Ukraine liquid biofuel market current state modeling

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Abstract

Development and use of alternative energy in Ukraine is one of the state priority directions. Production and use of liquid bioenergy fuels from energy crops and biomass cultivation for the production of biofuels of various types' provision are the main priorities for Ukraine. The purpose of the study is to determine the opportunities of Ukraine liquid biofuel market development scenario binary econometric model design. In the article, based on the method of economic and statistical modeling with the use of statistical software environment «R» econometric models of Ukraine liquid bioenergy fuels market formation and functioning have been designed. The objective of the study is to substantiate the possibility of an econometric model and regression analysis in the study of prospects for the development of the liquid biofuel market application. The possibility of usage the alternative energy in Ukraine has been substantiated, as one of the state priority directions. The conducted study on Ukraine bioethanol market development and functioning until 2023 forecast enabled to establish that volumes of corn export and export price for wheat affect the Ukraine bioethanol production scope. It has been substantiated that in the country it is expedient to form the products consumption culture in the context of low-carbon economic development in the face of global climate challenges and taking into account future trends. A multifactor correlation model that is based on the bioethanol market in Ukraine's development and functioning study has been suggested.

Keywords: *alternative energy, fuel market, econometric model.*

Моделювання сучасного стану ринку рідкого біопалива в Україні

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Анотація

Розвиток та використання альтернативної енергетики в Україні є одним із пріоритетніших державних напрямів, який базується на впровадженні новітніх технологій та використанні світового досвіду в розвитку та функціонуванні ринку біоенергетичних видів палива. Одним із основних пріоритетів для України є виробництво і використання рідких біоенергетичних видів палива з енергетичних сільськогосподарських культур та вирощування біомаси для забезпечення виробництва біопалива різних видів. Метою дослідження є визначення можливостей розробки бінарної економетричної моделі сценарного розвитку ринку рідкого біопалива в Україні. У статті на основі методу економіко-статистичного моделювання із використанням статистичного програмного середовища – «R» розроблено економетричні моделі формування та функціонування ринку рідких біоенергетичних палив в Україні. Авторами визначено задачу обґрунтувати можливості застосування економетричної моделі та регресійного аналізу при дослідженні перспектив розвитку ринку рідкого біопалива. Проаналізовано розвиток факторних ознак, які впливають на розвиток ринку біоетанолу в Україні. Обґрунтовано можливості використання альтернативної енергетики в Україні як одного з пріоритетних державних напрямів, який базується на впровадженні новітніх технологій та використанні світового досвіду в розвитку та функціонуванні ринку біоенергетичних видів палива. Проведене дослідження щодо прогнозування розвитку та функціонування ринку біоетанолу в Україні до 2023 р. дало змогу встановити, що на обсяги виробництва біоетанолу в Україні впливають обсяги експорту кукурудзи й експортна ціна на пшеницю. Визначено, що на обсяги споживання біоетанолу в Україні впливають вартість бареля нафти на світовому ринку та середня ціна бензину А 95 на вітчизняних АЗС. Розроблено сценарні прогнози стимуляції споживання біоетанолу в Україні на основі розгляду припущень щорічного зростання та зменшення середньої ціни нафти Brent та бензину А 95 на АЗС України. Обґрунтовано, що у країні доцільно формувати культуру споживання нафтопродуктів в умовах низьковуглецевого розвитку економіки за глобальних кліматичних викликів і врахуванні трендів у майбутньому. Запропоновано багатофакторну кореляційну модель, в основу якої покладено дослідження розвитку та функціонування ринку біоетанолу в Україні.

Ключові слова: *альтернативна енергетика, ринок палива, економетрична модель.*

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Introduction

The rapid pace of post-industrial development in most countries objectively require society to find effective tools to preserve the ecological balance of the environment, compliance with the sustainability requirements and to inclusive growth transition. In the long run, one of these instruments is to replace primary energy sources with alternative sources. The countries of the world and Ukraine are sharply aware of climate and natural balance change, and their impact on health, the economic development and the environment. Human activities results (social, economic, ecological) lead to that governments are forced to consider and implement new environmental, economic and social policies on bioenergy development and use.

Formation and development of biofuel industry in the world operates on the basis of state regulation through laws, resolutions, regulations and programs. In the EU, the development and use of biofuels are regulated through the state support, namely directives, standards for biofuels, financial support for research and design-development work, contributing to the development of the biofuel industry and financial support for biofuel plants construction. Biomass is the largest source of renewable energy carrier in the European Union (EU) contributing to over 60% of renewable energy, with the majority of supply coming from domestic sources (Dafnomilis et al, 2017). Descriptive and statistical methods were used by Borawski and others to describe the changes in bioenergy development in the EU (Bórawski et al, 2019). The model, where multimodal combining multiple transportation modes, seasonal, and other data regarding the current situation of the market, and all the players are assumed to be perfectly competitive, that enable to optimize simultaneously the supply chain design and to find the equilibrium quantity of feedstocks, crude oil and final products in the integrated supply chain, have been designed by Najmi A. and others (Najmi et al, 2016). However, the issue of modeling the state of the European biofuel market has not been considered in recent years.

As for Ukraine, it is an energy-deficient country that is highly dependent on imported energy from Russia, Kazakhstan, Belarus and others. The price of imported energy is growing from year to year rapidly, because the primary energy production sources is reducing and, over time, may be completely depleted. It is necessary to promote actively the development and production of bioenergy fuels (biodiesel, bioethanol, biogas, solid fuel) in order for Ukraine to be a less dependent on primary energy sources imports country. This will help to reduce the country's energy dependence and unemployment rate in the country, to improve ecological environment and economy development of and agriculture in general.

Economics plays a critical role in creating a self-sustaining biofuels industry, so diorefinery remains a key concept for improving the economics of the biofuels industry (Littlejohn, 2018). Berndes G. determines strategies that induce a relevant development and exploit existing energy infrastructures in order achieve risk to reduction and lower costs reach; in order to implement them he proposed an attractive complement the present and prospective biofuel policies (Berndes et al, 2010). Karka P. conducted the study that became a useful source for biorefinery design studies especially in adopting a modular approach to represent and to analyse biomass process chains and market (Karka et al, 2017). Today, Ukraine needs to form a policy to promote the production of biofuels, which would be based at specifically developed models of the biofuel market.

The world biofuels market is developing rapidly, which is the reason for increasing interest to bioenergy in Ukraine, at the same time, the prospects of bioenergy in Ukraine have not been sufficiently explored, and the concept of potential for biofuel production and use in Ukraine needs to be revised (Lutsiak et al, 2019). The current state of Ukraine biofuels industry in and the possible ways of implementation of the world experience for the development of Ukraine biofuels market were determined by Kirieieva E (Kirieieva, 2018). Dibrova A. and Cheban I. carried out scenario modeling of Ukraine liquid biofuel market for 2019–2030 (Dibrova et al, 2018). In our opinion, the above mentioned determines the need for a thorough study of the biofuel market in Ukraine, based on global trends and domestic specifics and conditions.

Strengthening of Ukraine's integration into European economics and transformation of the global energy market trends revealed the formation of solid biofuels in the EU, including the acceleration of scientific progress and international energy cooperation in the field of energy and renewables market capacity increase (Bilotskiy, 2017). The state and prospects of renewable energy development in Ukraine were determined by Kudrya S. (Kudrya, 2015). Cheteni P. consider that in order for the biofuels market to function well, the government needs to iron some problems faced by farmers and create a support structure specifically for smallholder farmers who wish to do biofuel crops. In its quest to support smallholder farmers producing biofuels, the government should not neglect other smallholder farmers rowing non-biofuel crops (Cheteni, 2017). Zulauf C. and Prutska O. carried out SWOT analysis of biofuels industry development in Ukraine which allowed to affirm that Ukraine's agricultural sector is a potential resource for biofuels production, but the export orientation of Ukraine's agricultural sector and resulting foreign currency earnings

pose trade-offs if crops are diverted from exports to biofuels feedstock (Zulauf et al, 2018). Cheban I. and Dibrova A. with the AGMEMOD model use indicated that implementation of the direct state support, introduction of the system of returning and cancelling excise duty for biofuels producers will stimulate the achievement of the indicative target of 10 % biofuels' consumption by the transport sector (Cheban et al, 2020). However, at the modern conditions, it is not possible to be limited only by knowledge about production possibilities and direct state support, and it is necessary to determine the market capabilities, model its various states, design appropriate development scenarios and forecasts.

According to the fact, that biomass production is different to fossil fuels, biomass could reduce the industry's issues related to the fluctuation of the fossil fuel prices, as well as overcome concerns related to fuel security and diversity – as long as an efficient utilization of the limited biomass resources is reached and biomass is sustainably sourced (Mandova et al, 2018). Thus, in recent years, bioenergy has drawn attention not only as a sustainable energy source that may cope up with rising energy prices, but also may provide income to poor farmers and rural communities around the globe (Banerjee et al, 2019). Awudu A. and Zhang J. presented an introduction of the evolution of biofuels and the general structure of the biofuel supply chain, discussed the number of types of decision making levels and uncertainties that are inherent within the biofuel supply chain, provided important methodologies for modeling uncertainties in the decision making process, reviewed sustainability concepts and models that give perspectives to the social, economical and environmental concepts (Awudu et al, 2012). The above-mentioned makes it possible to state that the production and use of biofuels play a significant role in sustainable development goals achievment.

Liquid biofuels play a significant role in the global transition to renewable and sustainable energy from various ranges of sources, which include residues from forestry sources, agricultural material associated with food crops, including non-food energy crops etc (Sandesh et al, 2021). Taking into account the current trends and requirements imposed by the competitive environment, leading business entities should not only produce high-quality products, but also be ecologically responsible (Chaikin, 2018). Biofuel is a renewable energy source, its main advantage is environmental friendliness, and modern production methods make it possible to obtain fuel samples that have advantages over traditional products in terms of their characteristics and value (Gołębiewski et al, 2020). Additionally, the transformation of the energy systems encompasses technological, societal, cultural, economic, and environmental aspects and calls for a more important role for citizens and communities (Zabaniotou, 2018). Biofuel market organization and meta-organizations as conceptual lenses to analyse the dynamics and challenges of market creation through policy-making with sustainability goals were studied by Peixoto I. and Temmes A. (Peixoto et al, 2019). The fact that market and technology are currently barriers to biofuel development, however, implies that biofuel sustainability governance should monitor market and technology development and, whenever possible, guide their development towards generating more sustainable outcomes. However, the issues of the current state of the biofuel market models design need further study.

Methods and Materials

The methodological basis of the research is general scientific and specific methods of economic phenomena and processes cognition. Therefore, the following methods have been applied: logical generalization (while current situation on liquid bioenergy fuels market issues defining); monographic (while the recent research on liquid bioenergy fuels market functioning study); economic and statistical modeling (when econometric models of Ukraine liquid bioenergy fuels market formation and functioning design); correlation multifactor modeling (while Ukraine bioethanol market development and functioning study); abstract-logical (when obtained during the correlation analysis of Ukraine bioethanol market development data interpretation); heuristic (when key scientific and research findings generalization and highlighting the future research area).

To study the development and functioning of liquid bioenergy fuels market in Ukraine we used economic and mathematical justification in the form of the given market econometric models based on official statistics dada (2010-2020) design. In our research to conduct a statistical study when the correlation matrix design we used a statistical software environment – «R». «R» (programming language) – software environment for statistical calculations and graphic images of obtained results. «R» has significant capabilities for statistical analysis, including linear and nonlinear regression, classic statistical tests, time series analysis, cluster analysis and much more.

Results

Imported energy price increase and Ukraine's energy security reduce leads to the implementation and development of renewable energy sources use. Development and use of alternative energy in Ukraine is one of the priority state directions that is based on the implementation of new technologies and world experience use in the bioenergy fuels market development and functioning. Production and resource potential of Ukraine agro-industrial complex is characterized by the versatility of both production systems and climatic conditions contributing to the cultivation of a significant number of crops.

Econometric modeling of the bioethanol market in Ukraine was conducted to identify the main factors that affect the production volume, consumption (industrial), bioethanol export and import. According to the conducted study, we defined that the process of Ukraine bioethanol market modeling consists of the following stages:

- the most important factors selection – correlation analysis;
- multifactor correlation-regression analysis conduction – least squares method (LSM);
- designed models adequacy check – "variance inflationary factor" to check for multicollinearity, Goldfeld-Kwandt method to check for heteroskedasticity;
- obtained results description – method of deduction and induction, abstract-logical and graphic method.

During the study, multifactor correlation model, based on Ukraine bioethanol market development and functioning study was used. We used correlation analysis in order to establish the most significant factors influencing the bioethanol export. Correlation analysis is a statistical study of the relationship between random variables. It is designed to assess the relationship between two or more factors, which are called «variables», and it is aimed at the relationship between Xi and Yi. variables identification. In our case, they are bioethanol export, exported wheat volume and price, gasoline average cost etc. The direction and strength of the relationship between two variables is characterized by statistical criteria, the so-called correlation coefficient (R). The correlation coefficient (correlation ratio) shows how significant the effect of the trait Xi at Yi is.

As a result of conducted correlation analysis, it was determined that the volume and the price of exported wheat (x4), corn (x5) and A95 gasoline average price (x8) have got the greatest impact on bioethanol exports, trade balance and this type of biofuel in Ukraine consumption, correlation coefficients for which are 0.88, 0.84 and 0.71. From the mathematical statistics point of view, such correlation coefficient values indicate a close relationship between the variables. In the process of calculations, we used a software statistical

environment – «R», software environment for statistical calculations and graphical representations of the obtained results.

The significant impact on bioethanol imports have such factors as: corn export price (x5), with the correlation coefficient – 0.69; bioethanol production in Ukraine is affected by the wheat export price (x2) and corn export (x4) with correlation coefficients of 0.84 and 0.76. The consumption of bioethanol produced in Ukraine is influenced by such factors: the average cost of Brent oil (x7) and the average cost of A-95 gasoline at gas stations in Ukraine (x8). Their correlation coefficients are 0.64 and 0.59.

The least squares method, underlying the basis of regression analysis, that is used to statistically estimate the parameters of the regression model from empirical data, was also used during Ukraine bioethanol market study. Based on the above listed facts, the regression equations of five models of this market were obtained and their adequacy analyses has been conducted. The conducted multifactor regression analysis demonstrated that designed bioethanol market development and functioning models are inadequate and cannot be used for further analysis as most of the coefficients for factor characteristics (xi) are not statistically significant. Therefore, the latest mechanism of econometric analysis was used to conduct the study – stepwise regression using the two-way method "Bidirectional elimination". As the result of the stepwise regression method application statistically strong dependence equations were obtained (Fig.1).

As the result of step-by-step regression conduction we obtained the results which represent the dependence of the effective features (Yi) from factorial features (xi). Therefore, for example, the study shows that Ukraine bioethanol export (Y4) depends on factors such as corn export price, corn export (x5; x4) and the average cost of A-95 gasoline at gas stations in Ukraine (x8). At the same time, their dependence is strong and the model explains the large number of data variations and is important. Before proceeding to the description of the model, it is necessary to check the designed models on multicollinearity and heteroscadesticity (Tab.1).

Tab.1

Designed bioethanol market regression models for multicollinearity testing

Models	Y_1	Y_2	Y_3	Y_4	Y_5
Influencing factor*	X_2 1.030663	X_6 1.043601	X_3 1.131506	X_5 1.610341	X_3 1.122249
	X_4 1.030663	X_7 1.043601	X_4 1.131506	X_4 2.952745	X_5 1.230934
				X_8 2.165346	X_8 1.185123

Note *: X_1 – Ukraine wheat exports, ths. tons; X_2 – wheat export price, thousand USA dollars / t; X_3 – Ukraine wheat exports, ths. tons; X_4 – Ukraine corn export, ths. tons; X_5 – corn export price, thousand USA dollars / t; X_6 – the average

cost of A–95 gasoline at gas stations in Ukraine, USA dollars / l; X_7 – the average cost of Brent oil, USA dollars / barrel; X_8 – the average cost of A-95 gasoline at gas stations in Ukraine, ua hryvnias /l.
Source: author's calculations

Regression dependence	Regression equation	Test
Y_1 – bioethanol production in Ukraine, million liters	$Y_1 = 259761 + 436x_2 + 0.5x_4$	R^2=0.72 Statistically significant: b coefficient (p-val<0.001) and x_2 (p-val<0.05) x_4 (p-val<0.0001)
Y_2 – bioethanol consumption in Ukraine, million liters	$Y_2 = 155759 + 1533x_8 + 4731x_7$	R^2=0.86 Statistically significant: b coefficient (p-val<0.001) and x_1 (p-val<0.001) x_7 (p-val<0.01)
Y_3 – Ukraine bioethanol trade balance, million liters	$Y_3 = 15.53x_5 - 0.21x_4 + 34.17$	R^2=0.88 Statistically significant: b coefficient (p-val<0.001) and x_5 (p-val<0.001) x_4 (p-val<0.01)
Y_4 – Ukraine bioethanol export, million liters	$Y_4 = 19.68x_5 - 15.30x_4 - 8.57x_8 + 40.23$	R^2=0.94 Statistically significant: b coefficient (p-val<0.001) and x_5 (p-val<0.01) x_4 (p-val<0.001) x_8 (p-val<0.05)
Y_5 – Ukraine bioethanol import, million liters	$Y_5 = 2.41x_3 + 3.74x_5 - 2.69x_8 + 6.06$	R^2=0.74 Statistically significant: b coefficient (p-val<0.001) and x_3 (p-val<0.05) x_5 (p-val<0.001) x_8 (p-val<0.01)

Fig.1. Bioethanol market indicators by the stepwise regression method dependence regression equations adequacy analysis
Source: author's calculations

Tab.2

Ukraine bioethanol market development models
Goldfeld-Kwandt test for heteroskedasticity

Model	Variable	p-value	Conclusion
Model 1	Y_1 – bioethanol production in Ukraine, mil l	0.0065	heterescadesticity is not present
Model 2	Y_2 – bioethanol consumption in Ukraine, mil l	0.0083	heterescadesticity is not present
Model 3	Y_3 – Ukraine bioethanol trade balance, mil l	0.0097	heterescadesticity is not present
Model 4	Y_4 –Ukraine bioethanol export, mil l	0.0090	heterescadesticity is not present
Model 5	Y_5 – Ukraine bioethanol import, mil l	0.4512	heterescadesticity is present

Source: author's calculations

Conducted multicollinearity analysis shows that the evaluations of dispersion coefficients for all factors, all models do not exceed the value of 10, that is evidence of multicollinearity absence. We used heteroskedasticity in the further study, which means the heterogeneity of observations that are expressed in unequal (non-constant) variance of the random error of the regression (econometric) model. The presence of random errors heteroskedasticity leads to inefficiency of estimates, obtained by the least squares method. Therefore, testing models for heteroskedasticity is one of the necessary procedures when regression models design. The Goldfeld-Quandt test was conducted to perform heteroskedasticity on Ukraine bioethanol market development models (Tab.2) that makes it possible to evaluate the original model from observations from the beginning of the sample and from observations at the end of the sample.

Therefore, after the Goldfeld-Kwandt test, it was established that heterescades is present only in the fifth mode Y_5 – Ukraine bioethanol import, mil l. Consequently, it is statistically impractical to adjust the indicators since the sample is not deep enough and there are a large number of zero values (30 %). That is why, to study the patterns, which affect the biodiesel import it is advisable to study new factors sets. But given that the four previous models are statistically defined and adequate to describe the bioethanol market and there are enough of them. As the result of the regression analysis, we obtained the results which indicate that Ukraine bioethanol import, mil l. (Y_5) are effected by the factors such as X_3 – Ukraine wheat exports, ths. tons; X_5 – corn export price, thousand USA dollars / t and X_8– the average cost of A-95 gasoline at gas stations in Ukraine, ua hryvnias /l. Thus, the results obtained during the correlation analysis of Ukraine bioethanol market development were interpreted and the following conclusions have been drawn:

Bioethanol production volume. When the export price of wheat changes by 1 US dollar per ton the volume of bioethanol production in Ukraine will change by 436 thousand liters; when all other factors are constant, and when the corn exports volume by 1 thousand tons change, production volumes will increase by 0.5 thousand liters.

Bioethanol consumption in Ukraine. When the price changes by 1 US dollar for 1 barrel of Brant oil, Ukraine bioethanol consumption volume will change by 1533 thousand liters; and at change of the price of gasoline A-95 UAH / l volumes of consumption will increase by 4731 thousand l., when all other factors are constant. Presented links between the gasoline price and barrel of oil on the level of bioethanol as a fuel consumption are quite logical, as the oil price tends to increase, while the cost of bioethanol depends only on production technology and climatic conditions. Also important in this study is that missing (expected by us) multicollinearity between factor features: the gasoline price and the price of oil. This unexpected result could be explained by the fact that in Ukraine the formation of fuel prices is based on additional factors, except for the price of oil.

Trade balance. With corn export price increase (x5) for 1 US dollar, trade balance of bioethanol foreign trade (У3), will decrease by 15.53 million liters; with corn exports increase (x4) per 1 thousand tons, trade balance of bioethanol foreign trade (У3) will decrease by 0.21 million liters, when all other factors are constant. Therefore, corn export price increase leads to bioethanol production decrease, and accordingly its export, and as the result – trade balance decrease. The volume of corn seed exports is the second negative factor of the foreign trade balance, and due to the fact, that corn is the main raw material for bioethanol production in Ukraine. Consequently, the increase in exports has the negative impact at the volume of raw materials for the production process of this type of fuel, as a result, production volumes fall, and, accordingly, the deterioration in the trade balance.

Bioethanol export. With corn export price increase (x5) by 1 US dollar total exports of domestic bioethanol, million liters (У4) increases by 19.68 million US dollars. With corn exports increase (x4) by 1 million US dollars, bioethanol export (У4) will

decrease by 15.30 million US dollars, when all other factors are constant. Export is the basis for the trade balance calculation, therefore, all justifications that were set out in the previous paragraph could be used for logical justification of factors that are affecting exports.

In the process of analyzing the development of the bioethanol market in Ukraine and econometric models design using regression analysis factor features that affect its development in the future were studied. As the result of econometric research methods use when studying the bioethanol market two econometric models were designed: production model and bioethanol consumption model in Ukraine. The models were designed taking into account such statistical tests: compliance with the determination coefficient (R2>0.65) and P–value (P–value > 0.005), multicollinearity test, heterescadesticity test.

$$Y_{prod} = 259761 + 436 * \chi_{P_{WHEAT}} + 0.5 * \chi_{corn\_exp})$$
$$R^2 = 0.72; \ P - value > 0.0000003,$$

where:

Y_{prod} – Ukraine bioethanol production volumes, mil l;

$\chi_{P_{WHEAT}}$ – wheat export price, thousand USA dollars / t;

χ_{corn_exp} – corn exports volume, ths. tons.

$$Y_{consamp} = 155759 - 1533 * \chi_{Brent} + 4731 * \chi_{P_A-95}$$
$$R^2 = 0.86; \ P - value > 0.00004,$$

where:

$Y_{consamp}$ – Ukraine bioethanol consumption volumes, mil l;

χ_{Brent} – the average cost of Brent oil, USA dollars / barrel;

χ_{P_A-95} – the average cost of A-95 gasoline at gas stations in Ukraine, ua hryvnias /l.

Based on the obtained results, we can conclude that the increase in wheat export price by 1 US dollar leads to the increase in bioethanol production by 436 thousand liters. Under such circumstances, bioethanol production will increase to 398 million liters. The second hypothesis is that the export price will decrease by 5 % annually and this will lead to bioethanol production to 357 million liters reduce by 2023.

Two assumptions were also considered when forecasts scenario to stimulate bioethanol consumption in Ukraine design: 1) annual growth of the average price of Brent oil and A 95 gasoline at Ukrainian gas stations by 5 %; 2) annual reduction of the price of Brent oil and A 95 gasoline at Ukrainian gas stations by 5 %. According to the first scenario, bioethanol consumption will increase to 435 million liters by 2023, according to the second scenario it will decrease to 325 million liters.

Discussion and Conclusion

The study was conducted to forecast the development and functioning of the bioethanol market in Ukraine until 2023, that allowed to establish the following: firstly, the volumes of bioethanol production in Ukraine are influenced by the volumes of corn exports and the wheat export price. At the current conditions of our country economic development it is impossible to influence world oil prices, while the regulation of domestic exports is the potential mechanism for regulating foreign economic activity through the non-tariff measures system. It is important to take into account international agreements between Ukraine and other countries and international organizations on export regulation methods and measures; secondly, bioethanol consumption in Ukraine is affected by the cost of a barrel of oil on the world market and the average price of A 95 gasoline at domestic gas stations (the correlation degree is significant, r = 0.64 and r = 0.59). When developing further programs for alternative energy development, additional indirect tax on fuel sales in Ukraine will promote the bioethanol production increase; thirdly, it is expedient to form in the country the culture of oil products consumption at the conditions of low-carbon development of economy under global climatic challenges and taking into account future trends.

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