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## Comparison Analysis of Energy Markets' Aspects in the Visegrad Group Countries

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**Abstract:**

**Purpose:** The aim of this paper is to compare (also to EU27) and analyze chosen aspects of Energy sectors, which are currently indispensable for the appropriate functioning of an economy. Based on the literature review, a research gap was identified in the form of a lack of studies related to the current situation of the use of renewable energy sources in the total energy supply of the Visegrad Group countries. Additionally, the comparison of the situation in question for the V4 countries is an extremely important issue because of the possibilities of cooperation in this area.

**Approach/Methodology/Design:** The undertaken research issues and the set goal determined the choice of research methods, such as critical literature review, statistical methods, analysis and synthesis methods.

**Findings:** The most important conclusions from the conducted analyses indicate the necessity to prepare and implement the decarbonization process, especially in Poland.

**Practical Implications:** V4 countries should take joint actions to increase share of renewable energy sources in total energy supply in order to 1) reduce negative emission and air pollution 2) tackle EU standards and goals set for RES share in Energy mix 3) increase in Energy independency and security of V4 members and group as a whole.

**Originality/Value:** The originality and value of the study results from the fact that the current comparison of the V4 countries in terms of the use of renewable energy sources and its structure does not exist in the available literature. It should be noted that this is an important aspect of the energy policy of modern countries.

**Keywords:** Visegrad energy, V4 energy comparison, V4 renewable energy.

**JEL classification:** N70, O13, Q40.

**Paper Type:** Research article.

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## **1. Introduction**

The authors of international publications undertake comparisons of economies to indicate and highlight chosen characteristics and phenomenon of such macroeconomic formations. It is crucial to monitor the effects of introduced changes in policies concerning Energy sector and correct them if needed, as it affects so many dimensions of an economy. Tracking changes in the energy sectors and identifying the economic conditions leads to the possibility of researchers' and governmental entities to correctly infer and suggest appropriate changes in the process of responding to changing conditions in the macro-economic environment, such as EU regulations, energy autonomy from suppliers of resources and fuels, and energy security. Such effects are being observed by conducting an analysis of statistical data.

The purpose of this work is to compare and analyze chosen aspects of Energy sectors in V4, such as amount of energy in circulation in different forms, their variations in time in period of previous years, share of energy from renewable sources, ie. "green energy" in the energy mix of these countries and values similar to mentioned. Consistent time periods and comparable units were used.

Such data is characterized by high significance due to major impact on economy functioning and citizen's level of life quality. Presented analysis finely resonates with a current of existing works: it both continues raised subjects and adds a fresh actualization, which - concerning lately changing conditions, caused by quickly expanding importance of Energy sector in political and economic dimensions – is needed, as it brings up current data.

Authors of the literature on the subject repeatedly raise the issues discussed, and this paper complements and updates the matter, bringing current data to science. Such factors as energy, energy policy, and international trade of energy affect particular economies' international competitiveness (Wach, Głodowska, Maciejewski, and Sieja, 2021; Nyga-Łuszczewska and Chilimoniuk-Przeździecka, 2017). Comparison of selected elements of energy markets is performed in recent years by such authors as (Antal, 2020; Petiet, Finon, and Janssen, 2017; Nie, Wang, and Yang, 2017; Torochio and Santarelli, 2010; Osieczko and Polaszczyk, 2018; Zimon, Sobolewski, and Lew, 2020; Rokicki and Perkowska, 2021).

Issues related to V4 energy have been discussed by scholars in recent years (Brodny and Tutak, 2021; Zapletalová and Komínková, 2020; Jirušek, 2020; Prontera and Plenta, 2020; Osička, Lehotský, Zapletalová, Černoch, Břetislav, and Dančák, 2018; Dyduch and Skorek, 2020) and concerned both the value and size of individual elements of the economy (Kuang, 2021) and important problems and solutions in the energy policies of member countries and the Group as a whole (Myszczyzyn and Suproń, 2021).

## **2. Energy Sector Characteristics of the Visegrad Countries**

The V4 energy sector is historically rooted in fossil fuels, which occur abundantly in these countries, and among them are some of the biggest coal producers (Poland possesses the ninth largest coal deposits in the world) (Sulich and Sołducho-Pelc, 2021). In considering the energy characteristics of the V4 countries, it is necessary to point out beforehand the partly apparent nature of this association. Founded in 1991 as the Visegrad Triangle, it was renamed after the division of the Czech Republic and Slovakia. Currently 14.3% of the EU27's population lives in the V4 countries (Górska and Krawiec, 2021). The members of the group cooperate in many areas of economic development, welfare of citizens and military cooperation.

The origins of the Visegrad Group can be traced back to 1335, when John of Luxembourg, King of Bohemia, Charles I, King of Hungary, and Casimir III, King of Poland, met in Visegrad to strengthen relations and cooperation between the three kingdoms of Central Europe (The Visegrad Group and the Central European Free Trade Agreement). The name of the association refers to this historic event. Even then - although the meeting received a lot of attention from all sides, each party tended to highlight its own points of interest.

Some studies point out that this collaboration is only used when beneficial, and not homogenic in sense of having common targets for the Group members (Četković and Buzogány, 2019; Tereszkievicz, 2018). Looking objectively at the developing relations between the countries of Central and Eastern Europe, it is possible to point out shortcomings in their cooperation. The example of the Visegrad Group illustrates this relation. These countries, despite significant similarities, have often encountered conflicts of the interests they represent. In the initial phase of its operation, the main purpose of the cooperation was to support efforts to join the European Union and NATO.

However, already during the EU accession negotiations, there was a rivalry between the V4 member states over the positions they held. Gradually, as the overarching goal was achieved, the importance of the Visegrad Group deteriorated. Difficulties of cooperation between countries are noticeable even when there are similar specifications of the countries belonging to the community (such as geographical location, relations between suppliers of resources, or historical outline). It was only when the energy conflict between Ukraine and Russia arose in January 2009 (Pirani, Stern, and Yafimava, 2009; Božić, Karasalihović Sedlar, Smajla, and Ivančić, 2021) that lack in the cooperation of the neighboring countries were recognized, which is one of the turning points towards the establishment of an agreement resulting in defense against dependence on imports of Russian resources (Sobczyk, 2011).

Cooperation between the Visegrad Group countries in terms of maintaining energy security and diversification of raw material supplies is based on significant geographical location and determination of the availability of natural deposits.

Insufficient resources to generate power results in seeking outside suppliers. Transport of key energy resources for the Central and Eastern Europe region (such as natural gas and oil) is carried out by infrastructure along the latitudinal axis (oriented from east to west). The significant shortage of infrastructure for the transport of raw materials along the North-South axis limits the choice of suppliers. The lack of energy self-sufficiency of the Visegrad Group countries further compounds this problem. This justifies the natural occurrence of the influence of Russian policy on the supply of these raw materials to Eastern European countries.

Construction of new gas and oil pipeline connections to import raw materials from other directions would allow diversification of supply directions, development of oil and gas price competitiveness and reduction of dependence of Eastern European regions on Russian imports. Cooperation established for the construction of a given infrastructure has not been treated as a priority factor for achieving independence from the supply of raw materials from the East. The decisive moment was the occurrence of a significant threat to the continuity of raw material shipments from Russia in 2009 (the so-called gas crisis).

The noticeable interruption of gas supplies in Ukraine over the winter of several days has apparently drawn attention to the importance of preserving the energy security of each country subordinated to Russian imports. These issues affected each member of the group differently, prompting a state-by-state analysis of the energy market.

### **3. Research Methodology**

The research was carried out on the V4 group, comparing the countries of the Visegrad Group with the EU27. In the context of the considerations carried out, a comparison was made between the analyzed entities in terms of total energy supply (in 2019) and the structure of individual renewable energy sources in the total energy supply. So far, no such detailed, up-to-date description has been included in the literature on the subject. Hungary, Poland, Czechia, Slovakia were subject to analysis in comparison to EU27. Data are presented for the years 1990-2019. The basic aim of the analysis was to compare the structure of Total Energy supply and the share of selected renewable energy sources in total energy supply among the V4 countries and with the EU27.

#### **3.1 The Republic of Poland: The Level of Dependence on External Energy Suppliers**

Poland is characterized by a relatively low degree of dependence on energy resources and energy of neighboring countries. Thanks to an index of approx. 25%, the country is in the forefront of the safest energy countries in the European Union (Oil & Gas Emergency Policy, 2011). Low imports of energy resources result in reliance on energy production predominantly from fossil fuel deposits available in the territory. There is a significant amount of hard coal and lignite mining. Considering the total

categories observed, energy generated by natural resource extraction accounts for almost half (47%) of the current energy mix (*Charakterystyka rynku paliw gazowych*). This basis carries with it numerous conclusions describing the political situation of the state. Polish government should introduce changes to its climate and energy policies, shifting from coal combustion to development of more environment and society-friendly technologies (Kubiczek, 2018).

Limiting generation capacity to only a few key fuels and technologies greatly reduces the level of diversification of energy sources. As a consequence, it leads to dependence on the availability of a given energy resource (in this case, coal). This fact has a significant impact on the stability of energy supply, and thus affects the level of energy security in the country in question (Szczerbowski, 2015). The predominant method of energy production by a country violates, as it were, generally accepted norms that are important in reducing energy inefficiency and reducing emissions of undesirable compounds into the environment (*Plan Rozwoju Elektromobilności w Polsce*). This results in a conflict of interest between the organization and the member state, ultimately influencing a change in energy policy.

### **3.2 The Czech Republic: An Import-Based Country**

Neighboring countries such as the Czech Republic also rely heavily on imported raw materials for their energy policy. Among the main suppliers of external energy sources, the Russian Federation holds a dominant position. This is noticeable in the volume of purchased natural gas, which provides about 60% of the Czech demand for this raw material. The rest is supplied from Norway and (in smaller quantities) from Germany. Despite the high degree of dependence on supplies from external suppliers of energy resources, the Czechs are able to store much larger amounts of energy than countries with a comparable degree of dependence (e.g., Poland).

Thanks to its reserves, the country is able to meet more than 1/3 of its annual energy needs, which positively affects the overall level of energy security. It thus makes them less dependent on the influence of neighboring states. An additional advantage is the extensive network of gas pipeline connections, which consequently leads to the maintenance of a constant supply of imported gas.

In the case of other energy resources used by the Czech Republic, it is possible to observe a synonymous approach to the way of ensuring constant energy supply. An example is the oil market, which is almost entirely controlled by outside suppliers. Currently, imports supply as much as 96% of the demand for this raw material. The main source of supply is oil pipelines of Russian origin (70.9%), which also makes the country drastically dependent on the Federation's influence on the price and availability of oil.

Moreover, the network of connections intended for transport of a given raw material in some parts of its construction does not have enough capacity. This leads to partial

utilization of the capacity of the oil pipeline components with higher transportation capabilities. Attempts by countries responsible for importing raw materials to counteract these circumstances are prompting a search for other forms of oil transportation. The promising option in this case is to use the sea route, which would unfortunately lead to a decrease in the significance of the raw material flow through the Czech territory.

A decrease in the volume of oil transfer through the territory of a given country will most likely lead to a directly proportional decrease in the Czech Republic's share of oil imports, ultimately reducing the volume of supplies and seriously threatening their stability. This situation is potentially a serious threat to the energy security of the country, which does not have sufficient storage capacity to make it independent of external suppliers, at least temporarily.

### **3.3 The Slovak Republic as a Monopolistic Energy Supplier Market**

In terms of energy policy, the Visegrad countries have an extremely low level of self-sufficiency. In the vast majority of cases, the production of its own raw materials does not exceed 10% of a country's energy needs. This results in the need for external supplies and increases the number of connections between countries. The Slovak Republic bases its energy market on almost 100% dependence on imported energy sources (Oil & Gas Emergency Policy, 2011). For natural gas supply, the country is 98.3% supplied by external suppliers.

Moreover, it is characterized by total dependence on Russian Federation supplies. This creates a serious threat of disruption to the continuity of energy supplies and the inability to temporarily change the source of energy imports. In addition, the monopolistic nature of Russian sources allows them to impose higher utility costs without being able to opt out of the services offered. The dependent state, in order to counteract this situation, implemented steps to use the same infrastructure to divert the flow of raw material from the Czech Republic and Austria (at the moment of threatening insufficiency of energy resources).

This problem is extremely difficult to solve because of the duplicative dependence on a particular supplier on multiple levels. This is because the supply of other key energy resources is following an almost twin pattern. An example is the situation in the oil market, where the share of imported raw materials is about 95.2% , most of which is met precisely by supplies coming from Russian territory. However, despite its almost total dependence on oil and gas supplies from the Russian Federation, Slovakia has a potential opportunity to diversify its energy sources. With adequate infrastructure to receive resource from the Croatian oil port, the country is able to cover most of its demand from another source. Another asset to increase the feeling of energy security in the Slovak territory is the potential arising from the possibility of oil storage. With stockpiled supplies, the country's needs can be met for up to 90 days.

### **3.4 The Republic of Hungary as an Example of Diversification Potential**

The large influence of the Russian supplier is also noticeable in the case of the supply of energy resources to the Republic of Hungary. It is responsible for the vast majority of natural gas (82%) and oil (90.2%) imports. An additional factor that exacerbates a country's dependence on external supplies is the lack of sufficient in-house generation capacity to meet the country's minimum energy needs. Unfortunately, the level of energy production in the Republic of Hungary is significantly low (only 23% of demand is covered by domestic production). Despite the significant influence of Russia, there is no dependence of the market on a single energy supplier (other countries supplying raw materials include France and Germany. Another important factor increasing the potential level of the country's energy security is the large gas storage capacity, which in the case of an emergency will allow to ensure continuity of supplies for at least half a year.

The situation is different for oil imports (BP Statistical Review of World Energy, 2021). Domestic production of this resource is almost unnoticeable, which focuses the Hungarian Republic on providing the needed energy from external sources. Despite being transported exclusively from the East, the country has the ability to diversify its energy supply, and thus has a positive impact on the level of energy security. This is possible by applying a change in the proportion of use of a given oil supply infrastructure in favor of a Croatian supplier that is able to fully meet the country's energy needs. As an additional protection against the loss of continuity in supply, there are significant reserves of energy resources, which will allow the country to extend its independence at the time of an unexpected crisis.

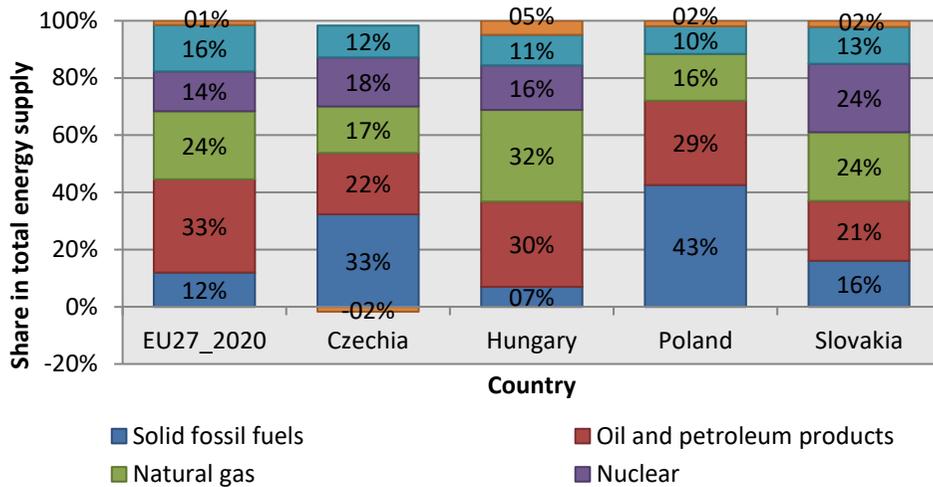
## **4. Methods**

The statistical methods used to conduct the statistical analyses were chosen according to the problems considered in the paper. The comparative characteristics of individual V4 countries in comparison with the EU27 is based on a set of descriptive statistics (mean, standard deviation and minimum and maximum (Agresti, Franklin, Klingenberg, and Posner, 2018; Hyk and Stojek, 2019; Wiktorowicz, Grzelak, and Grzeszkiewicz-Radulska, 2020) for selected data of analyzed countries and the distribution of percentage structure of analyzed aspects. Descriptive statistics are complemented by elaborate Figures and Tables to facilitate data analysis.

## **5. Research Results: A Comparative Analysis of the Structure of Energy Sources**

### **5.1 Structure of Total Energy Supply in the Visegrad Group and EU27**

The comparison and analysis of the energy sector of the Visegrad countries, also in relation to the EU27, should begin with the structure of total energy supply, which is presented in Figure 1.

**Figure 1.** Share of energy sources in total energy supply in 2019

**Note:** Other\* included: manufactured gases, peat and peat products, oil shale and oil sands, electricity, heat, waste, non-renewable.

**Source:** Author's elaboration on EU Commission, 2021.

An analysis of the contribution of individual energy sources to total energy supply in 2019 makes the following observations:

1. Oil and petroleum products, natural gas, renewables and biofuels, nuclear energy and solid fossil fuels have by far the largest share in the total energy supply of the V4 countries and the EU27.
2. Oil and petroleum products account for almost a third of total energy supply in EU27 in 2019 (32.6%), and an equally high share in Hungary (29.9%) and Poland (29.4%). In the Czechia and Slovakia the share is more than one fifth (Czechia 22.2% and Slovakia 20.9%). This means that countries like Hungary and Poland have reached a level similar to all EU27 countries in 2019.
3. Natural gas has a significant share of total energy supply in Hungary, where it accounted for almost a third of total energy supply in 2019 (32.0%). In the other countries and in the EU27 it had a much smaller share.
4. The largest share of renewables and biofuels in total energy supply was achieved in 2019 by the EU27 countries combined (16.3%). Among the V4 countries, Slovakia dominates in this respect, having achieved a share of renewables and biofuels of 13.0%. The smallest share of renewable energy in total energy supply was achieved by Poland (9.6%). In terms of the share of renewable energy sources, each of the Visegrad countries has a lot to do to catch up with the EU27.
5. Nuclear energy's share of total energy supply varies. The highest occurred in Slovakia in 2019 (23.9%), which is dictated by the amount of nuclear energy produced in Slovakia in 2019 (15,282 GWh) [Eurostat]. Other countries, including nuclear energy's share in total energy supply was much lower. In

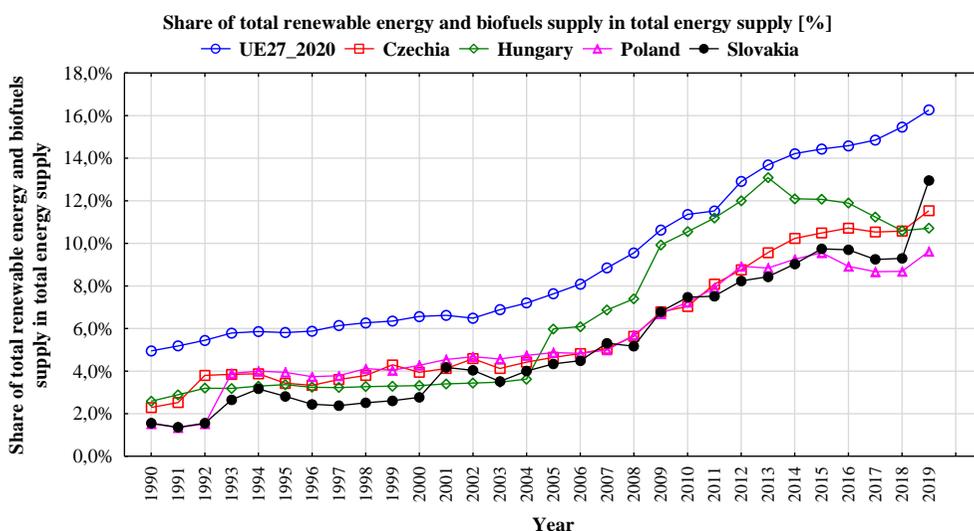
the Chechia, it was 17.7% (even though the country's annual nuclear power generation in 2019 was 30,246.21 GWh In Hungarythis share was 15.6% (16 288 GWh) and in the EU27 13.9% (765 337.86 GWh) (Mapa energetyki jądrowej w Europie, 2021)]. Poland does not have any nuclear power plant, so it does not derive energy from this source.

- The share of solid fossil fuels in total energy supply was the highest in Poland (42.6%), which is due to the fact that the Polish economy is largely based on hard coal and lignite mines. The second V4 country with the highest share of solid fossil fuels is Czechia, where it amounts to one-third of the total energy supply (33.4%). Hungary had the lowest share of this type of energy (6.9%). Analyzing all EU27 countries, the share of solid fossil fuels in total energy supply is 12.0%.

## 5.2 Structure of Total Energy Supply in the Visegrad Group and EU27

The share of total renewable energy and biofuels supply in total energy supply from 1990 to 2019 has changed, as shown in Figure 2.

**Figure 2.** The share of renewable energy in the total energy supply in 1990-2019



**Source:** Own compilation based on EU Commission, 2021.

The data presented in Figure 2 shows that over the entire analyzed period (1990-2019), the EU27 countries had a significantly higher share of renewable energy in total energy supply, which illustrates how much the Visegrad Group countries diverge from the EU. It should also be noted that for Hungary, 2005, when the share of renewable energy in the total energy supply was 6.0%, was a breakthrough year. Since then, Hungary has strongly increased the share of renewable energy in the total energy supply, until 2013 (13.1%), bringing it close to the EU27 level (13.7%).

In 2014, there was a gradual reduction in this share to 10.7% in 2019. At the same time, Slovakia experienced the largest increase in the share of renewable energy in the total energy supply in 2019 compared to 2018 (from 9.3% to 13.0%). Poland is characterized by a steady increase in the share of renewable energy in the total energy supply, apart from a slump in 2016-2018. The share then declined from 9.6% in 2015 to 8.7% in 2018. In 2019, Poland achieved a 9.6% share of renewable energy in the total energy supply. Czechia has a continuous increase in the share of renewable energy in the total energy supply, apart from a slight decrease in 2000 and 2017. Complementing the data analyzed is a summary of descriptive statistics over two time periods: 1990-2019 (from data availability to 2019) and 2009-2019 (the most recent decade). Details are presented in Table 1.

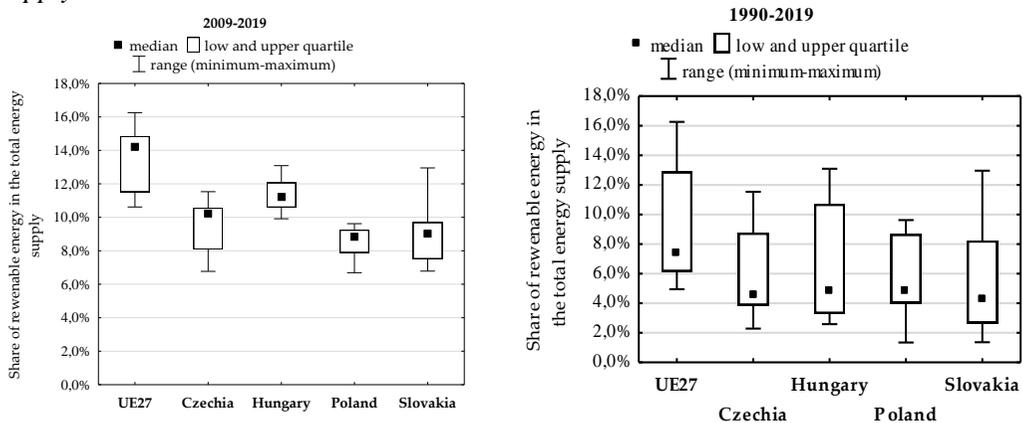
**Table 1.** Statistics of the distribution of the share of renewable energy in the total energy supply in the analyzed time periods

Region/ country	Share of renewable energy in the total energy supply in date range (%)									
	Data from 1990-2019 (N=30)					Data from 2009-2019 (N=11)				
	Mean	Me	Std. dev.	min	max	Mean	Me	Std. dev.	min	max
UE27	9.2	7.4	3.7	4.9	16.3	13.6	14.2	1.8	10.6	16.3
Czechia	6.0	4.6	2.9	2.3	11.5	9.5	10.2	1.6	6.8	11.5
Hungary	6.7	4.8	3.9	2.6	13.1	11.4	11.2	0.9	9.9	13.1
Poland	5.6	4.8	2.5	1.3	9.6	8.6	8.8	0.9	6.7	9.6
Slovakia	5.3	4.3	3.1	1.4	13.0	8.9	9.0	1.6	6.8	13.0

Source: Authors' elaboration on EU Commission, 2021.

Figure 3 shows the values of the positional statistics and the exact distribution of the share of renewable energy in the total energy supply for both compared periods (1990-2019 and 2009-2019).

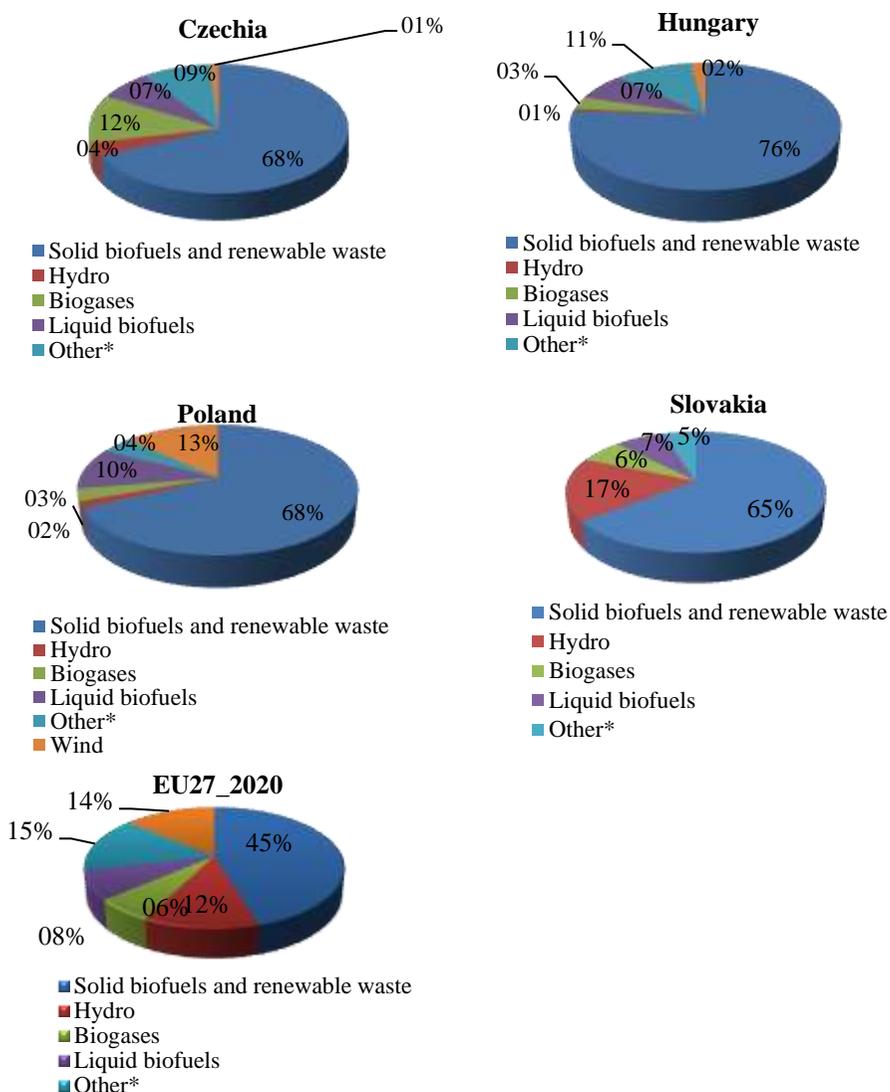
**Figure 3.** Positional statistics of the share of renewable energy in the total energy supply in 1990-2019 and 2009-2019



Source: Calculations and authors' study.

Based on the analysis, the share of renewable energy in total energy supply is much higher in the last decade than in the last 30 years (medians in the Visegrad Group and EU27 are much higher). All calculated ratios show a significant increase in the share of renewable energy in the total energy supply in recent years, as illustrated in Figure 3. This has been caused by an increased emphasis on the use of renewable energy sources. The next step of exploration is to analyze the contribution of each type of renewable energy to the total supply in 2019, as presented in Figure 4.

**Figure 4.** Structure of renewables and biofuels in V4 and EU27 (2019)



**Note:** Other\* included: solar photovoltaic, solar thermal, tide, wave and ocean, geothermal, ambient heat (heat pumps).

**Source:** Authors' elaboration on EU Commission, 2021.

The data are also presented collectively in Table 2.

**Table 2.** Structure of renewables and biofuels in V4 and EU27 in 2019

Country/ Region	Share renewable source in total structure					
	Solid biofuels**	Hydro	Biogases	Liquid biofuels	Wind	Other*
EU27_2020	45.4%	12.0%	6.1%	7.7%	13.7%	15.0%
Czechia	68.0%	3.5%	11.8%	6.9%	1.2%	8.6%
Hungary	75.6%	0.7%	3.2%	7.1%	2.1%	11.0%
Poland	67.7%	1.7%	3.0%	10.4%	13.1%	4.2%
Slovakia	64.5%	16.8%	6.4%	7.3%	0.0%	5.0%

*Note:* Other\* included: solar photovoltaic, solar thermal, tide, wave and ocean, geothermal, ambient heat (heat pumps), Solid biofuels\*\* included renewable waste.

*Source:* author's calculations on EU Commission, 2021.

The structure of particular renewable energy sources in the V4 countries and in the EU27 as a whole varies. Analysis of the data presented in Figure 4 and Table 2 allows the following observations:

1. In all V4 countries solid biofuels and renewable waste have the highest share in total renewable energy supply.  
Most in Hungary, where they account for more than  $\frac{3}{4}$  of the energy supply from renewable sources (75.6%). This share is also high in the other countries, ranging between 64-68%. However, when comparing the V4 countries and the EU27 as a whole, it should be noted that this source of renewable energy accounts for less than half (45.4%) in the community.
2. The share of hydro energy in total renewable energy is the highest in Slovakia (16.8%). The other Visegrad countries have very low levels of this type of energy in their total renewable energy supply. For the EU27 as a whole, the share was 12% in 2019.
3. Czechia had the highest share of energy from biogas relative to other V4 members (11,8%).
4. Among the analyzed V4 countries and the whole EU27, the highest share of energy coming from liquid biofuels was recorded in Poland (10.4%). On the other hand, the highest share of wind energy in the total structure of renewable energy was achieved by Poland (13.1%) and all EU27 countries (13.7%). This is primarily due to Poland's location with access to the Baltic Sea, which enables the installation of efficient wind farms.

## 6. Conclusions

Presented data and facts provide several conclusions that might be useful in constructing next strategies and policies aimed at decarbonization of V4 countries (especially Poland) and increase in RES share in total energy supply, which compared to EU majority is still insufficient. Positional statistics of the share of renewable

energy in the total energy supply show that over past decades that has been a matter to tackle. Some actions were taken, but due to difficulties raising from both geopolitical and infrastructural fields set targets are still not achieved. Therefore it is needed to intensify cooperation in investment in proper infrastructure between V4 countries.

Cooperation between V4 members in Energy sectors matter could be strengthened and intensified, seeking benefits from added value in fields such as policies transition, demand side management implementation, technologic areas and common technical regulations, which could have a positive influence on markets (e.g., labour, infrastructure, materials, etc.). EU pressure on reducing negative emissions from electricity production are set to lead to achieving goals, but in longer term and while conducting right policies and solutions. Eventually it leads to an increase in mentioned share of renewable sources.

Slovak struggle for that direction should be underlined and is illustrated by a fair share of hydropower, succeeding in an increase for about 4% in 2019. On the other hand, due to geographical reasons and wind density areas (Polaszczyk and Markiewicz, 2020) Poland is a clear leader in V4 in using wind power despite the decrease in RES share in 2015-18 years, caused by heavy coal dependence and no working nuclear power plant. Hungary also lacks in means of RES share as it is strongly dependent on natural gas transits from East. Czechia presents the highest share of biogases in their overall RES structure, steadily increasing that value in their Energy mix.

In conclusion, it should be noted that it is necessary for the V4 countries to take actions that will result in increasing the amount of energy obtained from renewable energy sources, as they are deviating in this respect from the entire EU27. Poland has the most catching up to do in this regard. This makes it necessary to actively transform the country's energy sector, which has the highest share of solid fossil fuels in total energy supply (in 2019). This is partly due to the lack of a nuclear power plant with which to reduce the use of energy precisely from solid fossil fuels.

A positive aspect of the analysis is that it indicates a gradual increase of renewable and biofuels in total energy supply over the years. A significant increase in their share in total energy supply over the last 10 years (2009-2019) is noticeable. At the same time solid biofuels and renewable waste characterize among the renewable energy sources with the highest percentage of the total renewable and biofuels, both in V4 and EU27. Other types of renewable energy are diverse and their use depends on inter alia natural conditions. Presented analyses fill the identified research gap and become a basis for continuing and deepening the provided conclusions. The monitoring of energy from renewable sources, particularly economic determinants, should be part of further scientific inquiry. It is recommended to conduct quantitative research on the subject in order to draw further conclusions, while compared to Energy sector management seen from macro-scale.

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