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The import of energy raw materials and the energy security of the European Union – the case of Poland

Introduction

One of the most important issues nowadays is energy security (Rybak 2020). It determines the standard of living for citizens and, most importantly, the sovereignty of countries. As energy resources are not evenly distributed throughout the world, the level of energy security of individual countries differs. Limited access to energy carriers is compensated by imports, which can be used as a tool of political pressure (Thaler and Hofmann 2022). It should be noted that this problem does not only concern energy resources. Rare earth metals are also critical raw materials, the access to which is limited and without which, modern industry cannot exist. The need to obtain energy raw materials by means of import may be associated with problems in terms of prices and the on-time delivery of appropriate amounts

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of raw materials. One of the most important issues related to the import of primary energy is the sources of diversification of the raw materials. The source of raw materials in the current political situation is of key importance in the context of national security. The undisturbed energy supplies for the economy and households supports the development of the country. The lack of access to primary energy may lead to a slowdown in economic development; therefore, the authors conducted research aimed at examining the level of dependence of European Union countries on the import of energy carriers. The biggest threat is currently the import of energy carriers from the Russian Federation.

The research was carried out in the European Union member states, with a particular emphasis on Poland. These were conducted in the following steps:

- It was determined which energy carrier is the basis of the country's energy mix.
- It was checked what share of this carrier comes from import.
- The share of Russian fuel in imports was determined.
- Scenarios of energy dependence on Russia for individual EU-27 countries were determined.
- A synthetic measure of energy security was developed and determined.
- The strengths and weaknesses of the energy-security system for Poland and the EU were determined.
- Remedial measures were identified that would enable the elimination of weaknesses.

1. Literature review

Energy resources in Europe and access to them is currently one of the key factors influencing the level of energy security as well as the economic and national security of the EU member states (Lewandowski 2019). As mentioned above, the problem is, of course, the need to obtain these raw materials through import (Chalvatzis and Loannidis 2017). One of the directions from which fossil energy sources were imported is the Russian Federation. In Russia's efforts to rebuild its position and significance at the level of the Soviet Union, it used an energy policy. This enabled Russia to use economic factors and energy resources for the control of the supply of raw materials to neighboring countries, including the European Union. This was possible because Russia is in first place among the countries with the largest natural gas reserves in the world and second in terms of coal resources and eighth in terms of crude oil (BP 2021). Russia also sought to take control of energy distributors in many countries. The implementation of this plan began in 1992 with the formulation of the Energy Development Strategy of the Russian Federation; this was followed by the Energy Strategy of the Russian Federation (MERFED 2019) until 2035, which was adopted in 2020 (MERFES 2019). Consequently, efforts were made to gradually increase the importance of the Russian Federation in the international arena. Energy resources were used to form the basis of the country's economic development as well as a tool used in political activities (OADB 2006). Such an energy policy was aimed at building and maintaining influence both in the former Soviet Union countries, the European Union, and in Africa, the Americas, and Asia.

In the case of Central Asia, the impact is aimed mainly at gaining the role of an intermediary in the transmission of raw materials or obstructing the implementation of projects that could threaten the interests of Russia. An example is the Nabucco gas pipeline. This was supposed to be an alternative to the Russian monopoly on gas supplies to Central and Eastern Europe. However, the project was abandoned in 2013 (ICFI 2013). In the case of EU countries, the main aim was to take over the infrastructure distributing oil and gas as well as the infrastructure for the storage of hydrocarbons, for example, in Germany, Austria, Hungary or Belgium (Brooks 2019). Long-term contracts were concluded with Gazprom and Lukoil, which strongly linked European consumers with supplies from Russia, for example, through direct agreements with Italy or Austria.

Russia also had the right to the retail sales of raw materials, for example, in Bulgaria or Germany, and the sale of raw materials to third countries by Russia with the participation of EU member states (Eletricite de France), as well as direct supplies of crude oil to the Czech Republic, excluding Polish Orlen (SGGW 2008). In 2007, the decisions of the European Commission on practices aimed at limiting the monopoly were challenged. Such decisions of the commission threatened the interests of Gazprom (Gryz 2009). Additionally, the provisions of the European energy security strategy concerning the level of energy sources diversification are being questioned (EP 2017). Such actions were aimed at making the EU dependent on Russian raw materials. It made it possible to influence the EU's energy security and economic development as well as to create the European Union's policy. The economic activities of the Russian Federation have therefore influenced the shaping of EU policy, not only in the context of energy. Some EU countries have taken measures to secure supplies in the event of a lack of access to Russian raw materials. This included the preparation of LNG terminals. However, because of the advantageous price of Russian gas, they were not used. In 2020, the Southern Gas Corridor was launched, which supplies gas from Azerbaijan to Europe. Due to the fact that it violated Gazprom's monopoly, Russia imposed an embargo on Azeri goods. The gas pipeline was built with the participation of BP and the European Union. An example is Bulgaria, which was 100% dependent on Russian gas. The Azerbaijani gas pipeline currently supplies 30% of the country's needs, and this share is expected to increase. In turn, Poland will be able to become independent from Russian gas thanks to the Baltic Pipe project (BPP 2022) – an offshore gas pipeline that connects the Norwegian gas system in the North Sea with the Danish gas system onshore. In the North Sea, the gas pipeline will be connected with the existing transmission infrastructure (i.e. with the Europipe II pipeline), thus ensuring access to gas from Norwegian deposits on the markets in Denmark and Poland as well as to customers in the neighboring countries of Central and Eastern Europe. At the same time, the Baltic Pipe Project will enable a bidirectional route, i.e., it will be used to transport gas from Poland to Denmark. Russia's policy works in both ways. This led to a situation in which Gazprom also became completely dependent on the EU. Therefore, the Russian Federation has taken steps that allowed it to enter the Chinese market thanks to the Power of Siberia pipeline. Therefore, the authors of the article conducted research aimed at examining the level of the dependence of the EU-27 countries on the import of energy resources. First, the level of dependence of each country on imported energy from Russia was determined, which at present poses a particular threat to the energy security of the EU. Statistical data on the structure of the energy mixes of the member states, the volume of raw material imports and the share of Russian fuels in this import was collected. This data was obtained from the Eurostat and BP websites (Eurostat 2022; BP 2021). Preliminary statistical analysis showed that the average level of the EU-27 dependence on the import of solid fossil fuels is 75%, of natural gas it is 86%, while in the case of crude oil it was as much as 96% in 2019. Over the years, its share has increased (Bluszcz 2017). This was confirmed by the dynamic analysis carried out by the authors. In 2012-2019, imports increased by 8, 6 and 14% for these fuels, respectively. Thus, it has been shown that the problem of the EU dependence on imports still persists, and most importantly, this dependence is increasing. The authors proceeded to the implementation of the next stage of the research, i.e. the share in the import of fuels from the Russian Federation was checked. This analysis, in turn, showed that the share of imports from Russia in the case of solid fossil fuels in 2020 was 50%, for natural gas it was 39%, and for crude oil it was 32%. In 2012, it was 23, 50, and 24%, respectively. Thus, the EU in the analyzed period tied its energy systems even more closely to Russia in the case of coal and oil. This preliminary statistical analysis led the authors to conduct the research presented in the article. First of all, it was necessary to identify those member states whose energy security would be most vulnerable if the supplies of raw materials from the Russian Federation were interrupted. In order to carry out the necessary research, the methods presented in the next section were used.

2. Materials and methods

An analysis of the spatial correlation of the dependence on the import of the energy carrier that forms the basis of the energy mix level was carried out. The correlation assumes that the studied phenomenon will be similar in neighboring objects. For this purpose, Getis-Ord Gi statistics were used. This is the statistic defined by Getis and Ord in 1992 (Ord and Getis 1995; Preprut and Zeng 2010). Getis-Ord statistics are determined according to the formula:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2}{n-1}}} \tag{1}$$

$w_{i,j}$ – spatial weight between feature i and j,
x_j – attribute value for feature j,
n – number of features.

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}, \quad S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2} \tag{2}$$

The Getis-Ord Gi analysis enables the determination of the so-called cold spots and hot spots (Getis and Ord 1992). Hot spots are clusters with high data values, whereas cold spots have low values of the analyzed data. The statistical significance of the autocorrelation degree was assessed using the z-score test. The z-score and p-value given for each feature indicate whether the spatial clustering of hot spots or cold spots is more pronounced than would be expected for a random distribution, i.e. whether it is possible to reject the null hypothesis about no visible grouping (Chun and Griffith 2013).

2.1. A synthetic measure of energy security

To be able to determine the synthetic index, a taxonomic method was used, i.e. a multidimensional comparative analysis created by Zdzisław Hellwig. This method enables the detection of regularities in a set of objects in order to determine a pattern with which these objects are compared for the purpose of determining the taxonomic distance. All indicators in Table 1 were used to determine the synthetic assessment measure. As the analyzed variables may be of a different nature (they may be stimulants, destimulants or nominants), it was necessary in the first step to eliminate the nature of the variable and its impact on the analyzed phenomenon. This was achieved using a differential transform method. Then, to standardize the data in terms of units, they were standardized and reduced to a nominal form (Kęsek and Ślusarz 1997; Kukuła 2000).

The distance from the pattern was calculated as follows (Dziechciarz 2003):

$$d_i = \sqrt{\sum_{j=1}^{n} w_j \left(z_{ij} - z_{0j}\right)^2} \tag{3}$$

d_i – distance of the i-object from the reference object,
w_j – weight of the j-th object,
z_{ij} – standardized value of observation of the j-th variable for object I,
$z_{0j} = \max \{z_{ij}\}$ – reference object – maximum value of z_{ij}.

The minimum value of the SES measure is 0, and the maximum value is 1. The higher the measure level, the higher the level of energy security. The synthetic measure of energy security assessment was calculated according to the formula (Jurkiewicz and Wycinka 2003):

$$SES = 1 - \frac{d_i}{d_0} \tag{4}$$

$$d_0 = \overline{d} + 2 \cdot \sigma \tag{5}$$

↳ SES – synthetic measure of energy security,
$\overline{d}$ – arithmetic mean of the variable d_i,
σ – standard deviation,
d_0 – standard ensuring that the development measure adopts values in the range 0–1.

3. Results and discussion

To conduct the presented research, tools of spatial information systems were applied. The QGIS 3.16.13 Hannover program (QGIS 2021) was used. The obtained statistical data made it possible to create a vector map, the contours of which were obtained on the website (FVM 2021). The map was combined with a relational database in which the following factors were placed:

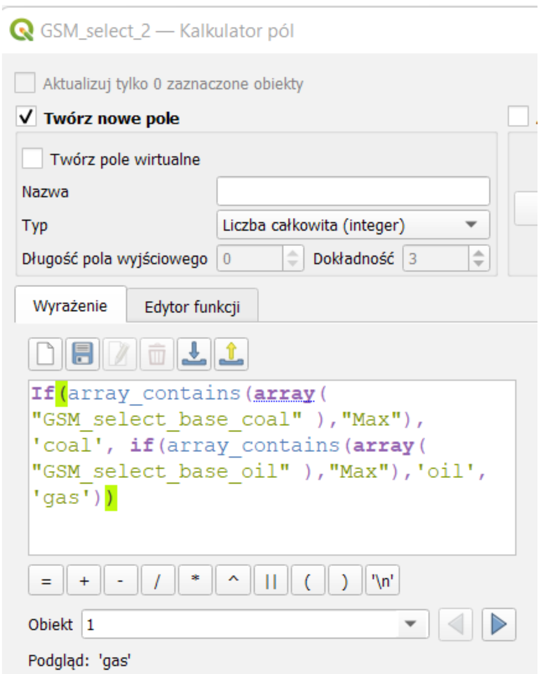

Fig. 1. Query for the Countries vector layer database
Source: own elaboration

Rys. 1. Zapytanie do bazy danych warstwy wektorowej Kraje

- primary energy consumption – coal, natural gas, and crude oil (TJ),
- import level of solid fossil fuels, gas, and crude oil (%),
- share of gas, oil and coal imports from the Russian Federation (%).

This led to the creation of a vector layer called Countries. It was determined which energy carrier is the basis of the energy mix of a given country. For this purpose, the consumption of primary energy was used. First, the maximum consumption level of a given energy source was found. For this purpose, a query was sent to the created database. The query was written in the SQL language:

If(array_contains(array("GSM_select_base_coal"),"Base"), 'coal',
if(array_contains(array("GSM_select_base_oil"),"Base"),'oil','gas'))

In the next step, the maximum value was assigned a string label (oil, gas, coal).

The results of the analysis are presented in Figure 2.

Next, the import level of the carrier that constitutes the basis of the energy mix was determined:

if("Base_mix" LIKE 'oil',"import_oil",if('Base_mix' LIKE 'coal',"import_coal",
"import_gas"))

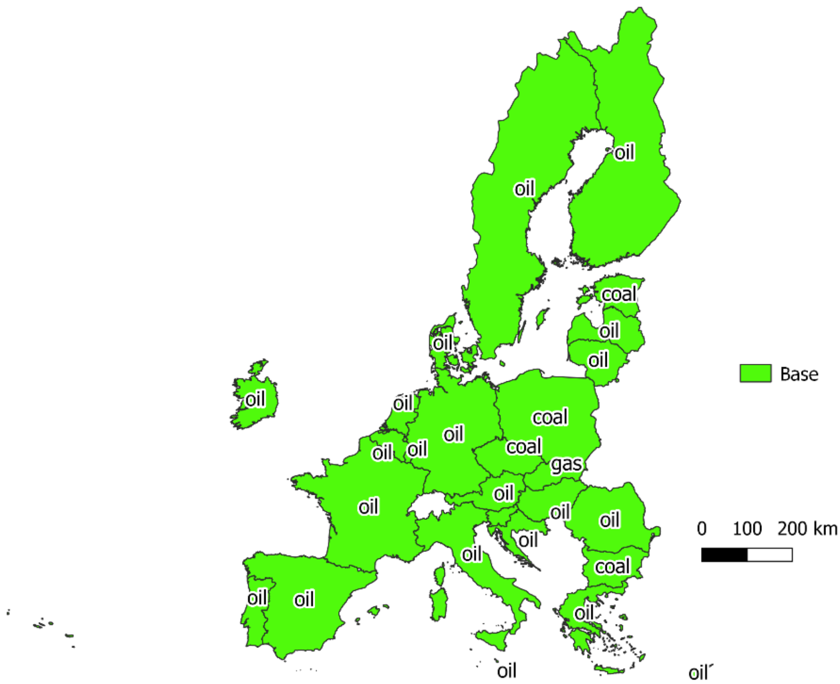

Fig. 2. The energy carrier constituting the basis of the energy mix of the EU-27 countries
Source: own elaboration based on statistical data from (Eurostat 2022)

Rys. 2. Nośnik energii stanowiący podstawę miksu energetycznego krajów UE-27

In the next step, it was verified whether the level of energy import was influenced by the geographical location of the countries. This analysis was performed to verify whether there is a relationship between the distance of countries from Russia and the level of energy carrier imports. It was also verified whether the EU-27 countries form clusters similar to each other in terms of the structure of imports. Local indicators of spatial dependence (LISA) were used to perform the spatial autocorrelation analysis. The LISA statistic was presented by L. Anselin in 1995 (Brook 2019; Anselin 1995). This is a statistic that indicates the degree of significance of the spatial concentration of similar values around the analyzed observation. This makes it possible to determine the similarity of a given unit to its neighbors. It also determines whether this similarity is statistically significant. The Getis-Ord Gi statistics were used for the purpose of the research. A high level of statistics and a low level of probability p indicate a statistically significant hot spot. A negative statistic and a low level of p indicate a cold spot. If the statistical value is close to 0, it means that spatial clustering does not occur. In the examined case, the p-value was 0.001. Figure 4 presents the values of the Getis-Ord Gi statistics for the EU-27 countries.

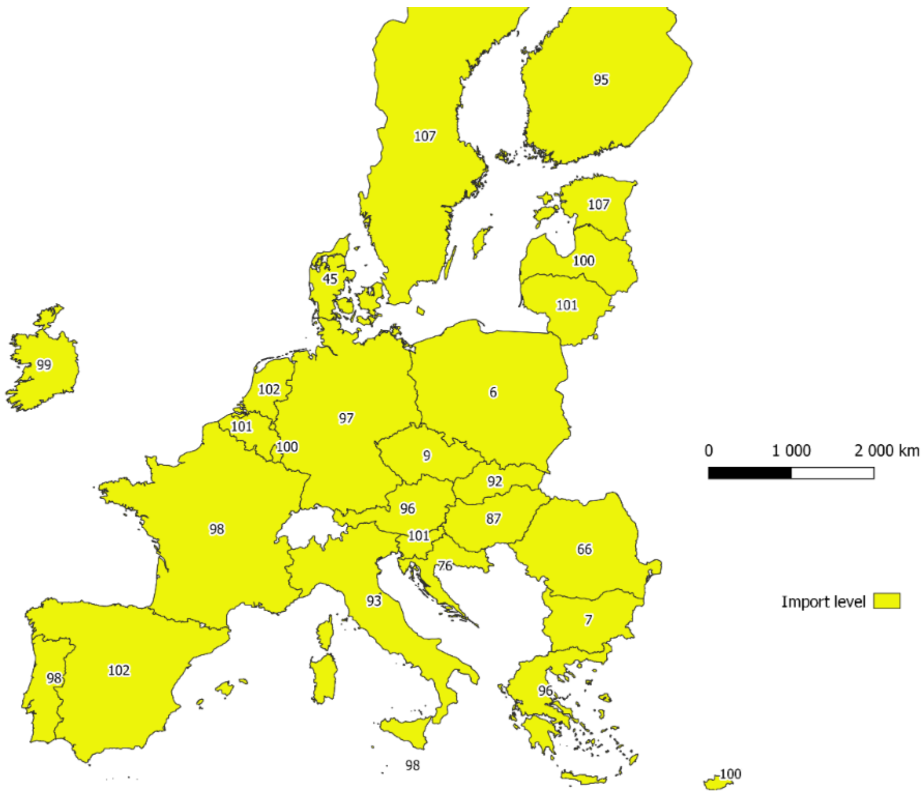

Fig. 3. The volume of energy carrier that constitutes the EU-27 countries on the basis of the energy mix
Source: own elaboration based on statistical data (Eurostat 2022)

Rys. 3. Wielkość importu nośnika stanowiącego podstawę miksu energetycznego krajów UE-27

It can be seen that there is no clear division of countries into hot spots (red polygons) and cold spots (blue polygons). The division turned out to be geographically independent – hot spots and cold spots are mixed. Clusters similar to each other in terms of volume of imports were not distinguished. Thus, the geographical location does not affect the dependence on the import of raw materials from Russia. In the next step, the share of imports from Russia in total imports was verified. In order to be able to take into account both the results obtained after the LISA analysis and the level of import from Russia, these two groups of information were used to filter the objects placed on the Countries layer. There is a theory that energy security is at an appropriate level when the share of a given carrier in the energy mix is at the maximum level of 30%. According to this assumption, the Select command was built and sent to the database:

Select Object

From Countries

Where "Import_volume">30 AND " Russia_import_volume 2020">30

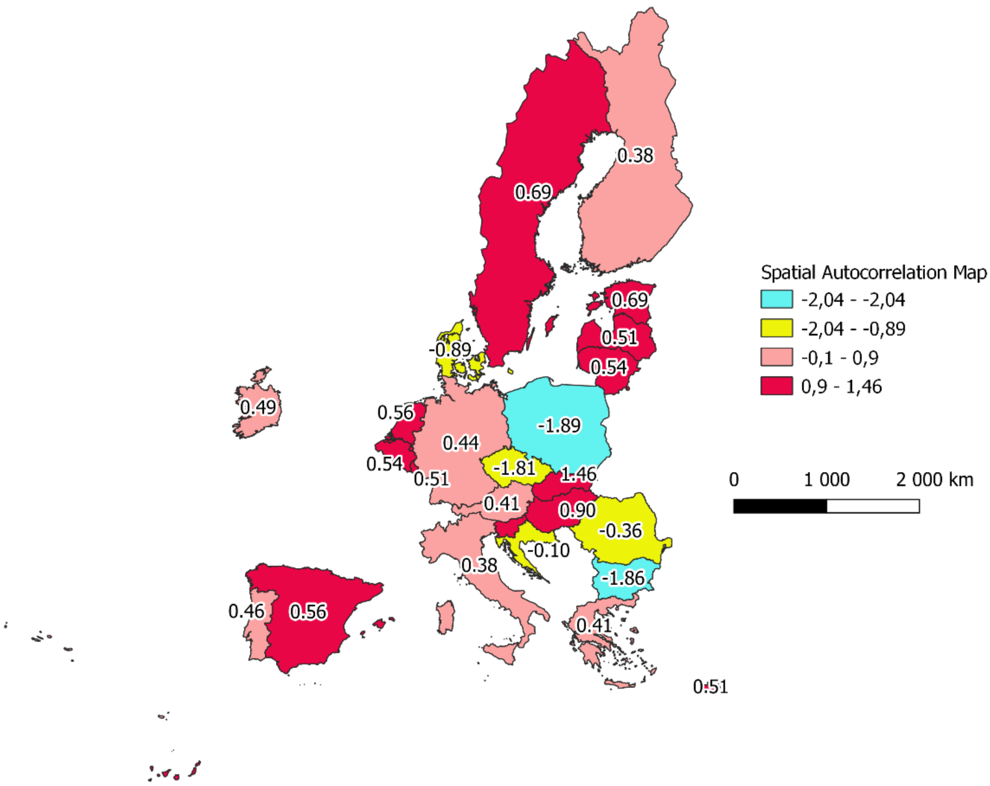

Fig. 4. The value of the Getis-Ord Gi statistics
Source: own elaboration

Rys. 4. Wartość statystyki Getis-Ord Gi

The results of this analysis form the most likely scenario. Furthermore, using the sensitivity analysis, the optimistic scenario was determined, where the most endangered countries include those where the level of imports is >5%, and the pessimistic scenario, where it amounts to 95%. The created scenarios are presented in Figure 5.

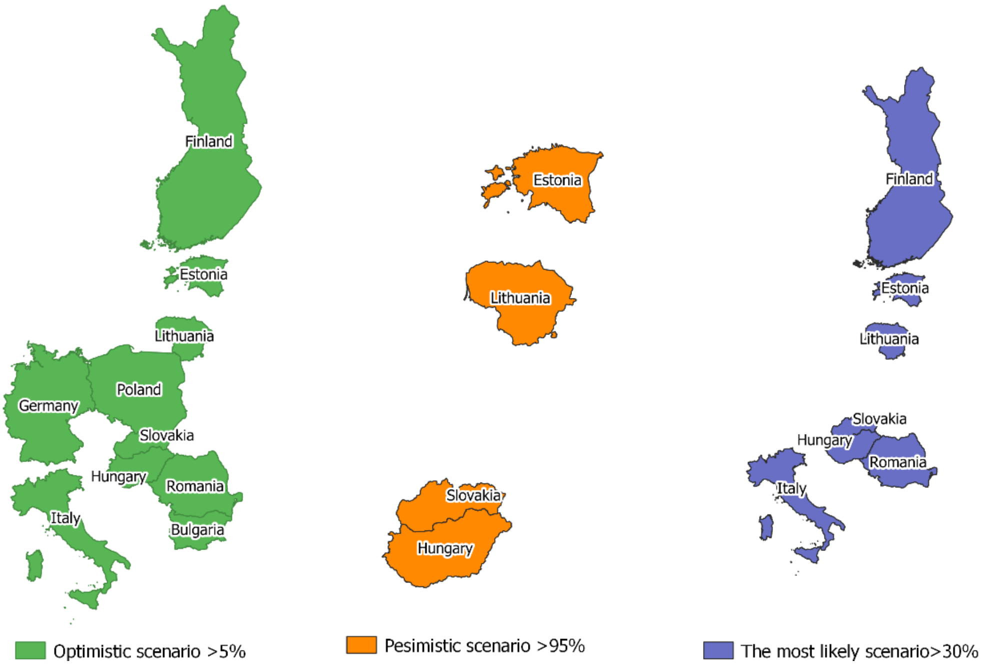

Fig. 5. The countries most sensitive to the suspension of fossil fuel supplies from the Russian Federation
Source: own elaboration

Rys. 5. Kraje najbardziej wrażliwe na wstrzymanie dostaw paliw kopalnych z Federacji Rosyjskiej

The most likely scenario includes seven countries. Poland found itself in the optimistic scenario together with 9 EU-27 countries. The countries that would be most severely affected by the suspension of fossil fuel supplies from Russia were included in the pessimistic scenario. There are four such countries: Hungary, Slovakia, Lituhania, Estonia. It should be noted that Hungary is the most dependent on imports from Russia. The basis of the energy mix in this case is natural gas. Gas imports are 115, 95% of which comes from Russia. Slovakia also uses natural gas and imports 137%, including 85% from Russia. The main problem is the import of natural gas, the transport and storage of which is much more complex than that of coal and crude oil (Economides and Wood 2009). The analysis therefore made it possible to identify countries for which energy security may be critically strained in the event of problems with the supply of fossil fuels from the Russian Federation. However, it should be remembered that there are more factors that affect a country's level of energy security. The authors created a measure that takes into account the most important factors.

As the research was carried out with particular emphasis on Poland, the safety index was determined for this country. Additionally, a benchmark of the obtained results was created – the value of the energy security measure for the EU-27. To unequivocally verify the level of energy security, the authors created a synthetic assessment measure. As the level of security consists of many factors, assessing each of them separately is very difficult and unclear. Therefore, to simplify this analysis, it was necessary to determine an indicator that would take into account all the factors that influence the level of energy security. Based on the analysis of the literature and an expert survey, it was determined which factors should be taken into account and which of them are the most important (MG 2014; Chech 2018; Leszczyński 2012). The measure was designated for Poland and the entire European Union for the years 2008 and 2020, i.e., the first and last known observation. The opinions of ten experts were taken into account (Rybak 2020). Each of them assessed the initial set of indicators on a scale of 1–10, where one means the least important factor and ten refers to the most important factor. According to the definition of energy security (Czech 2018), the factors considered were divided into three categories:

Access to energy in the context of price acceptability by consumers. When analysing energy and fuel prices, the ratio of Polish earnings to the average remuneration in the EU was also taken into account.

Sustainable production, which is a category in which factors related to the impact of energy on the natural environment are placed (i.e., greenhouse gas emissions).

Security of energy supply, which takes into account the level of native energy carriers' resources, the diversification of energy carriers and the difference between energy production and consumption.

The indicators are presented in Table 1.

Figure 6 presents the value of the designated SES measure for Poland for 2008 and 2020, and the EU average for 2008 and 2020. The value of the measure is 39% for the EU for 2008, while for 2020, it increased by 2%. In the case of Poland, the SES increased by only 0.1% for the analyzed period and amounts to less than 16%. Both for Poland and for the EU average, the trend of changes in the SES index is unfavorable.

Figure 7 shows the factors that influenced this level of the SES measure in each of the four cases. The radar chart shows the areas for each of the component factors. The larger the area, the more favorable the value of a given factor. This made it possible to identify the strengths and weaknesses of the energy policy of the EU countries.

Thanks to the radar chart, it is also possible to observe in which areas a given variant excels over the others and which of the categories require correction. For Poland, both in 2008 and 2020, the biggest issue is the first group – access to energy in terms of affordability. Taking into account the level of prices and average wages in Poland and the EU, prices in Poland are several times higher. First of all, energy price is influenced by the level of taxes, which increased by 54% during the considered period. The prices of coal, which forms the basis for electricity production in Poland, are more than four times lower in Poland than the EU on average. This was possible thanks to long-term contracts for Polish fuel, which guar-

Table 1. Indicators taken into account during the SES measure determination

Table 1. Wskaźniki wzięte pod uwagę podczas wyznaczania SES

Group	Factor	Poland		EU-27	
		2008	2020	2008	2020
Access to energy	Electricity prices for household consumers, EUR/kWh	0.13	0.16	0.06	0.088
	Electricity prices for industrial consumers, EUR/ kWh	0.08	0.08	0.04	0.032
	Gas prices for household consumers, EUR/GJ	11.56	11.8	5.94	7.168
	Gas prices for industrial consumers, EUR/GJ	8.36	7.99	3.57	2.772
	Energy taxes for households, mln EUR	7,967.03	12,312	3,153.91	4,171
	Coal prices, USD/Mg	97.33	62	147.67	281
Sustainable energy production	Energy productivity, kg_{oe}	3.5	4.71	7.3	9
	CO_2 emission, m·Mg	287	277	112	94
Reliability of energy supply	Energy dependence, %	30.2	42	54.5	57
	Natural gas resources, 10^{18}·m^3	0.11	0.07	0.09	0.11
	Coal resources, mln Mg	7,502	28,395	1,056.07	2,871
	Crude oil resources, 10^3 m·bbl	0.02	0.02	0.2	0.2
	Difference between energy production and consumption, m. toe	2.3	6	–1.24	3.17

Source: own elaboration.

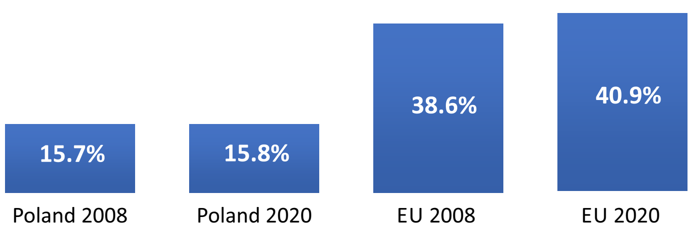

Fig. 6. Values of the SES measure
Source: own elaboration

Rys. 6. Wartość miernika SES

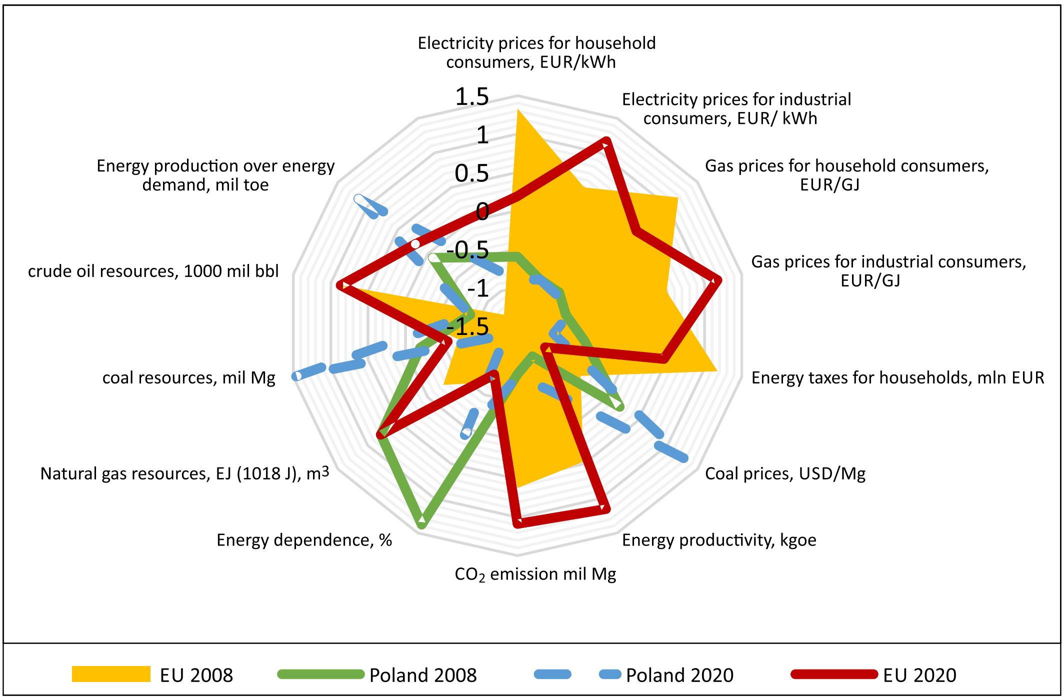

Fig. 7. Radar chart of the values of individual factors included in SES measure
Source: own elaboration

Rys. 7. Wykres radarowy poszczególnych składowych wskaźnika SES

anteed the fuel for power plants at such a favorable price. However, CO_2 emissions in Poland are twice as high as the EU average. Therefore, the area covered on the radar chart by this indicator is very small for Poland compared to the EU. In the third category, the reliability of the energy supply, the level of the SES measure in Poland is positively influenced by the level of energy dependence and the access to domestic energy resources. The SES level is most adversely affected by the low level of domestic gas and oil resources. Table 2 summarizes the strengths and weaknesses of the SES measure. To raise the level of Poland's energy security, it is necessary to eliminate the revealed weaknesses.

3.1. Ways to increase the level of energy security

Methods to increase energy security must be adapted to the specificity of a given country. The research was focused on Poland, and on its example, remedial measures to increase the level of the SES indicator were presented. In the case of Poland, coal should be the natural leader and fuel of the energy transformation period. Natural gas was to be the fuel that

Table 2. Strengths and weaknesses of the energy policy of Poland and EU-27

Table 2. Mocne i słabe strony polityki energetycznej Polski oraz UE-27

Strengths	Weaknesses
Poland	
Coal prices	Electricity prices for household consumers, EUR/kWh
Coal resources	Electricity prices for industrial consumers, EUR/ kWh
Energy production over energy demand	Gas prices for household consumers, EUR/GJ
	Gas prices for industrial consumers, EUR/GJ
	Energy taxes for households, mln EUR
	CO_2 emission
	Natural gas resources
	Crude oil resources
EU-27	
Electricity prices for household consumers, EUR/kWh	Coal prices
Electricity prices for industrial consumers, EUR/ kWh	Coal resources
Gas prices for household consumers, EUR/GJ	Energy dependence
Gas prices for industrial consumers, EUR/GJ	
Energy taxes for households, mln EUR	
Energy productivity	
Crude oil resources	
Natural gas resources	

Source: own elaboration.

supposed to play the role of a safety buffer. However, in the case of Poland, it is not a fuel for which the demand can be met based on native fuel. It is only possible in 30%. Coal was not taken into account due to the emission of pollutants generated during the combustion process. However, it should be remembered that this fuel is optimal in terms of energy security. Coal provides security both in terms of access to the carrier as well as the price of the generated energy. The long-term contracts of Polish energy companies protect Polish citizens against sudden and intense changes in fuel prices (Rybak and Włodarczyk 2022).

The developed fuel conversion technologies also enable the conversion of coal into both oil and gas. Poland, thanks to its rich coal resources, may also become a significant coal exporter again. At the beginning of the 1990s, the exploitation of this raw material in Poland was twice as large as it is today. In turn, the negative impact of coal combustion on the natural environment can be eliminated due to the technologies already developed, such as CCS, CCU and membrane techniques (Bryan et al. 2014; Sarfaz and Ba-Shammakh 2018). The gases obtained in the process of coal combustion can be used during the extraction of crude oil and natural gas, accelerating their production. Additionally, after extraction, it will be trapped in a dumped deposit. CO_2 can also be used in biomass production (Davis et al. 2016). Furthermore, this approach is consistent with the assumptions of the circular economy (Geissdoerferab et al. 2017; McDowall 2017).

3.2. Energy security and the circular economy

In addition to gases and slag, fly ash is produced during the coal combustion process. Fly ash is a source of rare elements (Kogarko et al. 1995, Baba and Usmen 2006). It contains a greater fraction of the critical REE (>30% of total REE) than ores containing REE (Rybak and Rybak 2021). It should be noted that most REEs are supplied by China (Balaram 2019), which may also generate an availability problem. Thus, in the event of an escalation of the current conflicts, the world may also be deprived of access to REE. These are key strategic metals, without which the development of modern electronics, aviation and the space industry would be impossible, and therefore, they are often used during the competition for economic power (Wdowin and Farnus 2014). Additionally, without access to REE, the energy transformation of EU countries would be impossible. They are necessary for the production of electric vehicles, photovoltaics, wind turbines and hydrogen technologies. Due to the strong expansion of renewable energy sources (RES), the demand for REE is growing intensively (IEA 2022). Just as Russia has pursued its energy policy, China has been shaping its REE strategy since the end of the Cold War. Russia and Europe were liquidating their rare metal reserves in the 1990s. China, on the other hand, purchased rare earths, simultaneously shaping prices at a very low level, which made it possible to eliminate competition from Europe. At the same time, efforts were made to conceal the fact that in Europe, REE was purchased from Chinese importers (Wiejaczka and Wilczyński 2021). Due to the European fact that the industry was largely transferred to China, the EU was able to tighten its environmental policy. However, this only allowed for the transfer of the location of the production of harmful substances (Pitron 2020). Every year, 10 million Mg of fly ash is produced in Poland (Mikuła 2014). The authors determined that a REE worth USD 22,970 can be recovered from 1 Mg of ash. The purchase cost of 1 Mg of fly ash is approximately USD 13 (Tauron 2019). Thus, an income of 275 billion USD (Rybak and Rybak 2021) can be obtained. In turn, these revenues may be allocated to the necessary investments that would allow the implementation and improvement of solid and gaseous waste treatment, recovery and storage methods.

Conclusions

The level of dependence on imports of the EU-27 member states depends on the specificity of a given country, access to domestic energy resources and the policy pursued by the state. All countries depend on imports from Russia; however, they differ in the level of dependence ranging from a few to almost 100%, regardless of the geographical location. Despite the fact that for many years the European Union has been striving to diversify supplies of energy resources, this is still not clearly reflected in the amount of fuels imported from the Russian Federation. This is clearly indicated by the share of imports from Russia in 2020 compared to 2012. For example, Germany assumed that Russian gas would be the basis for the conversion of their energy system. In turn, Hungary has entered into long-term agreements with Russia, further increasing the transmission capacity via the Turkish Stream pipeline. By contrast, Polish policy was aimed at limiting the supply of raw materials from Russia. In the face of recent geopolitical events, the level of diversification and independence from imports has become a matter of key importance. Those countries which have so far not sought to find additional importers of energy resources will have to make up for this delay and verify their energy policy.

Poland is privileged in terms of access to fossil fuels due to its rich coal deposits, which can last up to 200 years. However, the potential of this fuel is not used, which is also indicated by the level of the SES measure. In the case of Poland, SES is less than 16%, despite the diversification of gas and oil sources, and the fact that Poland appears only in the optimistic scenario of import dependence (Figure 5). Poland's SES is almost three times lower than the EU-27 average, which should be considered to be unsatisfactory. Efforts should be made to eliminate the revealed weaknesses of the Polish energy policy in all three identified areas. Renewable energy sources are a hope for the independence of not only the European Union countries but of the whole world in this respect. However, before the day comes when renewable energy sources will be able to cover 100% of the constantly growing energy demand, it is necessary to provide access to an energy carrier enabling a smooth and trouble-free shaping of the energy mix based on renewable energy sources. To obtain clean energy, access to rare-earth metals is essential. Therefore, access to them should be secured today, so that a situation similar to that in the case of energy resources does not occur. Renewable energy sources are a source of hope for the energy independence of EU member states. However, China may block the energy transition by limiting access to REE. It should be remembered that there are already technologies that make it possible to obtain clean energy and renewable energy based on coal; their use is also economically justified.

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THE IMPORT OF ENERGY RAW MATERIALS AND THE ENERGY SECURITY OF THE EUROPEAN UNION – THE CASE OF POLAND

Keywords

energy raw materials, energy security, dependence on the import of energy carriers

Abstract

This article presents research on the structure of energy mixes and the dependence on imports of the EU-27 member states, with a particular emphasis on Poland. During the conducted research, a spatial information system was used. GIS tools made it possible to build layers presenting information based on the countries' energy mix, the level of dependence on the import of this fuel, and the share of the Russian Federation in fuel imports. It was also examined whether the level of dependence on imports from Russia was dependent on the geographical location. Since it has been shown that the share of Russian fuel is significant in the energy mixes of many member states, and that security does not depend solely on import dependence, an energy security assessment measure has been created (SES). As the level of security consists of many factors, assessing each of them separately is very difficult and unclear. Therefore, in order to simplify this analysis, it was necessary to determine one indicator that would take into account all the factors influencing the level of energy security. Poland is privileged in terms of access to fossil fuels due to its rich coal deposits; however, the potential of this fuel is not used, which is also indicated by the level of the SES measure. In the case of Poland, SES amounts to less than 16% and is almost three times lower than the EU-27 average. The indicator made it possible to indicate not only those factors that positively affect the level of energy security but also those that adversely affect it. It also enabled the identification of possible remedial measures.

IMPORT SUROWCÓW ENERGETYCZNYCH A BEZPIECZEŃSTWO ENERGETYCZNE UNII EUROPEJSKIEJ. PRZYPADEK POLSKI

Słowa kluczowe

surowce energetyczne, bezpieczeństwo energetyczne, uzależnienie od importu nośników energii

Streszczenie

W artykule przedstawiono badania dotyczące struktury miksów energetycznych oraz uzależnienia od importu krajów UE-27, ze szczególnym uwzględnieniem Polski. W prowadzonych badaniach wykorzystano system informacji przestrzennej. Narzędzia GIS umożliwiły zbudowanie warstw prezentujących informacje o podstawowym składniku miksu energetycznego krajów, stopnia uzależnienia od importu tego paliwa oraz udziału Federacji Rosyjskiej w imporcie paliw. Zbadano również, czy stopień uzależnienia od importu z Rosji jest zależny od położenia geograficznego. Ponieważ wykazano, że udział rosyjskiego paliwa w miksach energetycznych wielu państw członkowskich jest znaczący, a bezpieczeństwo nie zależy wyłącznie od importu, stworzono syntetyczny miernik oceny bezpieczeństwa energetycznego (SES). Na poziom bezpieczeństwa składa się wiele czynników, a ocena każdego z nich z osobna jest bardzo trudna i niejasna. Dlatego w celu uproszczenia tej analizy konieczne było wyznaczenie jednego wskaźnika, który uwzględniłby wszystkie czynniki wpływające na poziom bezpieczeństwa energetycznego. Polska jest uprzywilejowana pod względem dostępu do paliw kopalnych ze względu na bogate złoża węgla, jednak potencjał tego paliwa nie jest wykorzystywany, na co wskazuje również poziom miernika SES. Jak wykazały przeprowadzone badania, w przypadku Polski SES wynosi niespełna 16% i jest prawie trzykrotnie niższy od średniej UE-27. Wskaźnik wskazał te czynniki, które pozytywnie i negatywnie wpływają na poziom bezpieczeństwa energetycznego. Umożliwiło to również wyznaczenie możliwych środków zaradczych.