ANNALS OF THE POLISH ASSOCIATION OF AGRICULTURAL AND AGRIBUSINESS ECONOMISTS

received: 18.03.2020
acceptance: 12.05.2020
published: 25.06.2020
Annals PAAAE • 2020 • Vol. XXII • No. (2)

JEL codes: C43, O13, O44, Q2, Q3
DOI: 10.5604/01.3001.0014.1386

ŁUKASZ PALUCH, MARIUSZ DACKO

University of Agriculture in Krakow, Poland

A MULTIDIMENSIONAL COMPARATIVE ANALYSIS OF THE LEVEL OF SUSTAINABILITY OF THE ENERGY SECTOR OF THE EUROPEAN UNION MEMBER STATES[1]

Key words: European Union, taxonomy, renewable energy sources, production, consumption, energy self-sufficiency

ABSTRACT. The paper addresses the problem of energy sustainability of European Union countries in terms of renewable energy sources, energy consumption levels as well as energy dependency and energy intensity of the economy. The aim of the study was to identify and assess the key characteristics of the energy sector of EU members states between 2006 and 2016 using taxonomy, which is one of the basic tools in a multi-dimensional comparative analysis. The analysis revealed that, despite common challenges, different member states showed varied levels of the implementation of EU climate and energy targets. In terms of the approach to the production and consumption of primary energy, EU countries can be divided into two groups. In most Western European countries, energy production is mainly based on renewable sources. However, it only meets a small portion of the domestic economy's needs. In contrast, Central Eastern European countries are characterized by greater concentration on aspects of self-sufficiency and security of own energy systems. In such countries, the share of renewable sources in overall energy generation is smaller.

INTRODUCTION

One of the greatest challenges for human development is to maintain energy sustainability and security. The energy sector, which involves energy generation and transmission, acts as a kind of lifeblood of every economy [Jankowska 2017]. Its stability has an impact on the sustainable functioning and development of different sectors of the economy (industry, agriculture and services in a broad sense). In the age of rapid technological, economic and social development, stable and uninterrupted energy supplies are among key elements determining a country's economic sovereignty. They also affect a country's position in international relations and impact the life quality of societies [Jankowska 2015]. Indeed, present generations (especially in Western civilization) cannot imagine functioning without electricity, which powers more and more items in everyday use, without fuels, which propel vehicles and machines, or without thermal energy, which ensures hot water

[1] Publication funded by a subsidy from the Ministry of Science and Higher Education of Poland for the University of Agriculture in Cracow for 2020.

and keeps buildings heated in the winter season. Lack of a sufficient quantity of energy resources and alternative energy sources would result in a severe global economic crisis. It could put the secure and stable functioning of such complex systems as modern states at risk [Popławska 2018].

An issue that should be an important element of every country's policy of socio-economic development is ensuring stability and security of the energy system. Analysis of this issue includes the implementation of two strategic objectives. The first is energy self-sufficiency, which, in the context of energy taken from non-renewable sources, is determined by the size and type of the raw material and energy base. In this case, the energy market of a given country is determined by how rich this base is and by its depletion. On a global scale, this market functions based on bilateral links and dependencies between suppliers and consumers. The guarantee of a stable price and supply systematicity is a huge challenge today for most countries and requires close cooperation and mutual support. This is because the market of conventional energy-producing raw materials, mainly crude oil and natural gas, is characterized by low price elasticity of supply and demand. It is determined by several factors such as terrorist attacks, natural disasters or political conflicts. Crude oil and natural gas are exhaustible nonrenewable resources. The market price of such resources, following Hotelling's rule, increases exponentially with their depletion at a rate determined by the value of the discount rate [Manteuffel Szoege 2005]. A rise in the prices of energy-producing raw materials in turn leads to increases in electricity prices. In this context, ensuring uninterrupted availability of energy may become quite a challenge in the future [Fabisiak et al. 2011].

The second objective of a country's energy policy should be energy sector sustainability. Measures in this area are primarily related to the capability of generating energy from renewable sources in order to reduce the excessive exploitation of what is non-renewable and exhaustible. The production and consumption of energy (on such a large scale as seen today) taken from non-renewable sources contributes to ever larger and negative environmental and climate changes (the ozone layer hole, global warming, smog, hurricanes, cyclones and tornadoes, floods, droughts, etc.) [Frodyma 2014]. Therefore, more and more countries, whose economies rely on these raw materials, are forced to diversify energy sources.

The above-described phenomena also apply to European Union countries. The paper addresses the problem of energy sustainability of European Union countries in terms of renewable energy sources, energy consumption levels as well as energy dependency and energy intensity of the economy. The aim of the study was to identify and assess the key characteristics of the energy sector of EU members states between 2006 and 2016 using taxonomy, which is one of the basic tools in a multi-dimensional comparative analysis.

MATERIAL AND RESEARCH METHODS

The starting point for conducting a multi-dimensional comparative analysis was proposing a set of diagnostic variables characterizing the phenomenon under study in quantitative terms. When selecting the variables, it was assumed that they would span a decade. The choice of the period 2006-2016 was dictated by the availability of up-to-date data, the source of which was the EUROSTAT database.

The final list of characteristics (Table 1) was made based on a substantive criterion (taking into account the aim, subject and time frame of the studies) and a formal criterion (assuming that the characteristics should weakly be correlated so as not to duplicate the information they convey, and show a relatively high degree of variation). In addition, when selecting the set of diagnostic variables, it was ensured that they are reliable, accurate, comparable, adequate and complete in temporal and spatial terms.

The degree of correlation between variables was examined using the Pearson correlation coefficient (rx_{ij}), and in order to eliminate highly correlated features, it was assumed that two highly correlated variables convey similar information, so one of them is redundant for the analysis.

Table 1. A set of diagnostic variables selected for analysis*

Symbol	Description of a diagnostic variable (feature)**
$x_{1\,(s)}$	hydro power [Mtoe/1,000 inhabitants]
$x_{2\,(s)}$	wind power [Mtoe/1,000 inhabitants]
$x_{3\,(s)}$	solar energy (solar collectors and photovoltaic cells) [Mtoe/1,000 inhabitants]
$x_{4\,(s)}$	bio-sources (solid biofuels without charcoal, biogas, renewable municipal waste, biogasoline, biodiesel and other liquid fuels) [Mtoe/1,000 inhabitants]
$x_{5\,(s)}$	geothermal power [Mtoe/1,000 inhabitants]
$x_{6\,(d)}$	energy from non-renewable sources/inland energy consumption
$x_{7\,(d)}$	energy dependency indicator (net energy import/inland energy consumption)
$x_{8\,(d)}$	inland energy consumption per capita [Mtoe/1,000 inhabitants]
$x_{9\,(d)}$	inland energy consumption/Gross Domestic Product [toe/EUR 1 million of GDP]

* the variables characterizing renewable energy sources (x_1, x_2, x_3, x_4, x_5) were selected after Jan Norwisz et al. [2006], ** toe – tonnes of oil equivalent, i.e. energy equivalent of 1 tonne of crude oil with a calorific value equal to 10,000 kcal/kg (1 toe = 11.63 MWh)

Source: own work based on the EUROSTAT data

The range of variation, i.e. variability of the values of the diagnostic variables within a set of objects under study, was determined using the coefficient of variation ($V(x_{ij})$) expressed in percentage (Table 2). The diagnostic variables for which $V(x_{ij})$ does not satisfy inequality: $0 \leq V(x_{ij}) \leq 0.1$ are referred to as "quasi-constants", and thus they should be eliminated from further analysis [Kukuła 2000, Parris, Kates 2003, Młodak 2006, Paluch 2015].

The character of the diagnostic features was identified by determining whether they had a positive or negative impact on the phenomenon under study. Each characteristic, once its character was determined, was classified into one of two subsets, i.e. stimulants (*S*) or destimulants (*D*). The set of stimulants comprised: x_1, x_2, x_3, x_4, $x_{5,}$ whereas the set of destimulants comprised: x_6, x_7, $x_{8,}$ x_9.

The identification of the character of diagnostic features was followed by their transformation to render them comparable. The selected diagnostic features were unified using the method of zero unitarization, and transformed using the following formulas [Kukuła 2000]:

Table 2. Selected numerical characteristics of diagnostic variables before transformation

Symbol	Type of characteristic									
	arithmetic mean		standard deviation		minimum		maximum		coefficient of variation	
	2006	2016	2006	2016	2006	2016	2006	2016	2006	2016
$x_{1 (s)}$	0.08	0.08	0.13	0.13	0.00	0.00	0.59	0.54	166.1	154.9
$x_{2 (s)}$	0.01	0.05	0.02	0.05	0.00	0.00	0.10	0.19	176.7	101.3
$x_{3 (s)}$	0.00	0.02	0.01	0.02	0.00	0.00	0.06	0.10	299.4	111.9
$x_{4 (s)}$	0.27	0.38	0.32	0.39	0.00	0.01	1.48	1.62	120.7	101.3
$x_{5 (s)}$	0.00	0.01	0.02	0.02	0.00	0.00	0.09	0.09	376.1	286.0
$x_{6 (d)}$	0.35	0.28	0.30	0.22	0.00	0.00	1.27	0.66	87.0	77.6
$x_{7 (d)}$	0.57	0.55	0.30	0.24	-0.35*	0.07	1.03	1.01	53.0	44.2
$x_{8 (d)}$	3.85	3.36	1.71	1.36	1.91	1.61	10.07	7.28	44.3	40.6
$x_{9 (d)}$	234.06	150.17	144.90	73.77	84.42	54.64	744.21	372.85	61.9	49.1

* The negative value for the minimum of the diagnostic characteristic $x_{7(d)}$ referred to Denmark, which in 2006 was the only net exporter of primary energy in the European Union. As from 2013, energy import in that country exceeded energy export. No EU country has since then received the status of a net exporter of primary energy.
Source: own work based on the EUROSTAT data

$$z_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad x_{ij} \in S, \quad z_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad x_{ij} \in D$$

where: z_{ij} – value of the variable being transformed, x_{ij} – value of the diagnostic variable, max x_{ij} – maximum value of the diagnostic variable in the set of objects, min x_{ij} – minimum value of the diagnostic variable in the set of objects.

With this transformation, all the variables being transformed (z_{ij}) assumed values from the bracket [0,1]. Value 0 signified the least positive state, whereas value 1 – the most positive one. The values of these features were then used to construct a synthetic measure (*SM*) to render a complex phenomenon by means of one numerical measure. In accordance with the assumption of the method of zero unitarization, this measure is an arithmetic mean of the transformed values of diagnostic characteristics [Kukuła 2000]:

$$SM = \frac{\sum_{i=1}^{n} z_{ij}}{n} \quad (i = 1, 2\ldots,r)$$

where: *SM* – value of the synthetic measure, z_{ij} – value of the variable being transformed, n – number of the variables being transformed.

The determined values of the synthetic measure *(SM)* enabled the construction of a ranking of European Union countries in terms of the sustainability level of the energy sector, and the categorization of them into four different typological groups (Table 3).

When creating the groups, synthetic measurement (*SM*) and its two features, i.e. the arithmetic mean (SM_{am}) and standard deviation ($S(SM_{am})$) were used [Kukuła 2000].

Table 3. Criteria for dividing EU countries into typological groups

Symbol	Characteristics of the group	Division criteria
I	highest level	$SM \geq SM_{am} + S(SM_{am})$
II	medium level	$SM_{am} + S(SM_{am}) > SM \geq SM_{am}$
III	low level	$SM_{am} \geq SM \geq SM_{am} - S(SM_{am})$
IV	lowest level	$SM_{am} - S(SM_{am}) > SM$

Source: own study based on [Kukuła 2000]

The presented division criteria showed that the higher the value of the synthetic measure (*SM*), the higher the level of energy sector sustainability for a given country and based on that it can be classified into an appropriate group.

RESEARCH FINDINGS

The ranking of European Union countries shows that over a decade, from 2006 to 2016, Sweden was the leader in energy sustainability (Table 4). In 2016, primary energy production in this country relied mostly on hydro power (0.54 Mtoe/capita) and energy from so-called bio-sources (1.08 Mtoe/capita). Sweden also stood out against other EU countries in terms of the value of the per capita wind power production indicator (0.13 Mtoe/capita). In 2016, over half of primary energy was produced in this country from renewable sources. And although it is not a leader in this area, as this position is held by Malta, Cyprus and Latvia, it is clearly ahead of most EU countries in terms of per capita volume of energy production from renewable sources. The following factors also contributed to Sweden's high position in the ranking: a small share of energy from non-renewable sources in total inland energy consumption (0.35), a low level of energy dependency as measured by the ratio between energy import and inland energy consumption (0.32) and a relatively low energy intensity of the economy as expressed by the level of inland energy consumption per million EUR of generated Gross Domestic Product (105 toe/EUR million of GDP).

High in the ranking, both in 2006 and 2016, were also Austria and Italy. Both these countries were characterized by a relatively low energy intensity of the economy, i.e. below 100 toe/EUR million of GDP. In Italy, 70% of primary energy was generated in 2016 from renewable sources. Energy from bio-sources (0.18 Mtoe/capita) and geothermal power (0.09 Mtoe/capita) dominated. Hydro power, wind power and solar energy was used to produce 0.12 Mtoe/capita. In Austria, energy from renewable sources accounted for 79% of primary energy production. It was mostly taken from bio-sources (0.64 Mtoe/capita) in the form of hydro power (0.39 Mtoe/capita). Italy was also characterized by a low level of per capita energy consumption (2.55 toe/capita). Unfortunately, the country's level of energy dependency was much higher than the EU average (0.77). For Austria, this indicator was slightly lower (0.62), but its inhabitants consumed markedly more energy overall as expressed by the sum of energy import and its primary production (3.89 toe/capita). Analysis of the values of the 2006 synthetic measure (SM) shows that the above-described countries and Denmark made up a group with the highest level of energy sector sustainability (I), and in 2016 were joined by Portugal and Spain.

Table 4. Ranking of EU states by synthetic measure value

Item	2006			2016		
	Country	Value *SM**	Group	Country	Value *SM**	Group
1	Sweden	0.492	I	Sweden	0.538	I
2	Austria	0.465	I	Italy	0.509	I
3	Italy	0.450	I	Austria	0.503	I
4	Denmark	0.449	I	Portugal	0.470	I
5	Cyprus	0.410	II	Spain	0.462	I
6	Finland	0.408	II	Denmark	0.457	I
7	Portugal	0.407	II	Latvia	0.445	II
8	Latvia	0.403	II	Finland	0.426	II
9	Spain	0.382	II	Cyprus	0.416	II
10	Croatia	0.364	II	Germany	0.410	II
11	Greece	0.363	II	Greece	0.393	II
12	Germany	0.361	II	Ireland	0.380	II
13	Ireland	0.356	II	Croatia	0.374	II
14	Slovenia	0.340	III	Malta	0.367	III
15	France	0.327	III	Slovenia	0.366	III
16	Malta	0.318	III	Lithuania	0.355	III
17	Hungary	0.314	III	Great Britain	0.336	III
18	Great Britain	0.314	III	Romania	0.336	III
19	Romania	0.312	III	France	0.329	III
20	Lithuania	0.310	III	Estonia	0.311	III
21	Estonia	0.301	III	Belgium	0.300	III
22	Holland	0.298	III	Slovenia	0.297	III
23	Poland	0.292	III	Hungary	0.297	III
24	Slovakia	0.284	III	Holland	0.285	IV
25	Belgium	0.279	IV	Poland	0.271	IV
26	Czech Republic	0.271	IV	Czech Republic	0.264	IV
27	Luxembourg	0.250	IV	Luxembourg	0.263	IV
28	Bulgaria	0.238	IV	Bulgaria	0.253	IV

* *SM* – value of the synthetic measure indicating the level of energy sustainability in EU countries
Source: own work based on the EUROSTAT data

Just as the leader of the ranking – Sweden – remained the same over the decade, the country at the bottom of the ranking – Bulgaria – remained unchanged. The latter was classified, along with Luxembourg, the Czech Republic and Belgium, in 2006 to a group of countries with the lowest level of energy sector sustainability (IV). In 2016, Belgium left the group, but Poland and Holland became its new members. It is also worth noting that, in both cases, Bulgaria came last in the ranking of all EU countries. Analysis of the values of the diagnostic variables used to calculate the synthetic measure (*SM*) shows that overall energy production in this country relies on renewable sources to a small degree. In 2016, energy production in Bulgaria was only 0.31 Mtoe per capita, and the share of renewable sources in it was less than 17%. However, relying on non-renewable sources, Bulgaria maintained a relatively low rate of energy dependency (0.37), and per capita energy consumption in this country stood at 2.53 toe. Although a high energy dependency rate made Bulgaria compare well with other EU states, it should be noted that, in 2016, the Bulgarian economy was the most energy intensive of the whole European Union. And although the energy intensity rate of this economy decreased almost twofold over the decade, still as much as 372 toe was used to produce EUR 1 million of GDP in Bulgaria.

In 2016, the group of countries showing the lowest energy sustainability included Poland. The diagnostic variables used to determine the values of the synthetic measure (SM) indicate that renewable energy is mainly produced in Poland from so-called bio-sources (i.e. biofuels, waste, biogas, etc.). In 2016, energy taken from those sources was 0.2 Mtoe/capita. Unfortunately, this is an extremely poor result against European leaders. For comparison, the volume of primary energy taken from bio-sources in Finland in the same period stood at 1.62 Mtoe/capita. Other renewable sources were used in Poland to produce only 0.035 Mtoe/capita, which means that renewable sources accounted for only 13% of produced primary energy. Poland also demonstrated one of the highest values of the ratio of energy produced from non-renewable sources to inland energy consumption (0.57, with the average for the EU standing at 0.28). Apart from Poland, other countries that also recorded a high value of this ratio were Romania (0.58), Great Britain (0.56), the Czech Republic (0.54), Holland (0.52), Estonia (0.51) and Bulgaria (0.51).

Analysis shows that Poland, along with Hungary, Denmark, Romania, Great Britain, Slovenia, Croatia, Latvia and Bulgaria, in 2016, can be classified into EU countries with a clearly lower rate of energy dependency (0.30, with an EU average of 0.55) and per capita energy consumption (2.63 toe/capita, with an EU average of 3.36 toe/capita). However, that does not translate into a low rate of economic energy intensity, as in 2016 234 toe was used to produce every million Euro of the Gross Domestic Product. This value places the Polish economy among such countries as: Bulgaria (372 toe/EUR million of GDP), Estonia (286 toe/EUR million of GDP), the Czech Republic (237 toe/EUR million of GDP), Hungary (223 toe/EUR million of GDP), Slovakia (203 toe/EUR million of GDP), Romania (190 toe/EUR million of GDP), Croatia 184 toe/EUR million of GDP) and Lithuania (180 toe/EUR million of GDP). It should be noted that all the above-listed countries demonstrate an energy intensity indicator above the average for the European Union (150 toe/EUR million of GDP).

SUMMARY

Energy policy today occupies an important place in the EU's policy of sustainable development. This is because access to energy raw-materials and stability of energy supplies is one of the conditions for the long-term socio-economic development of individual EU states. Socio-economic development also draws attention to issues connected with the protection of the natural environment, which is gradually degrading as a result of excessive exploitation of non-renewable energy sources and pollution emissions of accompanying the use of energy. This prompts the need for linking energy policy objectives of individual EU member states with postulates of the EU's climate policy, one of the main objectives of which is to achieve a low-emission economy by 2050 [EU 2018]. However, in order for that objective to be achieved in accordance with the "Framework of the climate and energy policy", as published on the website of the European Commission, by 2030, EU countries should: ensure that energy from renewable sources accounts for 32% of total inland energy consumption, reduce greenhouse gas emissions by at least 40% (compared to the 1990 level) and increase energy efficiency by at least 32.5% [EU 2014].

Research reveals that despite common objectives and challenges, different EU member states show varied levels of their implementation. In terms of the approach to the production and consumption of primary energy, EU countries can be divided into two groups. The first group shows an increasing level of energy sector sustainability through an intensive development of renewable energy. However, such production only meets a small portion of domestic economy's needs (currently most countries of Western Europe). The second group of countries, in turn, focuses on the aspect of self-sufficiency and security in the development of their energy systems (Central and Eastern European countries). In such countries, primary energy production is more balanced against consumption, but there is a lower level of the use of renewable energy sources.

BIBLIOGRAPHY

EU (European Union). 2014. *Ramy polityki klimatyczno-energetycznej do roku 2030* (2030 climate & energy framework), https://ec.europa.eu/clima/policies/strategies/2030_pl, access: 25.04.2020.

EU (European Union). 2018. *Długoterminowa strategia do roku 2050* (2050 long-term strategy), https://ec.europa.eu/clima/policies/strategies/2050_pl, access: 25.04.2020.

Fabisiak Jacek, Jerzy Kupiński, Jarosław Michalak, Hanna Nowik. 2011. Dywersyfikacja źródeł pozyskiwania energii jako element bezpieczeństwa państwa (Diversification of energy sources as an element of national security). *Logistyka* 5: 537-543.

Frodyma Katarzyna. 2014. Statystyczna analiza nośników energii ze źródeł odnawialnych w Polsce i wybranych krajach Unii Europejskiej (The market of renewable energy sources in Poland – statistical analysis). *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach* 203: 68-78.

Jankowska Izabela Maria. 2015. Bezpieczeństwo energetyczne w polityce bezpieczeństwa państwa (Energy Security in the State's Security Policy). *Studia Lubelskie* XI: 147-166.

Jankowska Ewa. 2017. Przestrzenno-czasowa analiza zróżnicowania poziomu rozwoju odnawialnych źródeł energii (Measures of development of renewable energy sources). *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach* 324: 33-44.

Kukuła Karol. 2000. *Metoda unitaryzacji zerowanej* (Zero unitarization method). Warszawa: PWN.

Manteuffel Szoege Henryk. 2005. *Zarys problemów ekonomiki środowiska* (Overview of environmental economics issues). Warszawa: SGGW.
Młodak Andrzej. 2006. *Analiza taksonomiczna w statystyce regionalnej* (Taxonomic analysis in regional statistics). Warszawa: Difin.
Norwisz Jan, Tomasz Musielak, Bożena Boryczko. 2006. Odnawialne źrodła energii – polskie definicje i standardy (Renewable energy resources – definitions and standards used by Polish legal acts). *Rynek Energii* 1: 10-20.
Paluch Łukasz. 2015. Zastosowanie taksonomii w procesie pomiaru i oceny poziomu rozwoju społeczno-gospodarczego jako efektu realizowanej polityki społecznej. [W] *Wybrane aspekty polityki społecznej w Polsce. Podręcznik dla studentów kierunków społecznych, ekonomicznych i rolniczych* (The use of taxonomy in the process of measuring and assessing the level of socio-economic development as an effect of implemented social policy. [In] selected aspects of social policy in Poland. a textbook for students of social, economic and agricultural faculties), ed. M. Kowalska, 199-225. Kraków: UR.
Parris Thomas, Robert Kates. 2003. Characterizing and measuring sustainable development (Charakterystyka i pomiar zrównoważonego rozwoju). *Annual Review of Environment and Resources* 28: 559-586.
Popławska Joanna. 2018. Dywersyfikacja źródeł energii jako metoda uniezależnienia energetycznego państwa (Diversification of energy sources as a method of energy independence of the state). *Annales Universitatis Paedagogicae Cracoviensis* 257 (8): 107-117.

***

WIELOWYMIAROWA ANALIZA PORÓWNAWCZA POZIOMU ZRÓWNOWAŻENIA SEKTORA ENERGETYCZNEGO PAŃSTW CZŁONKOWSKICH UNII EUROPEJSKIEJ

Słowa kluczowe: Unia Europejska, taksonomia, źródła energii, produkcja, konsumpcja, samowystarczalność energetyczna

ABSTRAKT

W opracowaniu podjęto problem zrównoważenia sektora energetycznego krajów Wspólnoty Europejskiej w aspekcie odnawialnych źródeł energii, poziomu jej konsumpcji, a także zależności energetycznej oraz energochłonności gospodarki. Celem badania była identyfikacja i ocena kluczowych charakterystyk sektora energetycznego państw członkowskich Unii Europejskiej w latach 2006 i 2016, przy wykorzystaniu taksonomii, stanowiącej jedno z podstawowych narzędzi wielowymiarowej analizy porównawczej. Z przeprowadzonej oceny wynika, że pomimo wspólnych wyzwań, poszczególne kraje członkowskie charakteryzuje zróżnicowany poziom realizacji celów klimatyczno-energetycznych Unii Europejskiej. W kwestii podejścia do produkcji i konsumpcji energii pierwotnej państwa Wspólnoty można podzielić na dwie grupy. W większości krajów Europy Zachodniej produkcja energii rozwijana jest głównie na bazie źródeł odnawialnych. W niewielkim stopniu pokrywa ona jednak potrzeby własnej gospodarki. Kraje Europy Środkowo-Wschodniej charakteryzuje natomiast większa koncentracja na aspektach samowystarczalności i bezpieczeństwa własnego systemu energetycznego. W krajach tych mniejszą rolę pełni udział źródeł odnawialnych w pozyskiwaniu energii ogółem.

AUTHORS

MARIUSZ DACKO, PHD
ORCID: 0000-0001-8424-4720
University of Agriculture in Krakow
Faculty of Agriculture and Economics
Department of Economics and Food Economy
21 Mickiewicza Av., 31-120 Kraków, Poland

ŁUKASZ PALUCH, PHD
ORCID: 0000-0002-3258-750X
University of Agriculture in Krakow
Faculty of Agriculture and Economics
Department of Economics and Food Economy
21 Mickiewicza Av., 31-120 Kraków, Poland