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TREND ANALYSIS OF CHANGES IN THE LEVEL OF ENERGY EFFICIENCY IN THE NATIONAL ECONOMY

The article examines trends in energy policy efficiency changes in Ukraine and EU countries during 2000-2021. Based on a comparative analysis of actual energy consumption with strategic guidelines for reforming state energy policy, gaps in energy efficiency in the national economy are assessed. A conclusion about the need to reform the state energy policy of Ukraine from the point of view of accelerating the transition of economic entities to alternative energy sources and attracting investments into the country's energy sector was made. The state mechanism for evaluating the effectiveness of the state policy of reducing energy consumption on the basis of comparing actual energy consumption with the declared strategic goals of transition to renewable energy sources has been improved.

Keywords: energy efficiency, national economy, environmental policy, renewable energy sources.

Introduction. One of the biggest global environmental problems is the problem of excessive energy consumption, the volume of which is constantly growing and, according to experts' forecasts, will grow almost 1.5 times by 2050. Realizing this, the EU countries developed strategic guidelines for reforming the state energy sector in the direction of reducing energy consumption: reducing greenhouse gas emissions by 40% compared to 1990, an increase in the share of renewable energy consumption to 32%, energy savings of at least 32.5% [3]. In 2021, the Cabinet of Ministers of Ukraine approved the National Economic Strategy until 2030, in which target indicators for the reform of the state energy sector were declared. However, the military actions in Ukraine, which were accompanied by the destruction of a significant number of power plants, only exacerbated the energy crisis and intensified the problem of finding additional mechanisms for the transition to renewable energy sources and reducing the total volume of energy consumption in the country and the world.

Literature review. The problem of excessive energy consumption attracts the attention of a significant number of scientists from different countries of the world. The role of renewable energy in ensuring regional sustainable development and the dependence between the volumes of renewable energy consumption and carbon emissions were considered in the work [4]. Based on the study's results, the authors proved that a 1% increase in renewable energy consumption in the region leads to a 0.05% reduction in carbon emissions. The role of atomic energy and natural gas in promoting environmental sustainability in India is substantiated in the work of T. Adebayo [1]. Based on causality analysis, the authors confirm that nuclear power, human capital, gas consumption and economic growth can predict long-term environmental sustainability in India. S. Tsemekidi Tseyranaki and others. studied the evolution of the development of the energy sector of the European Union (EU) in the context of the energy and climate goals of the EU for 2020, 2030 and 2050 [5]. Based on econometric modeling and decomposition analysis, the authors identified indicators that affect the volume of energy consumption and analyzed the impact of state policy and technology improvement on the speed of achieving EU goals.

At the same time, the issue of analyzing the compliance of the actual performance indicators of the country's energy sector with the declared goals and the compliance of the rates of change in the consumption of individual energy sources with the expected indicators requires a more detailed analysis.

The purpose of the article is to carry out a trend analysis of energy efficiency in the national economy.

Results and discussion. For comparative analysis of the actual volumes of energy consumption to the target orientations of the reform of the energy sector of Ukraine and the EU countries, we will analyze the degree of activation of the transition processes to renewable energy sources in terms of their

main components. The dynamics of changes in the share of renewable energy sources in the volume of total final energy consumption shown in Figure 1 shows that over the past 20 years, this indicator has increased 6.7 times in Ukraine and almost 2.5 times in EU countries.

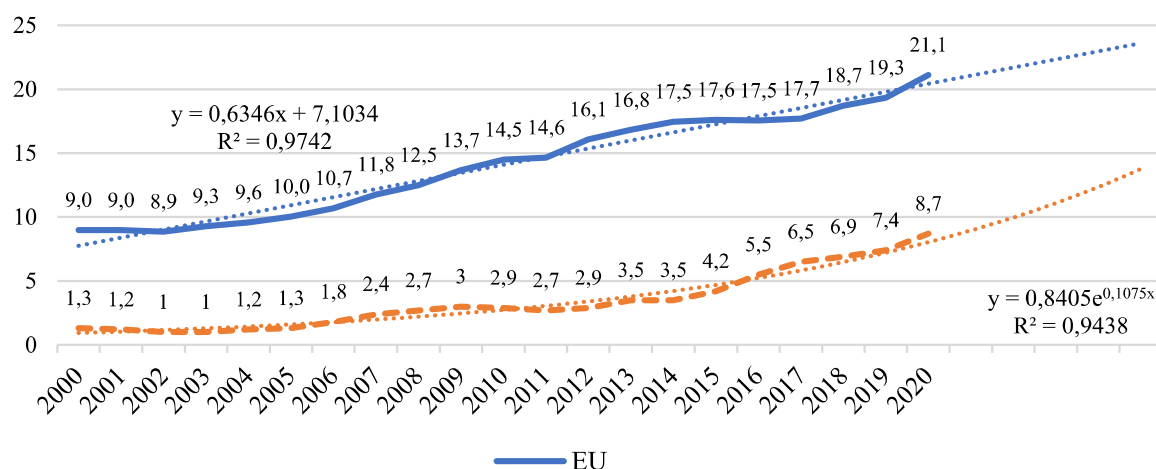


Figure Помилка! У документі відсутній текст указанного стилю. – **The trend of changes in the share of renewable energy sources in the volume of total final energy consumption in EU countries and Ukraine**

Source: Constructed by the authors based on data [2]

According to the energy strategy of Ukraine for the period until 2035, “Security, energy efficiency, competitiveness”, by 2020, the share of renewable energy sources in Ukraine should be 7%, by 2025 – 10%, by 2030 – more than 13% and by 2035 – exceed 25%. Achieving the targeted values is possible only under the continuous implementation of measures to transform the country’s energy market, search for and implement innovative methods of achieving carbon neutrality, transition to renewable energy sources, etc. In March 2023, the Cabinet of Ministers of Ukraine approved the “National Economic Strategy for the period until 2030”, the mission of which is to create an opportunity to realize the country's existing geographical, resource and human potential, including to achieve climate neutrality of Ukraine no later than 2060 [6]. It involves balancing the volume of greenhouse gases removed from the atmosphere over the importance of their emissions due to human activity.

In addition, one of the vectors of transformation of the state energy policy is the reduction of CO₂ emissions within the framework of decarbonization of the economy. CO₂ emissions 2020 should be at least 60% of the 1990 level, and in 2035 – at least 50%. By 2025, CO₂ emissions from final fuel consumption should be reduced by 10% from the 2010 level, by 15% in 2030, and by 20% in 2035.

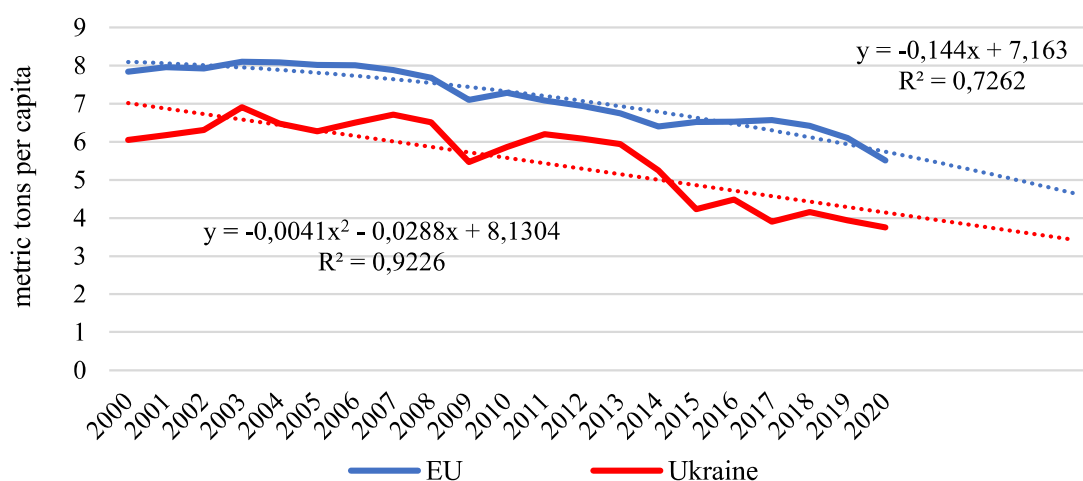


Figure 2 – The trend of changes in the volume of CO₂ emissions in EU countries and Ukraine

Source: built by the authors based on data [2]

At the same time, as shown in Figure 2 results of the trend analysis, during the entire analyzed period in the EU countries and in Ukraine, there is a constant decrease in CO₂ emissions. According to the results of 2020, the volume of CO₂ emissions in Ukraine was almost 3.5 times less than the indicator of 1990. Thus, it can be said that in the absence of a significant increase in CO₂ emissions by 2035, the targeted indicators will be significantly exceeded.

An equally important indicator characterizing the country's energy market is the amount of carbon intensity of electricity, which reflects the amount of CO₂ emissions emitted per kilowatt-hour of electricity. The change trend of this indicator (Figure 3) shows a significant decrease in the carbon intensity of electricity in all analyzed countries.

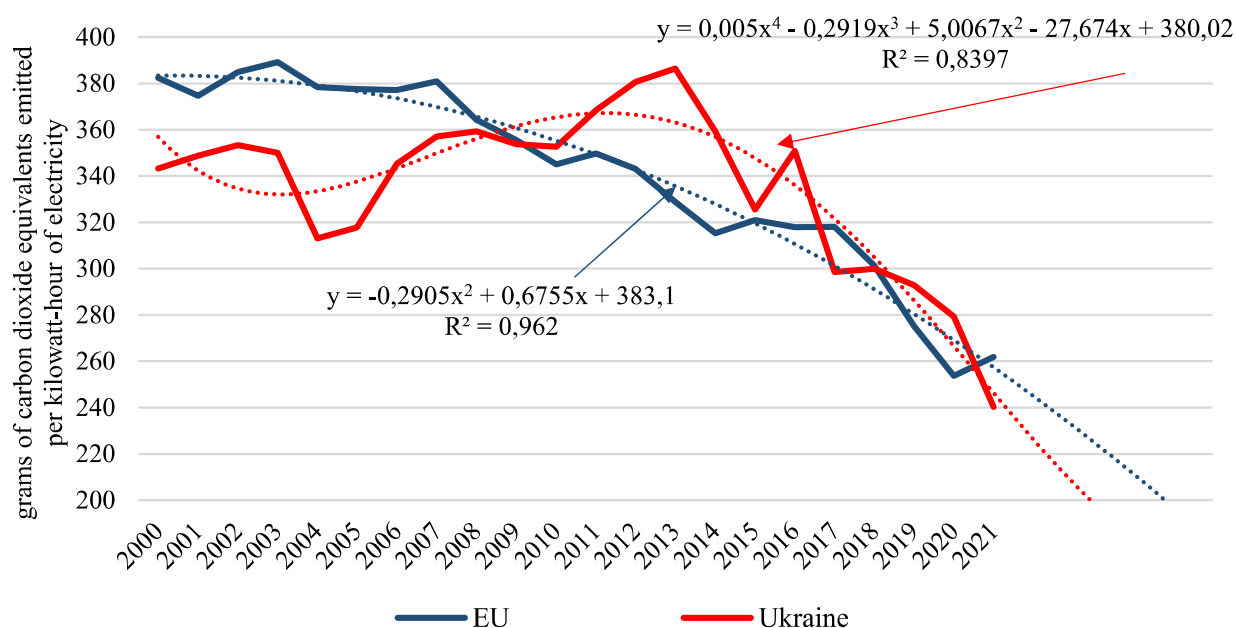


Figure 3 – The trend of changes in the carbon intensity of electricity in EU countries and Ukraine

Source: Constructed by authors based on data [2]

At the same time, the comparative analysis shows the inconsistency of trends in Ukraine and EU countries. Constant fluctuations characterize the level of carbon intensity of electricity in Ukraine. The highest values of the carbon intensity of electricity were obtained in 2014 and 2016. Thus, it can be concluded that there is no stable and effective policy for reducing the carbon intensity of electricity and the significant dependence of this indicator on external factors (political and economic crisis in the country, the COVID-19 pandemic, etc.).

Positive dynamics are characterized by the policy of EU countries in the direction of reducing the share of coal in energy production, which decreased by 6.7% over the period 2000-2021 (Figure 4). In Ukraine, there are no stable positive dynamics in the direction of reducing the share of coal in energy production. Since 2013, this indicator has been increasing periodically, and according to the results in 2021, it was 28.6%. At the same time, the energy strategy of Ukraine for the period until 2035 plans to reduce this indicator to 16.1% by 2025, 14.3% by 2030, and 12.5% by 2035.

Thus, the given data testify to the low effectiveness of the current mechanisms of reforming the state energy market of Ukraine and their inability to ensure the achievement of targeted values. This actualizes the need to find additional mechanisms for switching to renewable energy sources and increasing their share in the country's energy balance.

An equally important direction of reforming the electricity market in both Ukraine and the EU countries is the gradual abandonment of gas. These issues became especially relevant during the period of military operations in Ukraine. In conditions where almost 40% of Ukraine's energy is imported from abroad, direct energy dependence on the aggressor country only exacerbates the problems of the country's economic danger.

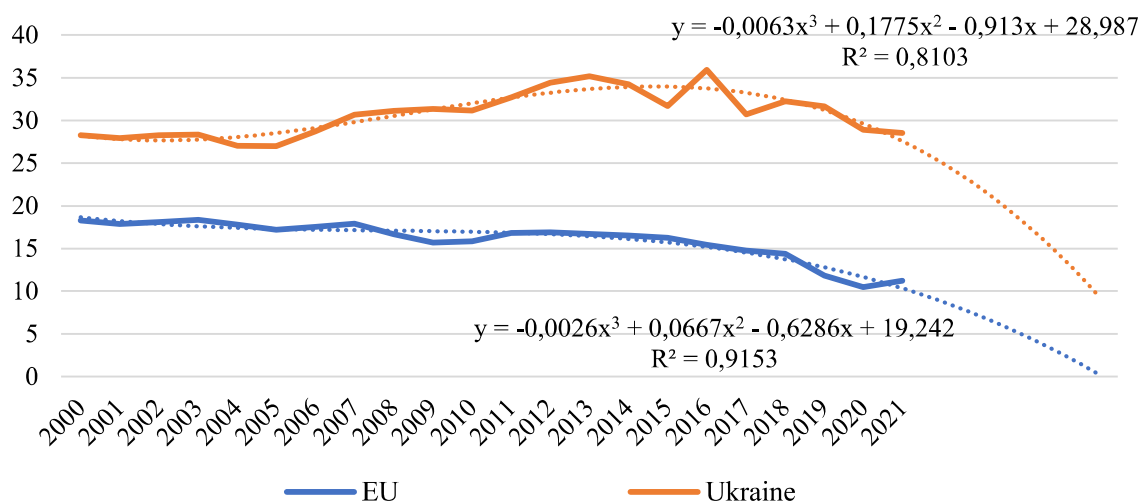


Figure 4 – The trend of changes in the share of coal energy in EU countries and Ukraine

Source: Constructed by authors based on data [2]

As evidenced by the data shown in Figure 5, a gradual decrease in the gas share of energy is observed in Ukraine. Over the past 20 years, this indicator decreased by 18.6% and at the end of 2021 was 28.18%. At the same time, in the EU countries, the average value of the gas share of energy in 2021 was 23.25%, which is 3.5% more than the figure of 2014 and 3.3% more than the figure of 2000.

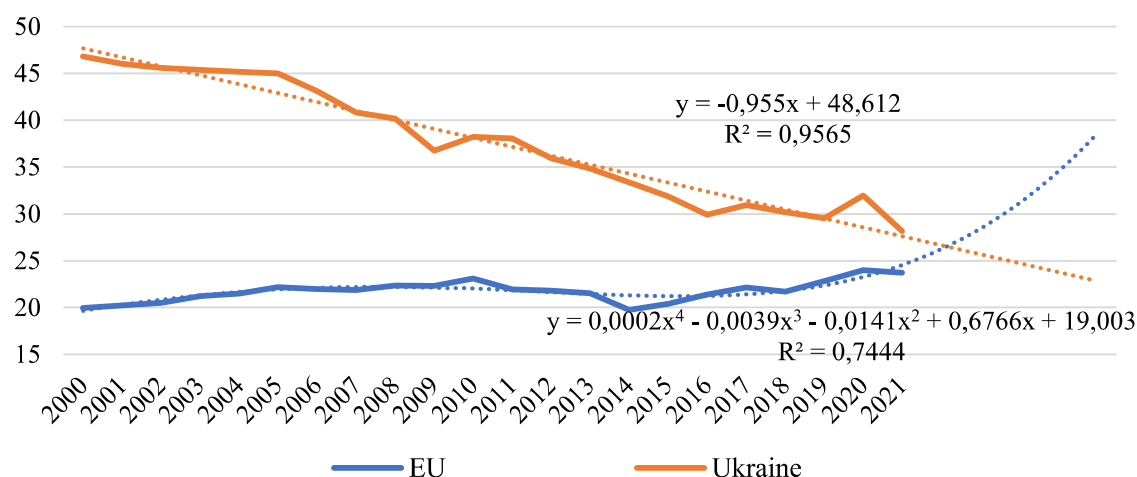


Figure 5 – The trend of changes in the gas share of energy in EU countries and Ukraine

Source: Constructed by authors based on data [2]

The given data show that in most EU countries, transition to renewable energy sources only allows partially abandoning gas and compensating for them at the expense of non-renewable energy sources.

The share of low-carbon energy indicates the effectiveness of the country's energy policy and the degree of its compliance with the Sustainable Development Goals. This indicator reflects the combined specific renewable, nuclear and hydropower weight in the country's overall energy balance. A comparative analysis of the trend of changes in this indicator in Ukraine and EU countries during 2000-2021 (Figure 6) shows its significant growth (9.2% in EU countries and 13.5% in Ukraine). By the end of 2021, Ukraine's share of low-carbon energy was almost equal to the EU countries (29.47% and 29.58%, respectively).

Thus, during the analyzed period, Ukraine managed to significantly reduce the level of carbon intensity of energy. One of the reasons for this situation is that the cost of such energy sources is minimal, while the cost of electricity production from gas-fired power plants in most EU countries exceeds 600 euros per megawatt-hour.

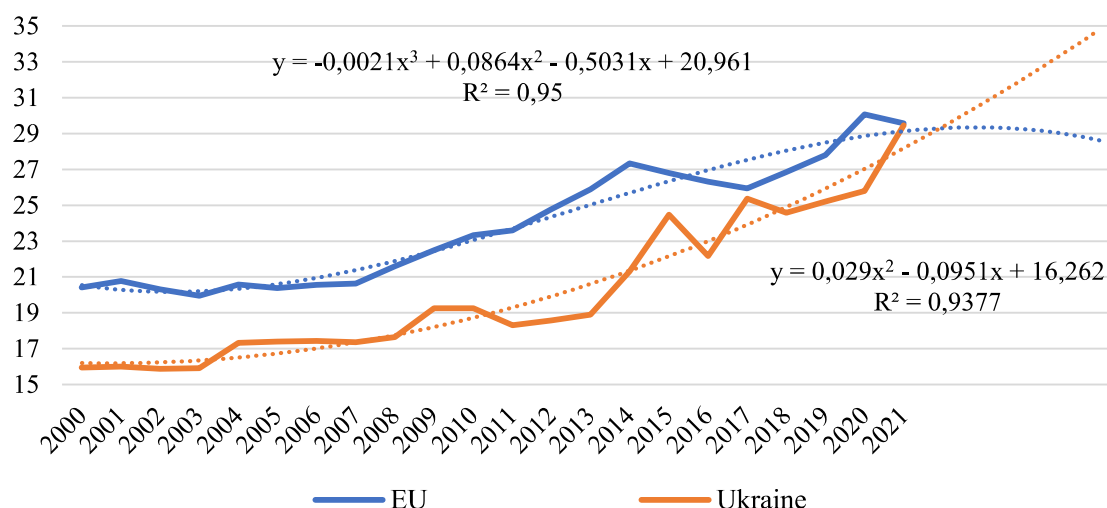


Figure 6 – The trend of changing the share of low-carbon energy

Source: Constructed by authors based on data [2]

One of the most cost-effective low-carbon energy sources is nuclear power.

According to IAEA estimates, by 2030 the share of nuclear energy in global energy production will range from 12.4 to 14.4%. In general, in 2021, more than 30 countries of the world produced electricity with the help of nuclear power plants, with a total volume of more than 15% of electricity production.

Trends in the share of nuclear energy in Ukraine show its significant growth in 2014-2015 (by almost 7% compared to last year) and the absence of stable and positive dynamics in the period from 2000 to 2014 and 2016-2021. At the same time, the share of nuclear energy in the EU countries is constantly decreasing and according to the results of 2021 it was 11% compared to 13.5% in 2000.

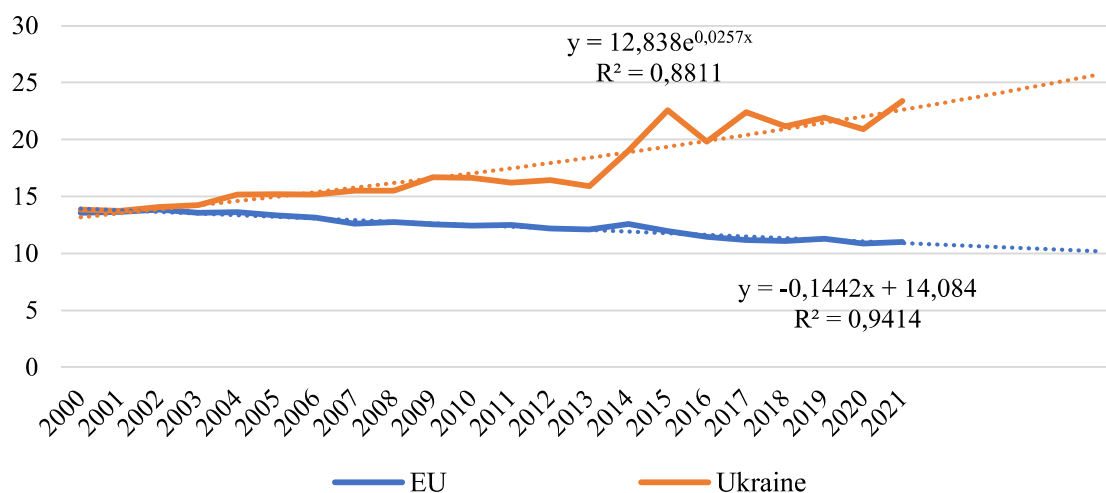


Figure 7 – The trend of changes in the share of nuclear energy

Source: Constructed by authors based on data [2]

The aggravation of energy problems in the world led to a more active search by the international community for alternative energy sources. One sustainable renewable energy source with a much lower impact on the environment is wind energy, which has been increasingly used for electricity production in recent years. It is primarily due to several economic advantages of wind energy compared to traditional sources: the absence of harmful emissions into the atmosphere, inexhaustibility, and safety. At the same time, the unpredictable nature of any natural element and the high equipment cost limit the possibilities for a complete transition to this energy source.

Analysis of the growth rates of the global wind energy market indicates a decline in the amount of energy produced in recent years. Thus, according to the results of 2022, the growth rate of the energy capacity level was 10.5%, which is one of the lowest indicators in the last 40 years. At the same time, Finland – 74%, Poland – 21%, Brazil – 19% and Sweden – 17% had the highest growth rates in 2022.

The trend of changes in wind energy power in EU countries shown in Figure 8 shows the constant growth of this indicator. At the same time, in 2014, 2016, 2018 and 2021, there was a reduction in the level of wind energy capacity.

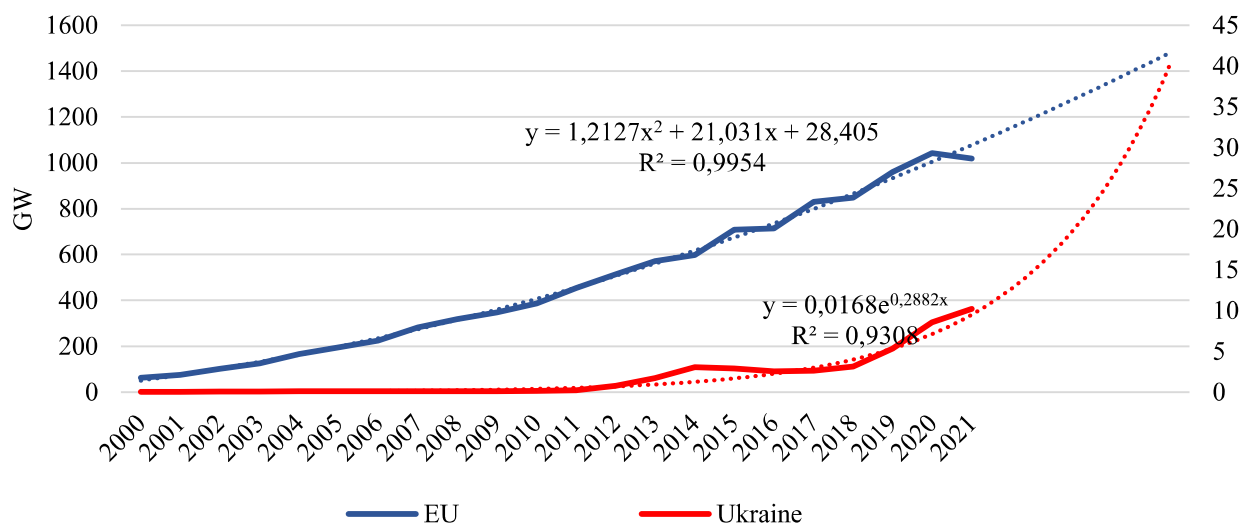


Figure 8 – The trend of changes in wind energy capacity in EU countries and Ukraine

Source: Constructed by authors based on data [2]

A comparative analysis of trends in the development of wind energy capacities in Ukraine and EU countries allows us to conclude that in Ukraine, unlike EU countries, a significant reduction in wind energy capacity was observed in the period from 2014 to 2018 (in 2016, a 13% decrease compared to from 2015).

The energy strategy of Ukraine for the period until 2035, “Security, energy efficiency, competitiveness”, envisages an increase in the share of solar and wind energy to 2.4% by 2025, 5.5% by 2030, and 10.4% by 2035. The data shown in Figure 9 shows that in 2022 the share of wind energy in Ukraine was 2.864%, which exceeds the planned indicator of 2025.

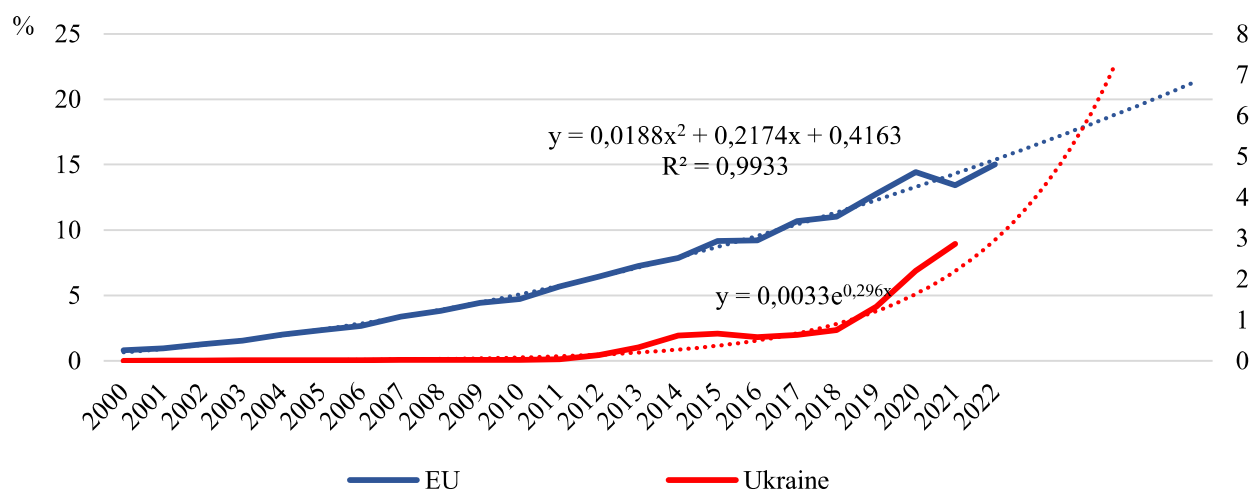


Figure 9 – The trend of changes in the share of wind energy in EU countries and Ukraine

Source: Constructed by authors based on data [2]

Along with wind energy, solar energy is gaining popularity worldwide as one of the safest energy sources. Every year, more and more households, hospitals and small businesses are focusing on installing solar collectors that can generate electricity, heat water, and more. It leads to a constant increase in the share of solar energy in the overall electricity production structure. The indicators shown in Figure 10 show a significant increase in the percentage of solar generation in electricity production in the EU countries starting from 2010. By the end of 2022, its value was 7.3%. At the same time, in Ukraine, the intensification of the processes of using solar energy for the production of electricity began only in 2018 and, by the end of 2022, was 3.8%.

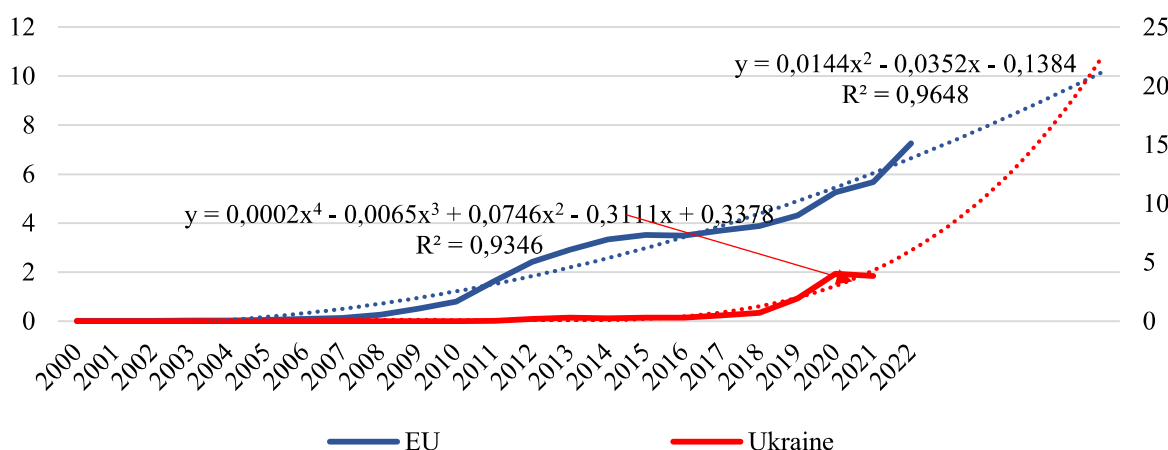


Figure 10 – The trend of changes in the share of solar generation in electricity production in EU countries and Ukraine

Source: Constructed by authors based on data [2]

An equally important source of energy is hydropower, which in the conditions of the Ukrainian-Russian war, the seizure of the Zaporizhzhya TPP and the shutdown of its units plays an increasingly important role in the successful and stable functioning of the country's energy sector.

Analysis of the dynamics of changes in the share of energy production from hydropower (Figure 11) confirms the absence of positive dynamics regarding the growth of the percentage of hydropower in the energy balance of Ukraine and EU countries. According to the results of 2021, the share of hydropower in Ukraine was 2.9% compared to 2.1% in 2000; in EU countries, this indicator decreased slightly and was 5.4% compared to 6% in 2000. At the same time, the Energy Strategy of Ukraine for the period until 2035, “Security, energy efficiency, competitiveness”, defines that by 2025 the share of hydropower should be 1.1%, and by 2035 it should decrease to 1.0%.

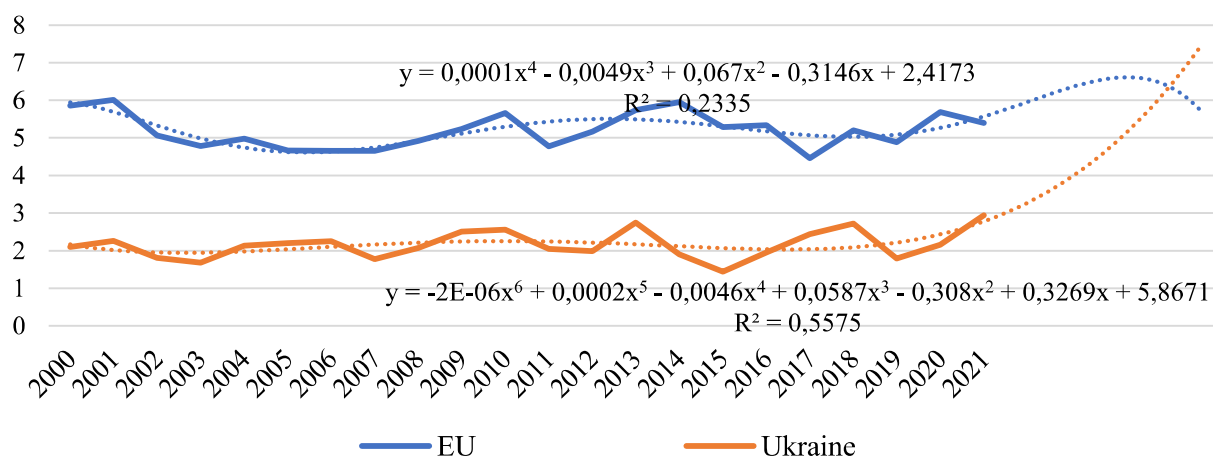


Figure 11 – The trend of changing the share of hydropower in the national energy balance of EU countries and Ukraine

Source: Constructed by authors based on data [2]

At the same time, table 1 shows the installed capacity volumes and hydropower plants' energy generation in 2021. Ireland, France, Spain and Italy have the largest capacities among the EU countries. The power of Ukraine's HPP is at an average level. At the same time, the volume of energy generated in Ukraine is one of the smallest (2 TWh*) among the analyzed countries of the world.

Table 1 – Installed capacity and energy generation of HPP in 2021

	Total installed capacity, including hydro accumulator (MW)	Production (MW)	Generation (TWh*h)
Austria	14,747	5,596	41
Belgium	1,427	1,307	1
Bulgaria	3,129	1,404	5
Greece	3,421	699	6
Denmark	7	0	<1
Estonia	4	0	<1
Ireland	508	292	1
Spain	20,425	6,117	32
Italy	22,593	7,685	47
Cyprus	0	0	0
Latvia	1,588	0	3
Lithuania	1,028	900	1
Luxembourg	1,330	1,296	1
Malta	0	0	0
Netherlands	38	0	<1
Germany	10,833	6,199	24
Poland	2,385	1,780	3
Portugal	7,199	2,827	13
Romania	6,313	92	17
Slovakia	2,522	1,017	4
Slovenia	1,301	180	5
Hungary	58	0	<1
Ukraine	6,317	1,887	2
Finland	3,263	0	16
France	25,494	5,837	63
Croatia	2,155	281	7
Czech Republic	2,281	1,172	4
Sweden	16,478	99	71

Source: [3]

Conclusions. The results of a comparative analysis of the actual and declared energy consumption indicators proved the presence of deficiencies in specific components of the state energy policy. The non-compliance of the share of renewable energy sources in the structure of energy consumption with the target indicators of 2025 and 2030 indicates the need to transform certain areas of implementation of the state energy policy, increase the level of investment attractiveness of this sector of the economy, identify and implement the most influential mechanisms for stimulating economic entities to switch to alternative sources energy.

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ТРЕНДОВИЙ АНАЛІЗ ЗМІНИ РІВНЯ ЕНЕРГОЕФЕКТИВНОСТІ В НАЦІОНАЛЬНІЙ ЕКОНОМЦІ

Проблема. Однією з найбільших глобальних екологічних проблем є проблема надмірного споживання енергії, обсяги якої постійно зростають і, за прогнозами експертів, зростуть

майже в 1,5 рази до 2050 року. Розуміючи це, країни ЄС розробили стратегічні орієнтири реформування державної енергетики в напрямі зменшення енергоспоживання: скорочення викидів парникових газів на 40% порівняно з 1990 роком; збільшення частки споживання відновлюваної енергії до 32%; економія електроенергії не менше 32,5%. У 2021 році Кабінет Міністрів України схвалив Національну економічну стратегію до 2030 року, в якій задекларовано цільові показники реформування державного енергетичного сектору. Проте військові дії в Україні, які супроводжувалися знищенням значної кількості електростанцій, лише загострили енергетичну кризу і проблему пошуку додаткових механізмів переходу на відновлювані джерела енергії та зменшення загального обсягу енергоспоживання в країні і світі.

Метою статті є проведення трендового аналізу проблем енергоефективності національних економік.

Результати. У статті виявлено тенденції зміни енергоефективної політики в Україні та країнах ЄС протягом 2000-2021 років. На основі порівняльного аналізу фактичного енергоспоживання зі стратегічними орієнтирами реформування державної енергетичної політики оцінено недоліки енергоефективності в національній економіці. Зроблено висновок про необхідність реформування державної енергетичної політики України з точки зору прискорення переходу суб'єктів господарювання на альтернативні джерела енергії та залучення інвестицій в енергетику країни.

Наукова новизна. Удосконалено механізм оцінки ефективності державної політики зменшення енергоспоживання на основі порівняння фактичного енергоспоживання із задекларованими стратегічними цілями переходу на відновлювані джерела енергії.

Висновки. Спостерігається значне зростання частки сонячної генерації у виробництві електроенергії в країнах ЄС, починаючи з 2010 року. На кінець 2022 року її значення становило 7,3%. Водночас в Україні активізація процесів використання сонячної енергії для виробництва електроенергії почалася лише у 2018 році і на кінець 2022 року становила 3,8%. Порівняльний аналіз тенденцій розвитку вітроенергетичних потужностей України та країн ЄС дозволяє зробити висновок, що в Україні, на відміну від країн ЄС, у період з 2014 по 2018 рр. спостерігалось значне скорочення вітроенергетичних потужностей (у 2016 р. 13% зниження порівняно з 2015 роком). Серед країн ЄС найбільші потужності вироблення електроенергії ГЕС у 2021 році мають Ірландія, Франція, Іспанія та Італія. Потужність ГЕС України знаходиться на середньому рівні. При цьому обсяг виробленої енергії в Україні є одним із найменших (2 ТВт·год*) серед аналізованих країн світу.

Результати порівняльного аналізу фактичних та задекларованих показників енергоспоживання засвідчили наявність недоліків окремих складових державної енергетичної політики. Невідповідність частки відновлюваних джерел енергії у структурі енергоспоживання цільовим показникам 2025 та 2030 років свідчить про необхідність трансформації окремих напрямів реалізації державної енергетичної політики, підвищення рівня інвестиційної привабливості цього сектору економіки, визначення та запровадження механізмів стимулювання суб'єктів господарювання до переходу на альтернативні джерела енергії.

Ключові слова: енергоефективність, національна економіка, екологічна політика, відновлювані джерела енергії.

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