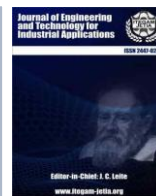




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RESEARCH ARTICLE

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GREEN ECONOMY AND ENERGY TRANSITION: ECONOMIC MODELS FOR INTEGRATING RENEWABLE ENERGY IN EASTERN EUROPEAN COUNTRIES

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ABSTRACT

Global energy systems are currently undergoing a fundamental transformation with an active transition from fossil fuels to renewable energy sources. Fueled by the fight against climate change and emissions, the energy transition has become a major challenge for the global economy. In this context, the inclusion of renewable energy sources in the energy balance is becoming a strategic way to promote further economic transformation. The aim of this scientific article is to analyze the structural features of the energy transition and assess the degree of integration of renewable energy into the overall energy balance compared to fossil fuels in Eastern European countries. The article provides an empirical analysis of simplified energy balances of Eastern European countries for the period 2022–2024. For this purpose, independent and dependent variables of the analysis were calculated, which made it possible to form descriptive statistics, perform correlation analysis, and conduct multiple linear regression. Results. Model M1 has greater explanatory power ($R^2 = 0.533$; Adjusted $R^2 = 0.471$) and is statistically significant ($F = 8.567$, $p = 0.003$), unlike model M0, which explains only 1.3% of the variance in the share of renewable energy ($R^2 = 0.013$) and is statistically insignificant ($F = 0.219$, $p = 0.646$). This proves that dependence on fossil fuels or nuclear energy is associated with a smaller share of renewable energy sources in the national energy balance. Dependence on fossil fuels and a significant share of nuclear energy serve two purposes in the energy systems of Eastern European countries, among other things: they ensure short-term stability of energy supply, while structurally slowing down the pace of integration of renewable energy sources, thereby limiting the possibilities for diversification and transformation of the energy balance. Therefore, a promising avenue for research is the development of integrated energy policy models that reconcile the stabilizing function of fossil and nuclear energy sources with long-term decarbonization goals.



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I. INTRODUCTION

Climate change and environmental degradation are an international existential threat, particularly in the European region. Therefore, the establishment of a green economy as a model aimed at decarbonising production, increasing resource efficiency and structurally transforming energy systems is an opportunity to overcome climate risks, environmental degradation and the energy vulnerability of national economies.

Consequently, the creation of the European Green Deal, adopted in 2020, which is a new growth strategy for Europe, allows the economies of EU member states to develop in the direction of increasing resource efficiency and competitiveness. This agreement aims to make Europe climate neutral by 2050, stimulate the economy through green technologies, create sustainable industry and transport, and reduce pollution [1]. Currently, according to [2], in 2023 the European Union (EU) produced about 42% of its own energy, while 58% was imported; while the EU's energy balance, i.e., the range of available energy sources, consisted mainly of crude oil and petroleum products (37.7%), natural gas (20.4%), renewable energy (19.5%), solid fuels (10.6%), and nuclear energy (11.8%). According to [3], by 2024, the record share of renewable energy sources had reached 44% in the EU's electricity sector for the first time. However, it is the countries of Eastern Europe, subject to EU regulations, climate targets, and decarbonization commitments, that remain constrained by inherited infrastructure, high dependence on fossil fuels, limited diversification of energy balances, and, in some cases, a legacy of nuclear energy. These structural conditions give rise to specific models of renewable energy integration that differ fundamentally from those observed in other European economies. In view of this, the novelty of this study lies in the creation of a harmonized cross-country dataset based on national energy balances; the application of structural indicators of energy concentration and diversification in combination with econometric models; and the provision of comparative data between subregional groups in Eastern Europe. The aim of this scientific article is to analyze the structural features of the energy transition in Eastern European countries. The article aims to assess the degree of integration of renewable energy into the overall energy balance compared to fossil fuels.

II. LITERATURE REVIEW

The main principles of the energy transition on the European continent are fundamentally geared towards sustainable development, energy security, and economic competitiveness, with a strong emphasis on decarbonization, energy efficiency, and the development of renewable energy sources [4–6]. This is explained by the definition of the concept of “energy transition” proposed by [7]: “The energy transition can not only reduce energy dependence, improve energy diversification and self-sufficiency, and mitigate the environmental damage caused by energy production and consumption, but also serve as an important pathway to energy security”. However, several studies [8–10] show that the path to achieving these goals is fraught with bottlenecks and structural shortcomings. One notable bottleneck, according to [11], is the integration of renewable energy sources into the existing energy grid, which requires significant investment in grid infrastructure to manage the variability of renewable energy. Furthermore, according to [12–14], regulatory frameworks and market structures often lag behind technological progress, hindering the smooth introduction of new energy solutions to the market. In contrast to the problem areas of the energy transition, the scientific discourse is characterized by a large number of energy-efficient solutions and opportunities for the establishment of a green economy as a fundamental model for the further development of society.

In particular, studies on renewable energy by [15–17], as well as a study by [18], conducted in the context of global energy transitions, highlight significant differences in the development of renewable energy technologies in different countries; the work of [19] on the implementation of a just transition to renewable energy sources and the results of the assessment of the implementation of the RED II Directive; Sivasubramanian's [20] study of the impact of public-private partnerships (further – PPPs) on the progress of renewable energy start-up industries for sustainable development; analysis of the impact of renewable energy technologies on a climate-resilient approach to agribusiness in regions [21], [22] conclusion on the tendency of Central and Eastern European countries to focus on cluster projects led by local authorities, which often serve as tools for modernizing outdated energy infrastructure; [23] on the effectiveness of the German experience in implementing bottom-up cooperative initiatives to replace old energy infrastructure with more modern ones; [24] assessment of the role of PPPs in achieving the Sustainable Development Goals (further – SDGs) through agrotechnological and renewable energy solutions. However, the theoretical aspects of forming complementary economic and energy policies for European countries based on harmonious development remain insufficiently substantiated and developed. Therefore, there is a need for research aimed at addressing local issues related to the energy transition, the structure and characteristics of renewable energy integration into the overall energy balance.

III. METHODS

The empirical analysis is based on a balanced panel dataset covering Eastern European countries (Bulgaria, the Czech Republic, Hungary, Poland, Slovakia, Romania, and Ukraine) for the period 2022–2024 (Appendix A). The dataset consists of 18 observations and was constructed using Eurostat (2025a) statistical information on simplified energy balances, in particular gross available energy measured in thousands of tonnes of oil equivalent (ktoe). The analysis variables and related indicators were calculated by the author. The dependent variable is Share_RES (%), which represents the share of renewable energy sources in the total energy balance. The formula for calculating this indicator is as follows:

$$\text{Share}_{\text{RES}} = \frac{\text{Renewables}}{\text{Total}_{\text{energy}} * 100}. \quad (1)$$

The independent variables are Fossil_dependency (%), which reflects dependence on fossil fuels, and Nuclear_share (%), which measures the contribution of nuclear energy. They are calculated using the following formulas:

$$\text{Fossil}_{\text{dependency}} = \frac{(\text{Solid}_{\text{fossil}} + \text{Natural}_{\text{gas}} + \text{Oil}_{\text{products}})}{\text{Total}_{\text{energy}} * 100} \quad (2)$$

$$\text{Nuclear}_{\text{share}} = \frac{\text{Nuclear}}{\text{Total}_{\text{energy}} * 100}. \quad (3)$$

In addition, to assess the structural concentration of national energy systems, the Herfindahl-Hirschman Index (further – HHI) was calculated as the sum of the squares of the shares of primary energy sources in gross available energy using the following formula:

$$HHI = \sum share_i^2, \quad (4)$$

Where $share_i$ – is the share of the i -th energy source in the country's total energy balance, calculated as follows:

$$share_i = \frac{Energy_{source_i}}{Total_{energy}} \quad (5)$$

Where i – each individual type of energy. Next, the diversification index was calculated, which reflects the structural flexibility of national energy systems and their ability to integrate renewable energy. The formula for calculating this indicator is as follows:

$$Diversification_{index} = 1 - HHI. \quad (6)$$

It should be noted that HHI and Diversification index are mathematically derived from the same components of the energy balance as other variables. Therefore, they are used only for descriptive and correlation purposes and are not included simultaneously in the regression model to avoid mechanical endogeneity. All variables were expressed as percentages to ensure comparability between countries and mitigate the effect of scale. Prior to econometric estimation, the dataset was checked for missing values and internal consistency of energy balance components. Given the limited sample size and short time horizon, the analysis uses an exploratory explanatory approach focused on structural relationships rather than long-term causal conclusions. First, descriptive statistics and Pearson's correlation coefficients were generated using JASP software to examine the prior relationships between energy structure indicators and renewable energy penetration. Next, for the selected dependent variable, i.e., the share of renewable energy in the energy balance (Share_RES), an empirical assessment was performed using multiple linear regression. A step-by-step modeling strategy was applied, starting with a baseline specification that included only dependence on fossil fuels, followed by an extended model that included the share of nuclear energy. This approach allows for the assessment of the additional explanatory power of additional structural energy variables. Model adequacy was assessed using standard diagnostic statistics, including the coefficient of determination (R²), adjusted R², F-statistic, and root mean square error (RMSE). Statistical significance was assessed using conventional confidence levels. Thus, the multifactorial linear model looks like this:

$$Share_{RES} = \beta_0 + \beta_1 * Fossil_{dependency_i} + \beta_2 * Nuclear_{share_i} + \varepsilon_i, \quad (7)$$

Where β_0 is the constant (intercept):

β_1, β_2 – coefficients for factors;

ε_i is a random error;

i is the country (or country and period).

The empirical model was developed to test the following hypotheses:

H1: Countries with higher dependence on fossil fuels show a significantly lower share of renewable energy.

H2: Nuclear-intensive energy systems show slower integration of renewable energy.

H3: More diversified energy structures are positively associated with renewable energy penetration.

The main limitations of the study are (1) the relatively small sample size ($N = 18$), which limits the use of advanced panel estimation methods and restricts causal conclusions; and (2) the focus of the analysis on structural links rather than dynamic transition processes, as short-term integration rates cannot be reliably recorded during the observation period. Nevertheless, the methodology used is appropriate for identifying statistically significant structural links and obtaining politically relevant conclusions regarding energy transition strategies in Eastern Europe.

IV. RESULTS

The transition to a green economy is central to contemporary economic policy, especially in regions that have historically been highly dependent on fossil fuels and carbon-intensive energy systems. In this context, the integration of renewable energy sources (further – RES) into national energy balances is a strategic path for economic transformation that affects macroeconomic stability, energy security, industrial competitiveness, and regional development trajectories. In addition, according to Eurostat statistics [25], there are currently sustained trends toward a structurally intensive energy balance associated with the dominance of fossil fuel use. The energy balance of Eastern European countries is based on coal, petroleum products, and natural gas, as shown in Figure 1.

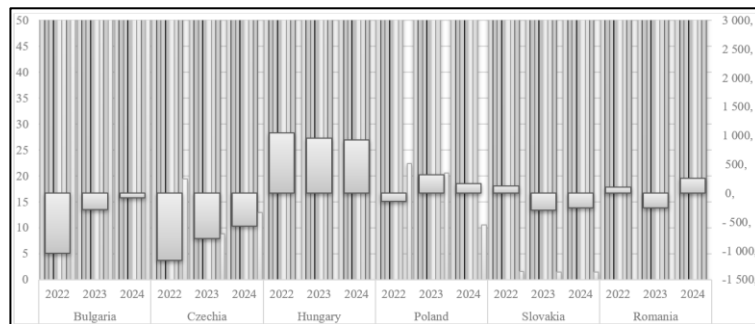


Figure 1: Energy balances dataset covering Eastern European countries for the period 2022–2024.

Source: [25].

During 2022–2024, the greatest absolute dependence on solid fossil fuels will be observed in Poland, where coal remains the basis for electricity and heat generation. In particular, in 2024, solid fossil fuels accounted for more than 32,000 units of total energy consumption, which significantly exceeds the contribution of renewable energy sources (14,779 units) to electricity generation in the country. Similar patterns can be observed in the Czech Republic (Solid_fossil = 9,588.072 units; Renewables = 5,430.68 units) and Bulgaria (Solid_fossil = 3,078.797 units; Renewables = 2,609.747 units), but these countries are distinguished by their intention to gradually reduce coal consumption and are characterized by moderate growth in the share of renewable energy sources. Hungary and Romania, on the other hand, show a mixed structure with a strong role for natural gas and nuclear energy. These patterns are consistent with broader EU energy trends. Central and Eastern European countries remain more dependent on coal and gas due to their historical infrastructure, industrial structure, and delays in the introduction of renewable energy sources. In this context, it is important to refer to data from the by [26]. That is, while Denmark, Sweden, Estonia, and Finland have shown the largest increase in the share of RES, growing by more than 23% since 2005, Croatia, Slovenia, and Romania have seen growth of less than eight percentage points since 2005. Looking at the short-term perspective of recent years, it is important to note that the share of renewable energy increased in 18 EU member states between 2023 and 2024. The leaders in renewable energy production are Lithuania, Poland, the Netherlands, and Denmark, with their share of RES increasing by more than 2% in 2024. In 2024, 25.4% of all final energy consumed in the EU came from renewable sources, which is approximately 1% more than in 2023. This increase was largely driven by the growth of solar and wind energy, as well as heat pumps; however, trends remain uneven across regions, with Central and Eastern European countries lagging behind Northern European and Baltic countries. In particular, the Baltic countries demonstrate a fundamentally different energy structure, characterized by a high share of renewable energy sources, minimal nuclear energy generation, and reduced dependence on fossil fuels. This is shown in Figure 2.

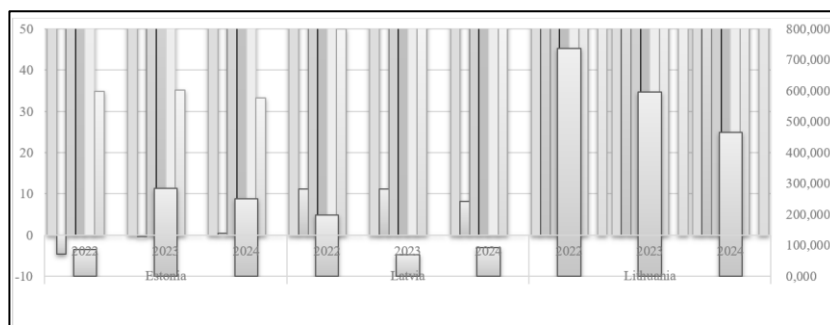


Figure 2: Energy balances dataset covering Baltic countries for the period 2022–2024.

Source: [25].

In Latvia, renewable energy accounts for 1,974.985 units, which is a significant share of the EU's energy balance. Lithuania, in turn, shows steady growth in renewable energy from 1,791.928 units in 2022 to 2,285.427 units in 2024 (i.e., 27.5% over three years). Estonia shows a more heterogeneous structure, with renewable energy accounting for 1,429.704 units. At the same time, there is volatility in the components of fossil fuels and electricity trade (Solid_fossil = 0.477 units and Nuclear_heat = 0.000 in 2024), reflecting its role as a regional exporter and importer of electricity. In other words, the Baltic countries represent a diversified model that differs from that of Eastern European countries, focusing on renewable energy and characterized by structural flexibility and low dependence on fossil fuels. In other words, the Baltic countries represent a diversified model that differs from that of Eastern European countries, focusing on renewable energy and characterised by structural flexibility and low dependence on fossil fuels. Given the above trends, it is important to identify the structural features of the energy transition in Eastern European countries and assess the extent to which renewable energy is integrated into the overall energy balance compared to fossil fuels. To this end, dependent (Share_RES) and independent (Fossil_dependency, Nuclear_share, Diversification index) analysis variables were calculated based on the data set provided in Appendix A. The results of the calculations are presented in Table 1.

Table 1: Results of calculating variables for analyzing the energy balance structure of Eastern European countries.

Country	Period	Share_RES	Fossil_dependency	Nuclear_share	Diversification index
Bulgaria	2022	13.99851679	68.77136853	21.84650703	0.7512681
	2023	14.86678097	61.7058353	24.2510386	0.7799558
	2024	15.0551438	60.77164688	23.73785427	0.7839336
Czechia	2022	12.93786553	70.51829339	18.43465364	0.7682141
	2023	13.63268277	67.87893104	19.69811325	0.7793429
	2024	14.31968094	66.70871151	19.54318924	0.7850735
Hungary	2022	12.85632313	66.76155984	15.48474165	0.7635857
	2023	13.69237592	65.03650658	16.52449292	0.7623036
	2024	14.77959593	64.01336922	16.63394408	0.7618225
Poland	2022	12.85094885	86.28535799	0	0.70046
	2023	14.22453888	84.44174485	0	0.7198792
	2024	15.04038196	83.75180823	0	0.7263562
Slovakia	2022	12.96910584	60.29093131	24.64116998	0.7962738
	2023	12.50177475	59.23960115	28.78852931	0.7800619
	2024	13.02959865	57.70959227	29.70170196	0.7763581
Romania	2022	18.97024223	70.69942284	8.909965775	0.7636358
	2023	20.40459904	70.01347832	9.310735687	0.7469855
	2024	19.40827256	69.49904499	9.141491039	0.7505916

Source: Authors, (2026).

Note: the complete table of source data is provided in Appendix B.

Next, Table 2 presents Descriptive Statistics for systematizing the source data and its quantitative description through key statistical indicators, revealing significant cross-country heterogeneity in energy transition models.

Table 2: Descriptive Statistics for analyzing the energy balance structure of Eastern European countries.

<i>Descriptive Statistics</i>						
	<i>Share_RES (%)</i>					
	Bulgaria	Czechia	Hungary	Poland	Romania	Slovakia
Valid	3	3	3	3	3	3
Missing	0	0	0	0	0	0
Mean	14.64	13.63	13.78	14.04	19.59	12.83
Std. Deviation	0.564	0.691	0.964	1.106	0.735	0.289
Minimum	14.00	12.94	12.86	12.85	18.97	12.50
Maximum	15.06	14.32	14.78	15.04	20.40	13.03
	<i>Fossil_dependency (%)</i>					
	Bulgaria	Czechia	Hungary	Poland	Romania	Slovakia
Valid	3	3	3	3	3	3
Missing	0	0	0	0	0	0
Mean	63.75	68.37	65.27	84.83	70.07	59.08
Std. Deviation	4.374	1.951	1.389	1.310	0.602	1.298
Minimum	60.77	66.71	64.01	83.75	69.50	57.71
Maximum	68.77	70.52	66.76	86.29	70.70	60.29
	<i>Diversification_index</i>					
	Bulgaria	Czechia	Hungary	Poland	Romania	Slovakia
Valid	3	3	3	3	3	3
Missing	0	0	0	0	0	0
Mean	0.772	0.778	0.763	0.716	0.754	0.784
Std. Deviation	0.018	0.009	9.114×10 ⁻⁴	0.013	0.009	0.011
Minimum	0.751	0.768	0.762	0.700	0.747	0.776
Maximum	0.784	0.785	0.764	0.726	0.764	0.796
	<i>Nuclear_share (%)</i>					
	Bulgaria	Czechia	Hungary	Poland	Romania	Slovakia
Valid	3	3	3	3	3	3
Missing	0	0	0	0	0	0
Mean	23.28	19.23	16.21	0.000	9.121	27.71
Std. Deviation	1.266	0.689	0.634	0.000	0.201	2.697
Minimum	21.85	18.43	15.48	0.000	8.910	24.64
Maximum	24.25	19.70	16.63	0.000	9.311	29.70

Source: Authors, (2026).

Romania has the highest average share of renewable energy (19.59%), while Slovakia has the lowest (12.83%). Poland stands out due to its extremely high dependence on fossil fuels (84.83% on average) and complete absence of nuclear energy. In contrast, Slovakia and Bulgaria have a relatively high share of nuclear energy, exceeding 23% on average. The diversification index ranges from 0.716 (Poland) to 0.784 (Slovakia), indicating that energy systems with a dominant fossil fuel component tend to be less diversified in terms of structure. The results show that the deployment of renewable energy is embedded in country-specific structural configurations rather than following a single regional trajectory. Next, to study two-dimensional relationships and identify potential multicollinearity risks prior to regression modeling, a Pearson correlation analysis was performed, the results of which are visualized in Figure 3.

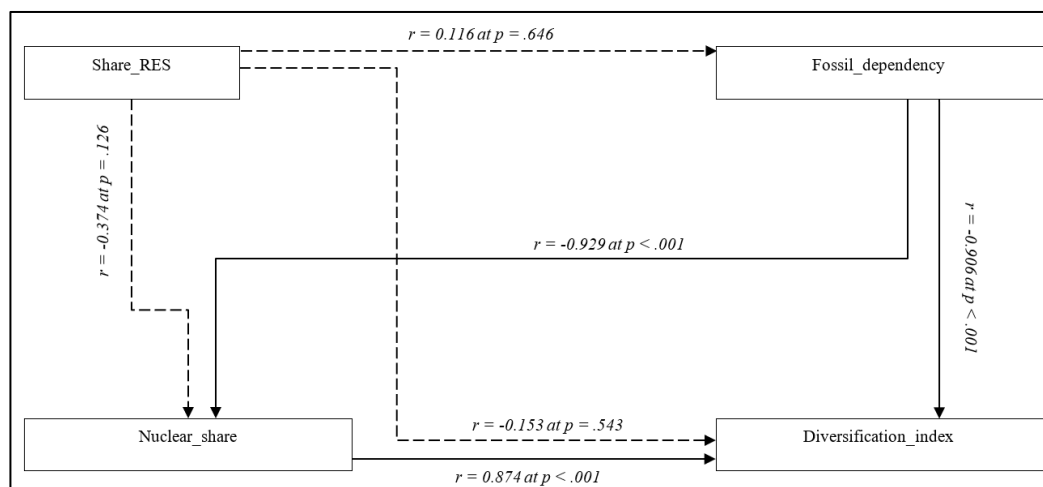


Figure 3: Results of correlation analysis of the energy balance structure of Eastern European countries.

Source: Authors, (2026).

Note: insignificant connections are marked with dotted lines.

The correlation between Share_RES and Fossil_dependency is weak and statistically insignificant ($r = 0.116$ at $p = 0.646$), indicating that an increase in renewable energy sources does not automatically correspond to a decrease in dependence on fossil fuels. The relationship between Share_RES and Nuclear_share is negative but also insignificant ($r = -0.374$ at $p = 0.126$). However, very strong and statistically significant correlations are observed between the structural variables themselves. Fossil fuel dependence has a high negative correlation with the share of nuclear energy ($r = -0.929$ at $p < 0.001$) and with the diversification index ($r = -0.906$ at $p < 0.001$), while the share of nuclear energy has a strong positive correlation with diversification ($r = 0.874$ at $p < 0.001$). A stepwise linear regression approach was used to assess the determinants of renewable energy integration (Table 3). The main theoretical assumption is that both fossil and nuclear energy can act as structural substitutes for renewable energy sources in energy systems characterized by outdated infrastructure.

Table 3: Results of regression analysis of the energy balance structure of Eastern European countries.

Linear Regression						
Model Summary - Share_RES (%)						
Model	R	R ²	Adjusted R ²	RMSE		
M ₀	0.116	0.013	-0.048	2.442		
M ₁	0.730	0.533	0.471	1.735		
ANOVA						
Model		Sum of Squares	df	Mean Square	F	p
M ₀	Regression	1.304	1	1.304	0.219	0.646
	Residual	95.427	16	5.964		
	Total	96.731	17			
M ₁	Regression	51.577	2	25.789	8.567	0.003
	Residual	45.154	15	3.010		
	Total	96.731	17			
Coefficients						
Model		Unstandardized	Standard Error	Standardized	t	p
M ₀	(Intercept)	12.519	4.810		2.603	0.019
	Fossil_dependency (%)	0.033	0.070	0.116	0.468	0.646
M ₁	(Intercept)	55.236	10.997		5.023	< 0.001
	Fossil_dependency (%)	-0.476	0.134	-1.699	-3.555	0.003
	Nuclear_share (%)	-0.491	0.120	-1.953	-4.087	< 0.001

Source: Authors, (2026).

Note: M₀ includes Fossil_dependency (%); M₁ includes Fossil_dependency (%), Nuclear_share (%).

Model M₀ (baseline) explains only 1.3% of the variance in the share of renewable energy ($R^2 = 0.013$) and is statistically insignificant ($F = 0.219$, $p = 0.646$). Dependence on fossil fuels does not have a significant independent impact on the deployment of renewable energy, confirming that the expansion of renewable energy cannot be explained solely by dependence on fossil fuels. Meanwhile, model M₁ (extended model) demonstrates a significant improvement in explanatory power ($R^2 = 0.533$; Adjusted $R^2 = 0.471$) and is statistically significant ($F = 8.567$, $p = 0.003$). Thus, both independent variables are statistically significant and negative, in particular dependence on fossil fuels ($\beta = -0.476$, $p = 0.003$) and the share of nuclear energy ($\beta = -0.491$, $p < 0.001$). Therefore, these coefficients indicate that greater dependence on fossil fuels or nuclear energy is associated with a smaller share of renewable energy sources in the national energy balance. The final form of the multivariate linear model is shown below:

$$Share_{RES} = 55.236 - 0.476 * Fossil_{dependency} - 0.491 * Nuclear_{share} + \varepsilon \quad (8)$$

The multiple linear regression model shows that both dependence on fossil fuels and the share of nuclear energy have a statistically significant negative impact on the integration of renewable energy sources. The model explains 53.3% of the variation in the share of renewable energy ($R^2 = 0.533$, $F = 8.567$, $p = 0.003$), indicating a significant structural link between outdated energy systems and the pace of the green transition in Eastern European countries.

V. DISCUSSION

According to the correlation-regression analysis of the study, the integration of renewable energy in Eastern European countries is fundamentally interchangeable rather than parallel to fossil and nuclear energy sources. First, descriptive statistics confirm the previous findings of [18] regarding cross-country asymmetry in the adoption of renewable energy technologies, confirming the striking variability of energy transition trajectories across Eastern Europe. It also reinforces the findings of [8], [9] regarding structural inertia and historical biases that continue to influence national energy systems and hinder the effectiveness of universal decarbonization plans. According to [11], who emphasizes that the growth of renewable energy does not lead to the displacement of fossil fuels due to infrastructure rigidity, network constraints, and institutional blockages, is consistent with the correlation analysis finding that there is no statistically significant two-dimensional relationship between the share of renewable energy and fossil fuel dependence ($r = 0.116$ at $p = 0.646$). At the same time, the presence of a high negative correlation between dependence on fossil fuels and the share of nuclear energy ($r = -0.929$ at $p < 0.001$) and the diversification index ($r = -0.906$ at $p < 0.001$) confirms the structural interconnection of traditional energy components, confirming the opinion of [12] that regulatory and market frameworks often reinforce existing technologies rather than promoting systemic transformation.

Given the ongoing scientific debate on the role of nuclear energy in the green transition, the regression results (M1), which show that the shares of both fossil and nuclear fuels are statistically significant negative factors for renewable energy integration, are particularly relevant. While some studies emphasize the role of nuclear energy as a stabilizing force with low carbon emissions [19], suggesting that nuclear energy serves as a structural replacement rather than a complement to renewable energy in Eastern European energy systems; others, notably [22], argue that market and regulatory frameworks often reinforce existing technologies rather than promoting systemic change.

VI. CONCLUSIONS

The integration of renewable energy sources into the national energy balances of Eastern European countries should be viewed as a gradual process of structural economic restructuring that affects regional development models, energy security, industrial competitiveness, and macroeconomic stability. Correlation and regression analysis has shown that the expansion of renewable energy in Eastern European countries is predominantly substitutive rather than additive in nature. Renewable energy sources do not function as a complementary addition to existing energy systems, but enter into direct structural competition with established fossil and nuclear energy sources. The results show that both dependence on fossil fuels and a significant share of nuclear energy perform dual functions in the energy systems of the countries in the region: on the one hand, they ensure short-term stability of energy supply, and on the other hand, they structurally restrain the pace of integration of renewable energy sources, limiting the possibilities for diversification and transformation of the energy balance. In view of this, a promising area for further research is the development of comprehensive energy policy models aimed at reconciling the stabilising role of fossil and nuclear energy sources with long-term decarbonisation goals, as well as the assessment of institutional, regulatory, and infrastructural mechanisms capable of ensuring the complementary integration of renewable energy into the national energy systems of Eastern European countries.

VII. AUTHOR'S CONTRIBUTION

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Approval of the final text: Viktoria Beliavtseva, Tetiana Gorokhova, Olena Cherniavska, Iryna Korostova and Iryna Makaliuk.

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APPENDIX A. DATA SET

Country	Period	Total_energy	Solid_fossil	Natural_gas	Oil_products	Renewables	Non-renewables	Nuclear_heat	Electricity	Heat
Core Eastern Europe										
Bulgaria	2022	19 635,766	6 277,994	2 325,298	4 900,493	2 748,716	77,534	4 289,729	-1 048,549	64,551
	2023	17 393,086	3 714,662	2 172,268	4 845,619	2 585,792	75,979	4 218,004	-286,628	66,094
	2024	17 334,587	3 078,797	2 333,076	5 122,641	2 609,747	82,916	4 114,859	-84,844	68,894
Czechia	2022	41 848,093	13 454,764	6 341,654	9 714,143	5 414,250	352,570	7 714,551	-1 163,271	19,434
	2023	38 439,580	10 722,001	5 756,472	9 613,903	5 240,346	315,777	7 571,872	-789,645	8,855
	2024	37 924,588	9 588,072	5 745,426	9 965,506	5 430,680	342,955	7 411,674	-572,608	12,882
Hungary	2022	25 780,217	1 241,963	7 902,816	8 066,496	3 314,388	217,302	3 992,000	1 044,884	0,000
	2023	24 297,266	897,084	7 063,478	7 841,531	3 326,873	198,959	4 015,000	954,342	0,000
	2024	24 359,827	743,643	7 068,809	7 781,094	3 600,284	191,554	4 052,000	922,442	0,000
Poland	2022	104 749,238	42 145,612	15 044,001	33 193,642	13 461,271	1 026,572	0,000	-144,223	22,362
	2023	98 413,960	34 037,957	15 763,142	33 301,366	13 998,932	970,691	0,000	321,331	20,541
	2024	98 262,325	32 007,501	16 967,401	33 321,572	14 779,029	1 007,323	0,000	168,990	10,509
Slovakia	2022	16 626,605	2 402,819	3 791,807	3 829,709	2 156,322	225,996	4 096,990	121,410	1,552
	2023	16 438,978	2 402,437	3 609,752	3 726,196	2 055,164	205,670	4 732,540	-294,239	1,457
	2024	15 729,671	1 969,169	3 736,738	3 371,622	2 049,513	182,526	4 671,980	-253,310	1,433
Romania	2022	31 672,400	3 513,394	8 349,351	10 529,459	6 008,331	326,589	2 822,000	105,234	0,000
	2023	30 792,411	2 590,307	7 838,458	11 130,073	6 283,068	328,269	2 867,000	-259,534	0,000
	2024	30 662,394	2 227,640	8 124,276	10 958,155	5 951,041	325,035	2 803,000	254,300	0,000
Ukraine	2022-2024	-	-	-	-	-	-	-	-	-

Source: Authors, (2026).

APPENDIX B. OUTPUT DATA

Country	Period	Share_RES	Fossil_dependency	Nuclear_share	HHI	Diversification index
Bulgaria	2022	13,99851679	68,77136853	21,84650703	0,2487319	0,7512681
	2023	14,86678097	61,7058353	24,2510386	0,2200442	0,7799558
	2024	15,0551438	60,77164688	23,73785427	0,2160664	0,7839336
Czechia	2022	12,93786553	70,51829339	18,43465364	0,2317859	0,7682141
	2023	13,63268277	67,87893104	19,69811325	0,2206571	0,7793429
	2024	14,31968094	66,70871151	19,54318924	0,2149265	0,7850735
Hungary	2022	12,85632313	66,76155984	15,48474165	0,2364143	0,7635857
	2023	13,69237592	65,03650658	16,52449292	0,2376964	0,7623036
	2024	14,77959593	64,01336922	16,63394408	0,2381775	0,7618225
Poland	2022	12,85094885	86,28535799	0	0,29954	0,70046
	2023	14,22453888	84,44174485	0	0,2801208	0,7198792
	2024	15,04038196	83,75180823	0	0,2736438	0,7263562
Slovakia	2022	12,96910584	60,29093131	24,64116998	0,2037262	0,7962738
	2023	12,50177475	59,23960115	28,78852931	0,2199381	0,7800619
	2024	13,02959865	57,70959227	29,70170196	0,2236419	0,7763581
Romania	2022	18,97024223	70,69942284	8,909965775	0,2363642	0,7636358
	2023	20,40459904	70,01347832	9,310735687	0,2530145	0,7469855
	2024	19,40827256	69,49904499	9,141491039	0,2494084	0,7505916

Source: Authors, (2026).