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SHAPING SUSTAINABLE ENERGY IN A CIRCULAR ECONOMY. CASE STUDY OF EU AND WESTERN BLOC COUNTRIES 2013-2020

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ABSTRACT: The countries must take steps to modernize the energy economy. This is important for countries whose primary energy source structure is based on coal consumption. Energy is a key factor in meeting human needs, including economic activity. The aim of the study is to present and assess the spatial differentiation of energy policies under circular economy conditions at the level of EU countries (including former Eastern Bloc countries). To achieve the objective, a literature analysis, synthetic measures, and statistical analysis were used. Empirical data was collected in spatial terms for EU countries in 2013 and 2020. Research confirms that there is a positive change in the energy policy aspect in EU countries in 2020 compared to 2013. The group with the highest measure of synthetic energy policy included Finland, Sweden, and Austria, while the weakest were Luxembourg and the Eastern Bloc countries of Bulgaria and Poland. The former EU countries are mostly in a better position in terms of energy policy than the Eastern Bloc countries.

KEYWORDS: energy, sustainability, energy policy, circular economy, synthetic measure (CRITIC-TOPSIS)

Introduction

The ever-increasing environmental problems of natural resource depletion, environmental crisis, environmental degradation and global warming have become visible dilemmas for regional policies. Many countries have implemented a variety of measures, including energy conservation, emission reduction, green growth policies, and renewable energy development, to improve environmental performance and achieve sustainable development (Lee et al., 2023). Rising energy costs associated with the war in Ukraine pose a direct threat to the purchasing power and survival of businesses in energy-importing countries, especially for households and companies (Amendola et al., 2024). The migration crises, the provisions of the European Green Deal, and the Green Growth Strategy have all pointed to an energy transition, including a move away from coal to meet European climate goals (Loewen, 2022).

Energy policy plays a key role in shaping the flow of energy to achieve specific goals. These have included for example, energy conservation, integration of renewable energy and reduction of carbon emissions. It affects energy security, sustainability innovation and efficiency in the energy sector (Shah Danish & Senjyu, 2023). Around the world, countries are accelerating the transition to low-carbon energy sources, reducing coal consumption and increasing the use of renewable energy (Li et al., 2023).

Energy prices significantly influence household energy consumption behaviour. Changes in consumer behaviour have the effect of reducing overall energy consumption, fostering an energy-saving culture in the community and contributing to a more sustainable society (Nguyen et al., 2023). A higher variable share of renewable energy affects the flexibility and reliability of the energy system (Paraschiv, 2023). A closed-loop economy characterised by a closed flow of materials and energy, combining natural and human resources, science and technology, may be the answer (Ioannidis et al., 2023). The communities are turning to non-polluting renewable energy sources. Adopting a green economy is key to achieving the common sustainability goals (Ma et al., 2023).

The aim of the study is to present and assess the spatial differentiation of energy policies under closed-loop economy conditions at the level of EU countries (including former Eastern Bloc countries: Czech Republic, Estonia, Slovenia, Lithuania, Latvia, Hungary, Slovakia, Poland, Bulgaria, Romania, Croatia). The results of the analysis are presented for 2013 and 2020. A synthetic measure, built according to the CRITIC-TOPSIS method, was used for the evaluation. The authors chose to present the following research questions: What are the diagnostic variables describing energy and CE policies? What were the concentration and dynamics of change of renewable energy consumption in the EU and Eastern Bloc countries? What are the similarities between EU countries in terms of energy consumption? To what extent does the use of renewable energy contribute to the transition to a circular economy? The main difficulty identified in conducting this study was the limited availability of up-to-date information on RES potential, prices, and environmental impacts of RES.

Energy insecurity, warming and climate change have made the transformation of the energy sector a necessity. It involves reducing energy consumption and decarbonising the economy. Energy transformation is the basis for sustainable development. This knowledge can be used by the authorities to assess the effectiveness of the development instruments and policies used so far. Further empirical research is needed on the implementation of the SDGs, the relationship with demographic variables, the financial situation, environmental changes and their impact on energy transition. Action taken in this aspect must be based on analyses that facilitate comparisons and on current information necessary for effective action. The study makes international comparisons in the energy field.

Literature review

Regions are making progress at the expense of environmental degradation, which can harm sustainable development. One of the main tenets of the Green Economy concept is that low-carbon energy technologies have significant potential to meet socio-economic objectives alongside environmental objectives. The Green Economy results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (Pahle et al., 2016).

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Energy transformation is essential and urgently needed. The high dependence of regions on fossil fuels as the primary energy source has led to air pollution, climate change and resource depletion. The transition to renewable energy sources is crucial to ensure sustainability. The crisis in Ukraine has brought a new level of concern and uncertainty about fossil fuels. High oil and gas prices are exacerbating energy poverty and leading to a loss of industrial competitiveness (Lu et al., 2023a).

Renewable energy reduces dependence on finite energy sources such as oil, gas and coal. It also improves energy security and stability, which are extremely important issues today. It contributes to economic growth and also provides employment opportunities (Syed et al., 2023). Renewable energy policies are developed taking into account societal benefits and the need to mitigate unpredictable environmental impacts (Tseng et al., 2021). Renewable energy is a low-carbon energy source to meet growing energy demand (Lin et al., 2024).

Global energy demand has been steadily increasing over the years, leading to growing concerns about the availability and sustainability of natural resources. Economic growth and development cannot occur without a noticeable impact on the environment. Energy consumption and depletion of natural resources are sources of pollution and environmental degradation. The huge demand for natural resources, which stimulates industrial and economic growth, simultaneously destroys the environment and the atmosphere, thus creating an ecological deficit. High dependence on non-renewable energy sources is a commonly cited cause of increased income inequality (Husaini et al., 2024).

Renewable energies reduce climate change without emitting greenhouse gases. Unlike fossil fuels, renewable energy sources do not deplete the Earth's resources. Sustainable energy is an important aspect of sustainable development and a key element of human development. The use of renewable energy is growing as innovations reduce costs and enable a clean energy future to become a reality. Emissions of carbon dioxide and other pollutants in the energy sector are decreasing due to the increasing use of renewable energy (Lu et al., 2023b).

Research methods

The CRITIC-TOPSIS method of linear object ordering was used to achieve the objective. The classical TOPSIS method involves calculating the Euclidean distances of each object under study from both the pattern and the anti-pattern (Łuczak & Kalinowski, 2020).

The selection of diagnostic variables was based on substantive and statistical analysis. The statistical analysis takes into account the variability of objects in terms of individual variables ($|V_i| \leq V^*$; where $V^* = 0.10$), the degree of correlation between the variables (according to the inverse correlation matrix method), and the type of variable (stimulant and destimulant) (Malina, 2004; Grabiński et al., 1989).

The variables indicated are interactive and intercorrelated. The following diagnostic variables were distinguished in the study, as shown in Table 1.

Table 1. Diagnostic variables in terms of energy policy and the circular economy

variables		Unit of measure	S/D	weight of dignstic variables	
				2013	2020
energy policy					
X1	Greenhouse gas emissions intensity of energy consumption (source: EEA and Eurostat)	Index, 2000=100	D	0.15	0.14
X2	Share of renewable energy in gross final energy consumption by sector	Percentage	S	0.09	0.09
X3	Share of fuels in final energy consumption	Percentage	D	0.11	0.11
X4	Use of renewables for electricity – details	Gigawatt-hour /1000 inhabitants	S	0.08	0.08
X5	Use of renewables for heating and cooling – details	Thousand tonnes of oil equivalent / 1000 inhabitants	S	0.09	0.09

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variables		Unit of measure	S/D	weight of dignstic variables	
				2013	2020
X6	Heat pumps – ambient heat captured by technology and climate	Gigawatt-hour / 1000 inhabitants	S	0.09	0.09
X7	Liquid biofuels production capacities	Thousand tonnes per year / 1000 inhabitants	S	0.13	0.14
X8	Solar thermal collectors' surface	Thousand square metres / 1000 inhabitants	S	0.11	0.1
X9	Stock levels for gaseous and liquefied natural gas	Million cubic metres / 1000 inhabitants	S	0.15	0.15
circular economy					
Y1	Recycling rate of waste of electrical and electronic equipment (WEEE) separately collected	Percentage	S	0.09	0.09
Y2	Recycling rate of municipal waste	Percentage	S	0.08	0.07
Y3	Circular material use rate	Percentage	S	0.07	0.08
Y4	Trade in recyclable raw materials	Tonne per capita	S	0.1	0.09
Y5	Generation of municipal waste per capita	Kilograms per capita	D	0.07	0.07
Y6	Resource productivity	Euro per kilogram, chain linked volumes (2015)	S	0.07	0.08
Y7	Material footprint	Tonnes per capita	S	0.08	0.1
Y8	Material import dependency	Percentage	S	0.07	0.07
Y9	Greenhouse gases emissions from production activities	Kilograms per capita	D	0.09	0.08
Y10	Consumption footprint	Per inhabitant	D	0.07	0.07
Y11	Private investment and gross added value related to circular economy sectors	Percentage of gross domestic product (GDP)	S	0.07	0.08
Y12	Persons employed in circular economy sectors	Full-time equivalent (FTE) per cpaita	S	0.14	0.12

S – stimulant; D – destimulants.
Source: authors' work based on Eurostat (n.d.).

The observation matrix – a set of objects and diagnostic variables – is presented as Z_{ij}:

$$X_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}, \tag{1}$$

where:
X_{ij} – denotes the values of the j-th variable for the i-th object, a matrix of diagnostic variables describing objects in terms of waste management and ecology and environment,
i – object number (i = 1, 2, ..., n),
j – variable number (j = 1, 2, ..., m).

The diagnostic variables were normalised according to the zero unitization method. The normalisation of variables is carried out according to the formulas:

$$X_j \in S; Z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, Z_{ij} = 0 \Leftrightarrow x_{ij} = \min_i x_{ij}; Z_{ij} = 1 \Leftrightarrow x_{ij} = \max_i x_{ij}, \tag{2}$$

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$$X_j \in D; Z_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}},\ Z_{ij}=0 \Leftrightarrow x_{ij} = \max_i x_{ij}; Z_{ij}=1 \Leftrightarrow x_{ij} = \min_i x_{ij}, \quad (3)$$

where:
S – stimulant,
D – destimulant,
max_{xij} – maximum value of the jth variable,
min_{xij} – minimum value of the jth variable,
X_{ij} – denotes the value of the jth variable for the it object,
Z_{ij} – normalised value of the jth variable for it object, the value belongs to the interval [0;1] (Sompolska-Rzechuła, 2021; Vafaei et al., 2018; Kukuła & Bogocz, 2014).

As a result of the process of unitisation we obtain a matrix of the unitised value of the jth variable for the ith object – Z_{ij}:

$$Z_{ij} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{m1} & \cdots & z_{mn} \end{bmatrix}, \quad (4)$$

In the next step, weights were determined for the variables on the basis of standard deviations and correlations between the variables, according to the CRITIC method (Criteria Importance Through Intercriteria Correlation). The weights of the variables were determined using the following formulas:

$$w_j = \frac{C_j}{\sum_{k=1}^{K} C_k}, j = 1,2,\ldots,K, \quad (5)$$

$$C_j = S_{j(Z)} \sum_{k=1} (1 - r_{jk}), j = 1,2, \ldots K, \quad (6)$$

where:
C_j – is the information value of the j-th variable,
$S_{j(z)}$ – is the standard deviation lopped from the normalised values of the j-th variable,
r_jk – is the correlation coefficient between the j-th and k-th characteristics.

The sum of C_j coefficients is 1. C_k is the sum of the information measure of all criteria. The normalised values of the diagnostic variables are multiplied by the weighting coefficient w_j ($Z^*_{ij} = Z_{ji} \times w_j$) (Slebi-Acevedo et al., 2019).

The TOPSIS method determines the Euclidean distances of individual objects from the pattern (=1) and anti-pattern (=0) , according to the formula:

- distances of the objects from the pattern:

$$d_i^+ = \sqrt{\frac{1}{n} \sum_{j=1}^{m} \left(z^*_{ij} - z_j^+\right)^2}, \quad (7)$$

- distances of objects from the anti-pattern:

$$d_i^- = \sqrt{\frac{1}{n} \sum_{j=1}^{m} \left(z^*_{ij} - z_j^-\right)^2}, \quad (8)$$

where:
n – means the number of variables constituting the benchmark or anti-benchmark,
z^*_{ij} – means the normalised value of the ith variable of this object multiplied by an appropriate weighting factor,
z_j^- / z_j^+– means the benchmark or anti-benchmark object (Głowicka-Wołoszyn & Wysocki, 2018; Ban et al., 2020).

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The value of the synthetic measure was determined according to the formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \text{where } 0 \leq q_i \leq 1, i = 1, 2, \ldots, n, \quad (9)$$

where:
d_i^- – denotes the distance of the object from the anti-pattern (from 0),
d_i^+ – denotes the distance of the object from the pattern (from 1) (Özkan et al., 2021; Kozera et al., 2021).

The final stage of the research was to group the objects in terms of a synthetic measure. Maps of spatial variation, bag plots were made in the Statystica programme. In addition, Spearman's rank correlation coefficient was calculated (Zeliaś & Malina, 1997).

The values of the synthetic measure made it possible to divide the studied population into typological groups using the mean ($\bar{x}$) standard deviation (S_d), according to formula (10):

$$\begin{array}{ll} \text{group 1} & \bar{x} + S_d \lesssim q_i \\ \text{group 2} & \bar{x} \lesssim q_i < \bar{x} + S_d \\ \text{group 3} & \bar{x} - S_d \lesssim q_i < \bar{x} \\ \text{group 4} & q_i < \bar{x} - S_d \end{array} \quad (10)$$

To assess the heterogeneity (inequality of distribution) of the study population, the Gini coefficient was calculated:

$$G(y) = \frac{\sum_{i=1}^{n}(2i-n-1)y_i}{n^2\bar{y}}, \quad (11)$$

where:
$G(y) \in [0,1]$,
y_i – is the value of the i-th observation,
$\bar{y}$ – is the average value of all observations y_i.

It should be interpreted that the higher it is, the greater the inequality of the variable (Makarewicz-Marcinkiewicz, 2015).

Results of the research

In 2020, there was a positive change in energy policy in all EU countries in relation to 2013. Finland, Sweden, and Austria led the way in both 2013 and 2020. However, the majority of EU countries (13 (48.15%) in 2020) belonged to group C in terms of energy policy. Unfortunately, in Poland, the level of implemented energy policy deviates significantly from other EU countries, resulting in a low value of the synthetic measure and a low ranking of the country. This points to a growing disproportion in the area under study between EU countries and Poland. The group with the lowest values of the synthetic measure (D) also includes Lithuania (in 2013), Bulgaria, Romania (Eastern Bloc countries in 2013 and 2020) and Luxembourg. The former EU countries are mostly in a better position in terms of energy policy than the Eastern Bloc countries. This is an unfavourable development in the context of cohesion policy.

The Gini concentration measure of the energy measure amounted to 0.203-0.215 (in relation 2013 to 2020) for the synthetic measure of the q circular economy 0.133-0.129, respectively. For the EU countries – the Eastern Bloc, respectively: 0.298-0.284 for q energy policy and q circular economy 0.220-0.220. The higher the value of the index, the greater the degree of concentration of the synthetic measure and the greater its variation.

Table 2. Synthetic measure of energy policy and circular economy of EU countries in 2013, 2020

	2013	q energy policy	q circular economy	2020	q energy policy	q circular economy	change of position in 2020 q energy policy	change of position in 2020 q circular economy
A	Sweden	0.64	0.49	Finland	0.64	0.46	↑	-
	Austria	0.64	0.52	Sweden	0.64	0.47	-	↓
	Finland	0.59	0.46	Austria	0.59	0.49	↓	↓
	Latvia	0.52	0.52					
B	Netherlands	0.49	0.58	Denmark	0.51	0.42	↑	↑
	Denmark	0.48	0.41	Greece	0.5	0.39	↑	↑
	Portugal	0.47	0.45	Portugal	0.49	0.39	↑	↓
	Spain	0.46	0.48	Netherlands	0.48	0.58	↓	-
	Greece	0.45	0.38	Latvia	0.48	0.5	↓	↓
	Italy	0.44	0.53	Estonia	0.46	0.46	↑	↑
	Hungary	0.43	0.48	Spain	0.45	0.49	↓	↑
	France	0.43	0.5					
C	Czechia	0.42	0.48	Slovakia	0.41	0.5	↑	↑
	Cyprus	0.41	0.37	Italy	0.4	0.53	↓	-
	Belgium	0.4	0.55	Hungary	0.4	0.46	↓	↓
	Germany	0.4	0.46	Cyprus	0.39	0.42	↓	↑
	Slovakia	0.39	0.47	France	0.39	0.51	↓	↑
	Croatia	0.38	0.49	Malta	0.39	0.42	↑	↓
	Slovenia	0.37	0.48	Germany	0.38	0.5	↓	↑
	Malta	0.37	0.49	Czechia	0.37	0.46	↓	↓
	Estonia	0.36	0.39	Slovenia	0.35	0.55	↓	↑
	Ireland	0.34	0.39	Belgium	0.35	0.52	↓	↓
	Romania	0.34	0.43	Croatia	0.34	0.52	↓	↑
				Lithuania	0.34	0.49	↑	↑
				Ireland	0.33	0.43	↑	↑
D	Lithuania	0.3	0.47	Romania	0.31	0.43	↓	-
	Luxembourg	0.29	0.5	Luxembourg	0.31	0.47	↑	↓
	Bulgaria	0.27	0.43	Bulgaria	0.31	0.44	↑	↑
	Poland	0.23	0.46	Poland	0.24	0.46	↑	-

sorted by q energy policy.
Source: authors' work based on Eurostat (n.d.).

The division of the EU countries (including the Eastern bloc) into four groups in terms of q energy policy and q circular economy was made on the basis using the mean and standard deviation. Figure 1 shows the classification due to the synthetic measure. The dark colour indicates the group of countries characterised by a better state in the main criterion studied, the lighter colour, the weaker units.

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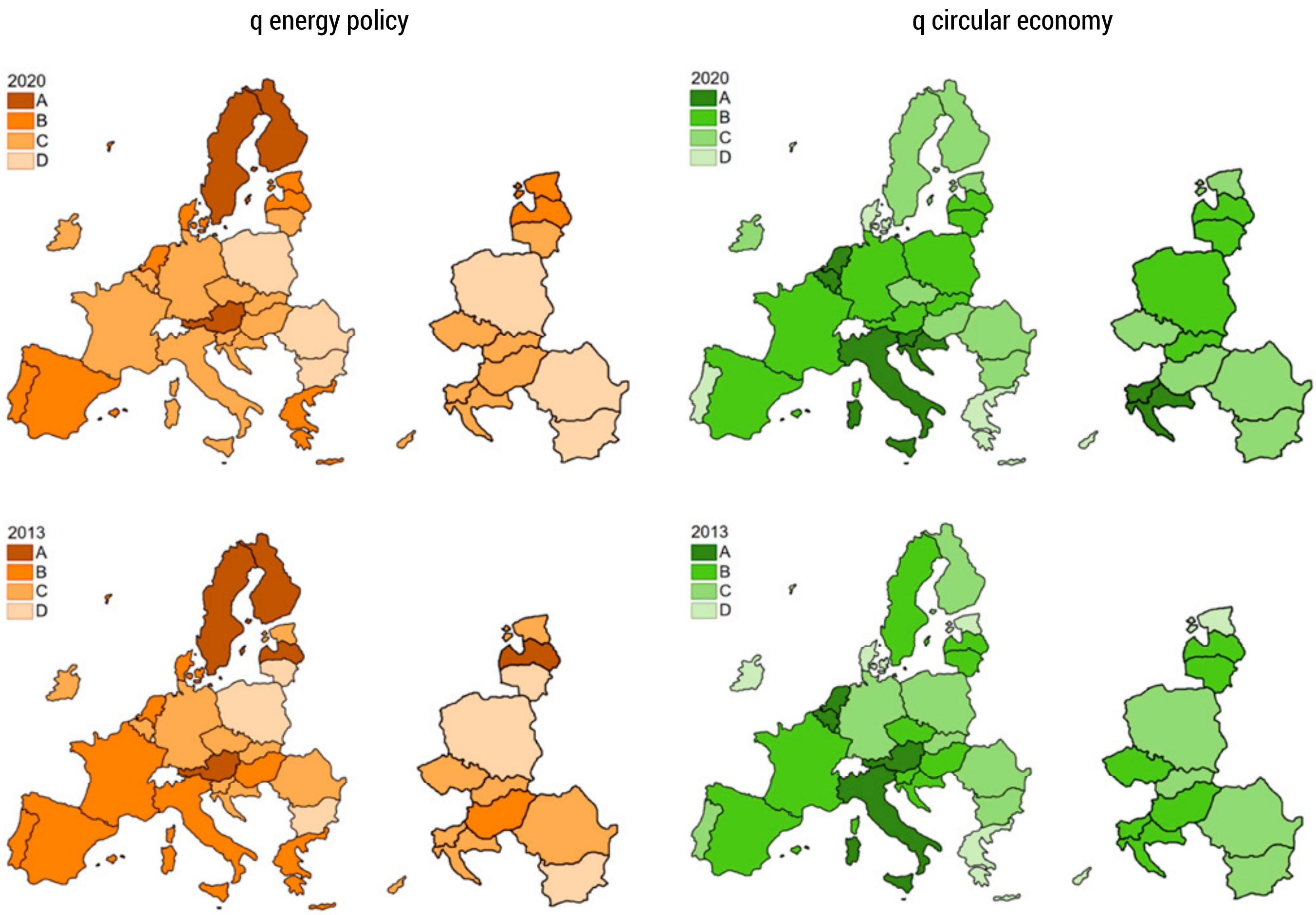

Figure 1. Spatial differentiation of the synthetic measure – energy policy and circular economy in EU countries in 2020, 2013

Source: authors' work based on Eurostat (n.d.).

Energy issues are important for EU member states. Convergence in this area can be problematic for these countries. Poland and other Central European countries, including the Czech Republic and Hungary, are largely dependent on coal for their energy needs. Poland, especially since 2015, is noticeably and increasingly distant from the other Visegrad countries. This can be seen as a gradual move away from the Europeanisation of EU climate and energy policy in Poland (Wach et al., 2021).

Figure 2 provides information on the relationship between the synthetic measure of GDS and energy and the outliers. Among the outliers in terms of the relationship between the synthetic measure and its variation are: Estonia, Slovenia (q circular economy), Latvia, Estonia, Poland, Slovenia, Croatia, Czech Republic (q energy policy).

Emissions of industrial and municipal pollutants, mainly as a result of the burning of fossil fuels, have become a serious problem. The correlation values (positive, negative) of the synthetic measure q energy policy and q circular economy and their diagnostic variables are presented in Table 3.

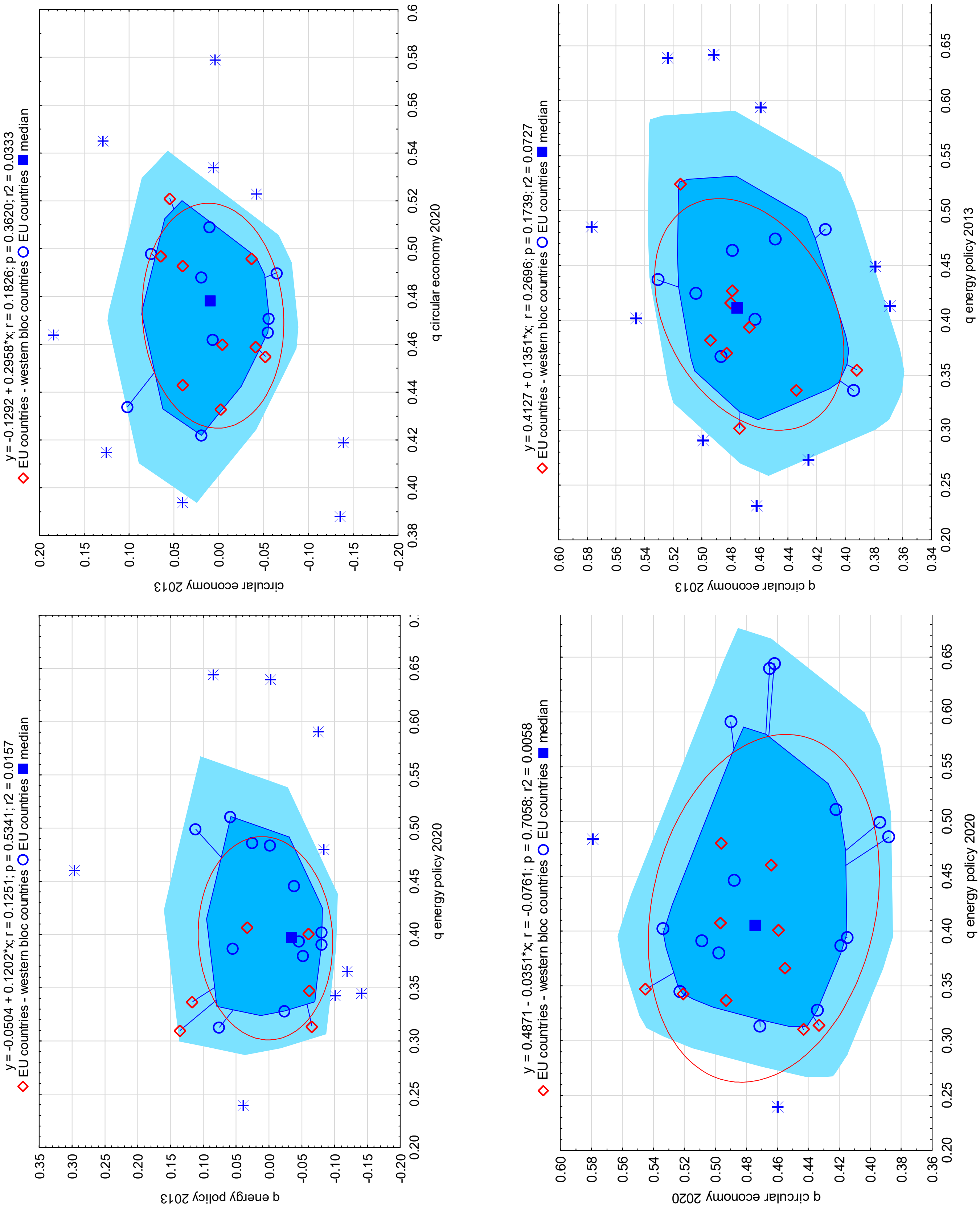

Figure 2. Synthetic measure relationship – energy policy and circular economy in EU countries (and western bloc countries) in 2013, 2020

Source: authors' work based on Eurostat (n.d.).

Table 3. Correlation of synthetic measure energy policy and circular economy and structure variables in EU countries (and western bloc countries) in 2013, 2020

	EU countries				EU countries – western bloc countries			
	2013		2020		2013		2020	
	q energy policy	q circular economy	q energy policy	q circular economy	q energy policy	q circular economy	q energy policy	q circular economy
Greenhouse gas emissions intensity of energy consumption (source: EEA and Eurostat)	-0.68	-0.22	-0.63	0.36	-0.7	-0.5	-0.7	0.15
Share of renewable energy in gross final energy consumption by sector	0.45	-0.06	0.52	-0.05	0.17	0.29	0.31	0.43
Share of fuels in final energy consumption	-0.53	-0.14	-0.57	0	-0.4	-0.3	-0.6	-0.3
Use of renewables for electricity – details	0.61	0.09	0.53	0.16	0.29	0.41	0.25	0.45
Use of renewables for heating and cooling – details	0.39	0.07	0.33	-0.02	0.35	0.44	0.43	0.35
Heat pumps – technical characteristics by technologies	0.3	0.07	0.66	-0.25	-0.2	-0.2	0.09	0.11
Liquid biofuels production capacities	0.62	0.34	0.43	0.18	0.4	0.64	-0.1	-0.1
Solar thermal collectors' surface	0.15	-0.1	0.06	-0.25	-0.2	0.09	-0.4	0.36
Stock levels for gaseous and liquefied natural gas	0.31	0.35	0.12	0.24	0.69	0.41	-0.1	-0.3
Recycling rate of waste of electrical and electronic equipment (WEEE) separately collected	0.19	0.1	-0.17	0.12	0.59	0.5	0.17	-0.1
Recycling rate of municipal waste	0.34	0.43	0.03	0.7	-0.1	0.18	-0.1	0.04
Circular material use rate	0.13	0.59	0.1	0.59	0.09	-0	0.3	0.29
Trade in recyclable raw materials	0.28	0.16	0.15	0.18	-0.2	0.41	-0.1	0.57
Generation of municipal waste per capita	0.29	0.06	0.19	-0.05	-0	0.39	-0.2	0.33
Resource productivity	0.29	0.54	0.15	0.37	0.6	0.71	0.42	0.76
Material footprint	-0.08	-0.37	0.04	-0.35	-0.7	-0.7	-0.3	-0.3
Material import dependency	0.08	0.6	0.05	0.46	0.48	0.5	0.47	0.63
Greenhouse gases emissions from production activities	-0.18	-0.32	-0.22	-0.12	-0.4	-0.6	-0.1	-0.3
Consumption footprint	0.28	0.22	0.23	-0.03	0.41	0.32	0.65	0.35
Private investment and gross added value related to circular economy sectors	0.07	0.37	-0.05	0.28	0	-0.1	0.36	0.23
Persons employed in circular economy sectors	-0.01	0.14	-0.07	0.13	0.29	0.46	0.21	0.15

Marked correlation coefficients are significant with $p < .05000$.

Source: authors' work based on Eurostat (n.d.).

Discussion/Limitation and future research

In the coming years, interest in the use of renewable energy sources is expected to increase due to their benefits. The development of low-carbon energy sources is linked to the challenges of the gradual depletion of coal, oil and natural gas resources. Energy policy should take into account the achievement of sustainable development goals in three dimensions: economic, social and environmental (Ligus, 2017).

In 2020, there was a positive change in the use of renewable energy in all EU countries compared to 2011, with Sweden, Austria, Finland and Denmark leading the way. However, most EU countries (16 in 2011 and 17 in 2020) have medium-low levels of green energy use. Cyprus and Malta, on the other hand, recorded low levels in 2011 but improved their position in 2020. In Poland, the level of renewable energy use diverges significantly from other EU countries (Grzebyk & Stec, 2023).

In the EU, the development of renewable energy sources is part of the energy and climate policy or climate strategy – the European Green Deal. The use of energy from RES is expected to improve environmental quality and reduce greenhouse gas emissions, improve energy security and diversify energy supply, boost sustainable economic development and reduce energy poverty (Tutak & Brodny, 2022). Renewable energy sources are essential to achieving sustainable development (Salem et al., 2023).

The country's environmental policy translates into the implementation of the principles of sustainable development and the increase in the share of RES in the energy balance. RES market operators, if only because of the specifics of the industry, contribute to improving the quality of life and, thus, the quality of the natural environment. They bring improvements in economic efficiency both on a social and individual scale (Graczyk, 2015).

The analysis of selected relationships between the goals of energy policy and the existing conditions for its implementation in Poland has made it possible to point out some problems and controversies related to this (i.e. economic, ecological, social and technological in nature). It is necessary to develop an energy-economic balance sheet for the energy carriers held to quickly carry out appropriate investments (Kryk, 2012).

Ensuring that people have access to sustainable energy and increasing energy efficiency in all sectors of the economy is essential to achieving the goals of the concept of sustainable development, Agenda 2030, the Europe 2020 strategy and European energy policy. Ensuring sustainable energy is also a sign of environmental responsibility and social justice (Kryk, 2019).

Energy insecurity, warming and climate change have made energy transformation a necessity. It includes reducing energy consumption and decarbonising the economy. Energy transformation is the basis for sustainable development. This knowledge can be used by the authorities to assess the effectiveness of the development instruments used so far and the tools of the policies implemented. Further empirical research is needed on the implementation of the CE, the relationship with the variables of demography, the financial situation, environmental changes, and their impact on changes in the energy field.

The value of the article is the set of variables and the results of the analysis presenting the indicated relationship in the EU countries, with an indication of the Eastern Bloc countries in 2013-2020. It is an important stimulus in the discussion on strengthening the effectiveness of the implementation of energy transition in the conditions of a country. The authors recognise the research gap in the area of CE and its impact on energy policy and the country because it is not analysed from an economic point of view.

The results obtained point to the directions of new research, i.e. comparing the results of ordering on the basis of a larger number of variables, carrying out analysis in dynamic terms, and analysing outliers. Subsequent studies should also pay attention to trends in the energy economy, the rapid development of energy technologies and policies, geopolitical factors and sustainability efforts.

Conclusions

Regional energy transition policies in Europe are characterised by their roots in the transition to coal, now using green growth concepts and capitalising on crises to further entrench and implement climate policies in regional development.

The relationship between energy depletion and growth trajectories is one of the main points for which policymakers are shaping long-term energy policy to balance the free flow of energy supplies around the world.

Pay attention to the natural conditions of countries that shape the possibility of using renewable energy sources. Build awareness of renewable energy sources for economic development.

The presented approach shows that the research problem is multidimensional; coupled with the lack of information, it is not possible to carry out analysis by a method limited only to the evaluation of energy indicators without a multi-criteria decision-making methodology.

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The contribution of the authors

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KSZTAŁTOWANIE ZRÓWNOWAŻONEJ ENERGII W GOSPODARCE O OBIEGU ZAMKNIĘTYM. STUDIUM PRZYPADKU UE I KRAJÓW BLOKU WSCHODNIEGO 2013-2020

STRESZCZENIE: Kraje muszą podjąć kroki w celu modernizacji gospodarki energetycznej. Jest to ważne dla krajów, których struktura głównych źródeł energii opiera się na zużyciu węgla. Energia jest kluczowym czynnikiem zaspokajania potrzeb człowieka, w tym działalności gospodarczej. Celem opracowania jest przedstawienie i ocena przestrzennego zróżnicowania polityk energetycznych w warunkach gospodarki o obiegu zamkniętym na poziomie krajów Unii Europejskiej (w tym krajów byłego bloku wschodniego). Do realizacji celu wykorzystano analizę literatury, miary syntetyczne oraz analizę statystyczną. Zebrano dane empiryczne w ujęciu przestrzennym dla krajów UE w latach 2013 i 2020. Badania potwierdzają pozytywną zmianę w aspekcie polityki energetycznej w krajach UE w 2020 roku w porównaniu do 2013 roku. W grupie o najwyższym poziomie syntetycznej polityki energetycznej znalazły się Finlandia, Szwecja i Austria, podczas gdy najsłabsze były Luksemburg oraz kraje bloku wschodniego – Bułgaria i Polska. Kraje byłej UE są w większości w lepszej sytuacji pod względem polityki energetycznej niż kraje bloku wschodniego.

SŁOWA KLUCZOWE: energia, zrównoważony rozwój, polityka energetyczna, gospodarka cyrkularna, miara syntetyczna (CRITIC-TOPSIS)

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