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ECO-FRIENDLY SOURCES OF ALTERNATIVE ENERGY IN UKRAINE

Abstract. *The analysis of alternative energy production in Ukraine is shown in the article. It was found that Ukraine is an energy-dependent country, and the main source of energy consumption is fossil fuels. At the same time, the share of renewable energy sources in Ukraine does not exceed 2%, which is one of the lowest in Europe. However, Ukraine has massive potential for energy savings by using natural renewable energy sources and in particular, there is huge potential of biomass available for energy production. Economically reasonable energy potential of existing biomass waste is about 25 million tons of fuel and energy potential of biomass that can be grown on unused agricultural land with an area of more than 4 million hectares – about 13 million tons. This potential can cover up to 18% of total primary energy consumption in Ukraine. Thus, agriculture in Ukraine has considerable potential for bioenergy development of our country.*
Keywords: *agriculture, alternative energy types, biomass.*

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ЕКОЛОГІЧНО БЕЗПЕЧНІ АЛЬТЕРНАТИВНІ ДЖЕРЕЛА ЕНЕРГІЇ В УКРАЇНІ

Анотація. *В статті проведено аналіз виробництва альтернативних видів енергії в Україні. Встановлено, що Україна є енергозалежною країною, і основними джерелами енергії, що споживається, є викопні енергоресурси. Разом з тим, частка відновлюваних джерел енергії в Україні не перевищує 2%, що є одним із найнижчих показників у Європі. Проте, Україна має в своєму розпорядженні масштабний недовикористовуваний потенціал енергозбереження у вигляді природних відновлювальних джерел енергії і зокрема, існує великий потенціал біомаси, доступної для виробництва енергії. Економічно обґрунтований енергетичний потенціал існуючих відходів біомаси складає близько 25 млн. т у.п., а енергетичний потенціал біомаси, яку можна виростити на невикористаних сільськогосподарських землях площею більше 4 млн. га – близько 13 млн. т у.п. За рахунок цього потенціалу можна покрити до 18% загального обсягу споживання первинних енергоносіїв в Україні. Отже, сільське господарство України має значний потенціал для розвитку біоенергетики країни.*
Ключові слова: *сільське господарство, альтернативні види енергії, біомаси.*

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ЭКОЛОГИЧЕСКИ БЕЗОПАСНЫЕ АЛЬТЕРНАТИВНЫЕ ИСТОЧНИКИ ЭНЕРГИИ В УКРАИНЕ

Аннотация. *В статье проведен анализ производства альтернативных видов энергии в Украине. Установлено, что Украина является энергозависимой страной, и основными источниками энергии, что потребляется, есть ископаемые энергоресурсы. Вместе с тем, доля возобновляемых источников энергии в Украине не превышает 2%, что является одним из самых низких показателей в Европе. Однако, Украина имеет в своем распоряжении масштабный не использованый потенциал энергосбережения в виде природных возобновляемых источников энергии и в частности, существует большой потенциал биомассы, доступной для производства энергии. Экономически обоснованный энергетический потенциал существующих отходов биомассы составляет около 25 млн. т у.т., а энергетический потенциал биомассы, которую можно вырастить на неиспользуемых сельскохозяйственных землях площадью более 4 млн. га - около 13 млн. т у.т. За счет этого потенциала можно покрыть до 18% общего объема потребления первичных энергоносителей в Украине. Следовательно, сельское хозяйство Украины имеет значительный потенциал для развития биоэнергетики страны.*
Ключевые слова: *сельское хозяйство, альтернативные виды энергии, биомассы.*

Introduction. Dependence of Ukraine economy on imported energy, the reduction of mineral resources, changes in the structure of agricultural production, constant growth of disparity in prices for energy, industrial and agricultural products inhibit the development of state economy and reduce the potential competitiveness of Ukrainian products on the world markets of goods and services.

Today the main source of energy is fossil fuel, burning of which destroys the environment and causes climate change. Over 80% of the energy is produced of fossil fuels such as petroleum, natural gas and coal. Another part of the energy (20%) relates to nuclear energy and hydropower, biofuels and renewable sources.

Because of the general environmental degradation professionals are looking for real possibility of using so-called renewable clean energy sources - wind, solar, marine and

terrestrial depths, biogas, biodiesel, bioethanol. Prospectivity of widespread use of alternative energy sources is confirmed by exploitation of relevant objects in some parts of our country and abroad. They are environmentally friendly that is extremely important for the recovery of air and water, their value increases in relation to the objective rising costs of traditional fuel resources - oil, gas and coal.

In this situation, the question of development, efficiency and implementation of alternative energy sources are gaining special importance, including bioenergy, which according to the structure of production of primary energy in the world amounted almost 77% of all types of renewable energy sources (Geletukha. G., 2012).

Problem statement. The problem of using alternative energy sources is widely investigated in domestic and foreign scientific literature. Thus, the main aspects of bioenergy development, production and evaluation of potential efficiency highlighted in scientific papers of scholars such as Ageev V.A. (Ageev, 2004) Geletukha G.G. (Geletukha, 2006), the Gorodov R.V. (Gorodov, 2009), Shlemko V.T. (Shlemko, 1997) and others [1, 6, 8, 15].

In the works of D. Meadows (Meadows, 2007) the problem of planning using natural resources to maintain the ecological balance and preserve conditions for further growth of economy [10]. In particular, the author expresses the idea of the necessity of a rapid transition from traditional to alternative forms of energy to prevent their deficit.

In studies of V. Fradkin (Fradkin, 2010) the high potential of alternative energy sources, especially geothermal, over traditional is substantiated [5]. Besides, specific recommendations for priority use of different energy sources in different geographical areas are provided.

In the works of B. Danylyshyn (Danylyshyn, 2006) the essence of the concept of 'energy security', as well as the problems of its provosion in our country are revealed [2]. However, currently the role of agriculture for the production of alternative energy in Ukraine remains unexplored.

So, the purpose of this article is to identify and evaluate prospective ways of development of alternative energy in Ukraine in agriculture.

Research methods. Theoretical and methodological basis of research were dialectical method of cognition and systematic approach during the studying of scientific papers of domestic and foreign scholars on the production of alternative energy sources, particularly in agricultural branch, legislative and other normative acts on the studied issues.

Results. Agriculture and power industry have always been closely connected, but the nature and strength of their relationship were changed. Agriculture has always been a source of energy, and energy - is one of the major determinants of modern agricultural production. Already today, some European countries actively use alternative sources of energy and with their help they hope to gain independence from famous suppliers of hydrocarbons. For example, Sweden in 10 years plans to completely abandon the organic fuel sources in favor of renewable sources, and Iceland plans to make it till 2050.

In Brazil, sugarcane is widely used. Five years later, ethanol produced from cane will provide with biofuels 80% of the country transport. Spain and Germany focus on wind energy, which increase amounted 25% each year.

Today Ukraine is much inferior to the European Union in the development of bioenergy. Globalization of energy processes will allow Ukraine, taking into account its unique geopolitical and geographical position, to act as a complete player on the international stage in the branch of introduction of 'green' energy.

According to the State Committee of Energy Conservation, Ukraine annually consumes about 220 m. tons of equivalent fuel and refers to the energy deficient countries. Energy demand is covered by own resources only by 53% and 67% of the required natural gas volume and 75% of oil are imported. Today the country is living on the Energy Strategy of Ukraine approved by the government until 2030, which provides for a substantial increase in consumption of fossil energy resources. According to it, energy consumption by 2030 will increase to 302.7 million tons and electricity to 398 billion kW/h. However, in the long term this situation is unacceptable, it puts the economy in full dependence on exporting countries of oil and gas.

Comparing the structure of primary energy resources consumption in Ukraine and the European Union (Table 1), following trends should be considered. The share of natural gas in Ukraine is unreasonably high - about 43%, which is almost 2 times higher than in the EU countries.

The share of renewable energy in Ukraine is unreasonably low - 1.6%, which is 6 times lower than in the EU. Moreover, different variants of development of Ukraine energy sector, proposed in the draft of the revised Energy Strategy to 2030, also don't coincide with the trends in the EU energy sector. For example, in Europe the reduction of coal consumption (from 15.9% to 7%) and reduction of the use of nuclear energy (from 13.5% to 11%) are planned, while in Ukraine the situation is opposite. Increase of coal usage from 27.9% to 30% and nuclear energy usage - from 17.9% to 22.5% are planned by the new version of the strategy to 2030 [11].

It should be noted that in contradistinction to many EU countries, Ukraine has massive potential for energy conservation in the form of natural renewable energy sources.

Natural renewable energy sources, as defined by the determination of International Energy Agency (IEA) are divided on the energy, derived from the sun; the wind; biomass; geothermal, hydropower and ocean resources; biogas, liquid biofuels [13].

According to the resolution № 33/148 of the General Assembly of UN in 1978, alternative renewable energy sources are: solar, geothermal, wind, waves energy, ebb-and-float of the ocean, biomass wood energy, charcoal, peat, draft cattle, shale, bituminous sandstone and hydropower.

The Law of Ukraine 'On Alternative Energy Sources' determines that alternative energy sources are renewable sources, which include solar, geothermal, wind, waves

Table 1

Comparing the structure of primary energy sources consumption in Ukraine and the European Union countries, % [4,12,3]

Type of energy	2010		2030	
	Ukraine	EU countries	Ukraine	EU countries
Natural Gas	42,6	25,1	28,0	24,0
Oil	10,0	35,1	14,5	33,0
Coal	27,9	15,9	30,0	7,0
Uranus	17,9	13,5	22,5	11,0
Renewable Energy Sources	1,6	9,8	5,7	25,0

energy, ebb-and-float of the ocean, biomass wood energy, charcoal, peat, draft cattle, shale, bituminous sandstone and hydropower [16].

Today our country uses its potential in renewable energy by only 1.6% (potential – 81 million tons of equivalent fuel, and the production is 1.6 million tons) (Table 2).

Despite the low level of renewable energy today, Ukraine has good preconditions for the future development of this direction, especially bioenergy. Ukraine has great potential of biomass available for energy production. Biomass is a carbon containing organic substances of vegetable or animal origin (wood, straw and other crop residues of agricultural production, manure, specially grown energy crops, organic portion of municipal solid waste and sometimes peat).

Solid biomass is used for energy production, and obtained from its processing liquid and gaseous fuels - biogas, biodiesel, bioethanol and others.

According to the accepted in Europe definition, biomass is biodegradable fractions of products, waste and residues of agriculture (plant and animal), forestry and similar to them various industries (carbon containing organic matter of vegetable or animal origin: wood, straw, plant residues of agricultural production, manure, etc.).

The potential biomass energy resources can be divided into two groups:

- fields of plants that are grown for energy purposes (corn, canola, energy willow, potato, artichoke, miscanthus, etc.);
- organic remains and wastes - the remains of plants, waste from the cultivation and processing of vegetable products, animal waste, municipal organic waste.

Raw materials for gaining energy are divided into liquid (vegetable oil, alcohol), solid (straw, wood or waste wood industry), gaseous (biogas). Biomass is a renewable, environmentally friendly fuel the use of which does not lead to the global greenhouse effect. This is the fourth by value fuel in the world, which gives about 2 billion tons of fuel per year, which is amounted about 14% of total primary energy consumption in the world (in developing countries - over 30%) [9].

The potential of using waste agricultural biomass as a source of energy is enormous. Thus, the use of crop residues for energy depends on crop nature and quantity of residues that can be obtained per unit of cultivated area. Field crops give more waste than vegetables. Approximate number of plant waste can be determined by multiplying the mass of culture on the characteristic coefficient of its balance. In soybean it is 0,55-2,60; corn - 0,55-1,20; wheat - 0,5-1,75; sugar beet - 0,07-0,20. The coefficients depend not only on the type of culture, but also on the conditions of cultivation, cultivation methods, as well as methods for determining the coefficient.

Straw is a major source of biofuels in Ukraine. The average quantity of cereal straw in Ukraine is 40.31 million tonnes. Using 20% of the total harvest of straw for energy purposes may be substituted by 4,3 million tons of equivalent fuel/year (about 2% of the total primary energy consumption in Ukraine). From straw briquettes weighing 50-60 kg, 4 kWh of electricity could be obtained.

Prospective opportunity for Ukraine is complex processing of animal waste using methane fermentation. Biogas is a product of fermentation. Depending on the proportion of methane, its energy intensity may vary. Biogas with a share 56% of methane has an energy intensity 20 mJ/m^3, 62% - 22.7 mJ/m3, 70% - 25 mJ/m^3 (natural gas - 33.6 mJ/m3).

Firewood was the main fuel until at the end of the XIX century it was replaced by fossil fuels - coal, natural gas, oil. The appearance of these types of fuel and steady increase in demands for raw materials of forestry engineering led to a sharp decrease in the use of forest products as fuel. About 85% of felled wood is used for paper and forest products, 4% - as fuel. The remaining 11% - waste during harvesting, transportation, which are recycled or can be used as an energy source.

Negative features of natural forest biomass are: low energy density of biomass; high humidity and energy consumption for vaporization during combustion; heterogeneity of forest biomass form, which complicates the mechanization and automation of harvesting and burning of the fuel.

To achieve the goals set by Ukraine in the field of renewable energy, it is necessary to obtain reliable information about the energy potential of biomass. According to the 2011 economically justified energy potential of existing biomass waste is about 25 million tons. And the energy potential of biomass that can be grown on unused agricultural land area of more than 4 million hectares is about 13 million tons (Table 3). Due to this potential up to 18% of total primary energy consumption in Ukraine could be covered. Thus, Ukraine's agriculture has considerable potential for development of bioenergy of the country.

In this case, several advantages of bio-economy should be defined, which are important incentives for further development of this industry in Ukraine. For the social sector, they are:

- diversification of the rural economy;
- creation of new jobs;
- development of rural areas;
- improvement of public health;
- ensuring the wellfare and quality of life in rural areas.

For the economic sector, they are

- reducing the cost of agricultural products;
- reducing dependence on energy imports;
- production of new types of products;
- careful monitoring of product quality;
- access to new markets of agri-food products.

For the environmental field:

- the creation of new products and biofuels;
- prevention of pollution;
- use of processed products of agriculture and so on.

At the same time, the main factors that significantly inhibit the development of the biofuels market in Ukraine should be noted. These are:

Table 2

The potential of renewable energy sources in Ukraine [14]

Type of energy	Annual technically feasible potential		Annual replacement of natural gas, bln. м^3
	billion kWh/year	million tons of equivalent fuel	
Wind	41,7	15,0	13,0
Solar power	28,8	6,0	5,2
Geothermal energy	105,1	12,0	10,4
Bioenergy	27,7	10,0	8,7
Hydropower	162,8	20,0	17,4
Environment power	154,7	18,0	15,7
Total	520,8	81,0	70,4

Table 3

Energy potential of biomass in Ukraine

Type of biomass	Actual amount, mln. tons	% of total amount	The economic potential, mln. tons of equivalent fuel
Straw of cereals	32,0	20	3,17
Rape straw	2,9	70	0,96
Wastes of grain maize production	34,0	52	8,59
Wastes of sunflower	17,0	67	5,55
Secondary agricultural wastes (glume, pulp)	9,7	77	0,99
Wood biomass	3,9	89	1,87
Biodiesel	-	-	0,35
Bioethanol	-	-	2,36
Biogas from manure	-	-	0,35
Biogas from solid domestic waste landfill	-	-	0,26
Biogas of wastewater	-	-	0,09
Energy crops:		-	
- Poplar, willow and others.	20,0	85	10,30
- Rape (straw)	3,2	70	1,13
- Rape (biodiesel)	-	-	0,77
- Maize (biogas)	-	-	1,10
Peat	-	-	0,40
Total	-	-	38,24

- poorly developed transportation and logistics infrastructure of the agricultural market and the market of bioenergy resources and lack of specialized terminals for handling large volumes of biofuels, resulting in very expensive logistics and reduction of the potential profitability of biofuel plants;
- lack of new agricultural technologies of cultivation and processing of biomass;
- lower, compared to EU, production capacity of domestic enterprises of the production of biofuels;
- lack of specialized equipment to handle cargo traffic of biofuel;
- information infrastructure lag: biofuel market is not transparent enough and potential customers are not aware of their capabilities in this area and the benefits of bioenergy as such;
- financial difficulties of the farmers with the implementation of novation technologies;
- lack of qualified personnel;
- imperfection of the legal framework;
- not improved matter of setting the 'green' tariff.
- an unfavorable investment climate in Ukraine for the development of alternative energy.

Conclusions. Ukraine has good capabilities and sufficient potential for dynamic development of the sector of alternative energy sources. The main motivation of this process is the constant price growth for traditional energy and the large potential of agricultural industry available for energy use.

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