumption in these countries was based primarily on the crude oil, and nuclear power was of the lowest importance. The energy dependence level was quite high in both analyzed years and exceeded 60% of the imports in the total energy consumption. The level of greenhouse gas emissions resulted from a significant share of crude oil and solid fuels in energy consumption. However, the greenhouse gas emissions decreased compared to those in 2005, especially in the CO<sub>2</sub> equivalent per capita.

**Figure 1.** Diversity of the EU countries based on the share of individual sources in energy consumption by typological groups.



*Source: Own.*

The third cluster included five Central and Eastern European countries (Bulgaria, Czechia, Estonia, Poland and Slovakia). As in the previously analyzed year, in the countries of the third group, the highest share of energy consumption was solid fuels, with consumption showing a 4.7 pp reduction. The leader in the consumption of solid fuels, which were mainly hard coal, was Poland. In this country, half of the energy consumption came from solid fuels. However, in this respect, the situation was improving; since 2005, a decrease of 4.7 pp energy consumption from this source could be observed. In these countries, however, the share of renewable energy increased by 7.8 pp (in Poland, it rose by 4.6 pp) and nuclear energy by 0.7 pp. In this cluster, countries had the smallest share of energy consumption from crude oil (20.4%). The greenhouse gas emissions decreased by 6.2 pp, which was the smallest change among the analyzed clusters. It should be emphasized that the third group was characterized by the lowest value of the greenhouse gas emissions factors (in CO<sub>2</sub> equivalent, 1990=100), which meant that the largest change occurred in comparison with 1990. On the other hand, the greenhouse gas emissions intensity from energy consumption was the highest in the third cluster, and the changes covered only 6 pp compared to 2005. The third cluster of countries was the most



energy independent. This situation resulted from local sources of consumption – mainly coal.

The fourth cluster consisted of six countries, namely, Denmark, Croatia, Lithuania, Latvia, Austria and Portugal. These countries reduced the share of solid fuels (by 1.2 pp) and crude oil (by 11.5 pp). As in the previously analyzed year, the countries in this group did not have any operating nuclear power plants and did not produce nuclear energy. In both analyzed years, the share of renewable energy sources was large – only in the fifth cluster was it slightly larger. In 2015, the countries increased the share of renewable energy (by 8.5 pp) in energy consumption. The greenhouse gas emissions decreased – in the CO<sub>2</sub> equivalent (1990=100) by 15.2 pp, per capita by 1.2 pp and according to intensity of energy consumption by 9.9 pp. In the analyzed cluster, the energy dependence increased from 47 to 55%. The energy independence level was average in the fourth cluster.

**Table 4.** *The energy dependence and greenhouse gas emission factors in 2005 and 2015 by clusters*

Specified	Energy dependence (% of imports in total energy consumption)		Greenhouse gas emissions (in CO <sub>2</sub> equivalent, 1990=100)		Greenhouse gas emissions per capita (tons of CO <sub>2</sub> equivalent per capita)		Greenhouse gas emissions intensity from energy consumption (2000=100)	
	2005	2015	2005	2015	2005	2015	2005	2015
	1 <sup>st</sup> cluster	100.0	97.3	150.3	128.0	10.8	8.3	98.2
2 <sup>nd</sup> cluster	63.8	64.4	104.1	83.7	13.5	10.2	98.6	90.0
3 <sup>rd</sup> cluster	37.4	33.6	67.6	61.4	11.4	10.5	97.7	91.4
4 <sup>th</sup> cluster	47.1	55.1	90.6	75.4	8.6	7.4	98.0	88.1
5 <sup>th</sup> cluster	49.0	43.2	101.4	83.1	10.1	7.9	93.4	80.6

**Source:** *Own study based on Eurostat data (Eurostat, 2017; Eurostat Database; 2019).*

The fifth group included only four countries, i.e., France, Sweden, Finland and Slovenia. The countries of this group were characterized by a high share of nuclear energy (24.3% on average), an increase in this indicator of approximately 2.7 pp was noticeable compared to that in 2005. In 2005, these countries had a high share of renewable energy; in 2015, this share increased further, and this was the best result compared those of the other groups. In the production of nuclear energy, France was still the leader, which increased the index compared to that in the base year by 4.2 pp. For the renewable energy sources, the highest rates were recorded in Sweden (53.9%) and Finland (33.9%), which increased their shares by 13.3 pp and 10.5 pp, respectively, in comparison to those in 2005. In fourth, the shares of solid fuels, crude oil and gas had downward trends and decreased by 1.6 pp, 2.5 pp and 2 pp, respectively, compared to those in 2005. The greenhouse gas emissions decreased significantly in all analyzed categories. The fifth cluster countries were characterized by the lowest greenhouse gas emissions intensity from energy consumption in both analyzed years.

#### **4. Discussion**

A sustainable energy mix should have a relatively high share of renewable energy sources, relatively low CO<sub>2</sub> emissions and quite high energy independence (World Bank, 2013). For energy security, the diversification of sources is also recommended (Policy Department A, 2017). Taking into account these assumptions and the research results, the countries of the 4th and 5th clusters were in better condition than the others. In the 5th cluster, the large share of nuclear energy may be controversial. Although nuclear energy has a positive effect on CO<sub>2</sub> emissions (according to Lee, Kim, and Lee, a long-term increase of 1% nuclear power proportion led to a 0,26-0,32% decrease in CO<sub>2</sub> per capita (Lee *et al.*, 2017), it is difficult to classify this type of energy as ecologically sustainable due to the Three Miles Island, Chernobyl and Fukushima accidents (Friedman, 2011).

According to the conducted analysis, energy independence results not from renewable energy sources but mainly from other national sources, such as coal. The 3rd cluster was the most energy independent and was characterized by the highest solid fuel share in the energy consumption. As shown by the greenhouse gas emissions, coal was a problem. Generally, in countries rich in coal, it is more difficult to give up this type of energy source for more environmentally friendly sources, although the consumption of coal in European Union countries has been decreasing in recent years. Some countries have even announced the date of cessation of coal usage. In addition, it has been forecasted that gas could overtake coal (Agora Energiewende and Sandbag, 2019).

In the examined time horizon, favorable changes in the use of energy from renewable sources were noticeable, but the changes were diverse at the national level. The type of renewable energy depends on the geographical location as well as on the economic and financial efficiency of using each source. Northern Europe has more environmentally friendly energy policy. On the other hand, the countries of Central and Eastern Europe rely on their own energy resources (Fischer, 2014, Ringel and Knodt, 2016). According to greenhouse gas emissions –lower emissions were characteristic of less developed countries – among others in Central and Eastern Europe. The growth of gross domestic product results in increased greenhouse gas emissions.

Generally, developed European Union countries are the leaders in environmental protection, but they also lead in CO<sub>2</sub> emissions (Lu and Lu, 2018). All goals cannot be achieved simultaneously. Governments and policymakers should decide which goals are achieved first. Although the level of CO<sub>2</sub> emissions are just one of the elements that can determine renewable policy targets, the Paris Agreement proves a growing accession in terms of the need for rapid reduction of greenhouse gas emissions. Acceleration of the reduction can be one of the main driving forces of renewable policy at the global level (Blazquez *et al.*, 2018).

Comparing the CO<sub>2</sub> emissions to those in 1990, significant changes have taken place in the countries of Central and Eastern Europe. Among others, these changes are related to the restructuring of heavy industry that resulted from transformation processes (for example, in Poland) (The National Centre for Emissions Management, 2016). Despite this, EU energy policy on the use of energy from renewable sources predicts a further increase in their consumption. It is assumed that by 2030, the share of energy from this source will be 27% (European Commission, 2014). Such actions are very important because the current changes in CO<sub>2</sub> emissions are insufficient (Intergovernmental Panel on Climate Change, 2019).

In renewable energy regulation according to a new approach, instead of a target for each country, a common target is shared for implementation within the European Union (Eurostat, 2019). In this situation, new and innovative solutions will dominate renewable energy sources implementation, and it is worth analyzing how individual countries could increase renewable energy sources diversity by expanding upon the most effective examples from other countries or by integrating the energy market segmentation (Mezősi *et al.*, 2018).

## 5. Conclusions

The European Union energy policy accelerate the implementation of renewable energy activities, even if the consequences of these actions may be limited by economic growth. Not all countries would decide on this direction themselves, especially coal-rich countries and less-developed countries.

The European Union energy policies oblige member states to introduce limitations on CO<sub>2</sub> emissions, among other types of emissions, by increasing the production and consumption of renewable energy. However, the results are insufficient. Further actions aimed at increasing the renewable energy share and reducing CO<sub>2</sub> emissions are necessary. Renewable energy sources are not only environmentally friendly; renewables can lead to energy independence in the future. Currently, coal-rich countries are characterized by high energy independence. Renewable energy sources have local characteristics. However, RESs are diverse, and every country is capable of achieving the European Union goals. It is also worth emphasizing that changes in the environment caused by anthropogenic pressure require a response not only from the European Union but also from the whole world.

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