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Energy security cultures in the European Union

Abstract: The research problem under analysis in this text is 'energy security cultures' in the European Union. The main goal of the research is to conduct a comparative analysis involving selected existing research papers on 'energy cultures.' In the analysis, attention is drawn to research employing quantitative methods based on object clustering methods.

Given the necessity to make the research problem more specific, the text addresses the following research questions: (1) Is the claim that the European Union presents special 'energy security cultures' legitimate?, (2) Did the period of 2008–2012 witness changes to the above-established 'energy security cultures' in the European Union?

In order to conduct the analysis concerned with the existence or non-existence of 'energy security cultures' in the European Union, the following indices have been adopted: (1) the index of the energy intensity of the economy, (2) the index of energy dependence, (3) the Stirling index, (4) the index of network losses and (5) the index of renewable energy use. It is considered that the selected indices constitute a definiens of the adopted term of an 'energy security culture.'

To verify the assumptions made in the analysis, use was made of one agglomerative method (i.e. Ward's method) and one method for optimising a given cluster of objects (the k-means method).

Key words: energy security, energy security indices, indices of energy security cultures, energy cultures, energy security cultures, methods of multidimensional comparative analysis, European Union

Introduction

The object of analysis in the present text is 'energy security cultures' in the European Union, that is an attempt at verifying the assumed legitimacy of the statements whereby European Union member states should be divided according to certain special practices of energy consumption which would thus mirror specific 'energy security cultures.' To begin with, the existence of two main directions in the analyses concerned with security cultures and energy cultures should be pointed out, which can be expressed as: (1) a presentation of culture in the form of the conversion of resources as well as the impact of that conversion on reality, (2) a culture as a special sphere of social awareness. These two directions of thought are associated with the two main origins of the research into culture itself (Kłosowska, 1969; Kłosowska 1972; Keesing, 1974, pp. 73–94; Nowicka, 1991, pp. 55–88; Burszta, 1998, pp. 35–57; Gajda, 2008, pp. 17–60; Strinati, 1998, pp. 15–49).

The main goal set in this text is to conduct a comparative analysis involving the research already featuring in scientific literature, and concerning 'energy cultures.' In the analysis presented, attention has been drawn to research employing statistical methods of multidimensional comparative analysis. In the first place, the comparative analysis draws on the research by A. Pach-Gurgul, but also on research by P. Tapio and his research team, as well as on research by P. Frączek and A. Majka (Tapio et al., 2007, pp. 433–451; Pach-Gurgul, 2012, pp. 160–202; Frączek, Majka, 2015, pp. 215–223). There have also been attempts at putting the problem of ‘energy cultures’ within a broader context, which is to be seen in the adduction of other traditions concerned with the research into an ‘energy culture.’

In the text, an ‘energy security culture’ has been adopted as an analytical category, which is both a development of the previous research into an ‘energy culture’ itself and a research proposition. Following A. Pach-Gurgul, specific indices of energy security have been adopted, and these are recognised as diagnostic characteristic of an ‘energy security culture.’

Given the necessity to make the research problem more specific, the text addresses the following research questions: (1) Is the claim that the European Union displays special ‘energy security cultures’ legitimate?, (2) Did the period of 2008–2012 witness changes to the above-identified ‘energy security cultures’ in the European Union? In order to see the research process through, the following working research hypotheses have been subjected to verification: (1) It must be posited that the discrepancies in the statistical indices for individual member states are a sufficient premise on which to base the existence of special ‘energy security cultures’ in the European Union, (2) It must be posited that the period of 2008–2012 witnessed changes to ‘energy security cultures’ in the European Union.

1. The concept of ‘energy security cultures’

It is impossible to conduct an exhaustive analysis of the comprehension of the notion of ‘culture,’ which is used in many branches of humanities and social sciences. As it was pointed out in the introduction to the text, the issue of culture can be approached using at least two basic lines of thought. In the first case it can be assumed that a culture is a specific way of converting resources and the impact of such conversion upon reality; whereas in the second case, a culture is to be linked with a special sphere of social awareness.

The two above-mentioned approaches come to be reflected in the research into ‘energy cultures.’ The first case, which is connected with the special way of converting resources, relates to the presentation of characteristic features of the production of broadly-understood energy. In this case, the most frequently conducted analyses are those of: energy production (and its diversity); energy consumption (and its diversity); import dependence; development of new energy technologies; pollution resulting from energy consumption. The second case, which is connected with a special kind of awareness, relates to an analysis of environmental awareness, green practices and attitudes towards infrastructure investments, such as nuclear power plants, wind farms and biogas plants (cf. Rosicki, 2016, pp. 225–237).

In the case of analyses concerned with special kinds of energy production and consumption practices, both qualitative and quantitative approaches can be highlighted. The qualitative approach is usually based on descriptive research involving synthesis and generalisation in terms of energy cultures. Such research results in ‘synthetic models’ exhibiting dominant features in the energy structures of individual states or/and groups of states (Łucki, Misiak, 2010, pp. 47–50, 72–78). For instance, the existence of the following types of energy cultures can be listed: Anglo-Saxon, French, Scandinavian, Mediterranean, etc. (Łucki, Misiak, 2010, pp. 75; Pach-Gurgul, 2012, pp. 163–166). As regards quantitative research, with regard to energy production and consumption practices, analyses conducted on the basis of a variety of classification algorithms may serve here as an example. Research papers containing cluster analyses should be reckoned among such research (Tapio et al., 2007, pp. 433–451; Pach-Gurgul, 2012, pp. 160–202; Frączek, Majka, 2015, pp. 215–223; Rosicki, 2016, pp. 225–237).

As for research into awareness, eco-friendly behaviours and attitudes concerned with energy saving, the most representative studies are quantitative ones based on questionnaire techniques or qualitative studies based on a variety of unstructured interviews. Scientific research in this area follows from the construction of a model of behaviours and customs – usually of households – to the construction of questionnaire studies targeted at a specific statistical sample of a population. In-depth analyses are frequently performed on the socio-demographic and psychological factors which are supposed to illustrate behaviours concerned with the consumption of energy by its end users (cf. Stern, Gardner, 1981, pp. 329–342; van Raaij, Verhallen, 1981, pp. 253–257; van Raaij, Verhallen, 1983a, pp. 39–63; van Raaij, Verhallen, 1983b, pp. 85–106; Stern, 2000, pp. 407–424; Lindén, Carlsson-Kanyama, Eriksson, 2006, pp. 1918–1927; Papuziński, 2006, pp. 33–40; Tuszyńska, 2007, pp. 233–236; Hłobił, 2010, pp. 87–94; Frederiks, Stenner, Hobman, 2015, pp. 573–609). Such analyses result in a variety of models of energy cultures which can be termed normative-cultural ones, that is, ones that point to the significance of factors affecting the goals of behaviour related to energy consumption, as well as ones that point to the significance of the ways of attaining goals related to energy consumption. In these models a number of dimensions are emphasised, e.g. the behavioural, the social, the economic and the systemic (cf. Lutzenhiser, 1992, pp. 47–60; Keirstead, 2006, pp. 3065–3077; Biggart, Lutzenhiser, 2007, pp. 1070–1087; Stephenson et al., 2010, pp. 6120–6129; Ford, Karlin, Frantz, 2016).

The concept of an ‘energy security culture’ on the one hand constitutes a proposition that points to a specific objective scope of the security-related issues; on the other hand, it is a consequence of the main goal set in the text, namely a comparative analysis of the research results presented by A. Pach-Gurgul. The research assumptions contained in the work of A. Pach-Gurgul are a consequence of the concepts and methods that were employed in the research by P. Tapio and his team, as well as descriptively presented in the publication by Z. Łucki and W. Misiak. The abovementioned publications presented only research into ‘energy culture’ alone. It must, however, be pointed out that A. Pach-Gurgul was lacking either confidence or consistency with regard to the presentation of a coherent proposition of a terminological framework in the analysis of subsequent spheres of the energy industry (at the same time applying the same methods, while applying different groups of indices). The author’s lack of confidence and consistency resulted in her using only the category of ‘energy culture,’ whereas, in the analysis of the issues concerned with energy security itself and energy markets, she did not apply the category of an ‘energy security culture’ or the category of ‘energy market cultures’ (Tapio et al., 2007, pp. 433–451; Pach-Gurgul, 2012, pp. 160–202).

It is to be noted that the use of the category of a ‘security culture’ within energy issues does not relate to the research papers on ‘strategic cultures of security,’ which feature in the research on international relations. We owe the approach to the issues of military security itself, with relation to the concept of a ‘strategic culture,’ to J. Snyder. However, his proposition served to expose ‘cultural’ factors, which were to affect the practice and normative assumptions in the sphere of military security. Hence, one cannot but get the impression that the category was there to cater to the jargon, which was supposed to legitimise the analyses focused on the presentation of socio-political factors affecting military security (cf. Snyder, 1977; Sondhaus, 2006, pp. 1–13; Toje, 2008, pp. 15–19; Czaputowicz, 2012, pp. 172–174).

2. Methodology

2.1. The scope of comparative analysis

The text proposes that an ‘energy security culture’ be adopted as an analytical category, which constitutes a development and elaboration of the previous research into ‘energy cultures.’ The analytical proposition constitutes a basis for the accomplishment of the goal identified in the text, that is the verification of the assumptions and results of the research presented in the publication by A. Pach-Gurgul, and concerned with the energy security of Poland and the European Union. It is also noteworthy that A. Pach-Gurgul’s publication contains a quantitative analysis of energy security in three thematic groups: (1) energy cultures, (2) energy security *sensu stricto*, and (3) a uniform energy market (Pach-Gurgul, 2012, pp. 163–202).

The assumptions and research methods adopted in the work by A. Pach-Gurgul, which had earlier been proposed by A. Tapio and his research team, were employed with a view to analysing both ‘energy cultures’ and energy security *sensu stricto* as well as the uniform energy market. There is some terminological inconsistency in the nomenclature adopted by A. Pach-Gurgul, for if the same methods were to be applied to the analysis of various spheres of energy production, then it must be posited that adopting such coherent terms as (1) ‘energy cultures,’ (2) ‘energy security cultures’ and (3) ‘energy market cultures’ would not pose a problem (cf. ibid.). In a consistent manner, in keeping with the remark made here, the present text proposes a category of an ‘energy security culture,’ while preserving the same indices that were used for the analysis of energy security *sensu stricto* in the work of A. Pach-Gurgul.

The text postulates that individual ‘energy security cultures’ can be characterised by the following statistical indices: (1) the index of the energy intensity of the economy, (2) the index of import dependence, (3) the Stirling index, (4) the index of network losses, (5) the index of renewable energy use. The above-mentioned indices have been adopted as a set of diagnostic characteristics useful in identifying countries with similar “energy security cultures” and/or as a set of diagnostic characteristics to be used in distinguishing the countries for that reason (cf. ibid., pp. 177–188).

The analysis timeframe presented in the work of A. Pach-Gurgul spanned the years 2000–2008, that is the analysis included the research results related to the attempt at grouping the countries according to various kinds of energy security *sensu stricto*, on account of the selected set of diagnostic characteristics for 2000 and 2008. In the case of the author's own analysis, undertaken in this text, the recognised set of diagnostic characteristics for 2008 and 2012 has been adopted. A repetition of the research for 2008 might show possible differences in the grouping of the countries with regard to their being assigned to individual 'energy security cultures.' In this case, the differences may above all result from a lack of the possibility of employing the data concerned with the value of the statistical indices selected for analysis. In the first place, there is the problem of the possibility of using the same sources of secondary data, whereas in the second place a possible emergence of differences in the indices resulting from differing methodologies in their calculation must be accentuated. The latter may be exemplified with the value of the Stirling index, whose evaluation and value may depend on the number of energy carriers taken in by the researcher (Kałążna, Rosicki, 2010, pp. 69–73; Leszczyński, 2012, p. 4). In addition, it must be pointed out that the comparative analysis involving the research results of A. Pach-Gurgul applies to 2008 only, and so it does not include the 2000 data presented by the author.

Conducting original research for 2012 makes it possible to capture potential dynamics in the attempt to group countries according to particular 'energy security cultures' with the aid of statistical analysis. It must also be noted that the differences between the results of the research by A. Pach-Gurgul and the results presented in the text for 2008 will be decisively impacted by the subjective scope of the analysis, because the publication by A. Pach-Gurgul contains the analysis for EU-27, whereas the research conducted for the sake of the comparative analysis in this text includes the analysis for EU-28.

2.2. The range of clustering methods

Given the intention to conduct a kind of comparative analysis, following A. Pach-Gurgul, only a selection of statistical methods has been adopted in the research, that is (1) *Ward's method* (the minimum variance method) and (2) the *k-means method* (Pach-Gurgul, 2012, pp. 159–177).

The first of the selected methods is *Ward's method*. It is one of the most frequently applied agglomerative clustering methods. The distinctive feature of this method is the use of variance analysis in order to determine the distance between clusters. The distance between one cluster composed of objects and another one cannot be directly expressed by way of the distance between the objects belonging to these clusters (Kaufman, Rousseeuw, 2005, pp. 230–234; Mirkin, 2015, pp. 111–136). Hence, "the method aims to minimise the sum of squared deviations of any two clusters which can be formed at any stage" (*Analiza skupień*, 2017). As a result of this operation, the clusters that "ensure the minimum sum of squared distances from the centre of mass of a new cluster that they create" are merged (Roszko-Wójtowicz, 2014, p. 74). The literature points out that this kind of agglomerative method is cognitively effective, while it yields small, and yet most natural clusters (Roszko-Wójtowicz, 2014, p. 74; *Analiza skupień*, 2017).

The other applied method is the *k-means method* (i.e. a non-hierarchical algorithm of cluster analysis). This clustering method is by design different from agglomerative and divisive methods (including *Ward's method*). While hierarchical methods generate arranged cluster trees, whereby lower-order clusters are subsumed under higher-order ones, the *k-means method* divides clusters in such a manner that no cluster is a sub-cluster of another one (Stanisz, 2007, pp. 127–128). The choice of a specified number of clusters results in groups of objects that are most similar (close), whereas objects from other groups are most different (distant). Importantly, it must be pointed out that it is the person conducting the analysis who makes an arbitrary choice as to the number of groups made up of particular objects (Sokołowski, 2002; Mirkin, 2015, pp. 75–110).

3. Indices of 'energy security cultures'

3.1. A selection of indices

The introduction contains assumptions to be verified, that is, in the first case, the assumptions of the existence or non-existence of special 'energy security cultures,' whereas in the second case, the assumption is made of any possible changes occurring in 'energy security cultures,' which have or have not been recognised. For these assumptions to be verified, the proper selection of indices is of vital importance, as these are intended to characterise an 'energy security culture.' Arguably, the very selection of indices is a *definiens* of sorts of the term of an 'energy security culture.'

A culture contains at least three components, a normative one, a component connected with specific practices, and a material component. It is possible to point to several dimensions within each one of these components; for instance, we can analyse a culture with regard to an individual or a larger group of people (cf. Nowicka, 1991, pp. 55–88; Gajda, 2008, pp. 17–60). By and large, the problem of security may also be analysed through the prism of the above-mentioned components, which frequently comes to be reflected in the discussion of the very concept or definition of security. The result of this assumption is the statement that similar components can be pointed out in the analysis of 'energy security' and 'energy security cultures' (cf. Baumann, 2008, pp. 4–12; Cherp, Jewell, 2011, pp. 202–212; Barton et al., 2013, pp. 13–15).

The concept of 'energy security,' and by extension of an 'energy security culture,' which would in addition incorporate the above-mentioned components along with their various dimensions, can be described as "a state of the economy that makes it possible to cover the end users' current and prospective demand for fuels and energy in a manner technologically and economically justified, while complying with the requirements of the natural environment protection" (Rosicki, 2012, pp. 35–66). The main points of energy security so understood will encompass the following aspects: (1) a social, (2) economic, (3) technological and (4) an environmental one. The following indices have been adopted as diagnostic characteristics of these four aspects: (1) the index of the energy intensity of the economy, (2) the index of energy dependence, (3) the Stirling index, (4) the index of network losses and (5) the index of renewable energy use. It must be pointed out that these indices were adopted as being crucial for such research by A. Pach-Gurgul, whereas in the present analysis they have been adopted only with a view to conducting comparative studies (see Table 1).

Table 1

Indices of energy security cultures in European Union member states in 2012 (EU-28)

STATES	Energy intensity of economy (kgoe /1 000 €)	Energy dependency rate	Stirling Index	Index of network losses	Index of renewable energy use
	[1]	[2]	[3]	[4]	[5]
BE	172.2	0.740	1.528	0.049	0.258
BG	669.9	0.361	1.514	0.088	0.414
CZ	355.4	0.252	1.514	0.047	0.219
DK	87.2	–0.034	1.390	0.071	0.324
DE	129.2	0.611	1.534	0.039	0.424
EE	478.7	0.171	1.091	0.075	0.093
IE	82.8	0.848	1.181	0.076	0.261
EL	165.7	0.666	1.197	0.026	0.292
ES	136.4	0.733	1.482	0.086	0.455
FR	142.9	0.481	1.379	0.066	0.286
HR	225.6	0.536	1.170	0.179	0.550
IT	117.3	0.808	1.262	0.070	0.379
CY	167.0	0.970	0.167	0.021	0.100
LV	328.6	0.564	1.252	0.180	0.614
LT	291.6	0.803	1.136	0.096	0.273
LU	133.8	0.974	0.808	0.026	0.708
HU	268.7	0.523	1.485	0.106	0.041
MT	147.4	1.005	0	0.130	0.032
NL	149.4	0.307	1.191	0.043	0.094
AT	123.9	0.636	1.365	0.050	0.643
PL	298.7	0.307	1.207	0.067	0.139
PT	146.5	0.795	1.293	0.100	0.526
RO	378.8	0.227	1.529	0.120	0.386
SI	227.7	0.516	1.519	0.057	0.416
SK	329.3	0.600	1.553	0.045	0.361
FI	204.0	0.454	1.528	0.041	0.204
SE	148.2	0.287	1.344	0.066	0.529
UK	105.1	0.422	1.419	0.078	0.159

Source: Author’s own study based on Eurostat and International Energy Agency data (some of the data have been obtained with the aid of the use of the indices after secondary data have been calculated).

3.2. A description of indices

The first of the indices is energy intensity, which is a diagnostic characteristic related to the workings of the economy. This index defines energy consumption in production processes in individual economic sectors. Differences in the level of energy intensity may be indicative of the level of economic development, an economic structure, a technological advancement as well as the kind of carriers used in primary energy production. A low level of energy intensity may give rise to conclusions of the higher efficiency of energy resource management. Still, it must be pointed out that a low energy intensity may characterise economically underdeveloped countries, with the proviso that we are dealing with low energy consumption in general. As regards the analysis of the issues concerned with energy intensity, a variety of indices may be applied, e.g. (1) an index of GDP energy intensity (calculated as the ratio of the amount of energy consumed to the value of GDP), (2) an index of energy consumption per capita (calculated as the ratio of primary energy consumed to the population) (Pach-Gurgul, 2012, pp. 166–167; *Energy glossary*, 2016; Rosicki, 2016, p. 232). In the analysis featuring in the text, the index defines the amount of energy consumed to generate a unit of GDP (expressed in kilograms of oil equivalent per 1000 euro), and hence a low value of the index means that less energy is needed to produce the same volume of GDP (GUS, 2016).

The second index that has been applied to analyse energy security cultures is the index of energy dependence, which constitutes a diagnostic characteristic of a country's energy self-sufficiency, for it defines the level of its import dependency. This index is used by Eurostat, among others, and thus it encompasses an assessment of import dependency for three energy carriers (gas, oil and coal) as well as a general assessment of import dependency. The value of the index is a ratio of net import to the gross internal consumption of a given carrier, allowing for reserves. The higher the index, the higher the import dependency of the particular country (Kałążna, Rosicki, 2010, pp. 76–85; EC, 2013, pp. 11–27; EC, 2014, pp. 37–38).

The third index that has been applied is the Stirling index, which constitutes a diagnostic characteristic of energy structure diversity in individual European Union member states. It is worth noting that this index enables an analysis of the diversification of various energy structures, e.g. the structure of primary energy production, the structure of electric energy production, as well as the structure of energy consumption. In the case of the presented analysis, the Stirling index served to calculate the structural diversification level of the gross internal energy consumption with a breakdown to the following kinds of fuel: (1) solid fuels, (2) oil, (3) gas, (4) nuclear energy, (5) RES, (6) waste not classified as RES (*non*-RES).

The Stirling index defines the relation between energy carriers and the share of individual carriers in energy supply (e.g. the share in the structure of gross internal energy consumption). This index depicts the degree to which the energy structure of a given country is balanced, whereby the more diversified the structure is, the better the appraisal of the level of energy security is (Kaliski, Staśko, 2003, p. 4; Kaliski, Staśko, 2007, pp. 11–12; Kałążna, Rosicki, 2010, pp. 69–73; Leszczyński, 2012. p. 4). Still, it must be pointed out that the assumption may be interpreted differently, which results from the fact that in some cases a lack of diversification may not necessarily be viewed as negative. For instance, if a given country has one dominant carrier in its energy structure, and at the same time it has substantial reserves of the very same carrier, then it is difficult to directly deem it negative in the situation where there is a necessity to quickly change the energy structure, or in the situation where a given country does not have sufficient reserves of a carrier that is the dominant one in the energy structure. Hence, it must be recognised that sometimes the use of the Stirling index alone may be of little explanatory value as regards the issues of energy security.

The optimal mathematical value of the Stirling index (i.e. an ideal state of diversification) depends on the number of carriers, e.g. for five carriers (and hence 20% share for each of the carriers in the energy structure) it will be 1.6. In the case of four carriers (and hence 25% share for each of the carriers in the energy structure) it will be 1.38 (cf. Kałążna, Rosicki, 2010, pp. 69–72).

The fourth index applied is the index of network losses, which constitutes a diagnostic characteristic for technical aspects of the culture of energy security. The index characterises the state of electric energy transmission and distribution infrastructure. The index value defines the difference between the electric energy that has been introduced to the electric energy network and the electric energy that has been received from the network (cf. Nazarko, Rybaczuk, 2003, pp. 320–330; Pach-Gurgul, 2012, p. 178; Niewiedział,

Niewiedział, 2014). It must, however, be noted that by way of a deeper analysis of network losses, a variety of these can be enumerated, e.g. the balance, technical (current and voltage) and trade losses (Nazarko, Rybaczuk, 2003, pp. 322–325).

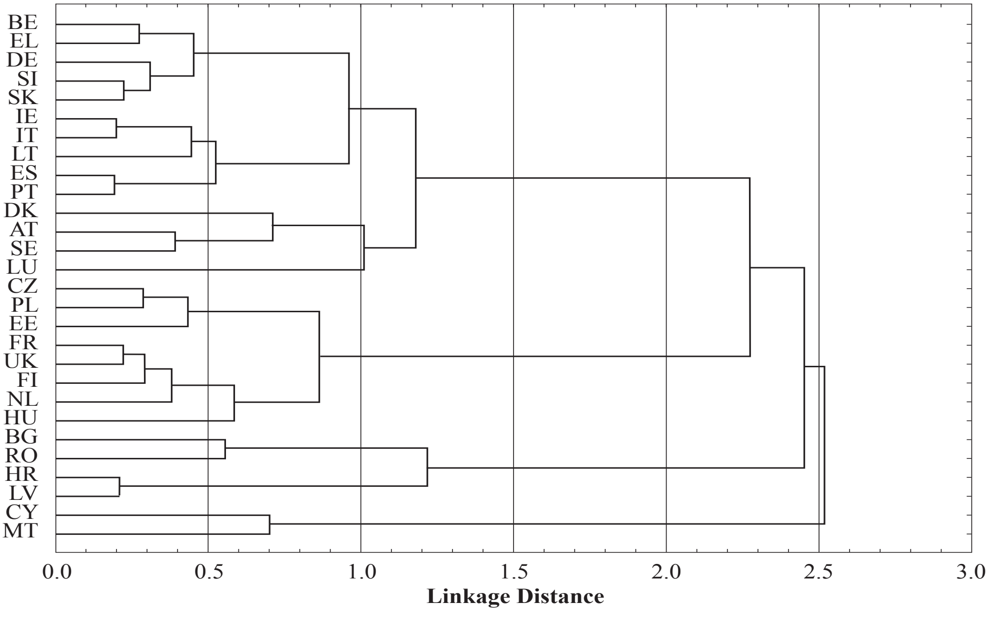
The fifth, and the last index applied in the analysis is the index of renewable energy use. This index constitutes a diagnostic characteristic for the development potential of new technologies, and additionally its value may affect the level of the diversification of carriers, the level of energy dependence and emission. The value of this index is a ratio of the share of the capacity installed in renewable energy to the total installed capacity (cf. Pach-Gurgul, 2012, p. 179; GUS, 2015).

4. An attempt at grouping the European Union member states

4.1. Ward’s method

Ward’s method was used to group the European Union member states (EU-28) in 2012, which made it possible to distinguish five existing clusters: (1) Belgium, Greece, Germany, Slovenia, Slovakia, Ireland, Italy, Lithuania, Spain and Portugal (however, it must be pointed out that the group shows a clear division into the former five countries and the latter five); (2) Denmark, Austria, Sweden, Luxembourg; (3) the Czech Republic, Poland, Estonia, France, the United Kingdom, Finland, the Netherlands and Hungary (however, it must be pointed out that the group shows a clear division into the former three countries and the latter five); (4) Bulgaria, Romania, Croatia and Latvia; (5) Cyprus and Malta (see Diagram 1).

Diagram 1. Dendrogram (*Ward’s method* with Euclidean distance)



Source: Author’s own study.

4.2. *K-means method*

With the optimal number of clusters established, the text sets out to find out what areas characterising an ‘energy security culture’ display the biggest differences between the distinguished groups (see Table 2). Thanks to the *k-means method* it is possible to conclude that the differences between the distinguished clusters are highly significant ($p<0.01$) in respect of all the analysed variables (see Table 3).

Table 2

The mean values of the analysed indices in individual clusters (*k-means method*)

Individual indices	Cluster					
	1	2	3	4	5	6
Energy intensity of the economy	0.3309	0.1102	0.1790	0.2163	0.1267	0.7262
Energy dependency rate	0.5621	0.8023	0.5691	0.3395	0.9832	0.2762
Stirling Index	0.7798	0.7844	0.9248	0.8954	0.0538	0.8873
Index of network losses	0.9969	0.3208	0.1806	0.2749	0.3428	0.4612
Index of renewable energy use	0.8136	0.6384	0.4949	0.2020	0.0503	0.3930

Source: Author’s own study.

Table 3

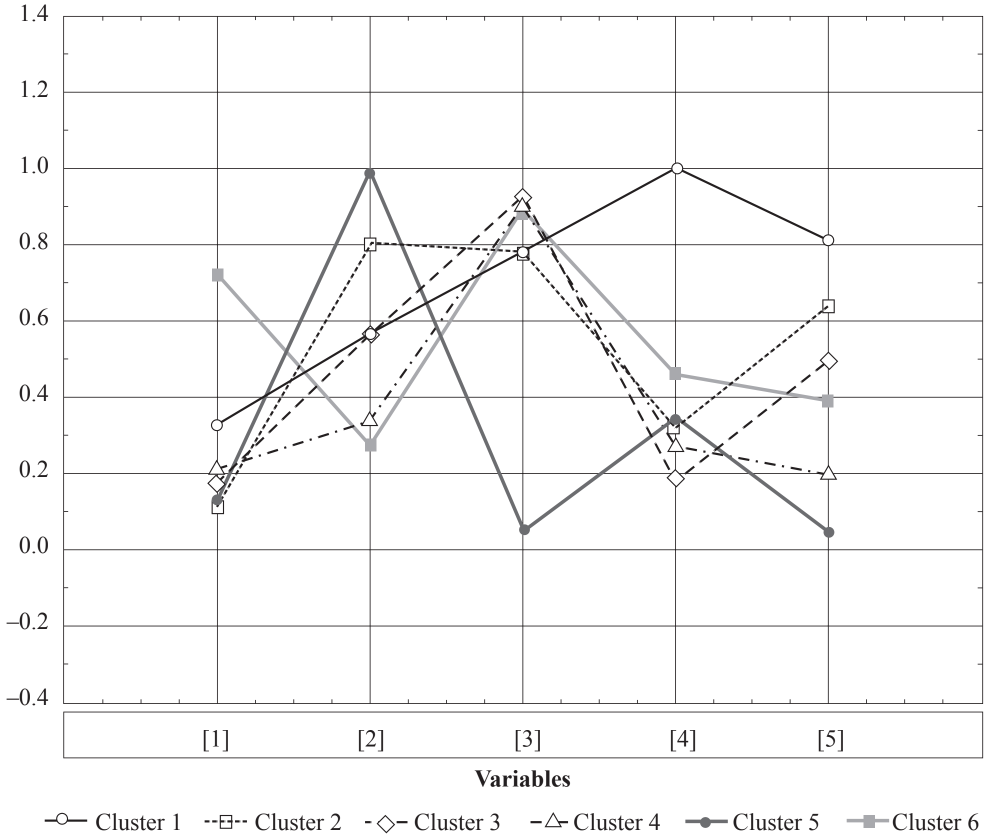
Differences between clusters – variance analysis results (ANOVA)

Individual indices	ANOVA					
	Between	Df	Within	Df	F	P
Energy intensity of the economy	0.90	5	0.49	22	8.14	0.0002
Index of energy dependence	1.35	5	0.38	22	15.47	<0.0001
Stirling Index	1.31	5	0.27	22	21.71	<0.0001
Index of network losses	1.12	5	0.62	22	7.89	0.0002
Index of renewable energy use	1.28	5	0.78	22	7.27	0.0004

Source: Author’s own study.

An extension of Table 2 is Diagram 2, which graphically presents mean levels of the analysed characteristics for the six distinguished clusters. The **first cluster** includes Croatia and Latvia (which is related to the high value of network losses and of the index of renewable energy use). The **second cluster** includes Ireland, Spain, Italy, Lithuania, Luxembourg, Austria and Portugal (a distinctive feature of this cluster is a high value of the index of energy dependence, of the Stirling index and of the index of renewable energy use). The **third cluster** includes Belgium, Germany, Greece, France, Slovenia, Slovakia and Sweden (a distinctive feature of this cluster is a high value of the Stirling index and the attendant lower value of other indices). The **fourth cluster** includes the Czech Republic, Denmark, Hungary, the Netherlands, Poland, Finland and the UK (a distinctive feature of this cluster is a high value of the Stirling index and the attendant lower value of the other indices). The **fifth cluster** includes Cyprus and Malta (a distinctive feature of this cluster is a very high index of import dependency). The **sixth cluster** includes Bulgaria, Estonia and Romania (a distinctive feature of this cluster is the highest value of energy intensity).

Diagram 2. Means values of particular clusters (*k-means method*)



Individual indices: [1] energy intensity of the economy, **[2]** index of energy dependence, **[3]** Stirling Index, **[4]** index of network losses, **[5]** index of renewable energy use.

Source: Author’s own study.

Summary of research results

Within the research process the following hypotheses have been subjected to verification: (1) It must be posited that discrepancies in the statistical indices for individual member states are a sufficient premise on which to base the existence of special ‘energy security cultures’ in the European Union, (2) It must be posited that the period of 2008–2012 witnessed changes to ‘energy security cultures in the European Union. With regard to the analysis conducted to verify the hypotheses, the following conclusions are to be drawn.

I. CONCLUSIONS

In a summary of the results of the author’s own research into an ‘energy security culture,’ obtained with the aid of *Ward’s method* (with Euclidean distance), compared to the results of the research conducted by A. Pach-Gurgul for 2008, it must be noted that the recurrent cluster in both result sets is: Cyprus and Malta. In other cases there is a different distribution of countries within the distinguished clusters. However, attention should be drawn to the concomitance of individual countries in particular groups – in these two studies. The recognised groups with concomitant countries are as follows: (1) Austria, Sweden, Portugal, Spain; (2) Bulgaria, Romania, Lithuania; (3) the Czech Republic, Estonia, Poland and Hungary; (4) Ireland, Italy, Greece; (5) Belgium, Finland, France, Germany, Slovenia. In the case of the latter group of concomitant countries, the clusters identified in the two separate studies give rise to the recognition of a relatively lasting coherence.

Interestingly, a comparison of the author’s own research results with the research results obtained by A. Pach-Gurgul with the aid of the *k-means method* for 2008 leads to the establishment of three recurrent clusters: (1) Austria, Luxembourg, Latvia, Portugal and Sweden; (2) Belgium, Finland, France, Greece, Spain, Ireland, Germany, Slovakia, Slovenia and Italy; (3) Cyprus and Malta. In the case of the first recurrent cluster, one can point to its following features: a mean value of the Stirling index at a relatively high level; a mean value of energy intensity in these countries at a low level; a mean value of the index of renewable energy use at a high level. As for the second recurrent cluster, the following features are to be observed: a mean value of the Stirling index at a high level; a mean value of the index of renewable energy use; the lowest mean value of the index of network losses; a mean value of energy intensity at a low level; a mean value of energy dependence at a high, but not the highest level – compared to Malta and Cyprus (cf. Pach-Gurgul, 2012, pp. 181–186). The third recurrent cluster will be described later in the conclusions.

As for the *k-means method* applied in the author’s own research concerned with an ‘energy security culture’ for 2008 and 2012, it must be pointed out that the recurrent cluster in the two results is Cyprus and Malta. Other cases offer a different distribution of countries within the distinguished clusters. Still, attention should be drawn to the fact of the concomitance of individual countries within particular groups in both analyses. The identified groups with concomitant countries are as follows: (1) Belgium, Germany, Greece, France, Slovenia and Slovakia; (2) the Czech Republic, Denmark, Hungary, the Netherlands, Poland and the UK; (3) Bulgaria and Estonia; as well as (4) Ireland, Spain and Italy; (5) Luxembourg, Austria and Portugal.

As for the results obtained, compared with other research into ‘energy cultures,’ it is difficult to point to deeper and more stable relationships between specific diagnostic characteristics and the specific locations of the countries which were obtained in the research by P. Tapio and his team (cf. Tapio et al., 2007, pp. 433–451; Frączek, 2014, pp. 443–449; Rosicki, 2016, pp. 225–237). This assumption concerns the lack of ability to point to coherent sub-regions within the European Union which would carry specific diagnostic characteristics used in the research. This does not mean that one cannot point to specific ‘energy security cultures’ with regard to the existence of individual and specific diagnostic characteristics of energy security.

From the viewpoint of the possibilities of linking specific diagnostic characteristics with specific locations of countries, and by extension with the grouping of countries within clusters, and at the same time the concomitance of these countries within characteristic sub-regions in the European Union, one can point to the countries in Central and Eastern Europe, that is the so-called new member states. The diagnostic characteristic that can serve to distinguish the countries in this region is the way energy is converted in a given economy, which is illustrated with the index of energy intensity. One can point to the power of this diagnostic characteristic, for in the research concerned with an ‘energy culture’ itself the index of energy intensity was also instrumental in distinguishing the countries in Central and Eastern Europe (Rosicki, 2016, pp. 225–237). Hence, it is to be assumed that there exists an ‘energy culture’ and an ‘energy security culture’ in the countries in Central and Eastern Europe.

The concomitance of characteristics, and the possibility of their being linked with geographic specificity can be exemplified by Malta and Cyprus. These two countries are characterised by a special geographical situation, both are small islands. On top of that, the lack of their own energy resources gives rise to a high import dependence, and thus the cluster is characterised by the mean value remaining at a high level for this index. In addition, the following aspects should be emphasised: (1) the mean value of the energy intensity index is at a low level, (2) the mean value of the Stirling index is at a low level, (3) the mean value of renewable energy use is at a low level, (4) the index of network losses is of a mean value.

It is important to note that if a change was made to the methodology as to the selection of indices, and thus as to the meaning of diagnostic characteristics, by allowing for a description of energy structures in individual member states, it would probably be possible to have coherent sub-regions within the European Union (cf. Tapio et al., 2007, pp. 433–451; Frączek, 2014, pp. 443–449; Frączek, Majka, 2015, pp. 215–223).

II. CONCLUSIONS

Given the recognition of the lack of deeper and more stable relationships between specific diagnostic characteristics and the specific locations of the countries, it is difficult to demonstrate the changes to ‘energy security cultures’ in the European Union. Still, it should be noted that the dynamics of changes in the values of individual indices of energy security give rise to changes in the results of grouping individual countries in clusters for 2012. One can point to many factors determining these changes, but it is worth emphasising the significance of the policies concerned with the energy industry and the natural environment in the European Union.

In the long term it should be assumed that the increase in the significance of renewable energy sources will affect the value of the index of renewable energy use, as well as the Stirling index. Still, the hardly definable processes with regard to the reduction of energy intensity and severance of the relationship between the increase in the demand for energy and economic growth make forecasting import dependency difficult. It is a well-known fact that the depletion of energy resources in the European Union member states will result in a rise in import dependency. The rise in dependence on imported resources may be limited by a significant development of renewable energy production and technology reducing the energy intensity of energy transformation processes.

The development of new technologies and their usefulness for the energy generating and transforming sector will be one of the main diagnostic characteristics of ‘energy cultures’ and ‘energy security cultures’ projected in long-term forecasts. The development of the technologies related to renewable energy sources and the technology reducing energy intensity will affect the economic competitiveness of individual European Union member states. Besides, these technologies will determine the internal EU division into countries at the centre of the ‘energy revolution’ and countries on the ‘energy outskirts.’ In the long term, this may lead to a division into technologically backward countries that use traditional carriers, and the ones that have made electric energy their main carrier.

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Kultury bezpieczeństwa energetycznego w Unii Europejskiej

Streszczenie

Problemem badawczym, będącym przedmiotem analizy w tekście, są „kultury bezpieczeństwa energetycznego” Unii Europejskiej. Głównym celem prezentowanych badań jest dokonanie analizy porównawczej z już istniejącymi wybranymi opracowaniami w zakresie „kultur energetycznych”. W prezentowanej analizie uwagę zwrócono na badania, które wykorzystują metody ilościowe w oparciu o metody grupowania obiektów.

W związku z koniecznością uściślenia problemu badawczego w tekście przedstawiono następujące pytania badawcze: (1) *Czy zasadne jest twierdzenie, że w Unii Europejskiej mamy do czynienia ze specyficznymi „kulturami bezpieczeństwa energetycznego”?*, (2) *Czy w okresie 2008–2012, następują zmiany w obrębie, stwierdzonych wcześniej „kultur bezpieczeństwa energetycznego” w Unii Europejskiej?*

W celu dokonania analizy w zakresie istnienia, bądź też nie „kultur bezpieczeństwa energetycznego” w Unii Europejskiej, przyjęto następujące wskaźniki: (1) wskaźnik energochłonności gospodarki, (2) wskaźnik zależności energetycznej, (3) wskaźnik stirlinga, (4) wskaźnik strat sieciowych i (5) wskaźnik wykorzystania energii odnawialnej. Uznano, że tak dobrane wskaźniki stanowią swoisty definiens przyjętego terminu „kultury bezpieczeństwa energetycznego”.

Do weryfikacji założeń przyjętych w analizie posłużono się jedną z metod aglomeracyjnych (czyli *metodą Warda*) i jedną z metod optymalizacji danego grupowania obiektów (czyli *metodą k-średnich*).

Słowa kluczowe: bezpieczeństwo energetyczne, wskaźniki bezpieczeństwa energetycznego, wskaźniki kultur bezpieczeństwa energetycznego, kultury energetyczne, kultury bezpieczeństwa energetycznego, metody wielowymiarowej analizy porównawczej, Unia Europejska

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