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PROSPECTS OF BIODIESEL PRODUCTION: THE PLACE AND ROLE OF UKRAINE IN THE CONTEXT OF IMPLEMENTATION OF THE EU GREEN COURSE

Oleksandr Klymchuk
Institute of Feed Research and Agriculture of Podillia, Ukraine
E-mail: kuskovas21@gmail.com

Olga Khodakivska
National Science Center "Institute of Agrarian Economics", Ukraine
E-mail: iae_zem@ukr.net

Olena Kireytseva
National University of Bioresources and Nature Management, Ukraine
E-mail: ox73@ukr.net

Olga Podolska
State Biotechnological University, Ukraine
E-mail: o_podolskaya@ukr.net

Iryna Mushenyk
Podillia State University, Ukraine
E-mail: mushenik77@ukr.net

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ABSTRACT

The purpose of the study is to conduct a systematic analysis of global processes of biodiesel production and to establish priority areas of biodiesel production in Ukraine based on the calculation of economic efficiency of production from different raw materials to ensure energy independence of the agro-industrial sector. The article highlights the historical processes, current trends and prospects for the production and consumption of biodiesel in the world. Modern approaches to the formation, development and support of biodiesel production in the European Union are outlined. The following methods as well as techniques have been used during the research: economic-historical and analytical generalizations; monographic; graphic; statistical analysis; prognostication; abstract-logical. Statistical results have been processed on a personal computer using special Windowsxp applications: Word, Excel 7.0 and the system "STATISTICA". The economic efficiency of biodiesel production in Ukraine from different types of raw materials (rapeseed, sunflower, soybean) is considered. Modern

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approaches to efficient biodiesel production in Ukraine and perspective directions of formation of raw material base for increase of biodiesel production are offered.

Keywords: *management, agro-industrial complex, biofuel industry, biodiesel, economic efficiency, energy independence*

1. INTRODUCTION

Macroeconomic and technical-technological priorities of different countries are formed and further changed under the influence of a significant set of objective and subjective factors determined by the level of economic development, resource provision of the country, social status, processes of internal decentralization, environmental component etc.

The beginning of the XXI century has been marked by a transitional period in the formation of the world energy system. Today the current problems of the economy are the growth of current production costs and specific investments in the energy sector, the formation of a favorable socio-political climate for further development of the fuel and energy complex on the basis of sustainable development, the development by the world community of perfect methods of regulation and a coordinated strategy for the development of world energy. The problem of energy saving is multifaceted and is a necessary strategic direction for the efficient use of production capacity with optimal energy costs.

Increasing the national wealth of our country, improving the living standards of the population and its socio-economic status will largely depend on the rational use of their own energy, which at the present stage of management becomes especially relevant. One of the ways out of Ukraine's economic and energy crisis is the implementation of broad state interventionism, using the modern technical and technological base as well as the latest achievements in the field of scientific and technological progress with innovative development.

The implementation of these measures should be ensured through the mobilization of domestic financial sources through the improvement of monetary, budgetary, fiscal and depreciation policies, transparent privatization and re-privatization of state facilities, as well as creating favorable conditions for increasing foreign direct investment in renewable energy. It should be noted that the size of investment revenues and the level of national production, which directly depend on structural changes in the economy and the national fuel and energy complex, which requires radical changes in the direction of accelerated transition to renewable energy, including production of various biofuels.

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The set of resource-saving and energy-efficient measures should be implemented on the basis of practical implementation of managerial, economic, organizational, technological and environmental components aimed at rational consumption of fuel and energy resources with gradual introduction and increase in energy consumption of the most economically viable energy sources, where biofuels, including biodiesel should have taken the main place in Ukraine.

2. LITERATURE REVIEW

Diesel fuel can be effectively replaced by biodiesel. The history of its use for internal combustion engines has been begun in 1990 at the World's Exhibition in Paris, where Rudolf Diesel won the highest award for his first engine, which then has been ran on pure peanut oil. However, at that time the cost of production of such biofuels has been much higher than the production of traditional petroleum fuels. Therefore, the practical use of biodiesel has been suspended until the end of the twentieth century, when intensive development of efficient technologies for biodiesel has been resumed (Balasubramanian & Steward, 2019; Bart, Palmeri & Cavallaro, 2010).

The modern use of world energy is gradually shifting to renewable energy due to the problems of climate change and environmental pollution. Renewable energy from biomass is one of the green options to meet the ever-growing demand for cleaner energy. Due to its clean, renewable and environmentally friendly nature, biodiesel is a possible alternative to petroleum fuels (Qadeer et al., 2021). Increased interest in biodiesel is due to its environmental friendliness, and although biodiesel is not completely environmentally friendly, but compared to its petroleum counterpart, it is still cleaner and consumes fewer harmful compounds and emissions into the environment. Thus, the use of biodiesel as a motor fuel reduces the emission of almost all harmful substances: emissions of hydrocarbons compared to petroleum is reduced by 56%, particulate matter - by 55%, carbon monoxide - by 43%, nitrogen oxides - by 5-10%, soot - by 60% (Kaletnik, Oliynichuk & Skoryk, 2012).

Biodiesel is a highly efficient vegetable oil fuel and lubricant that can be used for internal combustion engines as an additive to conventional diesel or in its pure form. In the process of mixing, a biodiesel mixture is obtained, denoted as “B XX”, where “B” means biodiesel fuel, and “XX” indicates the percentage of biodiesel content in the mixture with diesel

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fuel (for example, B 2, B 5, B 20 etc.), or pure biodiesel - B 100. Such biofuel when exposed to soil or water undergoes almost complete biodegradation (99%) in 28 days as a result of microorganisms. In the production of biodiesel there is a closed carbon cycle: it contains almost no sulfur, it is a relatively safe fuel because the combustion temperature exceeds 100ºC (Gavrish, 2008).

From the first attempts to enter the market, biodiesel has met with fierce opposition from automakers. They have not guaranteed the operation of cars whose owners filled the tank with biodiesel instead of traditional petroleum fuel. But with the gradual rise in black gold prices and the concern of most of humanity about environmental issues, car owners have begun to pay more attention to the use of biofuels and produce cars that can run on diesel-biodiesel blends. Currently, biodiesel is widely used in many countries of the European Union and the world. Its production for use in its pure form requires considerable additional investment, so it is introduced the mixing of petroleum fuel with rapeseed oil or used as an additive in the range of 5-30% to traditional diesel fuel in most countries (Dubel, 2010).

However, despite all the environmental benefits, biodiesel cannot be widely used as a complete replacement fuel for conventional diesel fuel. The main reason, which has been repeatedly mentioned by many researchers, is the higher cost of production. Reducing the cost of biodiesel production (unit cost) can be achieved by increasing the productivity of technologies to increase yields, reduce capital investment and reduce the cost of raw materials. They require careful economic analysis among the available possible technological alternatives, catalysts, and alternatives to raw materials so that the best option can be chosen economically. In this regard, a number of studies have been conducted to study the economically best way to produce biodiesel as a fuel substitute (Gebremariam & Marchetti, 2018).

In energy-dependent countries, much attention is paid to the development of biodiesel production and consumption, especially in the agro-industrial sector of the economy. It is believed that the demand in the medium term for oilseeds in the European Union will grow much faster than the demand for feed and food markets, bringing agro-industrial production to a new level of investment (capital). Until recently, agriculture could only rely on part of the money spent by mankind on food. However, these revenues at reasonable prices and demand have not been insufficient, so the support of the agricultural sector has been required a heavy burden on the state budget.

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Thus, the ability to provide consumers with environmentally friendly energy gives agriculture a new direction of development. Biodiesel production allows the cultivation of new agricultural land that has not been used for a long time and creates new jobs. Thus, biodiesel is widely used in many countries around the world and has a positive trend in the growth of total world production.

The purpose of the study is to conduct a systematic analysis of global processes of biodiesel production and to establish priority areas of biodiesel production in Ukraine based on the calculation of economic efficiency of production from different raw materials to ensure energy independence of the agro-industrial sector.

3. DATA AND METHODOLOGY

The speed and efficiency of solving Ukraine's energy security problems are determined by its economic capacity, and important problems of the energy sector are the growth of production costs and specific investments in energy. The system of effective management of production processes should take into account territorial features and consume the optimal production-appropriate amount of energy resources, giving priority to biological fuels, including biodiesel.

The following general and special scientific methods as well as techniques have been used during the research: economic-historical and analytical generalizations; monographic; graphic; statistical analysis; prognostication; abstract-logical. Statistical results have been processed on a personal computer using special Windowsxp applications: Word, Excel 7.0 and the system "STATISTICA".

4. RESULTS AND DISCUSSIONS

The development of world production and consumption of biodiesel is a priority innovative direction of energy security of both the agricultural sector and the economy as a whole. Rapid growth of capacities in the production and consumption of biodiesel indicates that the world market has a progressive dynamics and significant prospects for the future (Figure 1).

World production and consumption of biodiesel is based on and subordinated to the principles of public policy, which includes legislative incentives and tax benefits.

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According to the OECD, in 2013, 30.2 billion liters of biodiesel have been consumed and 30.0 billion liters have been produced. It is projected that by 2026 the dynamics of biodiesel consumption in the world will increase to 39.1 billion liters at a price of 92.3 dollars. USA / ch (Figure 2).

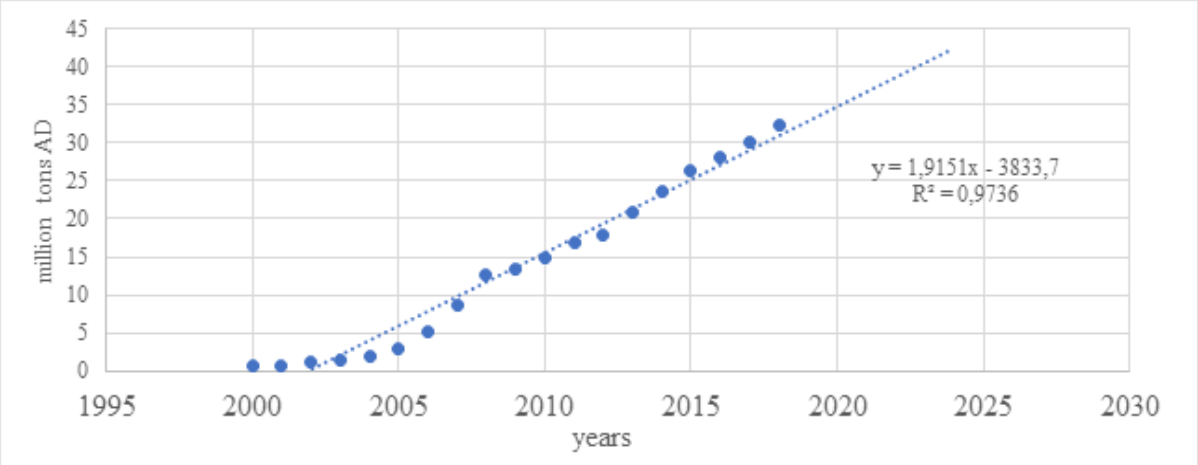

Figure 1: World processes and prospects for biodiesel production
Source: Knoema (2018) and calculations of the authors.

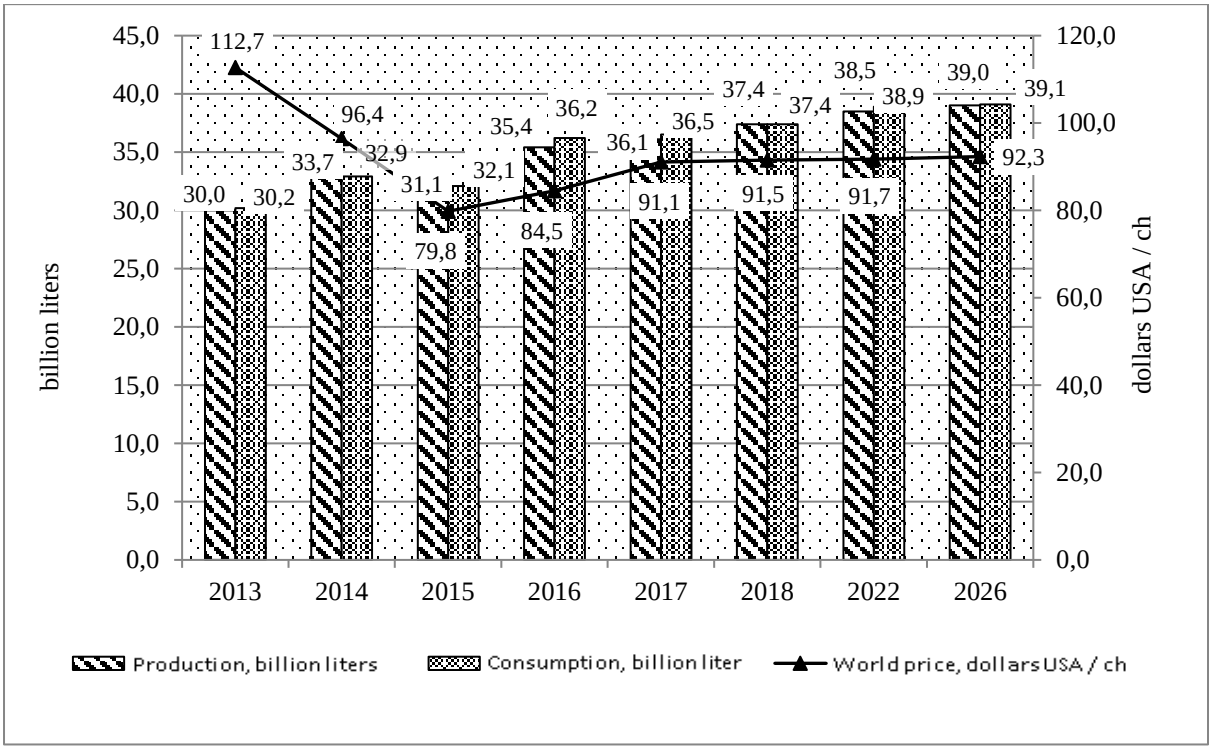

Figure 2: World trends and prospects of production, consumption and pricing policy for biodiesel
Source: OECD (N/D) and the authors' calculations

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Prices for biodiesel in the world for the forecast period will be in the range of 112.7-92.3 dollars. US / ch, which is much higher than the price of regular fuel. High prices for bioenergy fuels are due to rising raw material costs and rising costs for biodiesel production.

Biodiesel production in 2018 has been increased by 3.6% and amounts to 37.4 billion liters compared to last year - 36.1 billion liters. According to OECD experts, biodiesel production will be 39.0 billion liters by 2026. This growth will be insignificant, as the pace of development of this industry has been galloping for five years. Leading positions in the field of biodiesel production belong to the EU countries.

The rate of biodiesel production will increase in the future, which may lead to:

a) a rapid increase in demand for oilseeds;
b) increased interest (demand) in imported raw materials;
c) rising prices for oilseeds;
d) suspension of the development of the biofuel market.

The European Union aims to achieve a share of 20% of final renewable energy consumption by 2020 and 27% by 2030. The transition to a low-carbon energy system is a key priority for EU countries, which have developed a number of different policy documents and tools to promote renewable energy.

Key instruments at EU level for the promotion of renewable energy include directives, in particular the Renewable Energy Directive (2009) (Klymchuk & Khodakivska, 2019). Today, Europe uses large-scale and small-scale biodiesel production technology, which is based on the "German" and "French" models (Figure 3).

It should be noted that the consumption of manufactured biodiesel in European countries is carried out on two basic schemes. The first is the "French" scheme, where biofuels are consumed by cars and buses, as the use of conventional diesel fuel while driving is banned in some cities due to excess emissions. Penalties for non-compliance with toxic emission standards exceed the difference between the cost of biodiesel and diesel fuel. Biodiesel is added to conventional diesel fuel up to 5% concentration (Pryvarnikova and Shevchenko, 2014; Melnyk, 2019).

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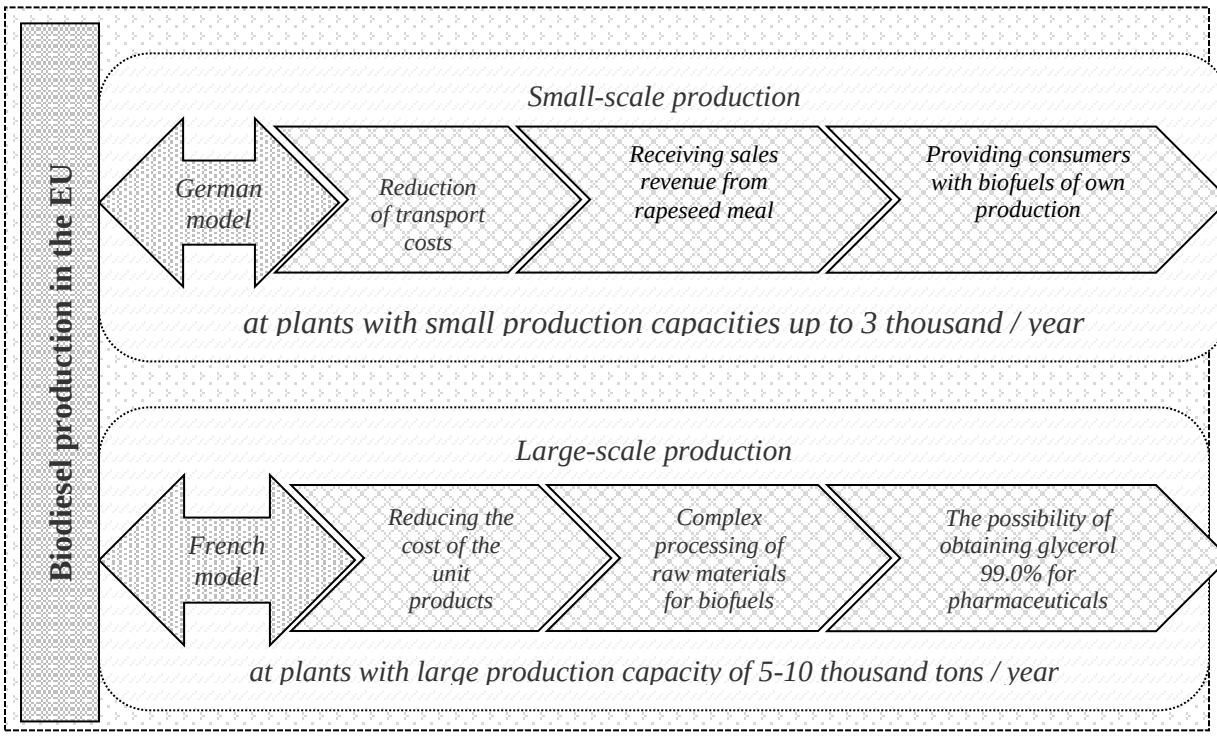

Figure 3: Characteristics of the main models of biodiesel production in the European Union
Source: formed by the authors on the basis of Pryvarnikova and Shevchenko, (2014) and Melnyk (2019)

In the "German model" biofuel production is up to 3 thousand tons per year due to farming and cooperative production and consumption. Farmers or farmers' cooperatives grow rapeseed, the sown area of which reaches 10-12% of arable land. Since farmers themselves grow raw materials and produce biofuels for their own needs, the German government has provided a subsidy to each farmer since 2001: about 360 euros per hectare on which rapeseed is grown for technical purposes. From each ton of rapeseed you can get about 300 kg of oil, and from it - 270 kg of biodiesel (Pryvarnikova & Shevchenko, 2014; Faizov, 2003).

Germany is one of the main leaders in the production and consumption of biofuels in the world, because the country has a leading position in research and development on biofuels, and most of the country's arable land is reserved for growing energy crops. Biofuel production is on a commercial basis due to the absence of political barriers and favorable legislative incentives. In 2017, biodiesel production capacity in Germany has been amounted to 3.04 million tons, and production increased to 4.0 million tons / year. In total, there are more than 50 biodiesel and bioethanol plants in the country. As of 2018, there are 26 biodiesel plants in Germany with a total production capacity of 3.04 million tons / year.

The largest biodiesel plants are: Cargill GmbH (Frankfurt am Main) with a production capacity of 300 thousand tons / year, New Natural Energies West GmbH (Neuss) - 260

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thousand tons / year, Mercuria Biofuels Brunsbüttel GmbH (Brunsbüttel) - 250 thousand tons / year, Louis Dreyfus commodities Wittenberg GmbH (Lutherstadt-Wittenberg) - 200 thousand tons / year, Biopetrol Rostock GmbH (Rostock) - 200 thousand tons / year and others (Bockey 2018).

Germany produces and sells pure B 100 biodiesel, which is sold at 1,500 gas stations. About 30% of biodiesel is distributed through a network of municipal filling stations, and 7% through major consumers or operators of municipal fleets, taxi companies and more. More than 65% of total biodiesel production is consumed by truckers, taxi drivers and farmers (Bockey 2018). Thus, the development of biodiesel production in Germany depends on the stable development of demand in the domestic market.

In France, there are four biodiesel plants with a total production capacity of over 360 thousand tons / year: Compiègne - 60.5 thousand tons / year, Gran Curon - 180.5 thousand tons / year, Verdun - 33, 5 thousand tons / year and Bussen - 33 thousand tons / year (Faizov, 2003). In 2017, biodiesel production has been increased to 2.0 million tons / year, and production capacity has been amounted to 1.7 million tons.

The strategy of using biodiesel or MERO (methyl-ether-rapeseed-oil) is a coordinated system between producers and refineries, which use biodiesel as an additive to conventional diesel fuel. This type of fuel is called "Dister", that is officially recognized by the French authorities and is distributed by oil companies in two forms (Bart, Palmeri & Cavallaro, 2010): 1) in the form of 5% mixture ("Shell": 2%) with fossil diesel fuel to improve the lubricity of the latter; 2) in the form of a 30% mixture used in more than thirty cities that are members of the Club des Villes Dister, the main purpose of which is to take advantage of the environmental benefits of biodiesel.

Thus, the development and use of biodiesel in France is due to legal protection and a common marketing strategy between biofuel producers and oil companies. And the production of biofuels for France is an alternative in agriculture on land withdrawn from agricultural use for non-food production (the share of land is 70% or 410 thousand hectares) (European e-Justice Portal, 2018).

With the growth of production capacity of biodiesel plants, the efficiency of their activities increases, and the cost of production decreases. Analysis of the peculiarities of biodiesel production in developed countries confirms that biodiesel plants with a capacity of

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up to 5 thousand tons of products per year are unprofitable because they cannot compete with large plants with an annual capacity of 20-100 thousand tons of biodiesel at the cost of the final product as well as ensure proper control over the quality of raw materials and manufactured biofuels (Kaletnik, Oliynichuk and Skoryk, 2012; Klymchuk, 2020).

The calculation of forecast indicators of world consumption and production of biodiesel for the period 2021-2025 is characterized by significant growth rates (Table 1).

Table 1: Forecast of world biodiesel production

Years of research	World production of biodiesel	
	million tons AD	increase, ±%
2021	36,6	5,5
2022	38,6	5,5
2023	40,5	4,9
2024	42,4	4,7
2025	44,3	4,5
Average value	40,5	5,0

Source: calculated by the authors

The obtained forecast results indicate that starting from 2023 the world production of biodiesel will exceed the mark of 40 million tons AD. with an average annual growth of 5.0%. It should be noted that the requirements for the mandatory content of biofuels in petroleum fuels exist in 62 countries around the world and they stimulate the growth of the biodiesel market. According to FAO forecasts, world biodiesel production will also continue to grow. The largest producers will be the EU - 55%, the United States - 15%, Brazil - 8%, Thailand and Argentina - 3%.

In its directives, the European Union has adopted a plan according to which the share of biofuels used by the European fleet should be constantly growing in the future. Biodiesel has been the first liquid biofuel to be produced in the EU since 1990s. Biodiesel now accounts for 70% of total alternative fuel consumption by vehicles in Europe. The largest producers of biodiesel among the EU countries are Germany, France, Italy, Spain and the Netherlands.

The main reason why the production and consumption of biodiesel in the European Union has begun to grow rapidly is the growing concern of the population about environmental problems (air pollution in large cities, global warming). In recent years, another problem has been added to these problems - the desire to ensure the energy independence of EU member states. This reason is more relevant today than ever for Ukraine.

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All this, as well as the expected effect of the Association Agreement between Ukraine and the European Union, the implementation of the Sustainable Development Strategy Ukraine 2020 require urgent changes in agricultural policy and strategy. First of all, the vector should be directed in the context of ensuring the competitiveness of agriculture, creating conditions for investment, implementing the principles of free and undistorted competition in trade relations, ensuring the sustainable development of agricultural production. In turn, this requires a scientific and methodological approach to assess the level of competitiveness of agriculture, tracking its dynamics, development and implementation of effective measures to improve it (Patyka et al., 2021).

It should be noted that in Ukraine the process of industrial production of biodiesel has not been established yet, but small agricultural enterprises and farms have already produced it for their own needs (about 20 thousand tons). According to the developed State program, the use of biodiesel should increase to 5.75% of total diesel fuel use, and by 2015 - up to 15% in Europe by 2010 (Kaletnik, 2008).

The technology of energy production from biomass is promising and should be developed in Ukraine (Jiang et al., 2019), active research is conducted on the efficiency of bioethanol production from sugar beets (Tsvei et al., 2020), but for the agro-industrial sector the priority is biodiesel. In the balances of economic calculations of biodiesel production, in addition to the price for ether, a significant role is played by funds from the sale of meal (about 2/3 of the mass of rapeseed). Given the available fat content, the storage period of meal should not exceed 3 months.

The proportion of meal in mixtures for individual groups of animals is differentiated. The largest amount (up to 40%) can be part of feed mixtures for cattle for fattening, up to 30% - for dairy cows, and for poultry - only up to 5%. The small proportion of meal in poultry feed is due to the high content of fiber in meal, which is a limiting factor. Attempts to apply breeding methods and genetics to reduce fiber content by increasing seed weight and changing the structure of the seed coat and mechanical degreasing of rapeseed have not yielded technical results that would reduce the fiber content. An additional incentive for the processing of rapeseed into ethers is the possibility of obtaining glycerols, which are not harmful to the environment and for which global demand is growing (Kaletnik, Oliynichuk & Skoryk, 2012).

In the context of the study, it is proved the necessity to improve the formation of the price mechanism for biofuels in the direction of a strategic transition to a pricing system that

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could timely influence on market regulation and reduce price fluctuations during the marketing year. Given the growing level of profitability, biofuel production in Ukraine should be considered as a significant alternative to traditional fuel and energy resources. The calculations indicate that the production of the finished bioenergy product for consumption is characterized by greater economic benefits than the mass export of raw materials, in particular rapeseed (Table 2).

Table 2: Comparative economic efficiency of rapeseed sales and production of biodiesel from it in Ukraine, 2016-2020

Indexes	**Sales of 1 ton of rapeseed**	
	domestic market	export
Total cost, UAH	6181,8	6181,8
Sales price, UAH	11150,0	12000,0
Profit, UAH	4968,2	5818,2
The level of profitability,%	80,4	94,1
Production of biodiesel from 1 ton of rapeseed		
Seed processing costs, UAH		1090,9
Total costs, UAH		7272,7
Biodiesel yield, l		400,0
Price of 1 liter of biodiesel, UAH		23,0
Total cost of biodiesel, UAH		9200,0
The cost of the cake, UAH		3025,0
The cost of glycerin, UAH		2608,2
Cost of manufactured products, UAH		14833,2
The cost of 1 liter of biodiesel, UAH		18,18
Profit, UAH		7560,5
The level of profitability,%		104,0

Source: Grain Trade (2021) and calculations of the authors

When selling 1 ton of rapeseed on average in 2016-2020, the level of profitability in the domestic market has been 80.4%, and when exporting - 94.1%. Instead, the introduction of domestic production of biodiesel from rapeseed provides a level of profitability of 104.0% with a cost of 1 liter of biodiesel 18.18 UAH.

At the same time, during this period the average price for diesel fuel has been 25.92 UAH for 1 liter.

In addition to rapeseed, sunflower seeds can be used to produce biodiesel. As a result, a comparative economic efficiency of sunflower seed sales and biodiesel production in Ukraine has been carried out (Table 3).

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Table 3: Comparative economic efficiency of sunflower seed sales and biodiesel production in Ukraine, 2016-2020

Indexes	**Sales of 1 ton of sunflower seeds**	
	domestic market	export
Total cost, UAH	7142,8	7142,8
Sales price, UAH	10256	10900
Profit, UAH	3113,2	3757,2
The level of profitability,%	43,6	52,6
Production of biodiesel from 1 ton of sunflower seeds		
Seed processing costs, UAH		1260,5
Total costs, UAH		8403,3
Biodiesel yield, l		420,0
Price of 1 liter of biodiesel, UAH		23,0
Total cost of biodiesel, UAH		9660,0
The cost of the cake, UAH		1672,0
The cost of glycerin, UAH		2759,4
Cost of manufactured products, UAH		14091,4
The cost of 1 liter of biodiesel, UAH		20,01
Profit, UAH		5688,1
The level of profitability,%		67,7

Source: Grain Trade (2021) and calculations of the authors.

When selling 1 ton of sunflower seeds on average in 2016-2020, the level of profitability in the domestic market has been 43.6%, and when exporting - 52.6%. Instead, the introduction of domestic production of biodiesel from sunflower seeds provides a level of profitability of 67.7% with a cost of 1 liter of biodiesel 20.01 UAH, while during the study period the average price of mineral diesel fuel has been 25.92 UAH for 1 liter. Also in modern conditions of development of the crop industry in the structure of sown areas soybean, which has an export orientation and can be used as a raw material in the production of biodiesel, is gaining significant weight. Therefore, comparative economic efficiency of soybean seed sales and biodiesel production in Ukraine has also been carried out (Table 4).

When selling 1 ton of soybean seeds in 2016-2020, the level of profitability in the domestic market has been 68.9%, and when it has been exported - 93.0%. Instead, the introduction of domestic production of biodiesel from soybean seeds provides a level of profitability of 89.5% with a cost of 1 liter of biodiesel 47.19 UAH. At the same time, for the period 2016-2020, the average price for diesel fuel has been 25.92 UAH for 1 liter. Thus, under the current pricing policy for oilseeds (rapeseed, sunflower, soybean) and petroleum diesel fuel, the process of biodiesel production in Ukraine will be economically viable from rapeseed and sunflower seeds and economically unprofitable from soybean seeds.

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Table 4: Comparative economic efficiency of soybean seed sales and production of biodiesel from it in Ukraine, 2016-2020

Indexes	**Sales of 1 ton of soybean seeds**	
	domestic market	export
Total cost, UAH	6217,6	6217,6
Sales price, UAH	10500	12000
Profit, UAH	4282,4	5782,4
The level of profitability,%	68,9	93,0
Production of biodiesel from 1 ton of soybean seeds		
Seed processing costs, UAH		1097,2
Total costs, UAH		7314,8
Biodiesel yield, l		155,0
Price of 1 liter of biodiesel, UAH		23,0
Total cost of biodiesel, UAH		3565,0
The cost of the cake, UAH		6552,0
The cost of glycerin, UAH		1020,6
Cost of manufactured products, UAH		13864,6
The cost of 1 liter of biodiesel, UAH		47,19
Profit, UAH		6549,8
The level of profitability,%		89,5

Source: Grain Trade (2021) and calculations of the authors

5. CONCLUSIONS AND RECOMMENDATIONS

Despite the high and previous high levels of economic efficiency of rapeseed and sunflower processing into biodiesel and a number of positive aspects of economic growth from biodiesel consumption in the agricultural sector of the economy, mineral diesel fuel continues to be used in the vast majority of Ukraine. To ensure the industrial production of biodiesel, a significant amount of oilseeds (rapeseed, sunflower, soybean, mustard, ryegrass, etc.) can be used as raw material. Programming the levels of oilseeds and optimizing the conditions of their cultivation for the production of cheap biomass is possible only with the use of scientific methods of production planning and labor organization with the inevitable use of innovative and computer technologies. It is also necessary to take into account the natural and economic conditions of Ukraine and the peculiarities of the development of the market of oilseeds as raw materials for industrial production of biodiesel.

The analysis of the calculations indicates that Ukraine's own production of biodiesel from rapeseed and sunflower causes a decrease in prices for mineral diesel fuel, obtaining high-quality feed for the development of the livestock industry and leveling the existing disparity in prices for agricultural, industrial and energy products. Intensive and dynamic development of bioenergy requires comprehensive optimization of this process, taking into account the needs

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of both the fuel and food sectors of the economy, as well as state regulation of exports of biofuel raw materials.

A perspective direction in the production of biodiesel is the use of special types of algae. They are the simplest plant organisms that can grow even in very harsh conditions: in salt lakes, deserts, where crop production is not practiced and even impossible in terms of existing climatic conditions. In addition, algae play an important role in the accumulation of carbon dioxide from the air, and produce a number of useful by-products. Algae are universal organisms that do not have a true root system or leaves. Unlike plants, algae do not consume water and nutrients through the roots, and do not release them through the evaporation of the leaves. In a closed system, algae need 99% less water than any other crop. Due to the fact that aquatic plants do not have a strong stem and roots and accumulate nutrients over their entire surface, algae are able to grow biomass much faster than any agricultural plant. The average lipid content in algae cells varies from 1 to 70%, and under certain conditions can reach up to 90% by weight of dry matter. Algae lipids are already used in the food and pharmaceutical industries. In addition, lipids are high-energy compounds - they burn about twice as much energy as burning carbohydrates or proteins. It follows that the lipid-rich biomass of microalgae can be successfully used as a raw material in the production of biofuels.

REFERENCES

Balasubramanian, N., & Steward K. F. (2019). Biodiesel: History of Plant Based Oil Usage and Modern Innovations. **Substantia** 3(2) Suppl. 1, 57-71. DOI: 10.13128/Substantia-281

Balabash, O., Kuznetsova, I., Karpenko, J., Dudziak, O., & Semenyshena, N. (2020). Management of Biofuel Production Development on the Basis of Scenario Planning. **Journal of Environmental Research, Engineering and Management**. 76(3), 35–46, DOI: 10.5755/j01.erem.76.3.25681.

Bart J. C. J., Palmeri N., & Cavallaro S. (2010). **Biodisel science and technology: from soil to oil.** Cambridge : Woodhead Publishing.

Bockey, D. (2018). Biodiesel 2017/2018 Assessment report and outlook : Excerpt from the UFOP annual report. Germany : UFOP.

Dubel, A. V. (2010). Economic mechanism of formation and functioning of the market of rape and products of its processing. **Innovative economy**, 5, 194–198.

European e-Justice Portal (2018). **European Judicial Atlas in civil matter**. Homepage.URL: http://www.europa.eu.int/comm/energy_transport/atlas/html/biordmarfutc.html

Faizov A. V. (2003). Economic and ecological needs of rapeseed production and processing in Ukraine. Bulletin of the Chernivtsi Trade and Economic Institute of KNTEU. **Ser. Econom. science**. 3(S), 271–282.

ISSN: 2236-269X
DOI: 10.14807/ijmp.v13i3.1990

Gavrish, V. I. (2008). Formation of economic incentives for diesel biofuel production. **Economics of agro-industrial complex**, 3, 121–125.

Gebremariam, S. N., & Marchetti, J. M. (2018). Economics of biodiesel production: Review, **Energy Conversion and Management**, 168, 74-84. DOI: https://doi.org/10.1016/j.enconman.2018.05.002.

Grain Trade (2021). **Electronic grain exchange of Ukraine**. Purchase prices for grain in Ukraine. URL: https://graintrade.com.ua/

Jiang, Y., Havrysh, V., Klymchuk, O., Nitsenko, V., Balezentis, T., & Streimikiene D. (2019). Utilization of Crop Residue for Power Generation: The Case of Ukraine. **Sustainability**, 11(24), 7004. doi:10.3390/su11247004

Kaletnik G. M. (2008). Development of the market of energy crops for bioethanol production. AgroIncom. (5-6), 10-15.

Kaletnik, G. M., Oliynichuk, S. T., & Skoryk, O. P. (2012). **Alternative energy of Ukraine: features of functioning and prospects of development: monograph**. Vinnytsia: "Edelweiss and K".

Klymchuk, O. V., & Khodakivska, O. V. (2019). Regulatory policy of competitive biofuel production in Ukraine. **Economics of agro-industrial complex**, 5, 6-14. DOI: https://doi.org/10.32317/2221-1055.201905006

Klymchuk O. V., Khodakivska O. V., Kovalov B., Brusina A., Benetyte R., Momotenko I. (2020). World trends in bioethanol and biodiesel production in the context of sustainable energy development. **International Journal of Global Environmental Issues**, 19(1/2/3), 90–108. DOI: 10.1504/IJGENVI.2020.114867

Knoema (2018). **Biodiesel production by countries**, [online] URL: https://knoema.com/atlas/topics/Energy/Renewables/Biodiesel-production

Melnyk N. V. (2019). Review of the world market of production and consumption of bioenergy fuels. **European Journal of Economics and Management**. 5(1), 39–51.

OECD (N/D). **OECD Statistics**, [online] URL: http://www.stats.oecd.org

Patyka N., Khodakivska O., Pronko L., Kolesnyk T., Klymchuk O., Kamenschuk B., Zayed N. (2021). Approaches to Evaluation of the Agriculture Competitiveness Level: Empirical Evidence in Ukraine. **Academy of Strategic Management Journal**. 20(1), 1939-6104-20-1-703. URL: https://www.abacademies.org/articles/Approaches-to-evaluation-of-the-agriculture-competitiveness-level-empirical-evidence-in-Ukraine-1939-6104-20-1-703.pdf

Pryvarnikova, I. Y., & Shevchenko, R. O. (2014). The use of biodiesel as one of the innovative areas of resource conservation and energy security of Ukraine. **Bulletin of Dnipropetrovsk University. Ser. Innovation management,** 3, 62–68.

Qadeer, M. U., Ayoub, M., Komiyama, M., Daulatzai, M. U. K., Mukhtar, A., Saqib, S., Ullah, S., Qyyum, M. A., Asif, S., & Bokhari, A. (2021). Review of biodiesel synthesis technologies, current trends, yield influencing factors and economical analysis of supercritical process. **Journal of Cleaner Production**, 309, 127388, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2021.127388.

Tsvei, Y. P., Prysiazhniuk, O. I., Horash, O. S., Klymchuk, O. V., Klymyshena, R. I., & Shudrenko, I. V. (2020). Effect of crop rotation and fertilization of sugar beet on the formation of maximum bioethanol yield. **Plant Archives**, 20, 268-274.