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Energy efficiency profiles in developing the free-carbon economy: on the example of Ukraine and the V4 countries

Abstract: This paper summarizes the arguments and counterarguments within the scientific discussion on developing the free-carbon economy in Ukraine. The main purpose of the paper is elaborating the energy efficiency profile of Ukraine to assure the development of the free-carbon economy. To achieve this purpose, the authors carried out an investigation in the following logical sequence. Firstly, the bibliometric analysis of 4674 of the most cited articles indexed by the Scopus database was conducted. The obtained findings indicated that the green economy transformation depended on the main factors such as economic performance, corruption, macroeconomic stability, social welfare, shadow economy etc. As a result, the forecast of the final energy consumption to 2030 was performed. The methodological tool of this research is based on the Autoregressive Integrated Moving Average (ARIMA) model. This study involved data of the Visegrad countries (Poland, the Czech Republic, the Slovak Republic and Hungary) and Ukraine from 2000 to 2018. The base of

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data is Eurostat, the EU statistical service. Based on the obtained results of analyzing the green economic transformation in the Visegrad countries and Ukraine, the authors intimated the existence of the significant energy-efficient gap in Ukraine compared to the analyzed countries. In reliance on the experience of the Visegrad countries and the forecast results, the authors provided the main recommendations for providing the green transforming in Ukraine. The authors highlighted that the obtained results of this paper were considered to be the base for future investigations considering the influence of endogenous and exogenous factors on developing the free-carbon economy in Ukraine.

Keywords: ARIMA, energy-efficiency, EU Green Deal, green economic transition

Introduction

In the view of the hardly controlled climate changes, it is generally accepted the definite necessity of establishing international cooperation for green energy transformation. Thus, in December 2019, the European Commission presented the new strategy "European Green Deal" (EGD) aimed at gaining the carbon-free economic development by 2050. It should be noted that implementing the EGD would be the powerful trigger for accelerating the green energy development influencing on all industrial branches of EU members and its partners, especially, potential candidates.

According to the above, Ukraine as a Party of the EU Energy Community Treaty, has faced both challenges and significant opportunities in the energy sector. Thus, the Ukrainian government announced the concept entitled the "Ukrainian Green Deal" to ensure the energy independence in the view of sustainable, predictable and accessible energy production and consumption as well as the depletion of greenhouse gas emission to the climate-neutral level of the economy by 2070. In the frame of this concept, the energy-efficiency and renewable energy sources are considered to be the main vectors of Ukrainian green energy transformation. Moreover, it is necessary to build the energy efficiency profile considering the implemented Agreements, gained goals, as well as real flops and its reasons. It would result in transforming the current climate and energy Ukrainian policy to the European Green Deal and gain long-term efficiency based on the multifactorial economic and mathematic modelling the future scenarios of developing the Ukrainian free-carbon economy.

It is worth emphasizing that Ukraine is presently implementing several Energy Directives of the European Parliament and the Council: Directive 2006/32/EU of 5 April 2006 on energy end-use efficiency and energy services; Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings; Directive 2010/30/EU of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy--related products. In turn, in 2017, the primary energy intensity of the GDP per capita decreased by more than 46% compared to 2000. However, there was a significant energy-efficient gap between the Visegrad countries (V4) and Ukraine – by 2.8 times compared to the mean value of V4 (Fig. 1). Moreover, the sharp decline of the energy intensity of GDP per capita was caused not just by the proper government policy, but also the features of methodology for GDP calculation, efficient external market conditions, the demographic situation, etc. In turn, as a result of the decreasing energy-efficiency and energy-savings, economic growth, the satisfaction of the society needs and competitiveness of national economy became priorities in the energy policy.

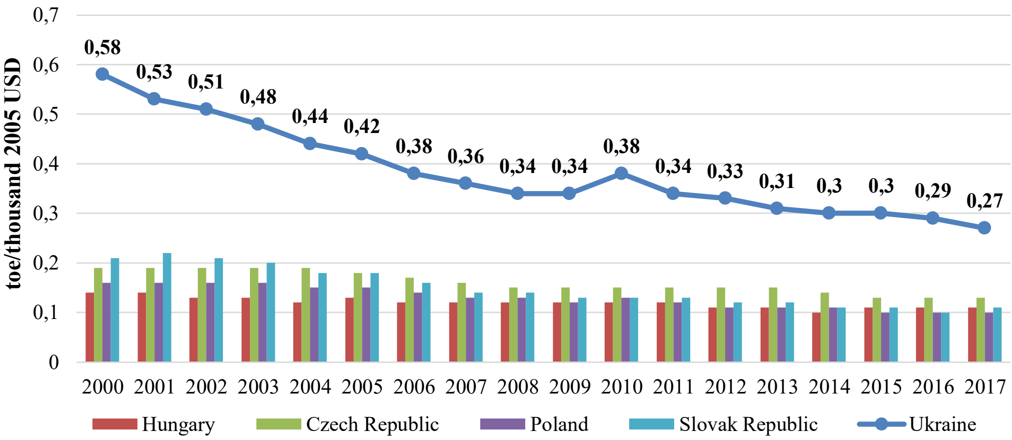

Fig. 1. Primary energy intensity of GDP per capita of Ukraine and V4, 2000–2017
Source: compiled by the authors based on data from (IEA 2020)

Rys. 1. Energochłonność pierwotna PKB per capita na Ukrainie i w krajach V4 w latach 2000–2017

Notably, Ukraine has become the Contracting Party to the Agreement on Establishing the Energy Community Treaty on 1 February 2011. As a result, by 2020 the first Ukrainian National Energy Efficiency Action Plan set the national indicative energy-saving goas for 2015––2020 as follows: in 2017 – energy-saving by 5% (3612K toe) from the average performance of final internal energy consumption for 2005–2009; in 2020 – by 9% (6501K toe). Herewith, for the EU countries, the goals provide decreasing energy consumption by 20% or more by 2020.

According to Figure 2, the volume of final energy consumption in 2018 decreased by 33% compared to 2000, while compared to 2015 – by 0.19%. In turn, in 2014 the final energy consumption decreased by 11.7% compared to the previous year. Though, it should be emphasized that data for 2014–2018 didn't include information from the temporarily occupied territories. Figure 2 demonstrates that Ukraine wouldn't be able to gain the established goal of decreasing the final energy consumption to 9% in 2020. As a result, it is necessary to attract the considerable financial resources into the energy sector from international financial institutions, the business sector, municipal budgets as well as the Energy Efficiency Fund; to develop the partnerships between the government and business sector in the field of energy efficiency; to promote the implementation of energy-efficient projects etc.

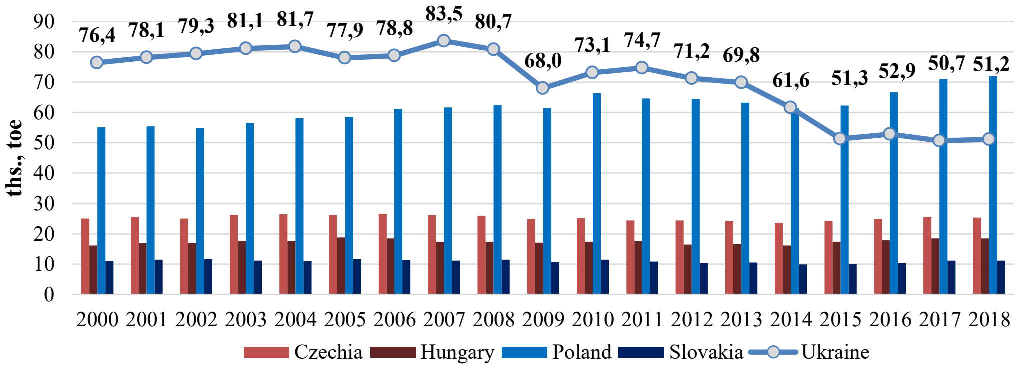

Fig. 2. Final energy consumption of Ukraine and V4, 2000–2018
Source: compiled by the authors based on data from (Eurostat 2020)

Rys. 2. Zużycie finalne energii na Ukrainie i w krajach V4 w latach 2000–2018

Notably, the slightly increasing volume of final energy consumption from 2000 to 2007 could be associated with vigorous GDP growth (Fig. 3). Although the fast-growing sector of trade, services and financial industry resulted in GDP growth, production modernization allowed for the level of energy consumption to be decreased. On the contrary, for 2007–2009 the lowering of final energy was caused by the world financial crises, which influenced the commodity output of the primary export-oriented industries such as the chemical, engineering and metal industries that had an impact on extractive and electrical energy industries. Furthermore, since 2010 the tendency of final energy consumption had a downward sloping trend due to reforming the energy sector.

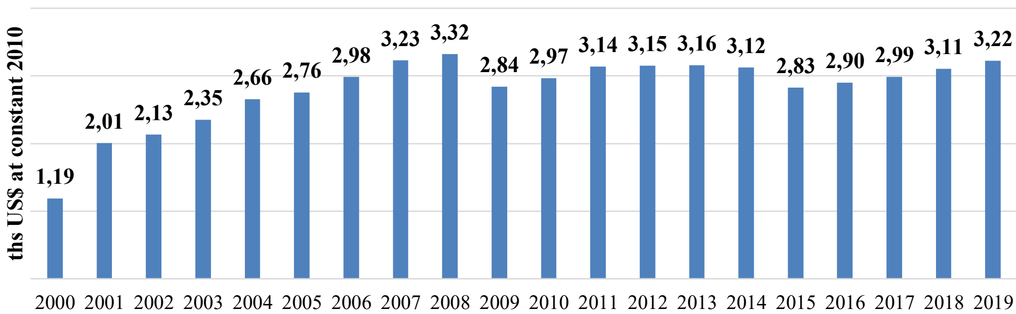

Fig. 3. GDP per capita in Ukraine
Source: compiled by the authors based on data from (World Bank 2020)

Rys. 3. PKB per capita na Ukrainie

According to the above, an energy-efficiency gap between Ukraine and V4 countries was present. However, the intentions to achieve the free-carbon economy by 2070 is causing Ukraine to investigate the effective mechanisms and implement the best practice of the EU countries to boost energy-efficiency development. Therefore, this article aims at elaborating the energy efficiency profile of Ukraine, comparing it to V4 countries, to provide the development of the free-carbon economy.

1. Literature review

The systematization of presented in the Scopus database literary background devoted to exploring the energy-efficient gaps indicated the rapidly growing tendency of publication activity since 2011 (Fig. 4). Furthermore, as a result of committing to the Paris Climate Agreement by nearly 200 countries in 2015, the number of publications boosted by more than 36% compared to the previous year.

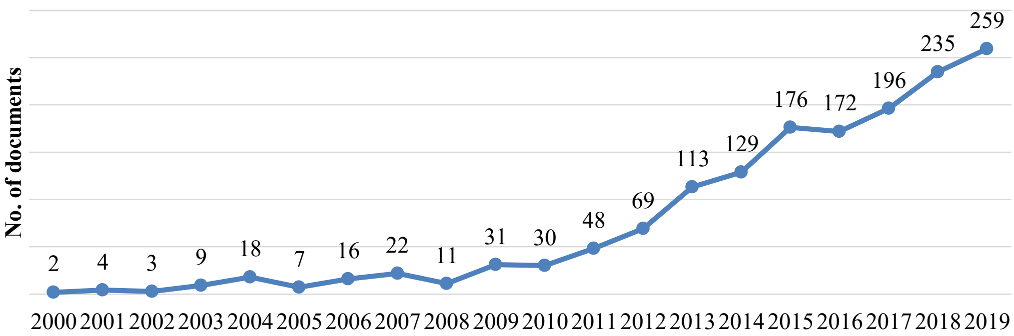

Fig. 4. The dynamic of publication activity on energy-efficient gaps, 2000–2019
Source: developed by the authors based on (Scopus 2020)

Rys. 4. Dynamika działalności wydawniczej dotyczącej luk w efektywności energetycznej w latach 2000–2019

The summary of scientific gaining in exploring the carbon-free economic development demonstrated a considerable amount of comprehensive investigating the energy-efficient aspects. Herewith, the authors of the study (Zhang et al. 2017) indicated an enormous level of carbon emissions caused by the industrial sector. Thus, in the frame of this paper, the retrospective investigation of the carbon intensity of the economy, R&D and investments were provided to determine the most impactful factor in gaining the green targets while implementing existing policies. In turn, in the frame of the article (Ayres et al. 2013), the authors gathered the arguments and counterarguments about the role of the energy factor in boosting economic growth. For the comprehensive analysis of publications on the energy efficiency aspects, different thematic directions of the scientific background were considered. The researchers of scientific papers

(Bataille and Melton 2017; Bilan et al. 2019a; Lyeonov et al. 2019; Sotnyk et al. 2020) tested the impact of renewable energy development and the amount of carbon emissions on the gross domestic product as a measure of economic growth. The authors indicated the importance of active implementation of renewable energy sources which allowed for the decrease of emissions to eliminate the negative anthropogenic impact on the environment.

Furthermore, the causal relationship between reducing greenhouse gas emissions and improving the economic performance was investigated by Italian researchers in the study (Costantini and Martini 2010). The scientist of the studies (Chygryn et al. 2018; Sotnyk et al. 2013) considered the EU experience in gaining targets in reducing carbon emissions. There was an indication that the existing stereotypes in the inefficiency of green investments were the main barrier on the way to implementing renewable energy sources. In turn, the author underlined the positive effect of implementing renewable installations not only in the economic sphere but also in the ecological and social ones. At the same time, the scientists (Bilan et al. 2019b; Bilan et al. 2020) confirmed that corruption and the shadow economy had a negative impact on green investors which limit the development of green energy and the increase of energy efficiency.

The scientists in the paper (Miśkiewicz 2018) proved the necessity to transform the energy market considering the energy efficiency and perspectives to enlarge the alternative energy resources while providing the country's energy security. The paper (Vasylyeva and Pryymenko 2014) aimed at developing ways to decrease the country's energy dependence and increase energy security. Furthermore, they confirmed that the energy sector should be transformed into the spreading of green energy.

The applied method of visualization for similarities (VOS) (Van Eck and Waltman 2007) by the VOSviewer software allowed for a comprehensive analysis of the thematic scopes of the investigated articles. It should be noted that the VOS method allowed for a visualization of the thematic directions of the articles based on the co-occurrence of items in the authors' keywords, article title and abstracts. Furthermore, the network map allowed the frequency of using the keywords, which was visualized by the circle size, to be identified. Thus, the greater the circle's diameter is, the more times this item appears in the analyzed documents. In turn, the distance between two items provides information about the frequency of their appearing in the documents. Herewith, the shorter distance indicates the strong relationship between these items. The number of links shows the number of one item interactions with others, while the total link strength gives the total number of links per one circle. The color allows for a visual sub-selectiobn of an item belonging to the particular cluster. It is worth noting that following boolean operators were used: "AND" to include all keywords in the results, "OR" – at least one keyword, and ("") to search for the phrases, while the proximity operators "*" to include all possible endings of a word. Furthermore, the limitation criteria were used to select the most appropriate final articles published in three subject areas – "Economics, Econometrics and Finance", "Social Sciences" and "Business, Management and Accounting" since 2000 to 2019. Herewith, the search of documents was carried out in the Scopus database, applying the combinations of keywords as follows: 1) "energy efficien*" AND gap* – 2000 articles; 2) "green growth" OR "green in*" OR "green development" OR renewable source* – 1958 articles; 3) "energy efficien*" AND GDP – 716 articles. Therefore, having excluded the inappropriate keywords, the survey sample was 4674 of the most cited articles.

Thus, under the limitation criteria as a minimum of 5 co-occurrences of the keyword, 1369 of 18193 met the threshold. Herewith, the visualized network map consists of 6 main clusters grouped by keywords accordingly the thematic relationship (Fig. 5). The biggest red cluster (150 items) mostly combines the research on investigating relationships among climate change, carbon emissions economic growth, emission management, environmental regulation, renewable energy sources, etc. Apart from that the cluster contains the combinations as local authorities and quality of governance. Noted that scientists in the paper (Bilan et al. 2019b) confirmed the hypothesis on the links between the quality of governance, social and energy development. Then, the second green cluster (101 items) focused on green and sustainable development, environmental impact, decision-making process and social aspects, etc. The third blue cluster (65 items) visualizes the thematic of studies on exploring the impact of economic activities, especially, from energy generations, the automobile industry. Thus, there were considered renewable energy sources and technologies, wind power, natural gas, fuel economy and emissions. The fourth

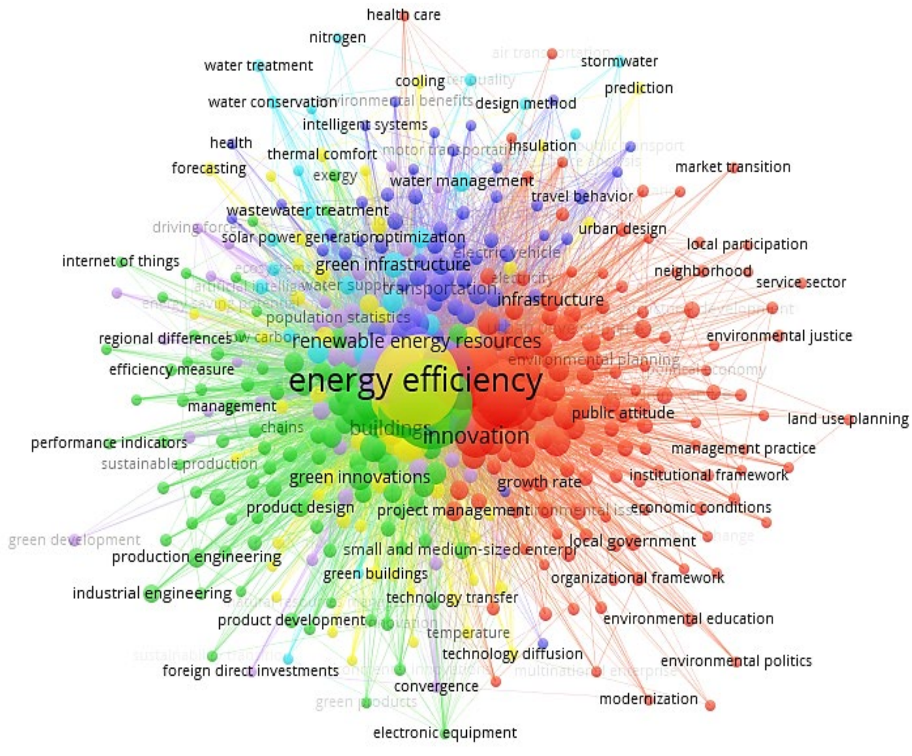

Fig. 5. The visualizing the thematic directions of articles devoted to green development, 2000–2019
Source: developed by the authors based on (Scopus 2020) using VOSviewer software

Rys. 5. Wizualizacja kierunków tematycznych artykułów poświęconych zielonemu rozwojowi, 2000–2019 yellow cluster (59 items) indicated a research direction on energy efficiency aspects, especially in the private sector. The fifth pure cluster (52 items) concentrated on the economic analysis of green growth, where exploring carbon issues was the most popular. The smallest cyan cluster (24 items) combined the scientific works in the field of the optimization of eco-efficiency, using green energy and waste treatment, etc.

In turn, Table 1 summarizes the top-20 most frequently keywords appearing in the article titles and keywords as well as abstracts. Thus, the analysis proved that investigating energy-efficient development, climate change and carbon emission issues, and economic growth could be the most effective directions for further scientific exploring on the strategical development of the carbon-free economy.

Table 1. Summary of the most frequently used keywords in the analyzed articles on green development, 2000–2019

Tabela 1. Zestawienie najczęściej używanych słów kluczowych w analizowanych artykułach dotyczących zielonego rozwoju w latach 2000–2019

Rank	Keywords	Occurrences	Rank	Keywords	Occurrences
1	Energy efficiency	601	11	Economics	170
2	Sustainable development	534	12	Green infrastructure	167
3	Sustainability	444	13	Carbon dioxide	163
4	Climate change	293	14	Innovation	161
5	Energy utilization	248	15	Environmental impact	158
6	Decision making	179	16	Environmental economics	155
7	Energy conservation	179	17	Economic growth	153
8	Energy policy	178	18	Carbon emission	134
9	Emission control	173	19	Energy use	133
10	Environmental managemet	172	20	Investments	129

*Source: developed by the authors based on (Scopus 2020).

To determine the most authoritative scientific journals in the field of investigation the relationship between energy-efficient aspects and economic growth, the journals were selected under the following criteria: at least 30 published documents and 100 citations per each scientific source. Thus, of the 1316 sources, 43 met the thresholds. As a result of calculating the total strength of the citation links with other sources, Figure 6 visualizes the sources with the highest total link strength. Moreover, the obtained results of analyzing sources citation highlighted 4 clusters which provide information about the citation of journals.

Due to the data of web portal, the SCImago Journal & Country Rank, the SCImago Journal Rank indicators (SJR) and h-index per source were detected (SJR 2020). In turn, SJR allowed the journal visibility in the Scopus database to be determined, while the h-index – the citedness of the journal (Table 2). Thus, considering the number of publication and source ratings, the

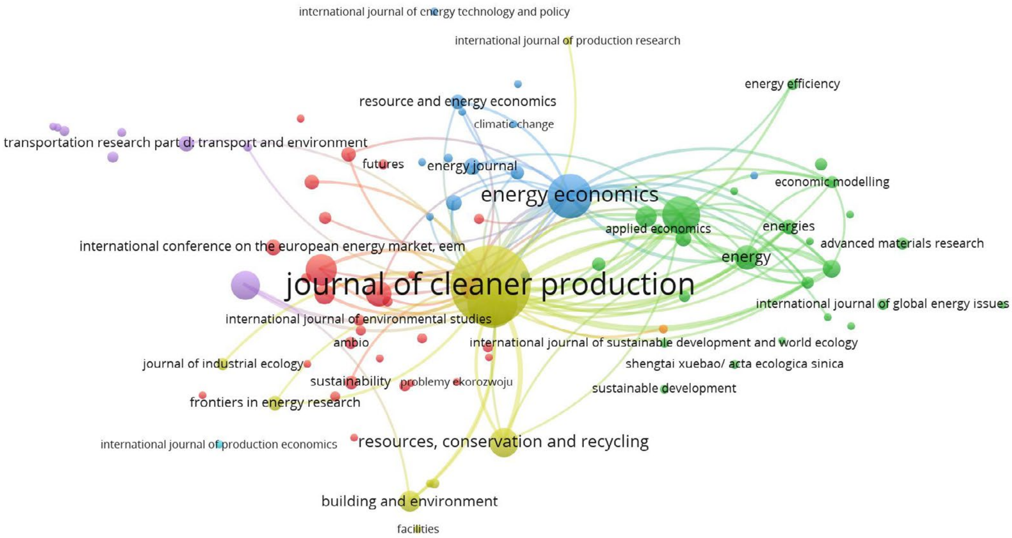

Fig. 6. The network of scientific journals issued of the analyzed articles on green development, 2000–2019
Source: developed by the authors based on (Scopus 2020) using VOSviewer software

Rys. 6. Sieć czasopism naukowych, w których opublikowano artykuły dotyczące zielonego rozwoju, 2000–2019

TABLE 2. The rank of top-10 productive journals by the number of publications, 2000–2019

TABELA 2. Ranking czasopism według liczby publikacji w latach 2000–2019

№	Source title	Country	Number of documents	SJR, 2019	h-index	Quartile
1	Journal of Cleaner Production	Netherlands	611	1.89	173	Q1
2	Sustainability	Switzerland	229	0.58	68	Q2
3	Energy Research and Social Science	United Kingdom	150	2.21	49	Q1
4	International Journal of Energy Economics and Policy	Turkey	83	0.37	25	Q2
5	Sustainable Cities and Society	Netherlands	64	1.36	43	Q1
6	Energy Economics	Netherlands	60	2.41	136	Q1
7	Ecological Economics	Netherlands	53	1.72	189	Q1
8	Building and Environment	United Kingdom	53	1.87	138	Q1
9	Energy Journal	United States	35	1.48	73	Q1
10	Urban Ecosystems	United States	32	0.87	50	Q1

*Source: developed by the authors based on (Scopus 2020).

most influential scientific journal in the field of energy-efficiency and green development was supposed to be the Netherlands International Journal of Cleaner Production (1.89 SJR and 173 h-index). It is worth underlying that the most cited articles, considered in the frame of this study, have been published in the sources ranked in the best quartile of Q1 (8 of 10 considered scientific journals) indicating the importance of investigating topics in green development, especially, energy-efficiency.

2. Methodology

The paper aims at elaborating the energy efficiency profiles in view of developing the free--carbon economy. The object of this research is the V4 countries (Poland, the Czech Republic, Hungary and the Slovak Republic) and Ukraine. Herewith, it worth mentioning that these countries were chosen because of their similar economic, social, political etc. aspects. Thus, the final energy consumption for V4 countries and Ukraine from 2000 to 2018 were analyzed to forecast its level to 2030. The empirical calculation conducted using the software EViews 11.

Herewith, the energy-efficient development forecast has been conducted using the Autoregressive Integrated Moving Average (ARIMA) model. It worth highlighting that ARIMA(p,d,q) model presents the class of statistical models used to analyze and forecast the time series data. Furthermore, it is possible to model down the non-stationary series to stationary by defining the d-tuple differences (I). From the perspective of the study (Krukov and Chernyagin 2011), the ARIMA(p,d,q) model has the formal description as:

$$\left(\Delta^d X_t\right) = \sum_{i=1}^{p} \varphi_i \left(\Delta^d X_{t-1}\right) + \varepsilon_t + \sum_{j=1}^{q} \theta_j \left(\Delta^d \varepsilon_{t-j}\right), \varepsilon_t \sim N\left(0, \sigma_t^2\right) \tag{1}$$

Moreover, the short form of the ARIMA(p,d,q) model could be described as:

$$\varphi(B)(1-B)^d X_t = \theta(B)\varepsilon_t \tag{2}$$

where:

$\varphi(B)$, $\theta(B)$ – polynomials of degree p and q,

B – lag operator ($B^j X_t = X_{t-j}, B^j \varepsilon_{t-j}, j = 0, \pm 1, \ldots$),

d – sequential difference order ($\Delta X_t = X_{t-1} - X_t = (1 - B)X_t$, $\Delta^2 X_t = \Delta^2 X_{t+1} - \Delta X_t = (1 - B)^2 X_t, \ldots$).

The fact that in 1976 the scientists George Box and Gwilym Jenkins presented the systematic approach for developing ARIMA(p,d,q) model at the first time (Ma et al. 2018) is noteworthy.

Given that, the methodology for developing the ARIMA(p,d,q) model provides performing several main steps as follows:

1. Identification of the model that best suits the actual process under consideration.

Under the calculated estimates for the autocorrelation (ACF) and partial autocorrelation (PACF) functions, the preliminary conclusion on the integration degree (d) and the order values of the autoregression operators (p) and the moving average (q) are done.

The autoregressive model with p-order is the primary model describing the stationary process. In turn, the autoregressive process means the dependence on the current level from the previous ones. The autoregression model (AR) p-order is expressed as

$$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t \tag{3}$$

where:

- Y_t – time-series level at the particular time point t (dependent variable),
- $Y_{t-1}, Y_{t-2}, Y_{t-p}$ – the time series levels at the time point t–1, t–2, …, t – respectively (independent variables),
- $\varphi_0, \varphi_1, \varphi_2, \ldots, \varphi_p$ – estimated coefficients,
- ε_t – random walks.

The moving average (MA) model is a linear regression of the predicted time series value relative to the current and previous observed variables. Moreover, the random components are expected to be mutually independent and conform to a normal distribution with mean 0.

Thus, the model of the moving average q-order is denoted as:

$$Y_t = \varepsilon_t - \omega_1 \varepsilon_{t-1} - \omega_2 \varepsilon_{t-2} - \ldots - \omega_q \varepsilon_{t-q} \tag{4}$$

where:

- Y_t – level of time series at the time point t (dependent variable),
- ε_{t-1} – the values of remains i-time periods (independent variables),
- $\omega_1, \omega_2, \ldots, \omega_q$ – estimated coefficients.

In accordance with the models mentioned above, the combination of the autoregression model (AR) and moving average model (MA) develops the model ARMA(p,q):

$$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t - \omega_1 \varepsilon_{t-1} - \omega_2 \varepsilon_{t-2} - \ldots - \omega_q \varepsilon_{t-q} \tag{5}$$

2. Parameter assessment on the base of regression methods.

In reliance on the calculated autocovariance for the identified ARIMA(p,d,q) model, the initial estimates of moving averages parameters is done. The parameters are estimated under the least square's method and the maximum likelihood principle.

3. The diagnostic testing the adequacy of the model.

The remains of the developed stochastic model (ε_t) are used to diagnose the adequacy of the model. Thus, the model quality and remains uncorrelatedness need testing.

4. Using the model for forecasting.

According to the above, a stationary series could be obtained using statistical tests for the presence of a unit root (Augmented Dickey-Fuller unit root test). In the case under the Dickey-Fuller statistics, the initial series was non-stationary, the operator of taking successive differences should be used to go to the stationary series. After obtaining a stationary series, the model is identified by evaluating its parameters. Its series of residuals are analyzed to check each trial model for adequacy.

3. Results and discussion

Having sung the EU Association Agreement in 2014, Ukraine is to meet the high EU standards on energy efficiency and participation in the energy market. Given that, increasing the energy efficiency and assuring energy savings is the priority direction of Ukraine's energy policy. Decreasing the level of energy consumption is the condition to gain energy independence and implement Ukraine into the EU.

It worth mentioning that the above analysis of statistical data indicated that the level of final energy consumption has a falling tendency. However, there is an energy-efficiency gap between Ukraine and the V4 countries. Notably, the energy-efficiency gap means the situation where the technical and technological capacity of energy-efficiency development isn't used completely despite its potential economic efficiency. In the case of the energy-efficiency gap this could be the insufficient using of alternative energy sources, insufficient green investing, asynchrony of state energy policy etc.

Figure 7 presents the forecast of the final energy consumption to 2030 based on the ARIMA model. The determinate sample for the forecasts were the values of final energy consumption in the V4 countries and Ukraine. The sample period was 2000–2018. The empirical calculation was conducted using EViews 11 software. Herewith, Table 3 demonstrates the forecast values of the final energy consumption per investigated countries.

The obtained forecast results demonstrate that in 2020 the final energy consumption decreased in Ukraine by 32% compared to 2018, while in Hungary – by 1.5%, in the Czech Republic – 4.77%, in the Slovak Republic – by 1.26%. On the contrary, in Poland, an increase in the level of final energy consumption by 1.16% is expected.

At present, the conservation of energy assures not only sustainable development but also enhances the competitiveness of domestic products. The modern tendency on energy-efficient development is the necessity to provide stable economic functioning and satisfying the population needs. Therefore, the complex realization of activities in energy efficiency and energy savings allows for economic growth to be accelerated.

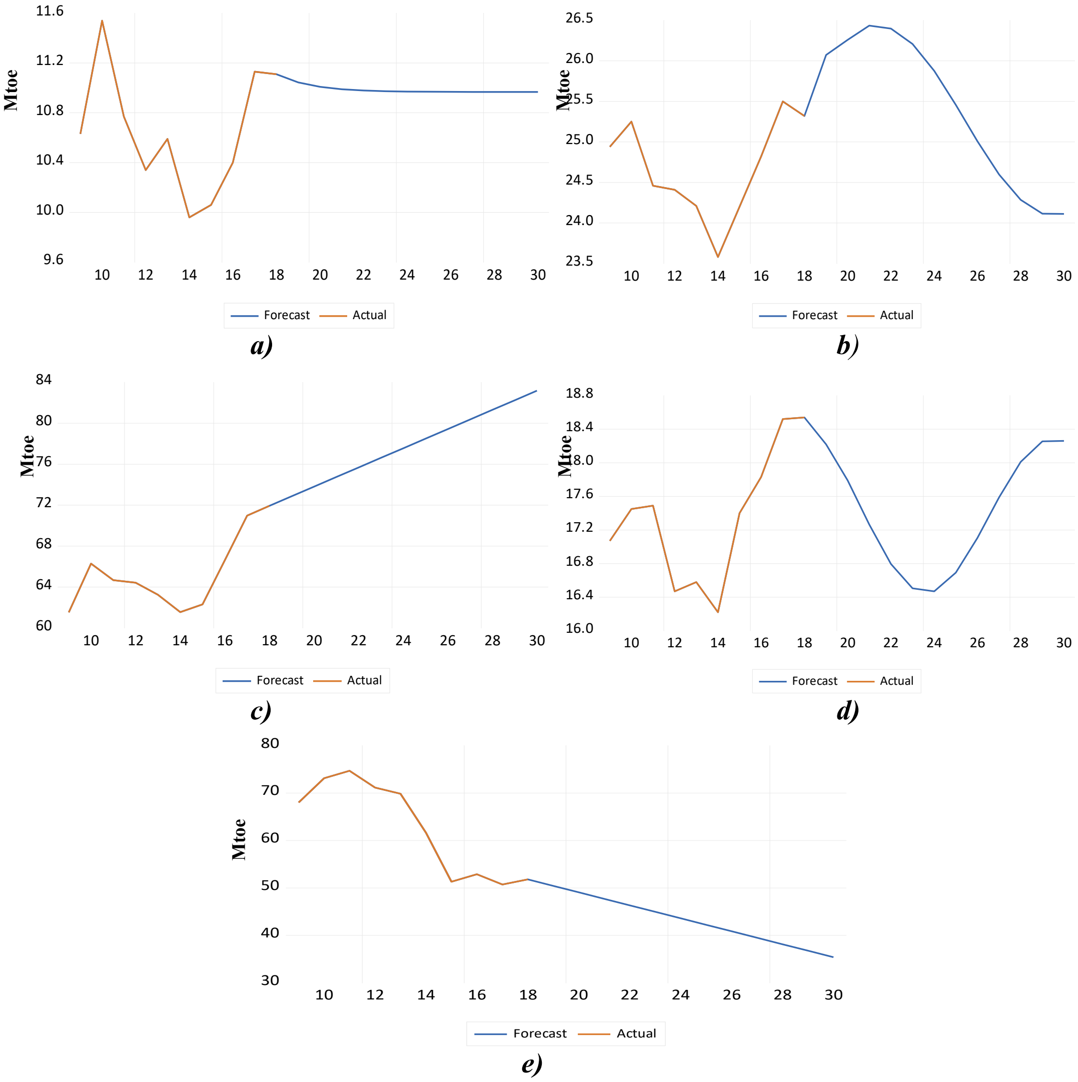

Fig. 7. The results of the forecast of the final energy consumption (Mtoe) of the V4 countries:
a) the Slovak Republic, b) the Czech Republic, c) Poland, d) Hungary) and e) Ukraine (2000–2030)
Source: formulated by the authors using the Eviews software

Rys. 7. Wyniki prognozy końcowego zużycia energii (Mtoe) dla krajów V4:
a) Słowacja, b) Czechy, c) Polska, d) Węgry) oraz e) Ukraina (2000–2030)

Thus, increasing the energy-efficient level of the Ukrainian economy should be upon expanding state support. In turn, it would boost the implementation of energy-efficient projects for small and medium enterprises; stimulating the energy market and implementing energy management systems, energy-efficient public procurement, green credits etc.

Table 3. The predicted values of the final energy consumption [Mtoe]

Tabela 3. Przewidywane wartości zużycia energii końcowej [Mtoe]

Country/ Year	Hungary	The Czech Republic	The Slovak Republic	Poland	Ukraine
2020	18	26	11	74	49
2021	17	26	11	74	48
2022	17	26	11	76	46
2023	17	26	11	77	45
2024	16	26	11	77	44
2025	17	25	11	79	42
2026	17	25	11	79	41
2027	18	25	11	80	40
2028	18	24	11	81	38
2029	18	24	11	82	37
2030	18	24	11	83	35

*Source: formulated by the authors using the Eviews software.

Conclusion

In the presence of socio-political crises during recent years in Ukraine, the issues of comprehensive energy safety play an extremely significant role. The obtained results of the bibliometric analysis indicated the growing scientific interest in investigating the problems in energy-efficiency development. Notably, since 2015 the rapid growth of scientific publications in the investigated fields has been observed. Moreover, the in-depth analysis of the most cited articles indexed by the highly reliable Scopus database allowed the main directions in developing the investigation trajectory of the investigated problem to be detected. Generally, researchers explore energy-efficiency in view of environmental, economic, social, legal, etc. aspects.

Thus, the systematization of literary sources allowed to confirm the permanent general deficit of natural resources and insufficient energy policy as the main problem of boosting the energy-efficient development in Ukraine. Furthermore, the statistical data analysis indicated the existence of the energy efficiency gap between Ukraine and V4 countries. Given this, the Autoregressive Integrated Moving Average model (ARIMA) with minimal parameters was used to forecast the final energy consumption to 2030. Thus, the obtained results indicated that it is vital to provide the synchronization of the Ukrainian energy policy to the EU standards, encouraging the EU-Ukraine energy market integration, etc. to give the green transition to the carbon-free economy in Ukraine. In the view of developing the free-carbon economy in Ukraine, the findings of this study could be considered the base for future investigations to explore the influence of endogenous and exogenous factors on energy-efficiency development.

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Profile efektywności energetycznej w rozwoju gospodarki bezemisyjnej na przykładzie Ukrainy i krajów V4

Streszczenie

W artykule podsumowano argumenty i kontrargumenty w ramach dyskusji naukowej na temat rozwoju gospodarki wolnej od węgla na Ukrainie. Głównym celem artykułu jest opracowanie profilu efektywności energetycznej Ukrainy w celu zapewnienia rozwoju gospodarki niskoemisyjnej. Aby osiągnąć ten cel, autorzy przeprowadzili badanie w następującej logicznej kolejności. Po pierwsze, przeprowadzono analizę bibliometryczną 4674 najczęściej cytowanych artykułów zindeksowanych w bazie Scopus. Uzyskane wyniki wskazywały, że transformacja w kierunku zielonej gospodarki zależy głównie od takich czynników jak wyniki gospodarcze, korupcja, stabilność makroekonomiczna, dobrobyt społeczny, szara strefa itp.

Następnie wykonano prognozę zużycia energii końcowej do 2030 roku. Narzędziem metodologicznym tego badania jest model autoregresywnej zintegrowanej średniej ruchomej (ARIMA). W badaniu uwzględniono dane z krajów Grupy Wyszehradzkiej (Polska, Czechy, Słowacja i Węgry) oraz Ukrainy w latach 2000–2018, których źródłem była baza Eurostat.

Na podstawie uzyskanych wyników analizy przemian gospodarczych w krajach wyszehradzkich i na Ukrainie autorzy stwierdzili, że na Ukrainie istnieje znaczna luka w efektywności energetycznej w porównaniu z analizowanymi krajami. Opierając się na doświadczeniach krajów wyszehradzkich i prognozowanych wynikach, autorzy przedstawili najważniejsze rekomendacje dotyczące zapewnienia zielonej transformacji na Ukrainie. Autorzy podkreślili, że uzyskane wyniki przedstawione w niniejszym artykule można uznać za podstawę do dalszych badań nad wpływem czynników endogenicznych i egzogenicznych na rozwój gospodarki wolnej od węgla na Ukrainie.

Słowa kluczowe: ARIMA, efektywność energetyczna, zielony ład UE, zielona transformacja gospodarcza