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DEVELOPMENT OF BIOENERGY AS A PRIORITY DIRECTION OF GRAIN MARKET ACTIVATION IN UKRAINE

Abstract. The article examines the role and importance of bioenergetics as a priority area of the grain market activation, outlines its state and problems, identifies approaches of its development considering current challenges and demands.

The need to develop bioenergetics is associated with the rapid growth of the production of grain and grain-legume crops, which generates additional challenges and problems. It is worth noting among these: intensification of competition in global markets; reduction of the world prices and, consequently, the decrease in export revenues; lack of capacity and warehouses for reliable storage and high-quality processing of grain and their obsolescence; low logistical capacity of domestic ports and railway transport; limited distribution channels; increasing unemployment in rural areas due to the application of modern innovative agricultural technologies with high productivity; low capacity of processing plants; deformation of traditional production chains.

This research clarifies the role of bioenergetics as a priority area for activation of the grain market, outlines its state and problems, and identifies the approaches to its development considering current challenges and demands.

The greatest threats to the implementation of plans concerning the development of biofuel technologies in Ukraine are the following: 1) steady tendency towards a decrease in energy prices on the world market is the risk of the unprofitability of biofuel technologies; 2) unstable tax legislation poses financial investment risks; 3) non-market prices for competing fuels for the population (in particular, electricity and gas) results in the lack of population's incentive to turn to alternative energy sources; 4) lack of sufficient capacity to store the required volumes of guaranteed sources of raw materials; 5) shortcomings in effective mechanisms to stimulate renewable energy, etc.

Elimination and overcoming of the above-mentioned barriers will intensify biomass involvement in country's energy balance and contribute significantly to strengthening

Ukraine's energy independence. Thus, in the near future, it is necessary to solve all the problems that hinder bioenergy development, which intensifies the progress of the grain market and directly affects the energy independence of our country.

Keywords: bioenergetics, grain market, biomass, bioenergy potential, energy crops, biofuels, priority area

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JEL Classification: L19, Q42, N70

Introduction. Within the framework of to the Kyoto Protocol, Ukraine has committed itself to reduce greenhouse gas emissions by 20% (from the level of the 1990th) and has declared a strategic goal to reduce emissions by 50% by 2050, compared to 1990th. Achievement of these results requires significant efforts on the reformation of the Ukrainian economy, and the main directions should be energy efficiency and increase in the share of renewable and non-conventional energy sources. The bioenergy sector combines agriculture and energetics, which are two main industries that form Ukraine's economy. And it can become a priority area for activating the grain market, which is focused on improving the efficiency of grain production and reducing its energy intensity through the use of renewable energy sources. The use of bioenergy in grain production would help to reduce the consumption of oil, natural gas and fossil coal.

The need to develop bioenergetics is associated with the rapid growth of production of grain and grain-legume crops, which generates additional challenges and problems. It is worth noting the following ones among them: intensification of competition in global markets; reduction of the world prices and, consequently, decrease in export revenues; lack of capacity and warehouses for reliable storage and high-quality processing of grain and their obsolescence; low logistical capacity of domestic ports and railway transport; limited distribution channels; increase in unemployment in rural areas caused by the application of modern agricultural innovative technologies providing high productivity; low capacity of processing plants; deformation of traditional production chains.

In addition, it should be emphasized that the COVID-19 pandemic has provoked a decline in incomes of the population. Under such conditions, we share the views of Kaletnik H. M., Klymchuk O. V., Mazur V. A., who argue that "since our state has chosen the direction of integration into the European and world economy, the strategy of agro-industrial complex development should be aimed at formation of food markets and industries that would provide priority positions and efficient operation" [Kaletnik, Klymchuk, Mazur 2019, p. 8].

Literature review and the problem statement. Today, biofuels are the only alternative substitute for mineral fuel. Agriculture can become the main producer of biofuels having a huge potential for bioenergy production as the main as well as by-products of crop and livestock production.

The issues on the essence and practical substantiation of the role and importance of bioenergetics as a priority area of grain market activation have been examined in many scientific publications. Some studies confirm the hypothesis of the high diversity in both biomass potential and bioenergy technologies among the Baltic Sea region countries and assess the potential of biomass and characterise the development of bioenergy technologies in nine Baltic Sea region countries [Stolarski, Warmiński, Krzyżaniak, Olba–Zięty, Akincza 2020], assess of bioenergy potential and associated costs in Japan

[Wu, Hasegawa, Fujimori, Takahashi, Oshiro 2020], in Russia [Svanidze, Götz 2019], an assessment of the influence of bioenergy and marketed land amenity values on land uses in the Midwestern US [Choi, Sohngen, Alig 2011], demand for bioenergy in residential heating applications in the UK [Jablonski, Pantaleo, Bauen, Pearson, Panoutsou, Slade 2008; Gómez-Marín, Bridgwater 2021], generic barriers to bioenergy technologies adoption in India [Yadav, Yadav, Singh, Giri 2021].

'Bioenergy plays a key role in the reduction of greenhouse gases and it is the main contributor to achieve the target of 20% of gross final energy consumption by renewable sources in 2020 in the EU-28 and 34% in Austria' [Anca-Couce, Hochenauer, Scharler 2021]. 'In recent years, the importance of the generation and application of bio-based feedstocks as a sustainable alternative of the fossil-based energy sources is increasing. Biomass powered energy systems will not only reduce dependency on fossil fuels but could potentially contribute towards elimination of global warming triggers' [Ahmadi, Kannangara, Bensebaa 2020]. Thus, research related to bioenergy is a key issue in the concept of sustainable development [Czyżewski, Matuszczak, Miśkiewicz 2019; Dalevska, Khobta, Kwilinski, Kravchenko 2019; Dzwigol, Dzwigol-Barosz 2020; Kharazishvili, Kwilinski, Grishnova, Dzwigol 2020; Miśkiewicz 2018; Miśkiewicz, Wolniak 2020] and technological development of enterprises, state and society [Drozdz, Miskiewicz, Pokrzywniak, Elzanowski 2019; Miśkiewicz 2019; Dźwigoł 2015; Dźwigoł 2020].

The analysis of the bioenergy market in the EU28 region [Alsaleh, Abdul-Rahim, Mohd-Shahwahid 2017] shows that 'EU28 countries should produce more comparative bioenergy outputs in the energy markets through the following 1) they should have sufficient use of the available bioenergy feedstock through a second generation feedstock for bioenergy; 2) technology efficiency tends to improve over time; 3) they should apply a capital integration approach between bioenergy and other energy sectors to reduce the capital input cost and use developed technology; 4) applying training programs to produce skilled labor can achieve a high rate of technical efficiency in the bioenergy industry'.

The studies about the integration of forest and energy sector shows that it is important to be aware of the interaction between the forest, energy, and bioenergy sector when optimizing bioenergy production [Dorning, Smith, Shoemaker, Meentemeyer 2015; Jåstad, Bolkesjø, Trømborg, Rørstad 2021; Jin, Sutherland 2018], 'the forest industry is transforming itself in order to foster new product development by utilizing forest biomass' [Abasian, Rönnqvist, Ouhimmou 2019].

However, for technical solutions related to the development of biomass energy to contribute to economic development, they must be accepted in the market [Nybakk, Lunnan 2013]. According to the some research results [Dorning, Smith, Shoemaker, Meentemeyer 2015] the impacts are from oil to gasoline to ethanol to grains in the energy–grain nexus, does not hold well in the long run because the oil price is influenced by gasoline, soybeans and oil. Other scientists pay attention to Dynamic analysis of policy drivers for bioenergy commodity markets [Jeffers, Jacobson, Searcy 2013], exploring the determinants of emerging bioenergy market participation [Galik 2015], wood bioenergy [Abt, Abt, Cubbage, Henderson 2010; Susaeta, Lal, Carter, Alavalapati 2012; Zhang, Gilless, Stewart 2014], efficacy of bioenergy markets in mitigating carbon emissions [Dwivedi, Khanna, Sharma, Susaeta 2016],

The purpose of the research is to clarify the role of bioenergetics as a priority area for activating the grain market in Ukraine, outline its state and problems, and identify the approaches of its development taking into account current challenges and demands.

A number of methods have been used during the research, in particular, monographic method to study scientific publications on these issues; systemic method to clarify the role and importance of bioenergetics as a priority area of grain market activation; analysis to outline the state of bioenergetics; logical method to identify problem issues, identify approaches of development, to summarize the results, and draw conclusions.

Research results. For Ukraine, bioenergetics is one of the strategic directions of the renewable energy sector development considering the country's high dependence on imported energy resources, primarily natural gas, and a great potential of biomass that is available for energy production [Lyulyov, Pimonenko, Kwilinski, Dzwigol, Dzwigol-Barosz, Pavlyk, Barosz 2021]. Unfortunately, the pace of bioenergetics development in Ukraine still falls significantly behind European ones. Today, the share of biomass in the total supply of primary energy in the country is only 1.2% [Haidutskyi, Sabluk, Lupenko et al. 2005], and it comprises 1.78% in the gross final energy consumption.

Domestic grain producers use energy potential of grain crops insufficiently. For Ukraine, bioenergetics is one of the strategic areas of development of the renewable energy sector (RES) considering the country's high dependence on imported energy and a great potential for agrobiomass production. Bioenergy accounts for about 60% of all renewables in the world [FAOSTAT] and about 70% of all renewables in Ukraine, in 2018 alone 4 billion m3 of the natural gas was replaced by bioenergy [Official website of the Bioenergy Association of Ukraine; Heletukha, Zheliezna, Drahniev 2019]. So far, the energy crop industry in Ukraine is in its infancy – almost 4,000 hectares of marginal land are under energy crops. They are mostly an energy willow, a poplar and a miscanthus, which provide an average annual yield of 20 t/ha.

However, the potential of the industry is enormous, and it can increase 250 times. According to estimates made by scientists, 11.5 million tons of energy crops can be harvested per 1 million hectare, which can replace 5.5 billion m3 of natural gas.

In the country, energy crops can potentially replace about 20 billion m3 of the natural gas, or two-thirds of the country's gas supply needs.

Biomass is a promising source of renewable energy both in the world and in Ukraine. Currently, biomass ranks fourth in the world in terms of its energy use. Unfortunately, bioenergetics development is much slower in Ukraine than in the European countries. Biomass share in the gross final energy consumption is currently 1.78%. Nevertheless, in recent years in Ukraine there has been observed a gradual increase in the number of facilities and capacity for the production of heat and electricity from biomass [Heletukha, Zheliezna, Matvieiev, Kucheruk, Kramar 2020; Heletukha, Zheliezna, Drahniev 2019].

In Ukraine about 2 million tons of equivalent fuel per year of biomass of various types is used annually for energy production. Energy potential of straw of grain crops is the lowest (at the level of 1%). More than 70 million tons of grain crops are harvested annually in Ukraine. According to various estimates, every ton of grain can provide 1.5-2.0 tons of straw or crop residues. 50-60% of wheat, barley, rye straw is used for livestock and soil fertilization, and corn stalks remain in the fields after harvesting. One of the ways of the biomass use is its processing into bioethanol and biogas. Its use enables to save about 1.2 billion m3 of natural gas annually. Bioethanol production is carried out

mainly in reconstructed distilleries [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019].

In the primary energy supply, the share of renewable energy accounts for 13% in the global scale, where biomass accounts for 10%, or 258 million tons of oil equivalent per year, i.e. the largest share of energy supply from renewable sources in the world is provided by biomass [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019]. In Ukraine, the share of biomass in the primary energy supply is only 1.4%, or 1695 thousand tons of oil equivalent [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019].

The main indicators of the production of electricity from biomass are as follows [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019]: the volume of electricity production from biomass remains stable amounting to 28 million kW per hour and from biogas – 43 million kW per hour, that is 14% of the total monthly production. In total, more than 656 million kWh of "green" electricity was generated from biomass and biogas in 2020, which is 6.8% of the total production of electricity from renewable sources in 2020. The total established capacity of facilities that received the "green" tariff increased by 16.6 MW (LLC "Biotech", 6 MW; PJSC "Kropyvnytskyi Oil Extraction Plant", 12.3 MW) and reached 108.7 MW; LLC "Poliska TPS" sold its first 200,000 kWh of "green" electricity; totally 18 companies/facilities received a "green" tariff for electricity from biomass. As before, a 10%-surcharge to the "green" tariff was received only by 3 thermal power stations / combined heat and power on biomass; the biomass share in the heat energy production is about 7% [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019].

An effective way to supplement and replace conventional fuel and energy resources is the production and use of biogas, which is especially attractive for farms. Energy production from biogas is not harmful to the environment, since it does not cause additional greenhouse gas emissions and reduces the amount of organic waste. Unlike wind and solar energy, biogas can be produced regardless of climatic and weather conditions, and unlike fossil energy sources, biogas in Ukraine has a very high renewable potential. The annual theoretical potential of biogas in Ukraine is 3.2 billion m3. The greatest potential of biogas is concentrated in Dnipropetrovsk, Donetsk and Kyiv regions and it is more than 150 thousand tons of oil equivalent per year [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019].

Biogas technologies have become widespread in the world. The largest number of biogas plants is located in China and India. Almost 44% of their total number in the world is concentrated in Europe [Kaletnik, Klymchuk, Mazur 2019; FAOSTAT]. Energy potential of agrobiomass in Ukraine reaches over 9 million tons of oil equivalent, which amounts to 43% of the total biomass potential (20.9 million tons of oil equivalent). Its largest components are agricultural residues (44% of the total amount) and energy crops (32%). Among agricultural residues, the largest share is occupied by the straw of grain crops (33%) and by-products of corn production for grain (35%) [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019].

Current expert estimates show that today agrobiomass (grain straw, by-products of corn production for grain) remains the main component of the biomass energy potential in Ukraine. Full use of the agrobiomass energy potential can satisfy about 18% of final energy consumption in Ukraine, which in 2017 alone amounted to 50.1 million

tons of oil equivalent [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Drahniev 2019]. The use of bioethanol and biogas will reduce greenhouse gas emissions and will have a significant impact on the reduction of imports of petroleum products. Unfortunately, this direction is still not developing actively enough.

It is interesting that in the world practice the share of biomass from the agricultural sector in biogas production is the largest [Energy Technology Perspectives 2014]. In EU countries, biogas from solid waste landfills is often used, but in some countries the share of agrobiomass in biogas production reaches more than 90% [Kaletnik, Klymchuk, Mazur 2019; Official website of the Bioenergy Association of Ukraine; Heletukha, Zheliezna, Matvieiev, Kucheruk, Kramar 2020; Energy Technology Perspectives 2014]. In Ukraine, agrobiomass potential can actually increase to 15 million tons of oil equivalent per year, but it should be noted that maximum amount of agrobiomass that can be used for energy production amounts to 30-40% of the total crop waste [Kaletnik, Klymchuk, Mazur 2019; Heletukha, Zheliezna, Matvieiev, Kucheruk, Kramar 2020].

At the same time, according to the Bioenergy Association of Ukraine, economic potential of livestock waste is 5 times lower than the economic potential of straw from grain crops, or 4.5 times lower than the waste of corn processing [Kaletnik, Klymchuk, Mazur 2019]. At the same time, according to experts, "the share of RES in the energy sector of Ukraine may reach 65% in 2050, where more than half is obtained due to bioenergy" [FAOSTAT]. And if you use about 37% of agricultural waste for energy production, it can be replaced in the equivalent of up to 9 billion m3 of gas per year. This is about a third of Ukraine's gas needs. It is also possible to grow energy crops on about 4 million hectares of infertile land and replace up to 20 billion m3 of gas per year. It should be emphasized that in Ukraine the field of biogas generation is gradually developing both using agricultural waste and landfills, but the potential for biomethane production is still insufficiently used. Therefore, bioenergetics can make a significant contribution to decarbonizing energy and reducing greenhouse gas emissions.

Conclusions. In Ukraine, there can be observed a number of barriers to the successful development of bioenergetics as a priority area of the grain market activation. The greatest threat to the implementation of plans concerning the development of biofuel technologies in Ukraine are as follows:

- steady tendency towards a decrease in energy prices on the world market is the risk of unprofitability of biofuel technologies;
- unstable tax legislation poses financial risks of investing;
- non-market prices for competing fuels for the population (in particular, electricity and gas) results in the lack of population's incentive to turn to alternative energy sources;
- lack of sufficient capacity to store the required volumes of guaranteed sources of raw materials;
- shortcomings of the effective mechanisms for stimulating renewable energy, etc.

Elimination and overcoming of these barriers will intensify biomass involvement in the energy balance of the country and will make a significant contribution to strengthening Ukraine's energy independence. Thus, in the near future it is necessary to solve all the problems that hinder bioenergy development, which intensifies the progress of the grain market and directly affects the energy independence of our country.

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