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Advantages and Problems of the Development of Efficient Biofuel Production

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Abstract*: The article discusses the advantages and problems of the development of efficient biofuel production. The experience of developed countries in the production of biofuels from agricultural raw materials. Defined economic and social aspects. There is a political side to the production of renewable bioenergy. The availability of verified energy sources gives the country a certain temporary "margin of energy durability" in the event of a sudden interruption in the supply of traditional fuels (oil, fuel oil, gas) and some opportunity for maneuvering energy resources within the state. The development of bioenergy based on the use of its own raw material base is economically feasible. This is not only biofuels and fertilizers, but also high-protein feed for livestock and poultry, as well as the possibility of energy supply of specific agricultural enterprises.

Keywords*: biofuels, ecology, energy efficiency, economic aspect, social aspect, energy costs.

I. INTRODUCTION

In programs for the development of renewable energy in many countries of the world, great importance is attached to the development of bioenergy (Korableva et al., 2019a; Popova et al., 2019). Transferring a part of the economy to bioenergy is an important national task. They are investing heavily in the development of new technologies, producing the necessary equipment, conducting research, including in the agricultural field: improving the technology of growing so-called energy crops that serve as raw materials for the production of biofuels.

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As a result, a relatively favorable innovation climate emerges around bioenergy (it improves as oil and gas prices rise). The state policy of prices for bioenergy makes its production profitable (Kireev et al., 2019; Zhundibayeva et al., 2013; Dautov et al., 2018; Akhtarieva et al., 2019; Sagdieva et al., 2019; Kashirskaya et al., 2019; Goryushkina et al., 2019; Voronkova et al., 2019c). Therefore, investors consider it profitable to invest in bioenergy production. They are confident in the profitability of their business, since the state obliged energy companies to buy bioenergy from producers at guaranteed prices, and at a relatively high price.

At the same time, there are two problems. The first problem is the limited resources for the production of biofuels from agricultural crops and the aggravation of contradictions with other uses of these crops. The second problem is increasing the profitability of biofuel production and developing correct methodological approaches to assessing this profitability (Bozhkova et al., 2019; .

II. METHODOLOGY

In some countries, there is already a shortage of raw materials for the production of biofuels. For example, in Germany, almost the entire harvest of rapeseed oil is for the needs of bioenergy. To get 1 ton of biodiesel fuel, it is necessary to process 2.2–2.5 tonnes of rapeseed. Opportunities for expanding the area under this culture are almost exhausted. Germany is likely to have to import raw materials in order to achieve the indicators stipulated by the EU Directive. As the capacity of bioenergy enterprises increases, the problem of shortage of raw materials will be exacerbated.

In the EU countries, farmers producing raw materials for bioenergy needs received subsidies at the rate of 45 euro / ha, which contributed to the expansion of production areas for biofuel raw materials.

The expansion of the area contributed to other circumstances. The reforms of the agrarian policy of the EU countries, removed many restrictions on the cultivation of crops. As a result, farmers switched to unconventional use of their products as raw materials for biofuels, as with the development of bioenergy a new market segment for agricultural products opened. In particular, the producers of sugar beet and corn benefited from the development of bioenergy.

The problem of shortage of land resources and food restrictions in the production of biofuels from agricultural crops can be resolved using alternative cellulose-containing raw materials, algae, etc.

However, so far such production needs a technological breakthrough and is not competitive enough not only with respect to traditional hydrocarbon fuels, but also with respect to first-generation biofuels. In the sphere of production of the latter there are also economic problems.

In Germany, for example, biodiesel fuel is produced both in small plants with a capacity of 6–20 thousand tons of diesel fuel per year, and in large industrial enterprises with a capacity of 200 thousand tons. The cost of installing an average power is 1.5-2 million euros. The problem is how to make such production profitable. While the production of rapeseed costs 0.65 euro / l (the cost of conventional diesel fuel is 0.35 euro / l).

The advantage of biodiesel fuel in the fuel market is ensured only due to its exemption from the tax on mineral fuels. As a result, biodiesel, despite the higher cost, is 20% cheaper than conventional diesel fuel, so the demand for it is growing, including in agricultural production. The state, therefore, has increased the competitiveness of a desirable from an environmental point of view, but too expensive to produce a product. However, since the consumption of conventional fuel is reduced, the state suffers losses due to a reduction in tax revenues (Arslan and Tanis, 2018).

The main thing in the other is that the state invests heavily in subsidizing the cultivation of energy crops and investing in biofuel production plants. During the construction of plants for the production of biodiesel fuel, the founders are compensated for 40–45% of the costs due to the EU and the federal land budget in which new jobs are created. Germany and other EU countries spend on these expenses in the interests of nature conservation.

What has been said regarding state support also applies to the production of bioethanol. In Germany, bioethanol is produced in three plants that work on grain. At the plant in Zerbig (Saxony-Anhalt) bioethanol is produced from rye. The plant was built by Bioenergia, the investment amounted to 35 million euros. The raw materials are provided by neighboring rye farmers. The contracts stipulate the conditions of its cultivation, the timing of the supply of raw materials, payment. Although special rye varieties adapted for bioenergy purposes have not yet been created, work in this direction is underway.

The plant is designed to process 240 thousand tons of grain per year with the release of 80 thousand tons of bioethanol and 80 thousand tons of bards. The carbon dioxide released during processing is used for technical purposes.

Major sugar producing companies in Germany also responded to the turn in the energy policy and the EU directive on the use of biomass, embarking on the launch of bioethanol production. It is planned to invest 70 million euros in the construction of a plant for the production of bioethanol from sugar beet in northern Germany with a capacity of 130 thousand tons. For such a large enterprise will require a significant amount of beets. It will be supplied on a contract basis 32 farms. It was also decided to build a plant for the production of bioethanol at a sugar factory in Anklam (Mecklenburg-Vorpommern). Investments will amount to 25 million euros, the design capacity of the workshop is 55 thousand tons of bioethanol. To produce such a quantity of bioethanol will require 450 thousand tons of sugar beet. For a economically depressed area, where unemployment is high, the development of biofuel production is important.

Verbio’s plans to build a plant for the production of bioethanol with a capacity of 200 thousand tons were also announced. Ethanol will be produced from grain, the demand for which is estimated at 680 thousand tons. Investments will be 100 million euros. The plant will operate on both local and imported raw materials, which will be supplied by sea and rail.

However, it should be noted that for all the positive aspects of the transition to environmentally friendly fuel, it is necessary to remember that this type of alternative fuel is relatively expensive, its production is financed by public funds. According to some Western experts, even when using the most modern technologies, it is still difficult to expect that the production of biofuels will be competitive compared to fossil fuels.

For the near future, the challenge is to expand the "set" of raw materials, improve the technology of biofuel production, introduce innovative developments. In the future, it is necessary to switch to the production of second-generation biofuels produced from cellulosic raw materials. Studies in this direction are already underway.

The experience of developed countries in the production of biofuels from agricultural raw materials is of particular interest for Russia.

In accordance with the goals and objectives of the Comprehensive Biotechnology Development Program in the Russian Federation for the period up to 2020, the Ministry of Agriculture of Russia has included the “Biotechnology Development” event (Tarasov, 2008) in the draft State Program, which will be implemented through subsidies to the budgets of the constituent entities of the Russian Federation to reimburse part of the costs of interest payments on investment loans for the construction, reconstruction and modernization of bioenergy plants, as well as other facilities for the production of various biotechnology environmental products.

The main source of funding for the implementation of the event is the federal budget and the budgets of the constituent entities of the Russian Federation at the rate of: 65% - the federal budget and 35% the budgets of the constituent entities of the Russian Federation. In order to develop biotechnology in agriculture in 2018, it is planned to allocate about 300 million rubles from the federal budget for the provision of state support. Federal budget funds are provided in the amount of two-thirds of the refinancing rate (discount rate) of the Central Bank of the Russian Federation. Funds of the budgets of the constituent entities of the Russian Federation are provided within one third of the refinancing rate (discount rate) of the Central Bank of the Russian Federation, but not less than 20% of the refinancing rate (discount rate) of the Central Bank of the Russian Federation.

Until recently, in the domestic scientific literature there was practically no detailed consideration of a very important issue in the field of renewable energy sources - an assessment of the energy efficiency of energy production: whether additional energy is obtained in excess of the cost of its production and what is its size.

This is especially relevant when assessing the efficiency of bioenergy production from various organic raw materials. To determine the efficiency of production of renewable energy in both domestic and many foreign scientific studies, economic methods based on cost analysis are mainly used. It is believed that if the cost of alternative energy sources is lower than the cost of traditional energy sources, then the production of renewable energy sources is reasonable.

The economic interest of biofuel-producing companies is a desire to make a profit, which is formed, on the one hand, due to high prices for oil products, with which the price of a new energy carrier is compared, on the other hand, due to various state preferences: reduction or cancellation of excise taxes, tax deductions for investments in new investments to be used for the production of renewable energy sources. In some countries, biofuels are exempt from energy, environmental taxes and fees. There is also a form of promoting its production, as subsidies.

In Austria, for example, farmers receive money for growing energy crops on steam fields. In the same country, tax privileges for biodiesel fuel are used: when using biodiesel in pure form - 100%, with a content of fossil fuel up to 5%, the tax privilege is applied to the entire biofuel component. In addition, the production of biodiesel in small plants owned by agricultural cooperatives, exempted from the tax on mineral fuels, provided that the fuel will be used only for domestic needs. Similar mechanisms operate in other European countries. The situation with the use of biofuels in the Old World shows that states economically stimulate the use of renewable energy. However, the economic assessment of the production of renewable energy has limited value. It shows only the ratio of cash costs and income received, but says nothing about the goal of production, which should be the main one, its energy aspect, the size of the additional energy received. The problem of production of renewable energy has at least five aspects: energy, economic, social, political and environmental.

In the production of alternative fuels, first of all, the main task should be set - to obtain free energy, that is, additional energy over and above the cost of technical energy for the production of energy carrier (Frolova et al., 2019; Shatunova et al., 2019; Tarman, 2016; Frolova et al., 2019; Ivanova et al., 2019). Whether additional energy is obtained and what is its size - this important question can be answered only after the energy analysis of the entire technological chain of production from planting a crop in a field to a tank of a car, tractor, or airplane. Similar studies are being conducted, but, unfortunately, by a limited number of scientists in the United States and some EU countries.

III. RESULTS

The efficiency of the production of non-traditional energy sources is usually estimated in monetary terms. Attention on the economic side of the problem is emphasized because economic evaluation is the main measure adopted in the world for assessing the effectiveness of human activity. It is known that in recent years the cost of energy in the world market is constantly growing. However, in general, the cost of oil in world markets has little to do with changes in the costs of its production and transportation, which is primarily due to the recurring financial and political problems in the world and on a long time scale has sharp fluctuations.

The short-term price movements on the stock exchanges are mainly related to the state of the economy of the leading world power and the main consumer of energy resources - the United States. If the world economy slows down significantly, then we should expect a drop in oil prices, and the production of alternative energy will be economically unprofitable, although the conclusion may be completely different from the point of view of obtaining additional energy.

Distorts the objectivity of biofuel cost estimates and time lag. The depreciation deductions for the financial costs of manufacturing equipment and building plants built in previous years with a relatively low energy price are automatically underestimated after a few years when calculating the cost of biofuel produced compared to the cost of energy in the billing period (Mapping the Impacts of Natural Hazards and Technological Accidents in Europe, 2011).

The economic situation in producing countries and global markets often changes unpredictably, so it is rather difficult to plan the strategic development of alternative bioenergy based on an economic approach (Korableva et al., 2018; Korableva et al., 2019b; Paptsov and Nechaev, 2019). For example, 80% of biodiesel in the United States is produced from soy. At the same time, the cultivation of other crops in order to process them for edible oil became noticeably more profitable with the increase in their prices. However, the price of edible oil increased, not least because of the expectations of high prices for biodiesel. As a result, 75% of the capacity for its production is idle, and the fields are again returning to the crops of rapeseed and other oilseeds. In the United States, until recently, investors in soybean processing plants and farmers sowing this crop were in an absolutely disadvantageous economic position. Contrary to the predicted growth in demand for biodiesel, which spurred prices for oilseeds, this demand almost did not increase, while for edible oils increased sharply. According to the National Association of Biodiesel Manufacturers of the United States - an organization uniting processors and farmers, only 25% of biodiesel was in demand. In fact, out of 171 built biodiesel production plants, only 40–45 work.

The development of biofuel production from agricultural raw materials is a socially controversial issue. The scientific literature has already expressed the view that its production is threatened by food shortages in world markets. In 2007, representatives of the International Monetary Fund issued a warning about the growing trend of using grain in the production of biofuel. The fund's experts believe that further trends may cause a rise in food prices in developing countries, which in turn will lead to negative consequences in these states. UN experts also warn that the world is heading towards a long period of conflict over food price increases. Many experts believe that one of the reasons for the increase in prices is the growing interest of the world economy in the production of biofuels, for which food crops are the raw material (Ivanova, 2018; Zeibote et al., 2019; Movchan and Yakovleva, 2019).

The important and socially acute question of how energetically justified is the use of food raw materials to produce fuel can only be answered after a thorough energy analysis of the entire process of its production. However, the next no less important question then arises: how much food for the global community can be easily processed into biofuels? Naturally, each country has the right to independently manage its resources. In the future, international agreements may be required under the auspices of the United Nations between countries that produce surplus food and consumer countries. Thus, there is a political side to the production of renewable bioenergy. The availability of verified energy sources gives the country a certain temporary "margin of energy durability" in the event of a sudden interruption in the supply of traditional fuels (oil, fuel oil, gas) and some opportunity for maneuvering energy resources within the state. When receiving renewable bioenergy, even with equal components in the chain “total technical energy costs for production - energy content in the energy carrier”, the state still provides itself with additional energy resources (in fact, due to the depreciation of the resources of the “accumulated” technical energy in the labor tools and production in previous years) (Voronkova et al., 2019a.b; Sycheva et al., 2019; Fedulova et al., 2019; Saenko et al., 2019; Tarman and Kılınç, 2018; Movchan et al., 2019; Sadriev et al., 2016). The question of how long such energy can be obtained in an “autonomous mode” without receiving renewable energy from outside can be answered after a detailed review of the depreciation terms of the means of production used. At first glance, it seems that the only source of energy received is recycled plant biomass or, ultimately, solar energy. Therefore, all the energy contained in the new energy carrier can be considered additional. In fact, this is far from the case. In the process of energy production from biomass of cultivated plants, a large number of various agricultural equipment, tractors, vehicles, mineral fertilizers and pesticides are used, as well as equipment of industrial enterprises, in which plant products are converted into liquid fuels. For the manufacture of machinery, equipment, buildings and structures consumes significant resources of technical energy (Hilkevics and Semakina, 2019; Prakash and Garg, 2019; Masood et al., 2019; Magmusov, 2013a,b; Vasilev and Tung, 2019; Vasilev et al., 2019a,b; Shaitura et al., 2018; Dagaev et al., 2019). In general, the period of receipt of renewable energy from vegetable raw materials in the energy balance of the country is determined by the duration of the depreciation of agricultural machinery and equipment. In agriculture, the time of rational use of technology is no more than seven years (a tractor after two overhauls). During this period, there is the possibility of the production of plant products, which are processed into non-traditional energy sources. This is one side of the problem. On the other hand, since the technical energy accumulated in machinery, fertilizers, pesticides, seeds is spent on the production of plant products, to assess the effectiveness of growing crops, it is necessary to compare depreciation and direct costs of technical energy, labor energy with the energy content of the crop. As a result, determine the energy efficiency ratio.

Thus, at the initial stage of assessing the feasibility of producing alternative energy carriers from vegetable raw materials, it can be concluded that the energy efficiency of the production of plant products in an agricultural enterprise, the ratio of stored energy in biomass and the cost of technical energy to produce this biomass (Ponomareva et al., 2019; Leonteva et al., 2019; Khalikov et al., 2018; Goloshchapova et al., 2018; Prodanova et al., 2019; Nazarova et al., 2018).

When calculating the energy costs of growing crops of agroecosystems, it should be borne in mind that the types of crops, the intensity of fertilizer use, the methods of tillage differently affect the components of its fertility, resistance to erosion processes. Prolonged use of the soil without restoring the material and energy composition and physical properties leads to degradation of the soil cover and significant loss of productivity of agroecosystems. Therefore, when analyzing the flows of technical energy in agriculture, it is necessary to take into account not only the expenditure of energy on the cultivation of crops, but also the energy input on the reproduction of soil fertility after a given crop and the possible energy savings as a result of positive aftereffect.

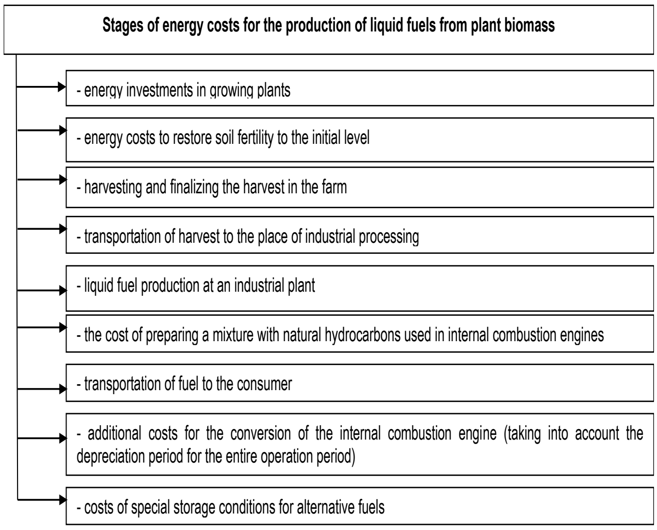

Fig. 1. Stages of energy costs for the production of liquid fuels from plant biomass

On the basis of domestic and foreign scientific data, in our country, methodological recommendations have been developed for assessing the energy efficiency of growing crops, which contain energy equivalents and depreciation rates for agricultural machines and tools, tractors, mineral and organic fertilizers, and methods for the operational and total calculation of total technical costs. energy in agroecosystems. In Russia, there are a number of other methodical recommendations and techniques that can be successfully used to assess the energy efficiency of agroecosystems. The cost of technical energy for the reproduction of soil fertility is significant and differs sharply depending on the indicators of soil fertility, crop groups (tilled crops, grains, perennial leguminous grasses) and the intensity of fertilizer use. However, in most studies on the analysis of energy efficiency of agricultural crops, the factor of change in fertility is not taken into account, and therefore the cost of energy resources for crop production is underestimated (Key World Energy Statistics 2012, 2012; Shumakova, 2016).

To assess the efficiency of the production of useful energy from plant products, one can apply the absolute energy efficiency coefficient, showing the ratio of energy contained in fuel synthesized from plant biomass and technical energy spent on its production. If in the final volume, for example, liquid organic fuel contains less energy than technical energy is spent on its production at all stages of production, the process is not effective.

The following stages of energy consumption for the production of liquid fuel from plant biomass, which are shown in Fig. 1.

However, it should be emphasized that even when the absolute energy efficiency coefficient is less than a unit, the production of alternative energy can be expedient: first, the production of such energy gives a certain political and temporary gain in the event of a sudden interruption in the supply of traditional types of energy carriers. Domestic renewable energy can be used to supply the most important national economic and strategic facilities; secondly, the production of energy with zero or negative balance is relevant if, when it is used, a positive environmental effect is achieved in places where "clean" energy is consumed. For example, it is known that the second place in the world in terms of environmental pollution is occupied by transport, especially automotive (Gradoboev and Tesleva, 2017; Plaskova et al., 2018; Puryaev et al., 2019; Gilmutdinova et al., 2018; Trofimova et al., 2019). The burning of fossil fuels by motor vehicles increases the concentration of hydrocarbons, heavy metals and particulate matter in the atmosphere.

IV. DISCUSSION

It is estimated that during the period of operation equal to six years, one averaged car emits 9 tons of CO2, 0.9 tons of CO, 0.25 tons of NO and 80 kg of hydrocarbons, not counting heavy metals, benzapyrene, sulfur and other pollutants. In many cities, especially in economically developed countries, motor transport is the largest source of pollution. The removal in the cities and megalopolises of the polluting effect of the exhaust of motor vehicles operating on hydrocarbon fuels requires significant expenditures of various resources. After all, air pollution not only destroys buildings and structures, the soil, but also causes great harm to human health.

Therefore, when evaluating new energy carriers, an additional energy analysis is required, which reveals the environmental effect from the use of produced "clean" fuel, and the calculation of the magnitude of this effect, expressed in energy units. If the environmental effect exceeds the difference between the cost of fuel production and the content of useful energy in the energy carrier, the process of obtaining energy from a new source on a large scale is appropriate. The amount of workable energy "clean fuel" and the positive impact of its use on the state of the environment in cities compared to hydrocarbon fuels can be called the ecological and energy effect. A similar accounting of the total costs of anthropogenic energy and the calculation of energy efficiency should be carried out in the production of any new types of energy carriers (Ganieva, 2017; Melnikov, 2018; Mullakhmetov et al., 2018).

A comprehensive environmental and energy analysis of the efficiency of the production of unconventional energy sources will allow us to objectively assess the size of the additional energy received, select the most suitable energy crops by their cultivation areas, crop area and acceptable level of productivity, recommend a rational use of clean energy. As a result, in each country a certain vector of strategic development of this important direction in the energy sector will be outlined. However, without a detailed consideration of this issue, it is impossible to plan further development of this area of energy.

V. CONCLUSION

Recently, the Government of the Russian Federation has been confronted with agriculture the task of energy-efficient work, reducing energy costs and developing alternative types of energy based on agricultural raw materials and industrial waste (RosBusinessConsulting, 2010; Tarasov, 2008). Agricultural waste in the Russian agro-industrial complex annually accounts for more than 770 million tons. They can be a significant energy resource if they are processed to produce biogas, electricity and heat. For example, as a result of processing this waste you can get: 66 billion m3 of biogas, which is equivalent to 33 billion liters of gasoline and about 120 million tons of high-quality granulated fertilizer.

The development of bioenergy based on the use of its own raw material base is economically feasible. This is not only biofuels and fertilizers, but also high-protein feed for livestock and poultry, as well as the possibility of energy supply of specific agricultural enterprises.

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