

SUBSTANTIATION OF PRODUCTION BIODIESEL AND ORGANIC BIOFUELS

DrSc., prof., eng., academician of the NAASU Kaletnik H.¹ PhD,
DrSc., prof., eng., academician of the NAASU Bulgakov V.² PhD,
Prof. Bandura V.¹ PhD, Eng. Ihnatiev Ye.³

¹ Vinnytsia National Agrarian University, 3, Soniachna Str., Vinnytsia, 21008, Ukraine

² National University of Life and Environmental Sciences, 15, Heroyiv Oborony Str., Kyiv, 03042, Ukraine

³ Tavia State Agrotechnological University, 18, Khmelnytskyi av., Melitopol, 72312, Zaporozhye region, Ukraine
E-mail: vbulgakov@meta.ua, yevhen.ihnatiev@tsatu.edu.ua

Abstract: There are in the article systematically finding out scientific-methodological and organizational-economical foundations of the development of biofuel market, forming of energy crops market, which used as plant origin bioraw material and economical estimation of their usage in the area of agro-industrial complex. World trends of development of biofuel from plant origin bioraw material were generalized, theoretical- methodological bases of forming biofuel market and its social-economic meaning in development of agro-industrial complex and economy integrally, other problems of organization of producing of bioenergy crops and competitiveness of biofuel market were examined. Prospects of development of biofuel were economically substantiated. The main problems, which restricting biofuel market are the absence of the accurate strategy of development.

KEYWORDS: ROOT CROP, BEET TOPS, ROOT CROP HEAD, CLEANER, WORKING MEMBER, SENSING MEMBER, NORMAL REACTION, DEFOLIATOR

1. Introduction

Optimistic forecasts concerning the inexhaustibility of traditional natural resources of energy carriers (coal, oil, gas, peat, etc.) are a thing of the past. There are calculations according to which the explored oil reserves will be exhausted by 2018, the production will be reduced by 30-40%, and the demand for energy consumption in the world will increase by 20%. And this trend will increase from year to year, as the extraction of fossil energy sources is reduced and in the near future the reserves of these energy carriers, according to international experts, will be exhausted. And these are global destructive phenomena in the biosphere, the rapid growth of the cost of natural energy sources, the accumulation of excessive amounts of organic waste from industrial, agricultural and domestic sources, which is a real threat to the existence of civilization, unless, of course, their new sources are found in time. Pessimists believe that this will happen for 20-25 years, optimists point to a period of 50-70 years. But both agree in one: the development of mankind is possible only if new types of energy-saving biotechnologies and raw materials, in particular renewable energy sources (RES), are attracted, which, as is known, can be used in more than ten areas of the economy.

Actually, today there is no need to agitate for the production of RES and biofuels. Europe has already understood this and started to grow biomass from specialized crops and solve the problem of renewable energy, when biofuel was worth ten times more expensive from traditional sources. After 10 years, the price almost equalized. And it's useless to think that the price of oil will fall [2].

The recoupment of capital expenditures for the construction of refineries and the purchase of appropriate means for processing bio-raw materials for fuel directly depends on the constant receipt of bioconcrete. Bio-raw materials in the form of energy crops (oil and sugar, sugar-containing), as shown by literature sources and domestic experience, are a reliable source for solving the problem of the development of the biofuel market in the countries of the world. For example, over the past few years, more than 100 ethanol plants have been built in the United States. Grain, especially corn, goes to ethanol production. The plant worth \$ 150 million pays off for the year; 60% of these enterprises belong to farmers. There is no question to give subsidies from the budget, subsidies. The US produces much more grain than it consumes. The "extra" grain there always tried to attach to the foreign market. Now, a decrease in exports is forecasted here, as it began to be used more in the production of ethanol. Therefore, now the corn market in the world has so rapidly increased. It is much more profitable to direct it to biofuels than to export. Profit American farmers are offering their customers a renewable, environmentally friendly alternative fuels.

The same picture with the use of reed in Brazil. The global sugar market is also heating up in other countries of the world.

For Ukraine, which every year consumed about 200 mil ton e.f. fuel- energetic resources (FER) and refer to the scarce energy countries, because it meet their electricity demand about 53% and imported about 75% of necessary volume of natural gas and 85% of crude oil and oil products, price of which constantly is growing up, the problem of new sources of energy is very urgent. Exactly development of biofuel market and new types of energy saving biotechnologies and raw material, namely, renewing sources of energy (RSE) as is generally known can be used more than in ten areas of economy, open for Ukraine, which have powerful potential of renewing sources of energy almost of all types (solar energy, wind energy, biomass, biofuel, geothermal energy, micro water power), the unique chance is the way to the energy and ecology- food safety. There is line of others important factors relative to the economic and social necessity in the growth of volume of fuel-energetic resources and development of biofuel market in Ukraine, starting with thinking of energy safety, diversification of national producing, supporting of innovation and ending of social-economic effectiveness of development of biofuel market on the base of high motivation of the growing of agrarian sector, positive social displacement about employment of rural population and ecological safety.

2. Preconditions and means for resolving the problem

Ukraine possesses a powerful potential for renewable energy sources of almost all types (solar energy, wind energy, biomass, biofuel, geothermal energy, microhydroenergy). The use of this resource promises a great potential according to the world trend of using renewable energy and taking into account the Kyoto Protocol, which Ukraine signed together with other states. According to expert estimates, the annual total potential of the biomass of agro-industrial production of Ukraine available for energy production is about 49 million tons of fuel equivalent, technically achievable– 36 million tons of fuel equivalent, and economically expedient– 27 million tons of fuel equivalent. Ukraine can provide food products using only up to 70% of land suitable for agricultural production. So, has reserves of increasing volumes of marketable crop production through innovative technologies, which makes it possible to export a significant part of it and convert it into biofuel. For potential investors, the development of the biofuel market in Ukraine provides for the acquisition of positive changes in terms of efficiency in business activities and, at the same time, economic and social expediency for the national economy as a whole. This factor, combined with favorable soil and climatic conditions for growing crops with a high level of biomass energy accumulation during vegetation and available labor, makes Ukraine extremely attractive for the development of the biofuel market. For the opportunity to develop bioethanol production in Ukraine, business companies from several countries are already competing, which makes it possible to

receive not only food but also renewable energy through agriculture.

The production and use of biofuels in agriculture in Ukraine, the development of its market is an objective prerequisite for creating additional jobs, increasing employment of the rural population, increasing the efficiency of production and the welfare of the peasants. After all, most processing enterprises are located in rural areas, and for some localities they are the main payers of taxes to local budgets. On their basis social and household infrastructure of rural settlements is built, and the irregular work of processing factories painfully hits precisely the most vulnerable layers of the population— leads, in particular, to problems with providing children's gardens, schools, and houses with heat and electricity.

To significantly increase biofuel in Ukraine's energy balance, it is necessary to create alternative energy facilities for the most promising technological areas and form an efficient market. But the use of new energy sources (hydrogen, direct conversion of solar energy to electric, thermonuclear fusion) is rather problematic, especially for large-scale use. The development of this direction inhibits the lack of an effective biofuel market. Meanwhile, it is bioenergetics that can develop at the fastest rates. Among renewable energy sources, energy carriers of biological origin or biofuels are becoming more widely developed: biodiesel, bioethanol, biogas [2].

There are several reasons for the economic and social need to increase the volume of fuel and energy resources and the development of the biofuel market in Ukraine, starting from considerations of energy security, diversification of national production, support for innovation and ending with the economic and social efficiency of the biofuel market development on the basis of high motivation for growth in the agricultural sector, positive social shift in relation to rural employment and environmental security.

3. Results and discussion

Practical experience in the formation of the biofuel market in European countries shows that biomass: carbonaceous (vegetation, wood chips, seaweed, grain, paper, packaging) or sugar-bearing (sugar beet, sugar cane, reeds, sorghum) is of the greatest importance among renewable energy resources that since ancient times it has been used by mankind and is still a source of energy on most of the planet. Energy-attractive plants of the European soil-climatic zone include the following: 1) one-year-olds with a high content of sugars and starch (sugar beet, cereals, corn, potatoes) for the industrial production of bioethanol; 2) oil crops (rape, sunflower, soybean, oil flax), from which oil and biodiesel are produced; 3) perennial herbaceous plants (miscanthus large or reed, interspecific hybrid of sorrel – rumex, millet, jerusalem artichoke, mallow pennilvan, peasant gopher, sakhalin mountaineer, etc.). Biotechnologies are also being developed that are based on the achievements of gene energy and genetic engineering, which makes it possible to revise the stereotypes of bioethanol production based on energy crops, expand the variety of sugar and starch-containing crops and reduce the cost of biofuel production.

The sown areas of energy crops have sharply expanded in recent years and in Ukraine— within the limits of more than 2 million hectares, the technologies of growing, harvesting and previous preparation of raw materials are improved, deepening research on improving the genetic potential of energy countries, efficiency and energy intensity of growing alternative crops suitable for processing on biofuels, scientific recommendations on the growing of bio raw materials are developed, which it is expedient to use when determining the forecast yield (and this, as well as observance of the scientifically grounded system of farming in the regions of Ukraine, optimal structures of sowing areas, crop rotation systems and the technology of their growing, is an indispensable condition for the formation of an effective biofuel market).

Our studies show that one of the most potential and unused sources of renewable energy for Ukraine is the production of rare biofuels from biomass (crops, wood cultures, herbaceous plants). For this purpose, it is most promising and economically justified to grow such types of energy crops as corn, triticale, wheat, various kinds of sorghum and millet, sugar beet and their processing products (melas), sunflower, rape, potatoes, agricultural and forestry waste,

miscanthus, poplar, energy willow, stems and sunflower husks, etc. With bio-raw materials, liquid, gaseous and solid fuels are obtained. Depending on the use, liquid biofuel is divided into: a) for carburetor engines with external formation of a fuel-air mixture, b) for diesel engines with internal formation of a fuel-air mixture, c) liquid biofuel for boilers instead of black oil. For the production of bioethanol – cereals, primarily corn kernels, sugar beets and potatoes; Biodiesel fuel – seeds of oleaginous crops, in particular castor oil, sunflower, soybean.



Fig. 1. – Sugar beet

Considerable prospects in Ukraine have some non-traditional cultures capable of accumulating large biomass, in particular because photosynthesis occurs in them for a long period, from early spring to late autumn, as well as fast-growing tree species and new varieties of poplar, willow and other tree species cultures. Potatoes have a record for accumulating energy per hectare of area in our conditions, but the problem of its storage for a long time before processing has not been solved.

An important culture, in terms of bioenergetics, is sugar beet. The latest scientific research and feasibility analysis confirm: in the list of alternative crops, sugar beet, which can be processed directly in sugar plants in a concentrated 25% syrup with further processing at distilleries, is the most attractive. For the production of 1 ton of 25% syrup, it is necessary to process 2 tons of sugar beet roots. In production conditions, you can get 166.5 liters of bioethanol. The technology of its cultivation, transportation and storage is well developed, but a number of problems with obtaining biofuel from this raw material, in particular a significant reduction in energy costs, are not solvable.

Ukraine has favorable conditions for growing rapeseed. Provided that 10% of agricultural land is taken as a crop and yield of 25 centners per hectare, the country can annually grow up to 8.5 million tons of seeds, processing of which provides an output of about 3 million tons of biofuel per year. Unfortunately, with respect to rapeseed, as a raw material for obtaining biodiesel fuel, there have not been thorough studies on the economic efficiency of its cultivation in different regions of Ukraine in comparison with other cultures. Are not developed in the regions and priority technologies for obtaining biofuel crops.

Perspective bioenergetic crops are chicory and jerusalem artichoke – plants, which, under appropriate climatic conditions, do not require very high quality soils.

Another high-performance sugar-bearing culture, which deserves additional research, is sugar sorghum. This drought-resistant plant up to 4 m in height contains up to 20% sugar in its leaves and stems. Given the great selection potential, unpretentious growing conditions, one can consider this crop as a perspective raw material. An important economic effect is that when processing sugar sorghum for ethanol there is no need to convert starch into a sacchariferous mass, both from raw grain and corn.

An important criterion for the industrial production of biofuels is the possibility of ensuring the processing of raw materials throughout the year, because transportation costs for the delivery of

raw materials to the plant and its storage prior to incorporation into the technological process are significant costs of the whole technology cycle.



Fig. 2. Energy willow in the breeding ground of the Yalthushkovskaya State seed-testing station (SSTS)

Actual tasks for development of bio-raw materials market in Ukraine are: development and using modern technologies for growing energy crops, which are planned for industrial processing for biofuels, increasing production crops, ensuring crop protection, technical modernization of agro-enterprises, reaching optimal power, developing and implementing regulatory frameworks, alignment with EU legislation [6].

Ukraine has collected a sufficient information and legal database for scientific and theoretical support of the main areas of renewal of the fuel and energy complex through the planned use of biofuels, in particular rare. To do this, it is necessary to establish a serial production of technological equipment at the existing machine-building and mechanical plants. At the same time, it is necessary to conduct economic studies and calculations on the further development of agricultural areas, which will transform some of the production potential into the development of agricultural crops for processing them for biofuel. The possibilities and expediency of using for the biofuel residues of such crops as wheat, barley, corn, taking into account the need to preserve the organic matter of the soil, etc., have not been determined. In the conditions of our state, because of the growing shortage of organic matter in soils, it is not yet practical to use agricultural waste as raw material for fuel, and therefore it is better to leave straw, corn stalks and soybeans on the field (except for sunflower leaves). But in some cases, if there is a surplus of waste, it can also be processed into chemical products and biofuels. And in any case, we must strive for the result of changes and transformations to become an increase in the economic efficiency of management and not create barriers to the country's food security.

Undoubtedly, by organizing the work on the formation of the biofuel market in Ukraine, the state should, as it is done in the leading countries, introduce temporary, by the way, significant, tax and other incentives for biofuel producers. An extremely important factor in increasing the efficiency of biofuel production is the selection of plants to increase the availability (by the content of useful substances) for the production of bioethanol and biodiesel fuel. In solving this problem, modern methods of biotechnology will play a leading role. It is not just about increasing the productivity and plant resistance to abiotic and biotic stresses, but also about changing the biochemical features of grain or other products (the content of pentosans, the change in the ratio of amylose and amylopectin, etc.). It should be emphasized that the participation of fundamental science in the development of bioenergy will largely be determined by its stock in the direction of both the creation of new genotypes of cultivated plants, more adapted to use their products and biomass for the production of biofuels, and in the search for new, non-traditional crops with an increased conversion factor of photosynthesis energy in the desired biomass at relatively low costs of fossil energy for their

production, transportation and storage. In solving these problems, genomics, in particular genetic engineering, botany, biochemistry, plant physiology, will play a significant, and perhaps decisive role. It is also encouraging that the Verkhovna Rada, the President and the Government have demonstrated support for the development of renewable energy sources and adopted a number of normative acts, the adoption of which will stimulate the production of alternative fuels [3].

In order to overcome obstacles to the development of the biofuel market in Ukraine on the basis of ethanol, biodiesel and to ensure sufficient export volumes of this fuel, it is advisable:

- develop a strategy – an action plan for at least 10 years for the sustainable development of biofuel. The plan should be consistent, systemic and clearly delineate the effective use of budgetary funds within the proposed ways of reforming in this area. To create a biofuel market and attract serious investors to Ukraine, a clear policy course is needed, supported by a functioning legislative and regulatory framework;

- to introduce a set of measures for the development of intensive technologies for the cultivation of high-energy plants (grains, oilseeds, sugar and starch-containing) and the necessary volumes of biomass for other crops for the production of biofuels and other energy carriers, which in turn can be used in cogeneration plants to provide the process with electricity and achieving non-waste production;

- implement arrangements for the entry of Ukraine into the market consumption of environmentally-friendly renewable fuel energy, including ethanol fuel, biodiesel, etc. components;

- adopt legislative and legal acts on the mandatory use in Ukraine of motor fuels with antiknock detergent oxygenic components;

- to ensure non-admission of mutual substitution, for the purpose of financial abuse in the sale of biofuels;

- to create energy-autonomous enterprises on radioactively contaminated lands of Ukraine in order to obtain rapeseed raw materials for biodiesel production and decontamination of these lands and their return to full-fledged activity [7, 8].

The issue of development and production of alternative energy sources in Ukraine is at the stage of development when financial support is needed and a deep understanding in state structures and scientific circles about the need for wider promotion of production and use of biofuels and changing stereotypes of bureaucrats' thinking [2].



Fig. 3. – Miscanthus

Energy independence is an extremely important strategic goal, because Ukraine has already felt that this means being in energy dependence. We need very different approaches to solving renewable energy. Analysis of the modern market of technological equipment and technologies proves that, technically, there are no important obstacles to the industrial production of biofuels. According to our research, the economic effect of production will increase under the conditions of the optimal choice of technology for growing and processing, the justified location of the necessary equipment in

places where raw materials are stored, as well as the complex provision of its processing and sale [2]. The economic effect will be enhanced by the right choice of technology for growing and processing, justified, as well as the integrated use of products obtained during processing. Experts argue that it should be done step by step. Having established a closed production system (from the field to the consumer) of biodiesel and bioethanol, Ukraine risks to turn not even to the raw material appendage of developed countries, but to become their industrial site, placing in its own territory a not entirely safe production, while the European countries will be sole their owners of clean biofuels. In this case, the prospect can be really rather sad. It is necessary to master the technology of complex processing of bioresources and re-equip some of the distilleries. Our close perspective is to attract investments for the commissioning of distilleries, oil-processing plants, to bet on their growing areas. Conditions should be the same for both domestic and foreign investors. For example, for 10 years– tax holidays. This was how America, Brazil acted, so that the biofuel market could be used at an accelerated rate. Set the rules for the functioning of the biofuels market for 7-10 years, which will not change. The commissioning of these facilities will create thousands of additional jobs, own raw materials base will be used for this production. Finished products will satisfy the demand of the domestic market and can be exported [2]. In solving the problem of the formation and development of the biofuel market in Ukraine, a significant place belongs to the government structures regarding the provision of the regulatory role of the state in this rather complicated process. For example, the alcohol industry in Ukraine, which is under the control of the state, fully meets the domestic requirements for alcohol for the manufacture of alcoholic beverages, working only on 30% of its total capacity. Obviously, new rules and mechanisms are needed to overcome obstacles to establishing a market for clean fuel, which is hampered by oil refiners and disinterested business structures.



Fig. 4. – Millet in the research areas of the Yalshushkovskaya SSTS

Efficiency and competitiveness of bioenergy potential is closely linked to the soil and climatic conditions, the development of innovative technologies, raw materials, the existing production capacity of the complex, the investment climate, development of the scientific and industrial infrastructure and, fundamentally new approaches to the development of complex technology of biofuels, protein and other components of maize, sunflower, soybean, wheat, triticale, rape, millet, sugar beet biomass and other including wood, with the maximum use of organic substances and the creation of low-waste technology cycles [9, 10].

The tendencies of recent years have a positive effect on the development of bioenergy and confirm the thesis: any state will stand firmly on its feet if the domestic market, including biofuel, works. Among such trends, a rapid rise in prices for natural gas; Increasing interest in the export of Ukrainian biomass to the EU countries– Germany, Poland, Sweden, Denmark, Italy; development of legislation for some sectors of bioenergy; surplus arable land (up to 5 million hectares); relatively inexpensive labor (\$ 500 per person per month); good harvest and relatively low prices for grain and straw.

The strengthening of the diversification of agribusiness with a view to reducing market risks remains topical. In this respect, it should be remembered that Ukraine should not repeat the mistakes of the global division of labor and globalization that led to the specialization of a number of countries in the production of raw materials or a limited set of export commodities for world markets [4, 5].

4. Conclusions

Considering the above, it is possible to draw conclusions regarding the possibility of forming a biofuel market in Ukraine to the level, as defined by the Kyoto Agreement and Directive 2003/30 / EC, without causing problems to provide the population with food in accordance with existing needs, norms, prospects. Bioenergy is a powerful stimulus for the development of the agricultural sector. It intensifies the flow of investment in agriculture, helps improve technology and infrastructure, increase food production and reduce its cost.

Of particular importance is the development of the concept of the organization of enterprises with processing of biomass with full provision of their local raw materials base. The use of non-traditional crops is a significant potential of the domestic economy and a guaranteed future reserve, which opens significant prospects for the development of society, the economy and overcoming environmental problems. Perspective development of RES in the country, according to the principles of the Green Book, should be based on economic competition with other sources of energy, while simultaneously implementing state support measures for advanced RES technologies that reflect public interest in improving energy security, environmental cleanliness and countering global climate change.

The development of the biofuel market in Ukraine should be consistent and justified, taking into account the possible impact on the national economy and the natural environment and rely on international experience and take into account the need to maintain a balance between food, feed and energy use of agricultural products. The state can not stand aside as regards the creation of bioenergy technologies for the production of biofuels, and in terms of developing the market and promoting the protection of this product and its international competitiveness.

The main problems that restrain the biofuel market are: the lack of a clear development strategy, which would take into account all the factors influencing the provision of energy and food security, ensuring an increasing demand for motor fuel and preserving the fertility of agricultural land; lack of a balanced system of legal, regulatory and other market instruments that would permit effective economic activities in the production and consumption of biofuels; Insufficient development of the storage and sale infrastructure for liquid biofuels; lack of effective control over the quality of biofuel at all stages of its production and sale; unfavorable conditions for attracting investments, including foreign ones; Low level of implementation of decisions and normative and legislative acts at all levels of government. With the aim of introducing and stimulating the development of alternative energy and the wider use of new fuels, the necessary state program for the scientific development of biofuel production from alternative sources of raw materials, preferential support of credit resources and a consistent investment policy of the state regarding the creation of financial funds to promote scientific research in the field of alternative sacchariferous crops. In programs on energy, ecology, land use, water supply and agricultural development, measures should be prescribed for preferential taxation of new types of fuel, reduction of customs payments for imports for foreign equipment that is used in alternative energy.

5. References

1. Ahropromyslovyi kompleks Ukrainy: stan, tendentsii ta perspektyvy rozvytku // Informatsiino-analitychnyi zbirnyk /Za red. P.T. Sabluka ta in. – 2003. – Vol. 6.– 764 p.
2. Kaletnik H.M. Rozvytok rynku biopalyv v Ukraini: Monohrafiia.– Kyiv: Aharna nauka, 2008. – 464 p.
3. Enerhetychna stratehiia Ukrainy na period do 2030 roku: Rozporiadzhennia Kabinetu Ministriv Ukrainy vid 15 bereznia 2006 goda. № 145. <http://www.mpe.kmu.gov.ua>

4. Elektronnyi resurs: <http://www.eco-live.com.ua/content/blogs/biopalivo-sche-odne-superechlive-pitannya>.
5. www.propozitsiya.com/?page=149&itemid=2985&number=98.
6. Wullschleger S.D. Photosynthetic rates and ploidy levels among populations of switchgrass / S.D. Wullschleger, M.A. Sanderson, S.B. Mc-Laughlin et. al // Crop Sci, 1996. – №36. – P. 306-312.
7. Ovdin V. „Zelene” palyvo / V. Ovdin // Ahrobiznes sohodni. – 2009. – № 14. – P. 12.
8. Roik M. Efektyvnist vyroshchuvannya vysokoproduktyvnykh enerhetychnykh kultur / M. Roik, V. Kurylo, M. Humentyk, O. Hanzhenko, V. Kvak // www.archive.nbu.gov.ua.
9. Kulyk M.I. Botaniko-biologichni osoblyvosti prosa lozovydnoho (*Panicum virgatum* L.) / M.I. Kulyk, Kh.V. Elbersen, P.A. Kraisvitnii ta in. // Materialy Mizhnarodnoi naukovo-praktychnoi konferentsii “Bioenergetyka: vyroshchuvannya enerhetychnykh kultur, vyrobnytstvo ta vykorystannia biopalyva”, Kyiv, Instytut bioenerhetychnykh kultur i tsukrovykh buriakiv , 25–26 zhovtnia 2011 r. – p. 25–27.
10. Andriienko V.V. Pro rozvytok enerhozberihaiuchykh tekhnolohii u silskomu hospodarstvi na suchasnomu etapi / V. V. Andriienko, H.O. Lapenko, A.A. Dudnikov, S.I. Chornenkyi // Visnyk poltavskoi derzhavnoi ahrarnoi akademii. – Vol. №4. – 2006. – p. 9–11.