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Potential of renewable sources in Ukraine

Summary. Bearing in mind a serious dependence of Ukraine on the import of oil products, it is of great significance for Ukraine to develop own manufacture and to increase the share of oil product substitution with biofuel. It is not possible to develop biofuel market without solving a number of economic and organizational problems, which is why it is expedient to introduce financial-economic stimuli for biofuel producers and to build a stable demand for alternative kinds of fuel. In Ukraine the manufacture of alternative fuels almost terminated, however the solution of the problem of biofuel manufacture will depend on the coordination of joint actions of the state, participants of market relations and the development of the system of measures aimed at the creation of pre-conditions to enhance a competitive biofuel market in Ukraine, taking into consideration foreign experience and current tendencies of the manufacture and use of the alternative energy sources.

Key words: bioethanol, biodiesel, biogas, energy safety, energy consumption, renewable energy sources, production potential, alternative kinds of fuel.

Introduction

An internal and external impact of the competitors on Ukraine's agro-industrial complex requires from domestic producers to intensively form competitive advantages of the produce and to hold strong positions in the market. Along with this, as the problem of providing our country with energy-carriers at affordable prices becomes urgent, it is advisable to set up a sufficient production of alternative kinds of fuel.

Such scientists as H. Kaletnik, M. Kodenska, V. Mesel-Veseliak, M. Roik, P. Sabluk, O. Shpychak, O. Zakharchuk, V. Bondar, Yu. Kernasiuk, A. Fursa and others study the urgent issues of alternative fuel manufacture in Ukraine. However, the issue of production efficiency of alternative fuels in the context of food and energy safety of Ukraine requires additional research.

The purpose of the research is to evaluate the potential of production and use of alternative kinds of fuel in Ukraine, taking into account its effect on economic efficiency of business performance of the companies.

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Research methodology

The methods of a system analysis and logical generalization to study the preconditions of the production and consumption of alternative fuels at farm enterprises were used in the process of research; comparative analysis – in the process of analyzing statistic information; induction and deduction – to generalize the research results; abstract-logical – to make conclusions and proposals.

Results of the research

The development of biofuel market depends on a well-coordinated public policy in the sphere of the substitution of traditional kinds of fuel with alternative fuels, prices of traditional energy carriers, and a political and economic situation in the country.

Every year Ukraine spends a lot of money on purchasing oil products, natural gas, coal. Namely, in 2020: US$ 3.806 bln – for purchasing oil products, US$ 1.948 bln – natural gas, US$ 1.786 bln to buy coal. It has to be stated that in 2020 the consumption of natural gas was 28 bln cub m, 15.9 bln cub m being imported. Ukraine's energy potential for natural gas substitution is about 37 bln cub m, including 20 bln cub m – energy crops; 9.3 bln m – wastes of agriculture, 7.8 bln cub – biometan[1].

The development and further functioning of the market is not possible without the introduction of a well-coordinated strategy to manufacture biofuel of different kinds and to work out adequate and transparent legislature which will determine the major trends in the facilitation of the development of alternative kinds of fuel. Thus, Energy Strategy of Ukraine for the period up to 2035 "Safety, energy efficiency, competitiveness"[2] was approved by the order of Ukraine's Cabinet of Ministers of 18.08.2017 No 605-p.

The mentioned strategy envisages the increase of the share of renewable energy to 12% from the initial energy supply up to 2025, and at least to 25% – up to 2035 (including all hydro-generating facilities and thermal energy). As to energy consumption in transport, it is to be increased by 20% up to 2025, by 25% – up to 2035 from the scope of general supply of initial energy[3].

According to Energy strategy, in final energy consumption greenhouse gas emissions have to be decreased by 20% in 2035, as compared with the indicators of the year of 2010. It is planned to reach the goal of decreasing greenhouse gas emissions due to the change in the structure of energy-saving facilities with the use of ecological safe technologies and by controlling over pollutant releases.

[1] Development of renewable energy sources in Ukraine. Successful practices. State Agency for Energy Efficiency and Energy Saving of Ukraine, https://saee.gov.ua/sites/default/files/SAEE_VDE_26.03.2021_0.pdf (access: 21.02.2021).

[2] Resolution of Ukraine's Cabinet of Ministers No 605 of August 18, 2017 "On approval of the Energy Strategy of Ukraine for the period up to 2035 Security, energy efficiency, competitiveness", https://www.kmu.gov.ua/ua/npas/250250456 (access: 21.02.2021).

[3] G. Geletuha, T. Zheljezna: Current state and prospects of bioenergy development in Ukraine, Part 1, http://dspace.nbuv.gov.ua/bitstream/handle/123456789/60547/11-Geletukha.pdf?sequence=1 (access: 21.02.2021).

Considering the current energetic and ecological situation in Ukraine, it is urgent to start a wide introduction of bioenergy technologies and the use of all kinds of biofuel – solid, liquid, gaseous. However, this can be done in the conditions of a stable development and the necessity to save biodiversity of the country.

The most promising kind of bioenergy for Ukraine is phyto-energy which is based on the raw materials of plant origin. Raw material for the manufacture of solid biofuel is mostly the wastes of wood-working industry (sawdust, chip), straw of grain and leguminous crops, sunflower husk, etc. The supply of this raw material is unstable and is of seasonal nature, which has a negative effect on the efficiency of business performance of the enterprises that produce solid fuels. So, a special attention should be paid to the trend which is connected with the supply of the producers with raw material for solid fuel, namely, the cultivation of new kinds of highly productive trees and perennial plants, which in turn will make it possible to annually receive a planned amount of biomass of a required quality[4].

In Ukraine, it is envisaged to compensate the difference between an economically grounded tariff for the production of heat from biofuel and an unprofitable tariff for the production of heat energy for population's needs. Besides, there is a mechanism of the compensation of 20% of a credit amount for the population for the purchase of solid-fuel boilers. Besides, a plan of measures to be taken for the reduction of the consumption volume of natural gas and for the development of renewable energy for the period up to 2020 was approved.

During recent years the implementation of this plan and its measures enabled to increase by three times the share of biofuel in the general structure of final energy consumption in Ukraine – from 1.3 % in 2010 to 4.2 % in 2019 (Tab. 1).

Table 1. Structure of final energy consumption in Ukraine in the years of 2010–2019

Year	To the volumes of final consumption [%]					
	Natural Gas	Coal and peat	Grude oil and oil products	Electricity	Heat	Biofuels and waste
2010	38.4	11.3	16.5	15.6	16.9	1.3
2013	35.9	12.5	16.2	17.0	16.8	1.6
2014	34.1	14.9	16.5	18.0	14.5	2.0
2015	31.5	12.4	18.6	20.1	14.8	2.5
2016	30.3	12.2	18.7	19.6	15.9	3.3
2017	29.9	10.4	20.1	20.2	15.6	3.8
2018	29.0	12.4	20.3	19.8	14.6	3.8
2019	27.3	12.1	21.5	20.3	14.5	4.2

Source: Energy balance of Ukraine for 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019: State Statistics Service of Ukraine, http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en_bal/arh_2012.htm (access: 21.02.2021).

[4] M.V. Royik, O.M. Hanzhenko, V.L. Tymoschuk: The concept of biogas production from bioenergy crops in Ukraine. Bioenergy 2014, No 2 (4), p. 8.

Instead, the share of natural gas consumption decreased from 38.4% in 2010 and to 27.3% in 2019. So in Ukraine all-preconditions for active manufacture and use of biofuel were created.

According to Ukraine's Law "On amendments to Ukraine's Law "On electric power engineering" as to the stimulation of the electric energy manufacture from alternative energy sources" (No 5485-VI of 20.11.2012) it is envisaged, from April 1, 2013, to establish "green tariff" for electric energy, produced from biogas and biomass, which encourages a flow of investments to this sector of bioenergy[5].

Also, in Europe, Ukraine has one of the highest potentials of biomass for biofuel and it has to use it efficiently on: biodiesel fuel – 2 mln t; bioetanol – from 2 mln t to 5 mln t; biogas ≈ 35 bln m3; solid biofuel – 40 mln t u.p.[6]

In most regions of Ukraine soil-climatic conditions are favorable for growing perennial energy plants which can transform sun energy into energy consuming biomass intensively. Soil fertility, many fertilizers and pesticides are not among those few needs of these plants; they prevent soil erosion, save and improve agro-ecosystems and ensure low cost production of high quality biomass.

In Ukraine there are many low-productive soils where plantation growing of energy biomass can be actively practiced, including – willow, poplar, miscanthus, switch-grass and others. However, there is a serious need in legal stimuli in the form of privileges and compensations to create energy plantations and other encouraging mechanisms similar to Europeans ones[7].

At present several economically expedient technologies for the preparation and processing of biomass exist in the world, the most promising one is the method of granulation which allows increasing the efficiency of receiving energy in the form of solid fuel. Fuel granules are highly productive fuel produced from biomass processing when it is kept under a strong press in a special matrix.

To determine the investment expediency into bioenergy crops, an indicator of energy efficiency of their cultivation technology gives valuable information – the energy coefficient which is calculated via a correlation of the accumulated energy in their yield and the energy spent to grow biomass.

One of the variants of the energy coefficient is the criterion of net energy return – NER of biofuel received from such plants. It is calculated as a relation of cumulative energy, accumulated in biofuel unit to the scope of energy consumption, required to carry out all technological processes for the manufacture of biofuel (Tab. 2).

[5] The Law of Ukraine "On Amendments to the Law of Ukraine »On Electricity« on the promotion of electricity production from alternative energy sources", https://zakon.rada.gov.ua/laws/show/5485-17 (access: 21.02.2021).

[6] I.V. Cheban, A.D. Dibrova: Liquid Biofuels Market in Ukraine: Scientific Approaches to Modernizing the Economy and Management System, 2017, p. 55–58.

[7] V. Ivakhiv: Energy willow as a solution for small cities of Ukraine: Ukrainian Energy, http://ua-energy.org/post/27476 (access: 21.02.2021).

Table 2. Net energy return of biofuel from some bioenergy crops

Crop	Kind of biofuel	Net energy return (NER)
Corn	bioetanol	1.2–1.8
Sugar beet	bioetanol	1.2–2.2
Wheat	bioetanol	1.2–4.2
Rape	biodiesel	1.2–3.6
Energy willow	fuel clips	16.6–55.3
Miscanthus	dry biomass	20.8–54.3

Source: own elaboration based on: D.J. Connor, C.G. Hernandez: Crops for Biofuel: Current Status and Prospects for the Future. In: Biofuels: Environmental Consequences and Interactions with Changing Land Use. Eds. R.W. Howarth, S. Bringezu. Scientific Committee on Problems of the Environment, Cornell University, Ithaca 2009, p. 70; G.A. Keoleian, T.A. Volk: Renewable Energy from Willow Biomass Crops: Life Cycle Energy, Environmental and Economic Performance. „Critical Reviews in Plant Sciences" 2005, No 24 (5–6), p. 385–406; I. Lewandowski, U. Schmidt: Nitrogen, energy and land use efficiencies of miscanthus, reed canary grass and triticale as determined by the boundary line approach. „Agriculture, Ecosystems and Environment" 2006, No 112 (4), p. 335–346.

So we can see, as compared with other bioenergy crops, energy willow together with miscanthus are characterized by the highest energy coefficients which can be equal to 54.3 and 55.3. This confirms a significant energy efficiency of the investment into the plantations of above-mentioned bioenergy crops.

If to compare with the fields of food crops, bioenergy plantations require less fertilizers and herbicides, they grow well on the soils which are not good enough for agriculture[8]. As tillage is not done every year, energy balance of such bioenergy crops improves as compared with traditional agricultural crops. They have a potential not only to ensure energy safety due to the use of biomass for the manufacture of renewable energy, but also to meet other needs of the ecosystem.

In Ukraine the most popular is energy willow. It has to be stated that first it is necessary to take some stages: preparation, planting, energy cutting (a plant has to be in the form of a bush, not a tree, later it can be harvested with special machinery). Namely, it is necessary to make one-time capital investments and after this to receive profits for about 25 years. Producers state that they have constant demand for chip, which is a resource for burning in boilers, or it is processed into fuel palettes or briquettes.

The highest level of profitability is reached when willow chip, without prior processing, is realized with 50% humidity at the price of 1085 hrn/t, a profitability level is 216.2% (24th year of vegetation of energy willow)[9].

[8] S. Njakou Djomo, O. El Kasmioui, T. De Groote, L.S. Broeckx, M.S. Verlinden, G. Berhongaray, R. Fichot, D. Zona, S.Y. Dillen, J.S. King, I.A. Janssens, R. Ceulemans: Energy and climate benefits of bioelectricity from low-input short rotation woody crops on agricultural land over a two-year rotation. Appl Energy 2013, No 111, p. 862–870.

[9] V.M. Sinchenko: Enerhetychna verba: tekhnolohiia vyroshchuvannia ta vykorystannia [Energy willow: technology of cultivation and use]. Vinnytsia: TOV Niland-LTD 2015, 340 s.

Considering the reactivation in the development of bioenergy in Ukraine and the necessity in a wider use of renewable energy sources to substitute fossils, the increase in the use of alternative kinds of fuel is predicted (Tab. 3). Along with this, in the structure of alternative sources of energy, the share of liquid kinds of fuel (11.8% – 2030) and biogas (35.3% – 2030) will increase, the share of solid kinds of fuel will decrease (52.9% – 2030).

Table 3. Prediction of the development of bioenergy in Ukraine

Kind of fuel	2025		2030	
	mln t n.e	%	mln t n.e	%
Solid	3.5	56.5	4.5	52.9
Liquid	0.7	11.3	1.0	11.8
Biogas	2.0	32.2	3.0	35.3
Total	6.2	100	8.5	100

Source: own elaboration based on: V.S. Bondar, A.V. Fursa, M.Ya. Gumentik: Strategy and priorities of bioenergy development in Ukraine. Economics of Agro-industrial Complex 2018, No 8, p. 17.

To solve the problem of dynamic production of alternative kinds of fuel, it is necessary to create a proper market of bioenergy crops as raw material for the manufacture of biofuel, to use low-productive soils suitable for growing energy crops.

Conclusions

Ukraine has a sufficient resource potential for the manufacture of alternative kinds of fuel. This opens perspectives to use bioetanol and biodiesel of own production in transport. In Ukraine, biofuel and wastes have the largest share in the structure of the production of renewable sources of energy. In Ukraine there are all pre-conditions for a faster development of bioenergy, regulatory, scientific-technical and financial support for its successful functioning. To ensure a stable development of agriculture and the market of alternative kinds of fuel, there should be a cooperation of two directions – the manufacture of raw material for biofuel and finished produce in the form of energy. It should be stated that the use of alternative kinds of fuel as well as the development and introduction of new technologies for their production is the current economic priority for the economy of our country.

References

Bondar V.S., Fursa A.V., Gumentik M.Ya.: Strategy and priorities of bioenergy development in Ukraine. "Economics of Agro-industrial Complex" 2018, No 8, p. 17.

Cheban I.V., Dibrova A.D.: Liquid Biofuels Market in Ukraine: Scientific Approaches to Modernizing the Economy and Management System, 2017, p. 55–58.

Connor D.J., Hernandez C.G.: Crops for Biofuel: Current Status and Prospects for the Future. In: Biofuels: Environmental Consequences and Interactions with Changing Land Use. Eds. R.W. Howarth, S. Bringezu. Scientific Committee on Problems of the Environment, Cornell University, Ithaca 2009, p. 70.

Development of renewable energy sources in Ukraine. Successful practices. State Agency for Energy Efficiency and Energy Saving of Ukraine, https://saee.gov.ua/sites/default/files/SAEE_VDE_26.03.2021_0.pdf (access: 21.02.2021).

Energy balance of Ukraine for 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019: State Statistics Service of Ukraine, http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en_bal/arh_2012.htm (access: 21.02.2021).

Energy balance of Ukraine for 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019: State Statistics Service of Ukraine, http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en_bal/arh_2012.htm.

Geletuha G., Zheljezna T.: Current state and prospects of bioenergy development in Ukraine, Part 1, http://dspace.nbuv.gov.ua/bitstream/handle/123456789/60547/11-Geletukha.pdf?sequence=1 (access: 21.02.2021).

Ivakhiv V.: Energy willow as a solution for small cities of Ukraine: Ukrainian Energy, http://ua-energy.org/post/27476 (access: 21.02.2021).

Keoleian G.A., Volk T.A.: Renewable Energy from Willow Biomass Crops: Life Cycle Energy, Environmental and Economic Performance. „Critical Reviews in Plant Sciences" 2005, No 24 (5–6), p. 385–406.

Lewandowski I., Schmidt U.: Nitrogen, energy and land use efficiencies of miscanthus, reed canary grass and triticale as determined by the boundary line approach. „Agriculture, Ecosystems and Environment" 2006, No 112 (4), p. 335–346.

Njakou Djomo S., El Kasmioui O., De Groote T., Broeckx L.S., Verlinden M.S., Berhongaray G., Fichot R., Zona D., Dillen S.Y., King J.S., Janssens I.A., Ceulemans R.: Energy and climate benefits of bioelectricity from low-input short rotation woody crops on agricultural land over a two-year rotation. „Appl Energy" 2013, No 111, p. 862–870.

Resolution of Ukraine's Cabinet of Ministers No 605 of August 18, 2017 "On approval of the Energy Strategy of Ukraine for the period up to 2035 „Security, energy efficiency, competitiveness", https://www.kmu.gov.ua/ua/npas/250250456 (access: 21.02.2021).

Royik M.V., Hanzhenko O.M., Tymoschuk V.L.: The concept of biogas production from bioenergy crops in Ukraine. „Bioenergy" 2014, No 2 (4), p. 8.

Sinchenko V.M.: Enerhetychna verba: tekhnolohiia vyroshchuvannia ta vykorystannia [Energy willow: technology of cultivation and use]. Vinnytsia: TOV Niland-LTD. 2015, 340 s.

The Law of Ukraine "On Amendments to the Law of Ukraine »On Electricity« on the promotion of electricity production from alternative energy sources", https://zakon.rada.gov.ua/laws/show/5485-17 (access: 21.02.2021).