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## Economy's agricultural sector potential in Ukrainian energy self-sufficiency forming

**Abstract.** The authors analyze the alternative types of energy production in Ukraine. It has been found out that Ukraine is an energy-dependent country and the main sources of energy consumption are fossil fuels. The share of renewable energy sources in Ukraine is less than 2%, which is one of the lowest indicators in Europe. However, Ukraine has a massive unused potential for energy savings in the form of natural renewable energy sources. In particular, there is a large amount of biomass available for energy production. The economically justified energy potential of existing biomass waste is about 25 million tons and the energy potential of biomass which can be grown on unused agricultural lands covering more than 4 million hectares is about 13 million tons. Due to this potential, we can cover up to 18% of total primary energy consumption in Ukraine from two above-mentioned sources. Thus, agriculture of Ukraine has a significant potential for its bioenergy development.

**Keywords:** Agriculture; Alternative Types of Energy; Renewables; Biomass

**JEL Classification:** O13; Q20; Q42

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### Потенціал аграрної сфери економіки у формуванні енергонезалежності України

#### Анотація

У статті проаналізовано забезпеченість як народного, так і сільського господарства України енергетичними ресурсами, а також ефективність їх використання. Виходячи з цього, у даний час для економіки України пріоритетним напрямком розвитку є забезпечення енергетичної безпеки як країни, так і галузей економіки. Проблема енергобезпеки загострилася на фоні значного перевищення енергоємності виробництва продукції в Україні порівняно з провідними країнами світу як мінімум у два рази.

Розглянуто причини необхідності державного втручання в регулювання енергозбереження та висвітлено основні сучасні теорії відносно даного процесу, а також проаналізовано нормативно-правову базу забезпечення енергозбереження в Україні та країнах ЄС.

**Ключові слова:** сільське господарство; альтернативні види енергії; біомаса.

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### Потенциал аграрной сферы экономики в формировании энергонезависимости Украины

#### Аннотация

В статье проанализированы обеспеченность как народного, так и сельского хозяйства Украины энергетическими ресурсами, а также эффективность их использования. Исходя из этого, в настоящее время для экономики Украины приоритетным направлением развития является обеспечение энергетической безопасности как страны, так и отраслей экономики. Проблема энергобезопасности обострилась на фоне значительного превышения энергоёмкости производства продукции в Украине по сравнению с ведущими странами мира как минимум в два раза.

Рассмотрены причины необходимости государственного вмешательства в регулирование энергосбережения и освещены основные современные теории относительно данного процесса, а также проанализирована нормативно-правовая база обеспечения энергосбережения в Украине и странах ЕС.

**Ключевые слова:** сельское хозяйство; альтернативные виды энергии; биомасса.

## 1. Introduction

Dependence of the economy of Ukraine on imports of energy resources, reduction of mineral reserves, restructuring of agricultural production, continuous growth of disparity in energy, industrial and agricultural products prices increasing impede the development of the national economy and reduce the potential for Ukrainian production competitiveness in the global markets.

Today, the combustion of fossil fuel which destroys environment and causes climate change is the main source of energy in Ukraine. Over 80% of the energy is produced from fossil fuels, namely oil, natural gas and coal. Another amount of energy (20%) is related to the share of nuclear energy, hydropower, biofuel and renewable sources.

In view of the general environmental degradation, professionals are increasingly looking for real opportunities to use the so-called renewable clean energy such as wind, solar, marine and terrestrial depths, biogas, biodiesel, bioethanol energy. Prospects of alternative energy sources use are confirmed by operation and installation of relevant objects in some areas of our country and abroad. They are environmentally friendly, which is extremely important for the recovery of air and water, their value increases in relation to the objective rise in time of the prices for traditional fuel resources.

In connection with the situation that has arisen, issues of development, effective use and implementation of alternative energy sources are particularly relevant, including bio-energy, which, according to data of structure of primary power engineering production in the world, accounts for almost 77% of the all types of renewable energy (G. Heletukha, 2012).

## 2. Brief Literature Review

The issues of alternative energy sources use are widely studied in domestic and foreign scientific literature. Thus, the main aspects of bioenergy development, evaluation of its production potential and efficiency of use are highlighted in scientific works of V. A. Ageev (Ageev, 2004), G. G. Heletukha (Heletukha, 2006), R. V. Gorodov (Gorodov, 2009), V. T. Shlemko (Shlemko, 1997) and others [1-5].

The problem related to planning of the natural resources use in order to maintain ecological balance and preservation of prerequisites for further economic growth is described in the works of D. Meadows (Meadows, 2007) [6]. In particular, this author expresses the idea regarding the need for a rapid transition from traditional forms of energy to alternative ones to prevent the deficit of the former.

The high potential of alternative energy sources, including geothermal capacity over traditional ones, is justified in the studies of V. Fradkin (Fradkin, 2010) [7]. In addition, specific recommendations for priority use of various energy sources in different geographical areas are given by him.

In the works by B. Danylyshyn (Danylyshyn, 2006), the essence of the concept of energy security, as well as the problems of its maintenance in our country, is revealed [8]. However, currently the question about what role agriculture should play in the production of alternative energy sources in Ukraine remains unexplored.

**3. Purpose** of the article is to identify and evaluate promising directions of alternative energy development in agriculture of Ukraine.

Dialectical method of knowledge and systematic approach in the study of scientific works of national and foreign scholars on the production of alternative energy sources, particularly in rural areas of Ukraine, legislative and other regulations on the investigated issues form theoretical and methodological basis of the research.

## 4. Results

Agriculture and power engineering have always been closely linked, but the nature and strength of their relationship have changed over time. Agriculture has always been a source of energy, and energy is one of the major determinants of modern agricultural production. Today many European countries actively use alternative sources of energy in hope to gain independence from leading suppliers of hydrocarbons. For example, in 10 years Sweden plans to completely abandon organic fuel sources in favor of renewables, and

Iceland plans to do so before 2050. In Spain and Germany, the focus is on wind energy with its increase by 25% annually.

In Brazil, sugarcane is widely used as a renewable energy source. In the next five years, ethanol extracted from cane will provide 80% of the country's transport with biofuel.

Today, Ukraine is far behind the European Union in bio-energy development. Globalization of energy processes will enable Ukraine to act as a full player in the international arena in the area of «green» power engineering introducing.

According to data provided by the State Committee for Energy Conservation of Ukraine, Ukraine annually consumes about 220 million tons of fuel equivalent of fuel and energy resources and refers to energy deficient countries. Energy needs are covered by own sources only by 53% and to 67% of the required volume of natural gas and 75% of oil and petroleum products are imported. Today, the country is living by the Energy Strategy of Ukraine until 2030 approved by the Government, which provides a substantial increase in consumption of fossil power resources. According to it, by 2030 energy consumption will have increased by 302.7 million tons; electricity alone will be up to 398 billion of kWh. However, in the long term, this situation is unacceptable, as it makes the national economy completely dependent on countries exporting oil and gas.

Comparing the structure of primary energy consumption in Ukraine and the EU (see Table 1), we found the following trends. The share of natural gas in Ukraine is unreasonably high – about 43%, which is almost twice as high as in the EU.

Tab. 1: Comparison of the structure of primary energy consumption in Ukraine and the EU countries, %

Type of energy resources	2010		2030	
	Ukraine	The EU countries	Ukraine	The 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
Uranium	17.9	13.5	22.5	11.0
Renewable energy sources	1.6	9.8	5.7	25.0

Source: Formed by the authors using [9-11]

Thus, the contribution of renewable energy sources in Ukraine is unreasonably small – only 1.6%, which is 6 times as low as in the EU. Moreover, developmental directions of various sectors of power engineering of Ukraine, proposed in the revised Energy Strategy until 2030, are not in agreement with the EU energy trends. Thus, in Europe they plan to reduce coal consumption (from 15.9% to 7%), as well as the use of atomic energy (from 13.5% to 11%), whereas in Ukraine the situation is opposite. In the new variant of the Energy Strategy until 2030, the increased consumption of coal is scheduled from 27.9% to 30%, and the consumption of nuclear energy comprises from 17.9% to 22.5% [12]. It should be noted that unlike many EU countries, Ukraine has significant unused potential of natural renewable energy sources.

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

According to the Resolution No. 33/148 of the UN General Assembly adopted in 1978, non-traditional renewable energy sources include: solar, geothermal, wind and wave power, energy of tides and low tides of the ocean, energy of wood biomass, charcoal, peat, dragging livestock, shale, bituminous sandstones and hydropower.

The Law of Ukraine «On Alternative Energy Sources» determines that alternative sources of energy are renewable sources which include solar, geothermal, wind and wave power, energy of tides and low tides of the ocean, energy of wood biomass, charcoal, peat, dragging livestock, shale, bituminous sandstones and hydropower [14].

Today, our country has been using its potential of renewable energy by only 1.6% (with a capacity of 81 million tons of

conditional fuel and its production equal to 1.6 million tons) (see Table 2).

Despite the low level of renewable energy development, Ukraine has good preconditions for the future growth of this area, particularly in bioenergy sector. Ukraine has a great potential of biomass available for energy production. Biomass is defined in Ukraine as carbon-intensive organic material obtained from plant and animal waste (wood, straw and other plant residues of agricultural production, manure, specially grown energy crops, organic parts of municipal solid waste and sometimes peat). Solid biomass, as well as liquid and gaseous fuels produced from it (such as biogas, biodiesel, bioethanol and others), is used for energy production.

According to the accepted European definition, biomass is biodegradable fraction of products, waste and residues of agriculture (plant and animal ones), forestry and close to them industries (carbon containing organic substances of vegetable and animal origin, wood, straw, plant residues of agricultural production, manure, etc.).

Potential energy resources of biomass can be divided into two groups:

- plants grown for the purpose of energy needs (e.g. corn, rape, energy willow, potato, Jerusalem artichoke, Miscanthus etc.);
- organic remains and waste which are plant remains, waste from the growing and processing of plant production, animal waste, and municipal organic waste.

Raw materials for energy are divided into liquid (vegetable oil, alcohol), solid (straw, wood or waste of wood industry) and gaseous (biogas).

Biomass is a renewable, environmentally friendly fuel, the use of which does not contribute to the global greenhouse effect. This is the fourth fuel by value in the world which gives about 2 billion tons of fuel a year, representing about 14% of total primary energy consumption in the world (over 30% in developing countries) [16].

The potential of waste usage in agriculture as a source of biomass energy is enormous. Thus, the use of crop residues for receiving energy depends on the nature of crops with which large areas are sown with and the number of residues that can be obtained per one unit of the cultivated area. Field crops provide waste more than vegetable ones. The approximate number of plant waste can be determined by multiplying crop mass by its characteristic coefficient of remains. It is 0.55-2.60 for soybean; 0.55-1.20 for corn; 0.5-1.75 for wheat; 0.07-0.20 for sugar beet. The values of coefficients depend not only on the type of a crop but also on conditions of its cultivation, harvesting methods and methods of coefficient determining.

Straw is one of the major sources of biofuels in Ukraine. The average amount of cereal straw in Ukraine is 40.31 million tons. Using of 20% of the total straw harvest for energy purposes can replace 4.3 million tons of fuel per one year (about 2% of total primary energy consumption in Ukraine). It is possible to get 4 kWh of electricity from a straw briquette weighing 50-60 kg.

In Ukraine, the complex processing of animal waste by means of methane fermentation is promising. The product of such fermentation is biogas. Depending on the content of methane in it, its energy intensity can be different. For example, biogas containing 56% methane has the energy intensity of 20 MJ/m<sup>3</sup>, 62% – 22.7 MJ/m<sup>3</sup>, 70% – 25 MJ/m<sup>3</sup> (natural gas – 33.6 MJ/m<sup>3</sup>).

Firewood was the main fuel to the end of the 19<sup>th</sup> century when it was replaced by fossil fuels. Appearance of these fuels and constant increase in needs of forest technical raw materials led to a sharp decrease in the use of forest products as fuel. About 85% of felled forests in Ukraine are used for paper and timber production, whereas 4% are used as fuel. The remaining 11% of wastes related to harvesting and transportation are recycled or can be used as an energy source.

The negative properties of natural forest biomass are: low energy density of biomass, high humidity and energy consump-

Tab. 2: Potential of renewable sources usage in Ukraine

Type of power source	Annual technically feasible potential		Annual replacement of natural gas, billion m <sup>3</sup>
	Billion kWh	Million tons of conditional fuel	
Wind power	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
Energy of the environment	154.7	18.0	15.7
Total	520.8	81.0	70.4

Source: [15]

tion for evaporation during combustion, heterogeneity of forest biomass form which complicates mechanization and automation of harvesting and combustion of this fuel.

To achieve the goals set by Ukraine in the field of renewable power engineering, the reliable information about the energy potential of biomass is necessary. According to the data received in 2013, economically justified energy potential of existing biomass waste is about 25 million tons of fuel and the energy potential of biomass which can be grown on unused agricultural land areas of more than 4 million hectares is about 13 million tons of fuel (see Table 3).

Due to this potential, it is possible to cover up to 18% of the total primary energy consumption in Ukraine. In that way, the Ukrainian agriculture has a significant potential for bioenergy development. However, it is important to introduce effective feed-in tariff mechanism in order to use natural advantages of the country [17-18].

Thus, several advantages of bio-economy should be emphasized, which is an important stimulus for further development of this industry in Ukraine.

For the social sphere:

- diversification of the rural economy;
- job creation;
- agricultural development;
- health improvement;
- improvement of welfare and quality of life in rural areas.

For the economic sphere:

- cost reduction relevant to agricultural products;
- eduction of the dependency on imported energy resources;
- development of the new types of products;
- careful monitoring of product quality;
- entering into new markets of agro-food products.

For the environmental sphere:

- creation of new products and biofuels;
- prevention of pollution;
- use of processed agricultural products.

Tab. 3: The energy potential of biomass in Ukraine

Type of biomass	Actual volume, million tons	% of the total volume	Economic potential, million tons
Cereal straw	32.0	20	3.17
Rape straw	2.9	70	0.96
Production wastes of corn for grain	34.0	52	8.59
Production wastes of sunflower	17.0	67	5.55
Recycled agricultural wastes (husk, bagasse)	9.7	77	0.99
Wood biomass	3.9	89	1.87
Biodiesel	-	-	0.35
Bioethanol	-	-	2.36
Biogas from manure	-	-	0.35
Landfill gas	-	-	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

Source: [15-16]

Along with above-mentioned, it should be noted that there are negative factors which significantly impede the biofuels market development in Ukraine. They include:

- insufficiently developed transportation and logistics infrastructure of the agrarian market and the market of bioenergy resources, as well as the lack of specialized terminals for large volumes of biofuel processing, which results in very expensive logistics and reduces the potential profitability of biofuel plants;
- lack of advanced agricultural technologies for biomass growing and processing;
- lower, if compared to the EU, production capacities of national enterprises for the production of biofuels;
- lack of specialized equipment for biofuel cargo traffics handling;
- backlog of information infrastructure: the biofuels market is not transparent and potential consumers are not aware of

their capabilities in this area and the advantages of bioenergy as such;

- financial difficulties for farmers while introducing innovative technologies;
- lack of qualified staff;
- imperfection of legal and regulatory framework;
- the unresolved issue of effective feed-in tariff for bioenergy;
- unfavorable investment climate in Ukraine.

### 5. Conclusions

Ukraine has good preconditions and sufficient potential for the dynamic development of the alternative energy sources sector. The main driving forces of this process are the problems with traditional energy imports and the existence of a great potential of agriculture available for energy use. To use its potential, Ukraine needs to change main directions of its energy strategy and introduce clear institutional framework for renewable energy market development.

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