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ENERGY POTENTIAL OF AGROBIOMASS AND AGROWASTE AS A SOURCE OF ENERGY INDEPENDENCE OF AGRICULTURAL ENTERPRISES AND COMMUNITIES

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The study is devoted to an overview of the energy potential of agrobiomass in general and agrowaste in particular as the sources of energy independence for agricultural enterprises and communities. It is substantiated that in the conditions of increasing costs of traditional energy resources, instability of energy supply and the need to increase the level of energy security in Ukraine, the effective use of local biomass for the production of biofuels and energy is of particular relevance. The experience and forecasts of the use of various types of biomass for the production of biofuels in leading countries of the world are studied. It is determined that the greatest potential for the production of biofuels is provided by by-products of crop production, organic waste from livestock farming, waste from the processing industry and energy crops. It is proven that the *development of second-generation biofuels based on non-food raw materials allows to increase the level of resource efficiency of the agricultural sector and reduce competition between energy and food use of raw materials. An algorithm for assessing the energy potential of agrobiomass and agrowaste has been developed, which includes the stages of identifying sources of biomass formation, collecting initial data, determining theoretical, technical, economic and energy potential, choosing processing technologies, assessing environmental efficiency and forming practical recommendations for the use of bioenergy resources. An algorithm for assessing the energy potential of agrobiomass and agrowaste has been proposed, which provides a comprehensive approach to determining the theoretical, technical, economic and energy potential of biomass, taking into account technological, environmental and organizational factors. It is substantiated that the introduction of modern bioenergy technologies will contribute to increasing the level of energy autonomy of agricultural enterprises, reducing energy costs, and reducing anthropogenic load on the environment. At the same time, the use of local types of agrobiomass creates the prerequisites for the formation of decentralized energy supply systems, increasing the sustainability of rural areas and strengthening the energy security of territorial communities.*

Keywords: agrobiomass, agrowaste, biofuels, energy potential, energy independence, bioenergy, agricultural enterprises, territorial communities.

Table: 3. Fig.: 3. Ref.:11.

ЕНЕРГЕТИЧНИЙ ПОТЕНЦІАЛ АГРОБІОМАСИ Й АГРОВІДХОДІВ ЯК ДЖЕРЕЛО ЕНЕРГЕТИЧНОЇ НЕЗАЛЕЖНОСТІ СІЛЬСЬКОГОСПОДАРСЬКИХ ПІДПРИЄМСТВ І ГРОМАД

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Дослідження присвячено огляду енергетичного потенціалу агробіомаси загалом й агровідходів зокрема як джерела енергетичної незалежності сільськогосподарських підприємств і громад. Обґрунтовано, що в умовах зростання вартості традиційних енергоресурсів, нестабільності енергозабезпечення та необхідності підвищення рівня енергетичної безпеки в Україні особливої актуальності набуває ефективне використання місцевих видів біомаси для виробництва біопалив й енергії. Досліджено досвід і прогнози використання різних видів біомаси для виробництва біопалив у передових країнах світу. Визначено, що найбільший потенціал для виробництва біопалив мають побічна продукція рослинництва, органічні відходи тваринництва, відходи переробної промисловості й енергетичні культури. Доведено, що розвиток біопалив другого покоління на основі непродовольчої сировини дозволяє підвищити рівень ресурсоефективності аграрного сектору економіки й зменшити конкуренцію між енергетичним і продовольчим використанням сировини.

Розроблено алгоритм оцінювання енергетичного потенціалу агробіомаси й агровідходів, який охоплює етапи ідентифікації джерел утворення біомаси, збирання

первинних даних, визначення теоретичного, технічного, економічного й енергетичного потенціалу, вибору технологій перероблення, оцінювання екологічної ефективності, а також формування практичних рекомендацій щодо використання біоенергетичних ресурсів. Цей інструментарій забезпечує комплексний підхід до окреслення зазначених складників з урахуванням технологічних, екологічних й організаційних чинників. Обґрунтовано, що впровадження сучасних біоенергетичних технологій сприятиме підвищенню рівня енергетичної автономії аграрних підприємств, скороченню витрат на енергоресурси, зниженню антропогенного навантаження на довкілля. Водночас використання місцевих видів агробіомаси створює передумови для формування децентралізованих систем енергозабезпечення, підвищення стійкості сільських територій та зміцнення енергетичної безпеки територіальних громад.
Ключові слова: агробіомаса, агровідходи, біопалива, енергетичний потенціал, енергетична незалежність, біоенергетика, аграрні підприємства, територіальні громади.

Табл.: 3. Рис.:3. Літ. 11.

Formulation of the problem. Ukrainian agricultural enterprises operate in extremely difficult conditions today. Along with the traditional problems of agricultural production – dependence on natural and climatic conditions, a long production cycle due to the biological characteristics of plant and animal development, etc.; martial law in Ukraine has led to the emergence of new problematic issues – starting from logistics and ending with the high cost of material and technical resources used in the production of agricultural products. In these conditions, agricultural enterprises should use their resource potential as efficiently as possible, ensuring not only the stability of production processes, but also increasing the level of their own economic and energy security. The problem of energy supply to the agricultural sector of the economy is becoming particularly urgent, since the rise in prices for traditional energy resources, interruptions in energy supply and dependence on external energy suppliers significantly increase the cost of agricultural products and reduce the competitiveness of enterprises. An important direction for the development of agricultural enterprises in such conditions is the search for alternative energy sources capable of ensuring partial or complete energy autonomy of production.

One of the most promising resources for achieving this goal is agrobiomass and its significant component – agrowaste, which is formed in significant volumes in the process of agricultural enterprises. Assessment of their energy potential is an extremely important task for the agricultural sector of the Ukrainian economy. In addition, the introduction of modern technologies for biomass processing creates additional opportunities for the economic development of not only individual enterprises, but also communities, contributes to the creation of new jobs, attracting investments and increasing the level of environmental safety.

Analysis of recent research and publications. The issues of bioenergy development and the use of agrobiomass as a source of energy independence of the agricultural sector of the economy are actively studied by domestic scientists. In particular, G.G. Geletukha, et al. [1] pay significant attention to the assessment of the energy potential of Ukraine’s biomass and promising areas of its use in bioenergy, focusing on the need to involve agricultural waste in the country's energy balance. Methodological aspects of assessing the environmental and economic efficiency of using agrobiomass for biofuel production are considered in the studies of N.V. Pryshlyak [2], which substantiates the need for comprehensive consideration of the economic and environmental consequences of using biomass. Ya.V. Gontaruk and G.V. Shevchuk [3] investigate areas for improving the production and processing of agricultural products into biofuels, emphasizing the importance of developing technologies for processing agricultural waste and increasing the level of resource efficiency of the agricultural sector of the economy. In turn, N.V. Zelenchuk [4] focuses on methodological approaches to determining the environmental and economic efficiency of biogas production at agro-industrial enterprises.

Despite significant scientific achievements in the field of bioenergy, the issue of comprehensive assessment of the energy potential of agrobiomass and agrowaste in the context of ensuring the energy autonomy of agricultural enterprises and territorial communities requires further research.

Formulation of the goals of the article. The goal of the study is to review the energy potential of agrobiomass and agrowaste to substantiate the possibilities of ensuring energy independence both at the level of individual agricultural enterprises and rural areas as a whole.

Presentation of the main research materials. The development of bioenergy in the world is one of the key areas of ensuring energy security and energy independence for both individual enterprises and rural areas in general. Depending on the type of raw material and production technology, biofuels are divided into the first, second and third generation biofuels. Each generation is characterized by the characteristics of the resource base, the level of technological development and environmental impact. The first generation biofuels are produced mainly from food crops, the second generation biofuels from waste and lignocellulosic biomass, and the third generation biofuels from highly productive biomass, in particular algae and microorganisms (Table 1).

Table 1

Generation of biofuels depending on the type of used raw materials

Generation of biofuels	Main types of raw materials	Main types of biofuels
the 1st generation biofuels	Food crops rich in sugar, starch and vegetable oils: corn, wheat, barley, sugar beet, sugar cane, rapeseed, soybeans, sunflower, palm oil	Bioethanol (from starchy and sugary raw materials), biodiesel (from vegetable oils), biobutanol.
the 2nd generation biofuels	Non-food lignocellulosic biomass and organic waste: cereal straw, corn stalks, sunflower husks, wood waste, sawdust, wood chips, energy crops (miscanthus, willow, poplar), pulp, molasses, manure, poultry litter, organic fraction of household waste, food industry waste	Biogas, biomethane, cellulosic bioethanol, synthesis gas, biochar, solid biofuels (pellets, briquettes), bio-oils, pyrolysis fuel.
the 3rd generation biofuels	Highly productive biomass of aquatic origin: microalgae, macroalgae, cyanobacteria, photosynthetic microorganisms, biomass of aquatic ecosystems	Biodiesel from algae, bioethanol from algae, biohydrogen, biomethane, aviation biofuel, biodiesel.

Source: summarized by the authors

Both traditional types of raw materials, characteristic of the first-generation biofuels, and alternative resources belonging to the second-generation raw material

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base are used for biofuel production in different countries of the world (Fig. 1). The choice of raw materials for biofuel production in different countries is determined by a combination of natural and climatic conditions, specialization of the agricultural sector of the economy, the level of development of biomass processing technologies and state policy in the field of energy security and decarbonization of the economy.

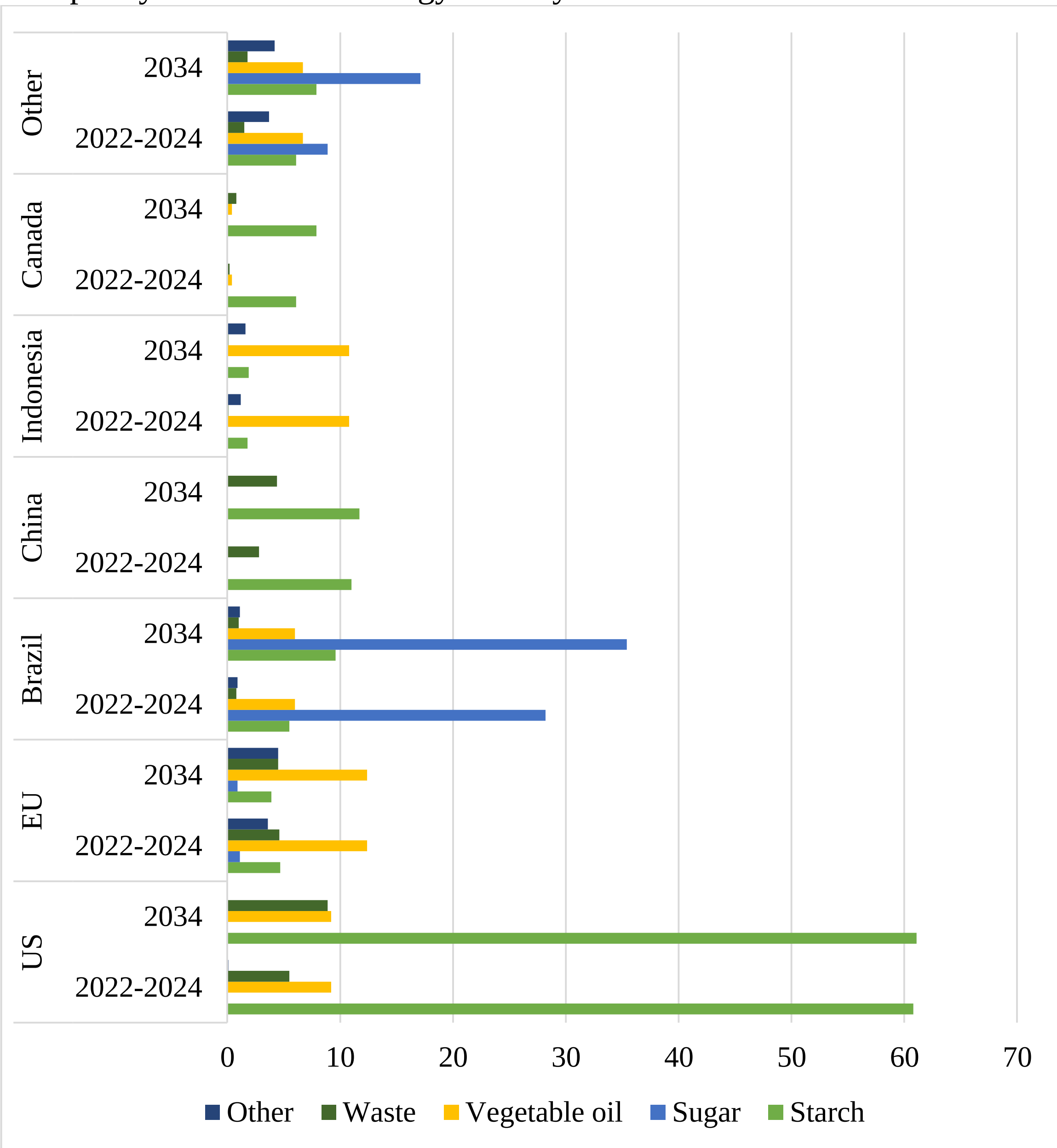

Fig. 1. **Biofuel production from various types of raw materials in the world, 2022-2024, forecast for 2034, billion liters**

Source: [5]

In particular, the main raw material for bioethanol production in the USA is corn, while in Brazil the use of sugar cane prevails, which is explained by the high efficiency of ethanol production from this crop. In the countries of the European Union, considerable attention is paid to rapeseed as the basic raw material for biodiesel production. Such trends indicate the orientation of the mentioned countries towards the development of the first-generation biofuels, the production technologies of which are quite widespread and economically mastered.

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At the same time, Fig. 1 shows a gradual increase in the role of second-generation biofuels, which are produced from non-food raw materials, in particular agricultural residues, lignocellulosic biomass, crop waste and other organic resources. The use of such raw materials is especially relevant for countries that seek to reduce competition between energy and food production, as well as to increase the level of environmental safety. In particular, Asian countries are experiencing significant use of vegetable oils and agricultural waste, which is associated with the development of biomass processing technologies and the desire to reduce energy dependence.

A promising direction for Ukraine is the combination of the production of the first-generation biofuels based on rapeseed, corn and sugar crops with the active development of the technologies for processing agricultural waste and by-products to obtain the second-generation biofuels. This creates the prerequisites for increasing energy independence, effective use of the resource potential of the agricultural sector of the economy and strengthening the energy security of the state. In general, the energy potential of biomass as a raw material for biofuel production is expected to grow in our country according to the Roadmap for the Development of Bioenergy in Ukraine until 2050, developed by the Bioenergy Association of Ukraine (Table 2).

Table 2

Assessment of Ukraine's biomass potential: forecast until 2050

Type of biomass	Theoretical potential, million tons	Potential available for energy (economic potential))	
		Share of theoretical potential, %	Mtoe
Straw of grain crops*	49.2	30	5.04
Rapeseed straw	4.9	40	0.68
By-products of grain maize production (stalks, cobs)*	58.1	40	4.45
By-products of sunflower production (stalks, heads)	26,.9	40	1.54
Secondary agricultural residues (sunflower husk)	2.4	100	1.00
Wood biomass (fuel wood, felling residues, wood processing waste)*	12.,3	96	2.88
Wood biomass (deadwood, wood from shelterbelt forests, biomass from APPR)	8,.	45	1.02
Biodiesel (I and II generation)*	-	-	1.10
Bioethanol (I and II generation)*	-	-	2.33
Biogas from waste and by-products of agro-industrial complex*	8.4 bln m^3 CH_4	83	5.92
Biogas from MSW*	0.7 bln m^3 CH_4	70	0.42
Sewage gas (industrial and municipal wastewater)	0.4 bln m^3 CH_4	31	0.11
Energy crops*:			
- willow, poplar, miscanthus (2 mln ha*);	34.5	100	14.65
- maize for biogas (2 mln ha*).	7.5 bln m^3 CH_4	100	6.43
Total	-	-	47.57

** Components of the biomass potential, the growth of which is expected by 2050*
Source: [6]

The key determinants of the growth of the energy potential of biomass in the long term until 2050, according to the Roadmap for the Development of Bioenergy in Ukraine until 2050 [6], are a complex of interrelated technological, resource and structural transformations in the agricultural, energy and forestry sectors of the economy. The expected increase in the volume of bioenergy resources is based on the following main factors:

1. Increasing the productivity of agricultural production, primarily the grain sector. One of the determining factors for the growth of the energy potential of biomass is the projected increase in the yield of the main agricultural crops. Analysis of the current state of agricultural production in Ukraine, trends in its development, and comparison of yield indicators with the countries of the European Union indicate the presence of a significant reserve for increasing land use efficiency. In particular, by 2050, wheat yields are projected to increase by approximately 1.5 times, and corn yields by 1.4 times, which will ensure not only an increase in the volume of the main product, but also a significant increase in by-products, which can be used for bioenergy purposes.

2. Expanding the economic potential of biogas production. A significant driver of the development of bioenergy is the expected increase in the potential of biogas production due to the diversification of the raw material base and structural changes in related industries. The main prerequisites for such growth are:

- involvement in the energy use of crop residues and other types of agricultural biomass;
- an increase in the production volumes of products of the agro-industrial and food sectors, which is accompanied by the accumulation of organic waste;
- the consolidation of livestock complexes, which contributes to the concentration of significant volumes of organic raw materials for anaerobic digestion;
- a gradual transformation of the solid household waste management system by switching from landfill to mechanical and biological processing technologies.

3. Expanding the area of energy crops and increasing their productivity. An important factor in the strengthening the resource base of bioenergy is the scaling up of the production of specialized energy crops. A significant increase in the area under energy crops, in particular willow, poplar and miscanthus, as well as corn for biogas production, is predicted. It is expected that the total area under energy crops will reach about 4 million hectares, of which 2 million hectares will be for perennial energy crops and another 2 million hectares for energy corn. At the same time, it is expected to increase the yield of such crops through the introduction of modern agricultural technologies and breeding achievements.

4. Increasing the level of use of forest resources for energy needs. A promising direction for increasing bioenergy potential is more efficient use of forestry resources. An analysis of European practices and the current state of forest use in Ukraine indicates the possibility of increasing the level of use of annual wood growth. In particular, it is predicted that the share of felling of annual wood growth

will increase by approximately 1.4 times - from about 51% to 71%, which will allow significantly expanding the volume of available wood biomass without violating the principles of sustainable forest use.

5. Technological transition to the production of new generation motor biofuels. An important trend in the development of the liquid biofuels market is the gradual reorientation from traditional first-generation biofuels to more environmentally and resource-efficient second-generation biofuels. While the basis for the production of the first-generation biodiesel and bioethanol is mainly rapeseed, corn, and sugar beet molasses, in the future the use of lignocellulosic raw materials, agricultural waste, waste vegetable oils, and animal fats will increase. This approach will help to reduce competition between energy and food use of raw materials, as well as increase the level of resource efficiency of biofuel production.

Agrobiomass is one of the most important resources for the development of bioenergy and biofuel production, since it is formed in significant volumes in the process of the agricultural sector of the economy.

By agrobiomass, N.V. Pryshlyak understands by-products and waste of agricultural production, which can be involved in energy use for the production of biofuels and thermal energy [2, p. 46]. The author emphasizes the need to assess the environmental and economic efficiency of the use of agrobiomass in the context of the development of bioenergy.

In the work devoted to the prospects for the use of agrobiomass in Ukraine [7, 99], the researchers interpret agrobiomass as a complex of organic resources of the agricultural sector of the economy, which includes plant residues, livestock waste, energy crops and organic waste of the food industry. Scientists emphasize that agrobiomass is the basis for the development of a circular economy and decarbonization of the energy sector.

In our previous studies [8, p. 67], agrobiomass was defined as a renewable resource of agricultural origin, which includes plant residues, livestock waste and organic waste of the agro-industrial complex, which can be used for the production, in particular, of biogas and biomethane.

In general, we note that agrobiomass includes plant residues, by-products of crop and livestock farming, energy crops, as well as organic waste of agro-industrial production. The use of such a resource allows not only to provide an additional source of energy, but also to increase the efficiency of using the raw material potential of the agricultural sector of the economy.

Waste or residues deserve special attention as a component of agrobiomass, which has significant energy potential. Quite often, agricultural enterprises in Ukraine practice quite limited options for their use - for bedding, as feed or leave part of it on the fields to preserve soil fertility. However, the effectiveness of such areas is not high: the animal feeding ration should be balanced, contain the necessary nutrients, which are not enough in agricultural residues and waste. Plowing should be carried out in compliance with the technology and with the application of necessary fertilizers, which enterprises often do not adhere to. The spectrum of the use of agricultural waste and residues is actually quite wide (Fig. 2).

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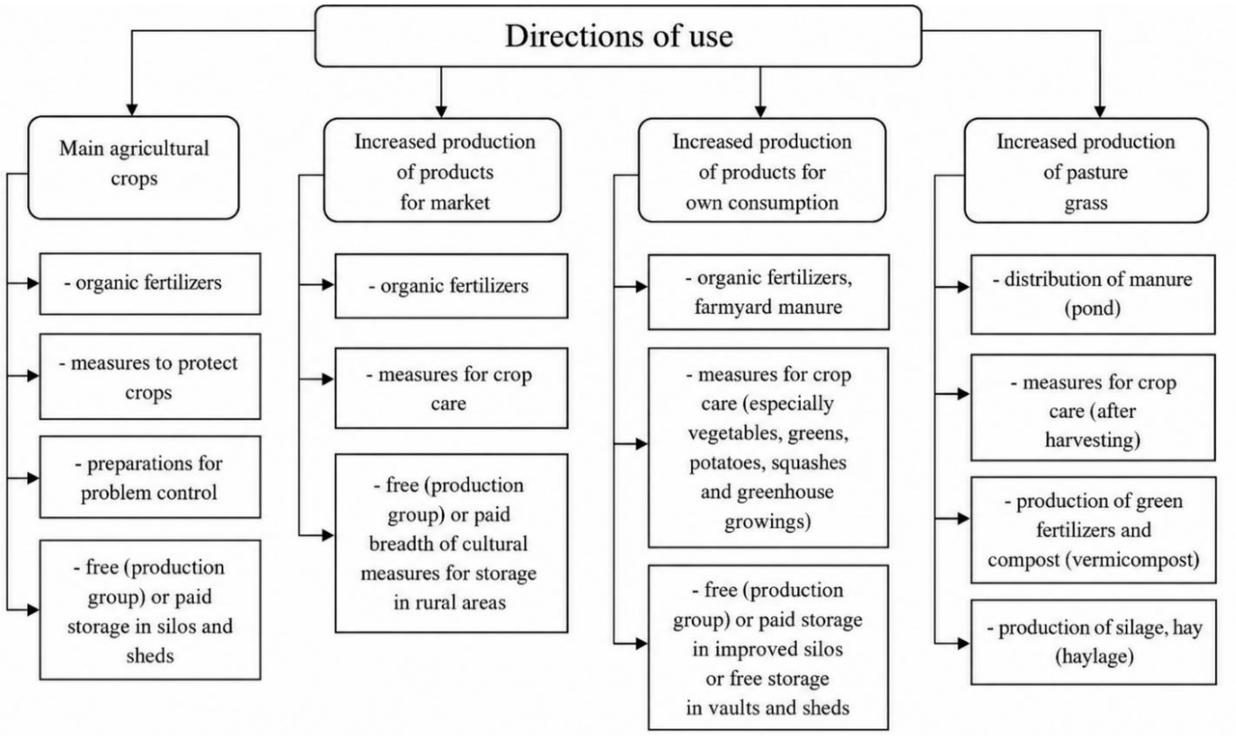

Fig. 2. **Directions of the use of agricultural waste and agricultural residues**
Source: [9]

It is advisable to assess the energy potential of agrobiomass and agrowaste of agricultural enterprises in stages, taking into account the production specialization of the enterprise, the structure of the resource base, technological features and possibilities of energy use of biomass. The proposed algorithm includes the following main stages (Fig. 3).

1. Defining the research objective
↓
2. Identification of sources of agrobiomass and agrowaste formation
↓
3. Collection of initial data
↓
4. Calculation of theoretical potential of agrobiomass
↓
5. Assessment of technical potential
↓
6. Determination of economic potential
↓
7. Calculation of energy potential
↓
8. Selection of processing technology
↓
9. Assessment of environmental efficiency
↓
10. Formation of recommendations

Fig. 3. **Algorithm for assessing the energy potential of agrobiomass and agrowaste of agricultural enterprises**
Source: developed by the authors

1. Defining the research objective. The first stage of assessing the energy potential of agrobiomass and agrowaste involves determining the purpose of the study and the main areas of analysis. At this stage, it is established for what purposes the assessment is carried out: determining the volumes of available biomass for its sale to bioenergy enterprises, assessing the possibilities of producing biofuels (biogas, solid biofuels, biodiesel), ensuring the energy autonomy of the enterprise.

In addition, the spatial and temporal boundaries of the study are determined. The spatial boundaries cover a specific agricultural enterprise, group of enterprises or territorial community, while the temporal boundaries are the period for which the analysis of the formation and use of agrobiomass is carried out. This allows us to take into account the seasonality of agricultural production, the dynamics of waste generation and the prospects for changes in the resource base in the future.

Thus, the first stage forms an information and methodological basis for further assessment of the energy potential of agrobiomass and the selection of effective areas of its use.

2. Identification of sources of agrobiomass and agrowaste formation. The goal of this stage is to form a complete resource base for further assessment of energy potential and determination of opportunities for using biomass for bioenergy purposes. At this stage, agrobiomass is classified according to its origin. A review of the resource base of agricultural enterprises showed that the main sources are:

- specially grown energy crops;
- by-products of crop production (cereal straw, corn stalks, sunflower husks, crop residues);
- organic waste from livestock farming (manure, poultry droppings);
- waste from processing agricultural products.

3. Collection of initial data – the systematization and analysis of statistical, production and technological information on the activities of an agricultural enterprise is carried out. In particular, the following are determined:

- area of crops;
- yield level;
- gross volumes of production;
- number of livestock;
- volumes of by-products and organic waste;
- agrobiomass yield coefficients;

physicochemical characteristics of raw materials (humidity, density, calorific value, biogas yield, etc.).

Particular attention is paid to determining the availability of biomass for energy use, taking into account the technological needs of the enterprise, logistical conditions, seasonality of waste generation and possible losses during harvesting, transportation and storage. Sources of information can be the enterprise's statistical reporting, accounting and production accounting data, results of field research, regulatory and reference materials, as well as scientific and methodological sources.

4. Calculation of theoretical potential of agrobiomass. The theoretical potential of agrobiomass is formed at the expense of two main groups of resources: energy crops and agro-waste, which are formed in the process of agricultural enterprises. At the same time, energy crops include not only specially grown energy plants (miscanthus, energy willow, poplar, sorghum, etc.), but also traditional agricultural crops that can be used for the production of first-generation biofuels. Despite the high energy potential of grain, starch-containing and sugar-containing crops, their excessive use for energy needs can pose a threat to food security and increase competition between food and fuel areas of raw material use. That is why the use of food crops for the production of biofuels must be economically and socially justified.

The second component of the theoretical potential is crop by-products, organic waste from livestock farming, agricultural processing waste and other types of organic biomass that can be used to produce biogas, solid biofuels or second-generation biofuels.

For a more objective assessment of the potential, the waste generation coefficient (by-product) and the energy use coefficient are taken into account, which characterizes the share of biomass suitable for energy production without violating environmental and agro-technological requirements (Table 3).

Table 3

Characteristics of agricultural waste and their theoretical energy potential by type of agricultural raw material

Type of raw material	Main types of agro-waste	Waste generation rate	Energy use rate
Wheat	Straw, chaff	1.0–1.5	0.30–0.40
Corn	Stems, leaves, cob stems	1.2–1.8	0.35–0.50
Barley	Straw, chaff	0.8–1.2	0.30–0.40
Sunflower	Husks, stems, baskets	1.5–2.0	0.40–0.60
Rapeseed	Straw, stems	2.0–2.5	0.30–0.40
Sugar beet	Tops, pulp, molasses	0.4–0.6	0.20–0.30
Potatoes and other starchy crops	Tops, processing waste	0.2–0.5	0.20–0.30

Source: summarized by the authors based on [10, p. 174-177; 11, p. 220]

5. Assessment of technical potential involves determining that part of the theoretical potential that can actually be involved in energy use, taking into account existing technological, logistical and organizational limitations. At this stage, biomass losses during collection, transportation, storage and processing are taken into account, as well as the level of technical availability of raw materials. Special attention is paid to the possibilities of using the existing infrastructure, the provision of the enterprise with technical means for biomass procurement and processing, as well as the compliance of raw materials with the requirements of specific bioenergy technologies. The result of this stage is the determination of the real volume of agrobiomass suitable for further production of biofuels or energy.

6. Determination of economic potential. Economic potential characterizes the volume of biomass, the use of which is financially justified and provides an economic effect for an agricultural enterprise. At this stage, the costs of harvesting, transportation, storage and processing of biomass, the cost of equipment, energy resources and technological maintenance are taken into account. At the same time, possible income from the production and sale of biofuels, savings on traditional energy resources, the payback period of investments and the level of profitability of bioenergy projects are assessed. Thus, determining economic potential allows us to substantiate the feasibility of implementing bioenergy technologies and select the most effective directions for using agrobiomass in the conditions of a specific agricultural enterprise.

7. Calculation of energy potential – involves determining the amount of energy that can be obtained from the use of agrobiomass and agrowaste for the production of biofuels or other types of energy. At this stage, the transition is made from assessing the quantitative indicators of biomass to determining its energy value. The calculation of the energy potential is based on the volume of available biomass and its energy characteristics, in particular the calorific value of combustion, biogas yield or the conversion factor into the corresponding type of biofuel. Depending on the type of raw material and processing technology, the potential for the production of heat, electricity or motor biofuels is determined.

The formula used to calculate the energy potential is:

$$Ep = M \times Q, \quad (1)$$

where Ep – the energy potential, MJ or kWh;

M – the volume of available agrobiomass (economic potential), t;

Q – the lower calorific value or energy value of biomass.

At this stage, the obtained energy potential is also compared with the enterprise's energy needs, which allows assessing the level of possible energy autonomy and the efficiency of using agrobiomass in the energy supply system of an agricultural enterprise.

8. Selection of processing technology – involves choosing the most effective technology for processing agrobiomass and agrowaste depending on the type of raw material, its physicochemical characteristics, volumes of formation and the target direction of energy use. At this stage, the technological method of converting biomass into thermal, electrical energy or biofuel is determined. For processing agrobiomass, technologies of anaerobic digestion, combustion, gasification, pyrolysis, production of pellets and briquettes, as well as technologies for obtaining bioethanol or biodiesel can be used.

9. Assessment of environmental efficiency is carried out taking into account the reduction of greenhouse gas emissions, reduction of organic waste accumulation, substitution of fossil fuels and reduction of anthropogenic load on the environment. At the same time, the impact of agrobiomass extraction on soil fertility, organic matter balance, erosion processes and ecological stability of agroecosystems is analyzed. Special attention is paid to compliance with the principles of sustainable biomass use, under which the energy use of agrowaste does not lead to the degradation of land resources and deterioration of the ecological state of the territories.

10. Formation of recommendations. The final stage of the algorithm is aimed not only at generalizing the results of the calculations, but also at transforming the obtained data into practical management decisions regarding the effective use of agrobiomass and agrowaste. At this stage, the most rational directions for using the available bioenergy potential are determined, taking into account the specialization of the agricultural enterprise, the structure of the raw material base, the level of technical support and economic opportunities. The formation of recommendations involves substantiating the feasibility of implementing specific bioenergy technologies, selecting optimal types of biofuels and determining the volumes of biomass that can be involved in energy use without negatively affecting the main

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production and the ecological state of the soil. At the same time, the possibilities of partial or complete replacement of traditional energy resources with their own types of fuel are assessed, as well as the prospects for increasing the level of energy autonomy of the enterprise. If we consider the level of territorial communities, then at this stage it is advisable to justify the directions of creating local bioenergy complexes, biogas plants, modular biomass boiler houses and cogeneration systems capable of providing heat and electricity production for the needs of social infrastructure, municipal services and agricultural production. This approach allows reducing the dependence of communities on imported energy carriers, increasing the sustainability of the energy system and ensuring more stable functioning of rural areas in conditions of energy risks.

Conclusions. Agrobiomass and its important component – agrowaste – are an important source of ensuring energy independence for both agricultural enterprises and rural areas in general. The experience of countries around the world shows that the production of biofuels from various types of raw materials is actively developing, and it is waste that has great hopes in terms of sustainable use.

Currently, Ukraine needs to intensify the development of biofuel production in view of the difficult economic situation associated with martial law, rising energy prices and economic instability. A review of the resource base of agricultural enterprises showed that energy potential is provided by energy crops; by-products of crop production, organic waste from livestock farming (manure, poultry manure); waste from processing agricultural products.

The developed algorithm for assessing the energy potential of agrobiomass will become an important basis for making informed management decisions regarding the effective use of bioenergy resources, choosing optimal biomass processing technologies and identifying promising areas for the development of bioenergy at the level of enterprises and territorial communities. Its practical application will contribute to increasing the level of energy autonomy, strengthening the economic sustainability of rural areas, and more rational use of local resource potential.

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СТРАТЕГІЧНІ ПІДХОДИ ДО ОПТИМІЗАЦІЇ ПРОДАЖУ ТОВАРІВ ЛОКАЛІЗОВАНИМИ ІНТЕРНЕТ-МАГАЗИНАМИ ЧЕРЕЗ МАРКЕТПЛЕЙСИ

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