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Renewable Energy Sources Based on Agricultural Production: Potential Applications Within the Silk Road Economic Belt Framework

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Abstract.
The article is devoted to the Ukrainian-Chinese cooperation in the context of the joint construction of the "Silk Road Economic Belt", in particular, the cost-effective production of renewable energy sources based on agricultural production on the territory of Ukraine with the involvement of investors from China is highlighted. It has been proved that it is advisable to create an agro-industrial park in the agricultural sector, whose activities can be aimed at research and development of new technologies for growing agricultural products and "green technologies" in the field of agriculture. Calculations indicate the possibility of substantiating the quantitative characteristics of biofuel production and the ecological state of the territories. It is shown that in order to identify the degree of influence of these economic and environmental factors on the efficiency of biofuel production enterprises, it is necessary to conduct a systematic assessment of them with the construction of a mechanism for the functioning of such an enterprise as part of an agricultural park, which reflects the relationship of factors of the efficiency of biofuel production.

Keywords: The economic belt of the Silk Road, Agricultural Park; Production of renewable energy sources, Production of biofuels, Efficiency of functioning of biofuel production enterprises.

1. Introduction

Ukraine was the first among European countries at the highest state level to declare support for the initiative of Chinese President Xi Jinping, and in the future, statements about the importance of participating in the "One Belt, One Road" initiative continued to be heard at the same high level. Ukraine cannot stand aside from the global project "One Belt, One Road", it is geographically and geo-economically an integral part of this large project. In Ukraine, the routes from north to south and from east to west converge and cross. For those who value Ukraine's sovereignty, history, culture, and people, it has been and continues to be a trustworthy partner. The Ukrainian and Chinese sides on the basis of a mutual desire to develop cooperation on the joint construction of the "Silk Road Economic Belt" and the "Maritime Silk Road of the XXI century" (hereinafter - "One Belt, One Road") agreed on the basis of an effective mechanism of the Commission for Cooperation between the governments of Ukraine and the People's Republic of China to jointly find and develop strategic points of contact within the framework of the "One Belt, One Road" initiative, strengthen policy coordination, promote practical cooperation on the principles of mutual benefit, implement bilateral peaceful development and achieve joint prosperity.

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For Ukraine, the "One Belt, One Road" initiative is one of the most attractive geo-economic projects, which not only does not contradict its European integration course, but, on the contrary, can strengthen the advantages of our country in this complex process. The idea of Ukraine's involvement in the "One Belt, One Road" initiative takes into account the partner economies' interdependence and complementarity, which is crucial in the current world for full-fledged state engagement. Our common opportunities are evidenced both by the pace of development of the agricultural complex of Ukraine, which ranks third in the world in terms of grain exports, and the level of confidence in Ukrainian products that has developed recently in many parts of the world and, in particular, in China. Ukraine has the capacity to increase its agricultural output, but doing so would need significant expenditures, particularly in the intensive processing of ecologically acceptable agricultural inputs. In fields including building airplanes, exploring space, developing new materials, heavy and energy engineering, and mining, Ukraine has been and continues to be a leader in the development of a number of key technologies that have been historically significant and are now succeeding. The participants of the initiative will jointly improve the trade environment, create and constantly develop conditions for bilateral trade, promote the growth and restoration of trade between the two states, increase the share of high-tech products and products with high added value in the structure of bilateral trade. It will also support enterprises of both countries to participate in exhibitions, interaction between electronic cross-border trade platforms, continue to deepen cooperation in the areas of standards and quality, and continuously improve the level of trade facilitation.

International trade as part of the foreign economic relations of Ukraine with the People's Republic of China is reflected in the scientific works of N. Chernenko, L. Solodovnyk, H. Randhawa (2017), O. Kratt, K. Pryakhina, M. Bilyk (2017), Y. V. Bilan, O. Yatsenko, V.S. Nitsenko (2019), P. Bożyk (2019), L. Prystupa, V. Koval, I. Kvach, A. Hrymalyuk (2019), Abuselidze (2021b), Z. Ji, G. Abuselidze, V. Lymar (2021), Chinese scientists R. Hsueh (2015), L. Li, J. Liu, H. Long, W. de Jong, Y. C. Youn (2017), Z. Zheng (2017), J. Zhang (2019), L. Xing (2019). On the other hand, the current situation of bilateral cooperation between Ukraine and China, dominant factors, significant trends and the impact on the economic security of the world and the state, the problems of expanding and subsequent transformation of trade relations in the global economy are not sufficiently covered. On the other hand, the current situation of bilateral cooperation between Ukraine and China, dominant factors, significant trends and the impact on the economic security of the world and the state, the problems of expanding and subsequent transformation of trade relations in the global economy are not sufficiently covered.

Many scientific works of scientists and economists have recently been devoted to the development of alternative energy sources. Among them are the works of AR Mohamed, KT Lee (2006), A.E. Atabani, A.S. Silitonga, I.A. Badruddin, T.M.I. Mahlia, H. Masjuki, S. Mekhilef (2012), J Ren, M Lützen (2017), Q. Chen, J.H. Hao, T. Zhao (2017), Ohanisian et al., (2022), Wrzaszcz, Zieliński, (2022) and other scientists.

The lack of scientific developments devoted to this problem with an emphasis on new promising areas of research has led to the relevance and choice of the research topic.

The task is a theoretical, methodological and methodological justification of the directions of functioning and economic development of biofuel production enterprises based on agricultural enterprises.

2. Research methodology

The main resource for considering the relations of strategic partnership is articles and speeches of the leaders of Ukraine and China. The literature sources used are valuable, representative and significant for presenting a complete, holistic picture of the "Economic Belt of the Great Silk Road" project based on the Ukrainian-Chinese strategic partnership. The methodological and theoretical basis of the research is the fundamental provisions of economic theory regarding the systematic assessment of biofuel production processes and the choice of an alternative development strategy. In the course of the research, the following methods were applied: abstract-logical (designing a flowchart for calculating the optimization of biofuel production of agricultural sector products); statistical groupings (determination of the dependences of the yield and the level of profitability of the production of oilseeds on the level of resource costs per 1 hectare of sowing and the size of enterprises); graphic (illustration of the dynamics of price dependencies and the cost of production of oilseeds, biofuels) economic and mathematical (optimization of the parameters of a biofuel production plant and transportation of seeds to plants) balance (structural analysis of the interaction of production volumes, biofuels and the raw materials necessary for this; forecasting variants of the structure and efficiency of production and nutrient losses under various criteria for optimizing the intersectoral balance).

3. Results and Discussion

The most interesting for the Ukrainian state and Ukrainian business is the trade, economic and investment opportunities of the "One Belt, One Road" initiative. Within the framework of which cooperation between enterprises and financial institutions of both states takes place on mutually beneficial principles: combine efforts in the implementation of trade in agricultural products; carry out work on the implementation of large-scale projects in the fields of infrastructure and energy, including renewable energy; actively develop cooperation in the field of high technologies; expand the volume and scope of investments for entrepreneurs; to strengthen and stimulate cooperation between Ukraine and China in the investment, trade and economic, scientific and technical spheres; to explore and promote environmentally friendly energy based on agricultural production and the use of renewable energy sources.

The Chinese side expressed interest in joint work in the field of genetics and breeding, the development of animal husbandry, renewable energy sources, which will significantly expand trade and investment cooperation.

Energy experts have recognized that the development of this industry and its components has primarily political signs at the state level or at the international level. The development of biofuels lies precisely in the plane of political decisions and at the first stage - measures of state support with the solution of the following problems on the efficiency of production of raw materials and its processing into biofuels, as well as its transportation, storage and consumption.

Currently, the annual technically achievable energy potential of solid biomass in Ukraine is equivalent to 35 million tons, and its use will save about 40 billion m3 of natural gas annually. Energy plants can also include by-products of traditional agricultural crops grown

for the production of biodiesel (rapeseed, sunflower), bioethanol (corn, wheat) and biogas (corn for silage). An effective way to supplement and replace traditional fuel-energy resources (FER), especially in rural areas, is the production and use of biogas, which is formed as a result of the use of methane fermentation technologies of livestock biomass and consists of 55-70% methane. Due to the use of biogas, it is possible to replace such types of fuel: natural gas, which is used in cogeneration plants for the production of electric energy for supply to the national energy system and thermal energy to meet local needs; gasoline, diesel fuel and kerosene in stationary and transport internal combustion engines.
In order to further develop cooperation between Ukraine and China in the agricultural sector, it is advisable to create a joint agricultural park, whose activities can be directed to research and development of new technologies for growing agricultural products and "green technologies" in the field of agriculture.
China plans to add more electricity generating capacity from renewable sources by 2035 than the United States, Europe and Japan combined. Leading analysts of the world predict that the share of renewable energy sources in the total power of the People's Republic of China will continue to grow until 2030. With state support and reduction of technology costs (Ukrinform, 2021).
In agriculture, all its branches are in complex relationships, when the product obtained at the subsequent stages of production is included in the previous stages of the production vertical as an element of production costs. With the help of modeling the intersectoral balance, it is possible to coordinate the final demand for products with the initial costs in the same areas through a system of intermediate demand in each of them for products of other industries.
The calculations carried out by us with the help of the developed intersectoral balances taking into account natural factors indicate the possibility of substantiating the quantitative characteristics of biofuel production and the ecological state of the territories, which may arise after structural shifts in the production of planned volumes of final products. Balance models for forecasting the development of individual industries and their interaction are based on linear static models.
The development of any joint programs or actions of the governments of Ukraine and China requires determining their impact on certain parameters of the economy, followed by the choice of an alternative option for the development of the agricultural sector of the economy and the appropriate formulation of measures to implement the chosen economic investment policy. It is the input - output model that is a simple tool for mathematical formalization of technological parameters of various industries or sectors of the economy and combining them into a single interconnected system, it is almost impossible to do by other methods.
Simultaneously with the possibilities of conducting structural analysis, the intersectoral input-output method allows us to develop a general forecast or a project of economic development that provides for determining the development of all branches of the agricultural sector of the economy. In such national programs, the main government measures or individual sectorial programs affect the development of the economy, both in terms of investment and control of certain production parameters related to compliance with food or environmental safety requirements. Government policy causes changes in the final demand (for example, as a reaction to stimulating or restricting the export of certain

types of products). According, to structural changes with the vertical of interaction with other sectors of the economy. In this situation, the task is to systematically check the possibility of implementing a general strategy for the development of the agricultural sector of the economy, including government programs.

To ensure such verification, certain procedural measures are carried out:

a) the volumes of final demand are projected by industry (or determined in advance by industry programs);

b) a matrix of technological coefficients of resource costs is being developed (A) and an inverse matrix-a matrix multiplier [(E-A) -1];

c) a system of restrictions is provided for both on the production volumes of individual industries (for example, row crops) and individual resources (for example, land, labor).

The check is carried out according to calculations in the matrix algebra environment, namely: determine the output of products (X) and the need for primary resources as the product of the inverse matrix by the volume of final products of each industry (Y), provided that the results are compared with certain restrictions.

The technological matrix (the coefficients of its direct costs aij - the number of products of the i industry for the production of a unit of production of the j industry) is the basis of information support for balance models of the economy. Hence, the system of equations of intersectoral balance can be represented in this general form:

$$X_i=\sum_{j=0}^{n} aijXj + Yj,\ i = 1, \dots . n. \quad (1)$$

Then, in matrix form, this system of equations can be presented as follows:

$$X = AX + Y. \quad (2)$$

After minor transformations, it will take the form:

$$X = Y / (E-A) = (E-A) -1Y \quad (3)$$

$$Y = (E-A) X, \quad (4)$$

Where,

X is the vector of gross output;

Y- vector of the final product (including processed);

A- matrix of direct cost coefficients;

E is an n order unit matrix.

Using the formula (3), the volumes of gross output are determined in the matrix expression, if the volumes of the final product are known (preset or found by optimization, the parameters of which are set by experts within certain limits). The following formula (4), on the contrary, allows us to determine the final one, if the volumes of gross output are known. The presence of the interconnection of all industries through the technological matrix allows you to optimize the structure of an agricultural enterprise, if the criterion is the maximum profit received, and the volume of final products is limited to a certain range of their values.

When building an intersectoral balance in value terms, production prices or final consumption prices are used. The requirements for the uniformity of the evaluation of the parameters of the model of an agricultural enterprise for the production of biofuels make their own adjustments. If trade margins are included only in the price of the final product, and there is no intermediate product, it is better that the products are calculated in the prices of the manufacturer (Abuselidze, 2021a). If the fiscal policy provides for the subsidies or exemption of individual buyers from certain types of taxes (Abuselidze, 2020; Abuselidze & Mamuladze, 2020), then it is better to evaluate products by factor value (by the cost of each product and resource or by the price of their purchase).
One of the main factors of the efficiency of biofuel production is our own raw material base, therefore, we have developed an intersectoral balance of the consolidated complex for the production of biofuels both in terms of the unit cost (own raw material base) and sales prices (raw materials are estimated at market prices). There is no doubt that the presence of stable markets for by-products (rapeseed meal, glycerin) with corresponding high prices is an important factor in the efficiency of biofuel production. In order to identify the degree of influence of the factors listed by us on the efficiency of the functioning of biofuel production enterprises, it is necessary to conduct a systematic assessment of them. For this purpose, we have constructed the following block diagram reflecting the relationship of the factors of biofuel production efficiency (Figure 1).

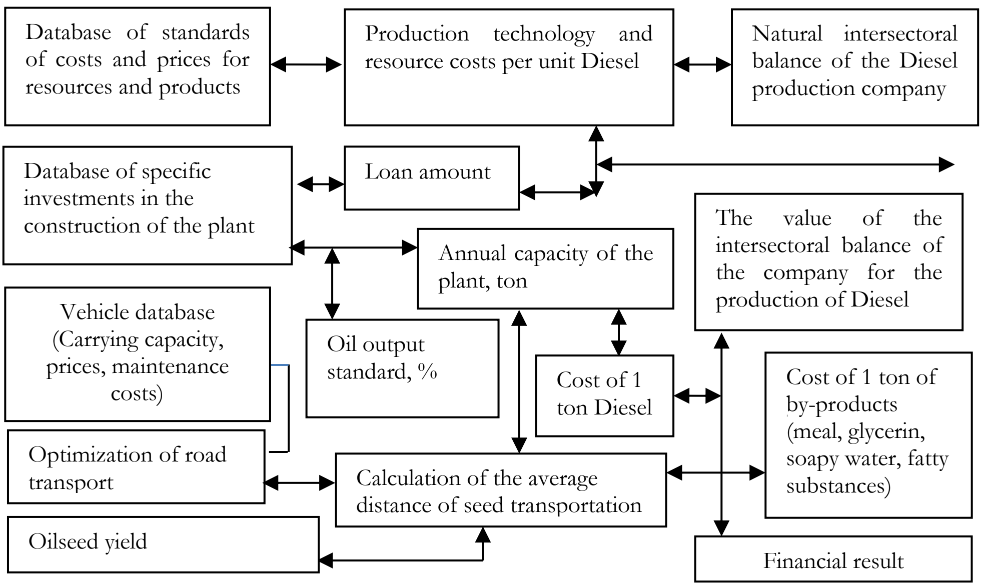

Figure 1: Block diagram of optimization of road transport and parameters of the Agricultural Park for the production of biofuels
Source: Author's own developments

Global structural shifts in the production of oilseeds and the redistribution of acreage between states have allowed Ukraine to occupy free market niches in this market segment

(Table 1). For 2009-2020 in the world, the sown area of sunflower increased by 27.3% and amounted to 25.1 million gallons in 2020. At the same time, there was a structural redistribution of sunflower sowing areas between different regions and countries.

Table 1: Acreage and gross sunflower seed production by region and major countries

Region and country	Year							
	2009		2020		2009		2020	
	Acreage				Seed production			
	million gallons	part, %	million gallons	part, %	million ton	part, %	million ton	part, %
Everything in the world	19.65	100	25.01	100	24.65	100	37.08	100
including in Europe	10.43	53.1	16.03	64.1	13.03	52.9	24.14	65.1
among them: Ukraine	2.72	13.8	5.08	20.3	3.27	13.3	8.39	22.6
France	0.61	3.1	0.68	2.7	1.49	6.1	1.57	4.2
Bulgaria	0.47	2.4	0.78	3.1	0.65	2.6	1.39	3.7
Romania	0.86	4.4	1.06	4.3	1.00	4.1	1.40	3.8
Spain	0.75	3.8	0.76	3.0	0.77	3.1	0.62	1.7
including in Asia	4.54	23.1	4.14	16.6	4.59	18.6	5.75	15.5
Among them: China	1.13	5.8	0.95	3.8	1.95	7.9	2.37	6.4
Turkey	0.55	2.8	0.61	2.4	0.85	3.4	1.37	3.7
Kazakhstan	0.32	1.6	0.79	3.2	0.19	0.8	0.40	1.1
India	1.64	8.4	0.72	2.9	0.87	3.5	0.58	1.6
including in America	3.35	17.0	3.00	12.0	5.53	22.4	5.24	14.1
Among them: USA	0.88	4.5	0.75	3.0	1.11	4.5	1.26	3.4
Argentina	2.01	10.3	1.82	7.3	3.84	15.6	3.34	9.0
including in Africa	1.25	6.4	1.79	7.2	1.42	5.8	1.90	5.1
south African republic	0.67	3.4	0.50	2.0	0.97	3.9	0.63	1.7
United Republic of Tanzania	0,28	1,4	0.75	3.0	0.18	0.7	0.80	2.2

Source: Calculated by the author based on FAO data (http://faostat.fao.org).

In many countries, there is an increase in the acreage of rapeseed. In countries such as Canada, China and India, in 2020, the area of sowing of this crop reached 59% of its global area, and seed production - 48%. In 2020, compared to 2009, Ukraine also increased the production of this crop by 19.8 times, including 2.5 times due to an increase in yield and 7.8 times due to the expansion of its sowing areas.

World soybean production in 2020 reached 253.1 million tons, which is 2.5 times more than the total production of rapeseed and sunflower seeds. More than 86% of soybean production is concentrated in America (in the USA-32.4%; Argentina-20.3; Brazil-26%) and 10.7% - in Asia (in China-5.1; India-4.5%). In Ukraine for 2009-2020 Soybean production increased 19.3 times and reached 2.4 million tons in 2020.

Due to the lack of sufficient technical means for the production of soybean meal (cake with a low fat content) and the possibilities for their long - term storage, Ukraine imports them 50-160 thousand tons annually (in 2020-only 6 thousand tons). At the same time, we export annually up to 300-400 thousand tons of sunflower seeds (in 2010 and 2017 – 0.7-0.9 million tons), up to 1-2 million tons of rapeseed (in 2016 - 2.4 million tons) and up to 0.2-1 million tons of soy (in 2020 - 1.5 million tons). As a result, export volumes exceed 50% of the gross production of these crops. That is, we can conclude about raw materials specialization with the formation of an insignificant amount of added value instead of organizing our own processing and export of finished products or semi-finished products. However, it should be noted that in addition to the export of seeds in recent years, Ukrainian processing enterprises have exported from 2 to 3.6 million tons of sunflower oil (over 80% of its production), or up to 65% of their world exports of this product (Ugwu, 2018). These three oilseeds (sunflower, rapeseed, soy) in 2020-2021 occupied 46% of the structure of sown areas. With the export of sunflower seeds, soybeans and rapeseed, more than 1 million tons of nutrients are exported abroad annually (Slobodianyk *et al.*, 2021).

The trend of increasing exports of food products was accompanied by an increase in the volume of its imports, especially from 2012-2013. However, the industry and its foreign economic activity developed at the highest rates (Figure 2).

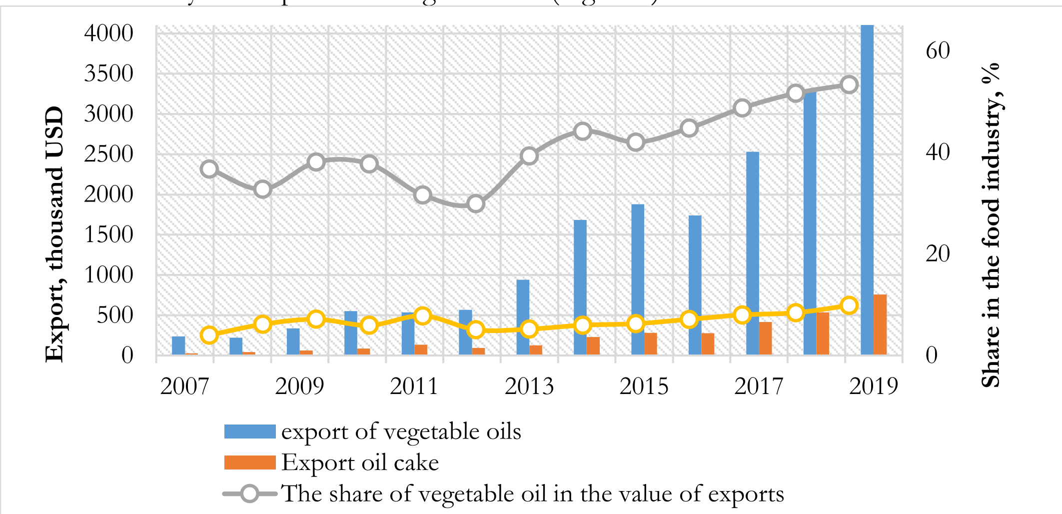

Figure 2: Dynamics of exports of products of enterprises producing oleic crops and their share in the value of exports of the food industry, 2007-2019.
Source: Calculated on the basis of customs statistics for 2007-2019.

In the export structure, the share of vegetable oil alone in all branches and productions of the food industry grew from year to year and in 2019 reached 53.4%. Similarly, the share of exports of sunflower, soy and rapeseed cake increased-from 4% (in 2007) to 9.8% (2019) of the total value of exports for the food industry. As a result, in the total amount of exports of food products in 2007, only vegetable oil and cake accounted for 40.1%, and in 2019 - 63.2%, while all other industries accounted for less than 37% of export revenue.

The completeness of the main fossil energy carriers in the near future, with a corresponding increase in prices for petroleum products and the deterioration of the environmental situation, forces the countries of the world to search for alternative and renewable types of energy, in particular biofuels produced from agricultural crops. However, the world community can allocate a small share of food crops to biofuels, and even more so in the conditions of an ever-growing population on the planet. According to various estimates, even the processing of all volumes of vegetable oil and grains for biofuels will replace no more than 16% of world oil consumption (State Statistics Service of Ukraine, 2021).

According to international experts, the cost of processing 1 ton of sunflower seeds at European and large domestic plants is 20-25 US dollars, and at small and medium - sized plants in Ukraine (or not reconstructed) - about 50 US dollars (Eurasian Economic Commission, 2017). That is, with a constant excess of demand from domestic and foreign processors relative to the supply of oilseeds, raw material prices will continue to grow, which will adversely affect less powerful plants. As a result, since 2011, the prices of the domestic market for sunflower seeds have exceeded the world ones, which have increased the investment attractiveness of the production of oilseeds. Analysts note that small oil-producing enterprises are the most vulnerable to market changes, and with the "consolidation" of the market, their competitiveness decreases.

Grouping of agricultural enterprises by the level of expenses per 1 gallon of sunflower and rapeseed crops shows that an increase in yield as a result of intensification does not always lead to an increase in the level of profitability of their production (Table 2).

Table 2: Dependence of yield and profitability of production on the cost per 1 gallon of oilseed crops

Groups of farms by the level of expenses per 1 gallon of crop sowing	**Year**							
	2013		**2019**		**2013**		**2019**	
	seed yield, price / gallon				**the level of profitability of seed production, %**			
	sunflower seeds	**rapeseed**	**sunflower seeds**	**rapeseed**	**sunflower seeds**	**rapeseed**	**sunflower seeds**	**rapeseed**
Less than 500	4.9	6.1	1.6	1.5	29.4	42.9	27.7	59.2
500,1 – 750	11.2	9.9	6.6	5.4	29.1	39.2	31.7	142.9
750,1–1000	14.4	14.1	5.0	3.8	26.4	34.3	55.1	25.2
1000,1–1250	17.2	16.1	6.4	4.5	21.6	40.7	53.1	32.6
1250,1–1500	19.4	18.4	10.8	6.0	16.2	29.9	122.8	73.8
1500,1–1750	21.2	19.9	9.2	10.5	9.2	18.7	63.0	57.0
1750,1–2000	23.9	19.3	10.5	18.4	10.1	1.3	51.3	120.4
2000,1–2250	25.3	23.4	10.8	9.2	12.3	7.4	54.5	19.4
2250,1–2500	28.2	28.9	12.6	11.4	-2.3	31.7	62.6	52.4
2500,1–2750	22.8	25.6	13.1	11.2	-0.8	5.3	56.2	77.0
2750,1–3000	23.2	27.3	14.7	14.0	42.3	3.1	57.6	45.7

3000,1–3250	25.7	29.3	15.8	17.8	12.8	9.7	63.8	86.6
3250,1–3500	8.0	32.8	17.6	17.8	34.9	-3.0	58.4	71.3
3500,1–3750	12.4	40.5	18.1	15.9	-22.3	29.6	62.4	38.8
3750,1–4000	19.3	25.6	17.9	18.8	10.2	-32.9	48.7	43.1
More 4000	27.0	34.6	23.3	25.6	41.2	-35.7	38.1	19.0
Total	14.5	15.9	18.2	23.5	20.8	46.5	45.9	22.4

Source: *database "Main economic indicators of agricultural enterprises for 2013, 2019"*

Thus, even with a lower yield of sunflower seeds and rapeseed, the level of profitability is higher than due to its higher level. Commodity producers sell sunflower and rapeseed seeds at market prices, regardless of their yield level. Therefore, the level of yield, in our opinion, does not affect the efficiency of the production of bio – seeds (except for some slight reduction in the distance of transportation of raw materials-seeds to the plant).

The prospect of cooperation in the field of renewable energy sources of Ukraine and the People's Republic of China is investing in the construction of plants with a capacity of 5-7 thousand tons of biofuels annually with equipment of domestic production, the cost of which is much lower than foreign. In Ukraine, it is proposed to organize the production of biofuels at installations and plants with a capacity of 0.3-100 thousand tons per year.

As for saving investments due to the adoption of domestic and much cheaper plant construction projects, it should be noted that in Ukraine, the highest share in the costs of biofuel production is occupied by raw materials-rapeseed seeds (70-75% - for the evaluation of raw materials at cost and 80-85% - at market prices), while depreciation is only 1.5-5% (Levkivskyi & Levkivskyi, 2013; Trade statistics for international business development, 2021). If the cost of a biofuel production plant is twice as high, then the cost of raw materials in the cost of biofuel production will be more than 70 times higher than the amount of depreciation charges. The increase in depreciation charges will practically not lead to a significant increase in the cost of biofuel production.

In order to take into account transport costs in the process of justifying the size of biofuel production plants, and even more so-its efficiency, it is necessary to clearly calculate the mathematical average distance (L_0) of seed transportation from enterprises to plants, depending on the zone of its supply. For example, O. Chayanov used the formula when determining it (UN Comtrade Database, 2021):

$$L_0 = \varepsilon * \frac{2}{3}\sqrt{\frac{S}{\pi}},$$

Where,

S is the area of the circle (land use area) from which cargo transportation will be carried out;

ε is the coefficient depending on the configuration of the land area and the location of the enterprise on this area ($\varepsilon = 1{,}3 - 1{,}5$).

The essence of this formula is that 2/3 of the radius of the distance of the far transport to the center approximately divides the area of cultivation of agricultural crops into two equal parts: near and far, as a result of which this distance is the average mathematical distance of transportation.

Some authors consider the average distance as the radius of the maximum distance from the center of cargo transportation (πL_0) (Belt and road portal, 2021), as if all cargo is moved to the extreme limit of the enterprise (zone), and then transported to the center (factory). We propose to clarify the formula somewhat.

The point of the average mathematical distance (L_0) on the radius ® of the land ownership area (S) is determined as follows:

$$\pi L_0^{\ 2} = \frac{\pi R^2}{2}.$$

From here:

$$L_0 = \frac{1}{\sqrt{2}} * R = \varepsilon * \frac{1}{\sqrt{2}} * \sqrt{\frac{S}{\pi}}.$$

Here we noticed one small discrepancy with the formula of Chayanov: instead of the coefficient 2/3 (0.667), we got (0.707). In addition, we have adopted a maximum road curvature coefficient of 1.4 ($\varepsilon = 1{,}4$), because moving in a zigzag (for example, along the legs of a triangle), the distance will be a maximum of 1.4 times greater than along a straight line (hypotenuse).

We have analyzed the economic efficiency of biofuel production (the plant's capacity is 1 ton per year).

Investments per 1 ton of the plant's capacity amount to 2.22 thousand UAH. The price of seeds in the calculations corresponds to the level of 2012-2013, which is 2-2.5 times lower than in 2017-2020, and the price of rapeseed cake, on the contrary, is overestimated. Recalculation of the efficiency of the plant's functioning shows that with a new ratio in the prices of raw materials and final products, the plant becomes inefficient. According to the technological data of the plant, 3.1 tons of seeds are consumed per 1 ton of biofuel. The difference between the price, which is taken as a basis for calculating efficiency, and the price of selling seeds in 2020 is 1245.5 UAH per 1 ton. The level of the cost of production of 1 ton of biofuel – 5723 UAH was previously calculated (Novoseltseva, 2011).

Table 3: The main technological and economic parameters of the biofuel production plant with a capacity of 1 t / day

Indicator	**Price, UAH/T**	**Annual volume, t**	**Annual amount, thousand UAH**
Raw			
rapeseed	1378	3100	4271,8
methanol	6000	201	1206,0
CON	5000	18	90,0
citric acid	6550	3	19,65
technical water	1	210	210,0
Products			
Biofuels	6500	1000	6500,0
rapeseed cake	1000	2000	2000,0
crude glycerin	800	270	216,0

Then the cost of production of 1 ton of biofuel only due to the rise in price of raw materials-sunflower seeds-will grow (taking into account that the cost of raw materials in all expenses takes 90%) to 9197.9 UAH [5723+ (3.1 * 1245.5 * 0.9)], which exceeds the price of diesel fuel (taking into account the energy equivalent of 0.91). The problems of determining the price of raw materials – rapeseed and diesel fuel (as a comparison base) and the efficiency of biofuel production are noted by the authors of the development of these projects (Novoseltseva, 2011).

In our opinion, it is the oil content in seeds and the degree of its withdrawal in raw materials (rapeseed oil) that is currently the main factor in the efficiency of biofuel production. After all, the cost of seeds (at market prices) takes up to 85-90% of the cost of biofuel production. Hypothetically, increasing the oil yield from a unit of seeds actually reduces production costs – we get savings of raw materials (seeds) per unit of biofuel.

The efficiency of biofuel production is influenced by technological parameters, the level of prices for resources and products, the annual capacity of the biofuel plant and the distance of transportation of seeds. The distance of transportation of seeds to the plant depends on the specific weight of arable land in the land fund of the territory-the zone of its cultivation. Therefore, the average mathematical distance in kilometers (L_0) was determined by us using the formula:

$$L_0 = \varepsilon * \frac{1}{\sqrt{2}} * \sqrt{\frac{Q}{100 * \pi * g_r * p_r * y}}, \qquad (5)$$

Where:

Q is the need for seeds for a certain plant capacity, ton;

y – Rapeseed yield in the area of rapeseed supply for processing, ton / gallon;

g_r – the specific weight of the rapeseed area in the crop rotation, the coefficient;

P_r – the specific weight of the arable land area in the total land area, the coefficient (in Ukraine, P_r = 0.5380417).

Fuel costs are calculated according to the official methods, according to them, the fuel consumption rate for the mileage of a road train as part of a car with a trailer per 100 km of mileage (Hsan) is determined as follows:

$$H_{san} = H_s + H_w * Gpr, \qquad (6)$$

Where:

Hs - is the basic fuel consumption rate for a car of the corresponding brand per 100 km of mileage;

Hw – fuel consumption rate for transport work per 100 t / km (l / 100 t / km);

Gpr – the mass of the loaded car trailer, t.

Then, based on the calculated total mileage of the car (Sh, km) and the work performed (W, t/km), the standard fuel consumption (Qh, l) will be:

$$Qn = 0.01 * (H_{san} * S_h + H_w * W) \qquad (7)$$

Since the volume weight of diesel fuel is 0.84 kg/l (Novoseltseva, 2012), the standard fuel consumption in tons (Qnt) will be calculated as follows: Qnt = (0.84*Qn). Depreciation charges and maintenance costs are calculated according to the accepted standards. Depending on the cost of cars with trailers (Va), the loan term (T=10) and interest rates (p=15 %), the annual expenses (Kr) associated with debt servicing and repayment in equal parts are calculated using the formula:

$$K_r = V_a * \{\frac{p}{100} / [1-(1+\frac{p}{100})^T]\}. \quad (8)$$

Since 0.2% additives and a stabilizer (against freezing) are used to improve the quality of biofuels, the costs of rapeseed oil for the production of 1 ton will be 0.996 tons (1-0.4 / 100), and for 100 thousand tons of biofuels - 99.6 thousand tons. Using this coefficient (0.996), the oil demand for the production of a specified volume of biofuels is calculated. The remaining fat (1.5%) from the crude oil is the so-called "fat substance". With the increase in the capacity of the plant, the yield of rapeseed oil increases, and much less oil remains in the cake. The dependence of the loss of oil content (gvo in %) on the annual capacity of the plant (Nt) is described by us as follows:

$$g_{vo} = 15{,}929 * e^{-0{,}0244*\frac{N_z}{1000}}. \quad (9)$$

Then the yield of rapeseed oil (Gwo y%), depending on the capacity of the plant (Nt) and the oil content of raw materials-rapeseed seeds (Gvo) will be equal to:

$$G_{wo} = G_{vo} - g_{vo}.$$

For example, when the oil content in rapeseed is 50% and the plant capacity is 100,000 tons of biofuel per year, 1.4 % of oil remains in the cake

$$(g_{vo} = 15{,}929 * e^{-0{,}0244*\frac{100000}{1000}} = 1{,}4\%).$$

Then the actual oil yield will be 48.6 % (50-1.4). According to the plant's capacity of 1000 tons of biofuels per year, the loss of oil content (the remainder in the cake) is 15.5%, and the actual yield of rapeseed oil will be only 34.5 %. That is, the need for rapeseed seeds (Q) for the production of biofuels of the established volume will decrease with the growth of the plant's capacity (technological ability to obtain a higher oil yield):

$$Q = \frac{0{,}996 * N_t}{G_{vo} - 15{,}929 * e^{-0{,}0244*\frac{N_z}{1000}}}. \quad (10)$$

For a plant with a capacity of 100 thousand tons of biofuel per year for 48.6% of the oil yield, the need for seeds is only 204.9 thousand tons [(0.996 * 100000) / (48.6 / 100)], and for a plant with a capacity of 1000 tons (oil yield-34.5%) - 2887 tons in the first case, 2 tons of seeds will be spent on the production of 1 ton of biofuel, and in the second - 2.9 tons, or 45% more. Provided that the starting oil content of rapeseed is 40%, its costs for the production of 1 ton of biofuel will need 2.6 tons of rapeseed (a plant with a capacity of 100 thousand tons), and for a plant for 1000 tons of biofuel per year - 4.1 tons or almost 60% more. Since seeds account for the largest share in expenses, it is seeds with high oil content and the technological possibility of increasing its yield at powerful plants that are the main factors for achieving the efficiency of biofuel production.
Using formula (5), we will give a more perfect formula for determining the average distance of transporting seeds to the plant, taking into account the qualitative indicator-oil yield:

$$L_0 = \varepsilon * \frac{1}{\sqrt{2}} * \sqrt{\frac{0{,}996 * N_t}{(G_{vo} - 15{,}929 * e^{-0{,}0244*\frac{N_z}{1000}}) * (100 * \pi * g_r * p_r * y)}}. \quad (11)$$

Depending on the plant's need for seed volumes, the distance of its transportation and all other technical and economic parameters are set. Such a record of vehicle parameters, where all its characteristics are calculated using interrelated formulas, allows you to apply optimization (choosing the most efficient vehicles) based on solving a linear programming problem with Boolean variables (using a logical variable). If this i^{th} type of motor transport is used for cargo transportation on the j^{th} route, it is accepted for use as effective (the variable is equal to one), if not, it is zero. Mathematically, this is written as follows:

$$x_{ij} \in \{0;1\},\ i = \overline{1,m},\ \ j = \overline{1,n}.$$

Important for establishing technological costs are the patterns of changes in the cost of the plant depending on the annual capacity. German researchers provided data on the cost of plants of various capacities and specific investments (per 1 kg of capacity) (Novoseltseva, 2012). Their use made it possible to identify the dependence of the relative investment coefficients (USD) per 1 ton of biofuel on the plant's capacity (R^2=0.9996):

$$V_{zi} = 0{,}8 * (0{,}171375 + 0{,}076176 * \frac{N_z}{1000} - 0{,}000059 * (\frac{N_z}{1000})^2) * V_{z10}, \quad (12)$$

Where:

V_{zi} is the cost of the plant of the i^{th} capacity, million UAH;

V_{z10}– the cost of the plant for 10 thousand tons of biodiesel, million USD (the investment coefficient is equal to one with the plant capacity of 10 thousand tons of biodiesel);

0.8 - the coefficient of reducing the cost of the plant during its construction with the involvement of domestic components.

Depreciation charges are taken in the amount of 10% of the cost of the plant, and for current repairs - 5%. For a plant with a capacity of 100 thousand tons of biofuels per year

(50% - oil content, 2.5 t / ha-seed yield), as an example, the technological matrix of direct costs (aij - the number of products of the i^{th} industry for the production of a unit of production of the j^{th} industry) will look like (table 4):

Table 4: Matrix of direct costs for the production of biofuels at a plant with a capacity of 100 thousand tons per year and an oil yield of 48.6%

Display	**Rapeseed seeds**	**Rapeseed oil**	**Rapeseed cake**	**Biodiesel**	**Glycerin**	**Soapy water**	**Fatty substances**
Seeds	0	2.05712	0	0	0	0	0
Rapeseed oil	0	0	0	0.996	0	0	0
Rapeseed cake	0	-1.026266	0	0	0	0	0
Biodiesel	0	0	0	0	0	0	0
Glycerin	0	0	0	-0.10388	0	0	0
Soapy water	0	0	0	-0.1066	0	0	0
Fatty substances	0	-0.030857	0	0	0	0	0

Source: authors' own developments

As a result, the cost balance of the biofuel production plant was obtained (Table 5), which shows the existing dependencies when calculating the cost of a unit of its final product-biofuels.

Table 5: The cost balance of the biofuel plant with a capacity of 100 thousand tons per year (48.6% - oil yield), thousand UAH

	rapeseed seeds	**Rapeseed oil**	**Rapeseed makuha**	**Biofuels**	**Glycerin**	**Soapy water**	**Fatty substances**
Final product	623990	504324	76662	910000	67404	1066	3243
seeds	0	623990	0	0	0	0	0
rapeseed oil	0	0	0	551413	0	0	0
rapeseed cake	0	-76662	0	0	0	0	0
glycerin	0	0	0	-67404	0	0	0
soapy water	0	0	0	-1066	0	0	0
fatty substances	0	-3243	0	0	0	0	0

methanol	0	0	0	82851	0	0	0
CON (potassium oxide hydrate)	0	0	0	3433	0	0	0
water	0	0	0	14	0	0	0
stabilizer	0	0	0	1000	0	0	0
supplement	0	0	0	1100	0	0	0
cold pressing	0	6300	0	0	0	0	0
final pressing	0	0	0	3869	0	0	0
steam	0	1028	0	0	0	0	0
payment	0	0	0	1293	0	0	0
depreciation	0	0	0	20272	0	0	0
Current repairs	0	0	0	10136	0	0	0
other costs	0	0	0	8196	0	0	0
general economic	0	0	0	15715	0	0	0
Loan with interest	0	0	0	40393	0	0	0
total expenses	0	551413	0	671216	0	0	0
Cost of 1 ton, UAH	3045.5	5536.3	0	6712.2	0	0	0

Thus, we have described and mathematically formalized all the main technological and economic dependencies (see Figure 1) that exist in any centralized organization of processing products with the transportation of raw materials from some territory with a concentration of crops within environmentally acceptable limits and a level of yield, which ensures a minimum of transport costs. We have developed variant calculations and set the following indicators, such as the plant's capacity, the level of seed yield, the oil content in it, the share of its crops in crop rotations, and all other indicators will be calculated automatically. Under these conditions, it remains to optimize transportation and thus complete the determination of all costs for the production of biofuels. The second criterion can be, for example, zero profitability with the specified technological parameters, and the result is the determination of the plant's capacity.

Table 6: The main parameters of the break-even production of biofuels, depending on the oil content in the raw materials, prices for rapeseed at the level of 2020 (3045.5 UAH per 1 ton)

indicators	**Capacity of the Biodiesel plant, ton**					
	67447	42313	27215	16621	9062	4531
Rapeseed area, gallon	69688	43846	28224	17196	9281	4510
including nearby squares	39822	25055	16128	9826	5304	2577
distant squares	29866	18791	12096	7370	3978	1933
Yield, t / ga	2.8	2.8	2.8	2.8	2.8	2.8
Production volume, t	195126	122770	79027	48150	25988	12628
Fat content in raw materials, %	37.5	40.0	42.5	45.0	47.5	50.0
Fat output, %	34.4	34.3	34.3	34.4	34.7	35.7
Area of crop rotations, ga	398216	250551	161279	98265	53036	25772

The share of rapeseed in crop rotation, coefficient	0.175	0.175	0.175	0.175	0.175	0.175
The selling price of rapeseed per 1 ton, UAH	3046	3046	3046	3046	3046	3046
Average transportation distance, km	48.0	38.1	30.6	23.9	17.5	12.2
Cost of 1 ton of biodiesel, UAH	8776	8831	8873	8911	8948	8981
Total cost of 1 ton of biodiesel (including transportation costs), UAH	9100	9100	9100	9100	9100	9100
Price of 1 ton of biodiesel, UAH	9100	9100	9100	9100	9100	9100
Profit for 1 ton of biodiesel, UAH	0	0	0	0	0	0
Profitability level, %	0	0	0	0	0	0
The cost of the plant, thousand UAH	141950	92617	61975	40021	24129	14512
Construction period, years	0.613	0.463	0.355	0.264	0.183	0.121
Loans with interest, thousand UAH	28284	18454	12349	7974	4808	2891
Technological costs:	0	0	0	0	0	0
- sunflower seeds	594256	373896	240675	146640	79146	38459
- rapeseed cake	-93766	-59089	-38051	-23155	-12429	-5944
glycerin	-45462	-28520	-18344	-11203	-6108	-3054
soapy water	-719	-451	-290	-177	-97	-48
fatty substances	-3089	-1943	-1251	-762	-411	-200
- methanol	55881	35056	22548	13771	7508	3754
- con (potassium oxide hydrate)	2315	1453	934	571	311	156
- water	10	6	4	2	1	1
- stabilizer	674	423	272	166	91	45
- supplement	742	465	299	183	100	50
- cold pressing	6000	3775	2430	1481	799	388
- final pressing	4732	2982	1920	1169	627	300
- steam	1257	792	510	310	167	80
- remuneration of labor	1132	911	738	599	490	421
- depreciation	14195	9262	6198	4002	2413	1451
- current repairs	7097	4631	3099	2001	1206	726
Other costs, UAH	7805	4911	3161	1926	1040	505
transportation costs	21824	11380	6180	3143	1380	541
general economic	10599	6649	4277	2612	1424	712
Loan with interest	28284	18454	12349	7974	4808	2891
Total costs, thousand UAH	613769	385044	247659	151252	82464	41234
Output of biodiesel, tons	67447	42313	27215	16621	9062	4531
Total cost of 1 t of biodiesel, UAH	9100	9100	9100	9100	9100	9100
Output of conjugated products, t:						
- glycerin	7007	4396	2827	1727	941	471
- soapy water	7190	4511	2901	1772	966	483
- rapeseed cake	125022	78785	50735	30873	16572	7926

fatty substances	2927	1842	1185	722	390	189
Motor transport:						
The cost of cars with trailers, thousand UAH	18075	9575	5286	2745	1239	503
Number of machines (100 working days)	44	23	13	7	3	1
Technological costs:	0	0	0	0	0	0
- remuneration of labor	1091	575	316	163	73	29
- fuel consumption	4157	2074	1072	509	202	68
- depreciation	4016	2128	1175	611	276	112
- current repairs	6859	3637	2009	1044	472	192
loan with interest	3601	1908	1053	547	247	100
Total costs, thousand UAH	21824	11380	6180	3143	1380	541
Transported cargo, t	195126	122770	79027	48150	25988	12628
Transported cargo, thousand tons / km	8712.4	4345.7	2245.6	1067.4	423.5	143.4
Cost of 1 t / km, UAH	2.51	2.62	2.75	2.95	3.26	3.78
The share of transport costs in expenses, %	3.56	2.96	2.50	2.08	1.67	1.31

Calculations show that the break-even point (2.8 tons / gallon-the projected level of seed yield for 2030; 17.5% - the share of rapeseed crops in the crop rotation, the price of 1 ton at the level of 2021-3045.5 UAH per 1 ton) 50% of the oil content in the raw material is achieved with the plant capacity of 4.5 thousand tons of biofuel per year, 45% - 16.6, 40% - 42.3 thousand tons, and at 37.5% - 67.4 thousand tons. The cost of such plants will be UAH 14.5, 40, 92.6 and 142 million, respectively, and for 1 ton of capacity - UAH 1.89, 2.10, 2.41 and 3.20 thousand. That is, due to the low price of raw materials - seeds, which in 2021 was 3045.5 UAH per 1 ton, a biofuel production plant with a capacity of 4.5 thousand tons per year will be effective if the oil content of raw materials reaches 50%. At a low level of oil content, for example, 40%, the required capacity of the bio-plant will be 42.3 thousand tons, or it will be almost 10 times higher. With a high level of prices for raw materials rapeseed seeds-the efficient production of biofuels will be at large capacities of plants for its production

4. Conclusion

The focus of the article, which focuses on Ukrainian-Chinese collaboration in the context of their joint development of the "Silk Road Economic Belt," is on the economically viable generation of renewable energy sources based on agricultural output on Ukrainian soil with Chinese investors. The authors proved that the concept of Ukraine's participation in the "One Belt, One Road" project includes the factor of interdependence and complementarity of the partner economies, which is the most important in the modern world for full-fledged interaction of states. The authors emphasize that Ukraine cannot stand aside from the global project "One Belt, One Road", it is geographically and geo-economically an integral part of this large project. It is proved that Ukraine can double the volume of agricultural production, but this requires quite serious investments, in particular in the deep processing of environmentally friendly agricultural raw materials. It is proved that in order to further develop cooperation between Ukraine and China in the agricultural sector; it is advisable to create a common agricultural park, whose activities can be directed to research and development of new technologies for growing agricultural products and "green technologies" in the field of agriculture. The calculations carried out by us with the help of the developed intersectoral balances taking into account natural factors indicate the possibility of substantiating the quantitative characteristics of biofuel production and the ecological state of the territories. According to the conducted research, it is shown that in order to identify the degree of influence of these economic and environmental factors on the efficiency of biofuel production enterprises, it is necessary to conduct a systematic assessment of them with the construction of a mechanism for the functioning of such an enterprise as part of an agricultural park, which reflects the relationship of factors of the efficiency of biofuel production. It is revealed that the prospect of cooperation in the field of renewable energy sources of Ukraine and China is investing in the construction of plants with a capacity of 5-7 thousand tons. Tons of biofuels annually with a complete set of equipment of domestic production, the cost of which is an order of magnitude lower than foreign. It is proved that at a high level of prices for raw materials-rapeseed seeds-effective production of biofuels will be at large capacities of plants for its production.

The study is justified and calculated on optimization models, depending on the yield and oil content of seeds, the share of its crops in the crop rotation, the level of the annual capacity of the biofuel plant and the corresponding oil residue in the cake, all technological and economic parameters of plants with a capacity of 1 -100 thousand tons of biofuel per year are in appropriate proportions.

The indicator of the break-even point for 2030 is achieved due to the following capacity: when the oil content in the raw material is 50% - 4.5 thousand tons of biofuels per year, 45% - 16.6 thousand tons, 40% - 42.3 thousand tons, and at 37.5% - 67.4 thousand tons. The cost per 1 ton of capacity of such plants in accordance will be-1.9, 2.1, 2.4 and 3.2 thousand UAH. According to the plant's capacity of 100 thousand tons of biofuels per year (the oil content in the raw materials is 50%), the break-even level will be reached at the price of 1 ton of seeds 4097 UAH, 10 thousand tons - 3251, and 1 thousand tons per year-only 2420 UAH. With a low level of oil content of seeds (for example, 40%), break-even will be achieved, respectively, at the prices of seeds of 3350, 2534 and 1892 UAH. Seed prices have fluctuated almost at this level in recent years. That is, in conditions of high price variation, the lower the capacity of the plant, the higher the risk for its construction and reaching the expected level of operational efficiency. While the construction of powerful plants requires significant investment investments.

Calculations carried out using the method of determining the average distance of seed transportation showed that with an increase in its yield in the range of 1.5-4.5 tons / gallon, the average transportation distance decreases by 42%, the share of transportation costs in the total costs of the plant-by 1-2, and the level of profitability of biofuel production - by 2.3. With an increase in the share of rapeseed crops from 12.5 to 27.5%, the distance of transportation decreases by 33%, and the level of profitability of biofuel production increases only by 1.5 percentage points.

At the same time, Chinese business is quite cautious about investing in Ukraine. In addition to political instability and problems in the economy, everything is complicated by the presence of problems with the protection of foreign investments and the failure to fulfill Ukraine's obligations regarding the funds already provided. Representatives of the People's Republic of China want guarantees from the Ukrainian side to preserve their investments. We are talking about working on a compromise solution that will suit all market participants, investors and the Ukrainian government. Thus, the development of Ukrainian-Chinese cooperation can become more multi-vector. Both sides approach the establishment of more productive cooperation primarily from the position of ensuring national interests. The PRC takes into account the real opportunities and prospects of Ukraine in the agro-industrial sphere. For Ukraine today, China is a market for promoting its products, as well as a source of attracting investment in the economy. The attractiveness of this direction of the foreign policy of the Ukrainian state is determined by many factors, not the least of which is the constantly growing political and economic weight of the PRC in the world.

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