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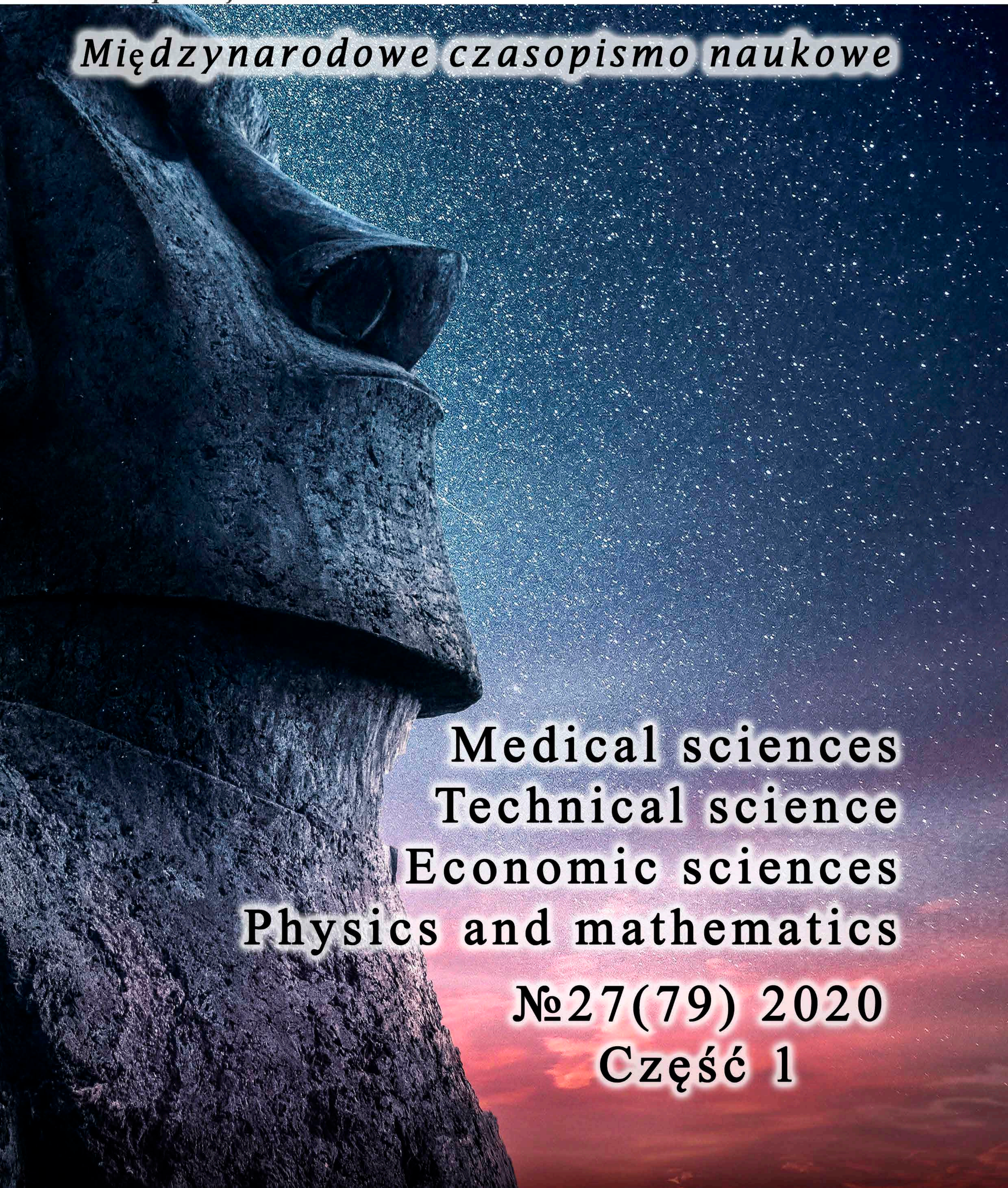

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- innovative (lack of financial resources due to low profitability of production; low quality of products, high production costs; low innovation susceptibility of industry enterprises; insufficient funding of research and development);

- competitive (underdeveloped quality management system; lack of experience and resources for the formation of an effective marketing policy; insufficiently developed system of service and technical support of manufactured products throughout the entire life cycle of the product; unequal conditions of competition in the market with foreign manufacturers of similar products of engineering enterprises, etc.);

- managerial (slowness in the preparation and implementation of managerial decisions; lack of departments ensuring the integration of production into a single economic space);

- personnel (an acute shortage of qualified personnel due to relatively low wages, a decline in the prestige of engineering and technical and working specialties; ineffective personnel policy, which does not contribute to attracting qualified specialists to the sphere of industrial production, scientific, technical and technological activities);

- organizational and legal (underdeveloped system of industrial cooperation; imperfection of the legislative framework in state industrial policy, technical regulation, pricing for engineering products; ineffective interaction of financial and credit organizations and the real sector of the economy, etc.).

The machine-building complex of Ukraine must be brought to a fundamentally new level of development. The main thing in this should be the development of modern technologies, the production of high-tech and science-intensive products that can not only cover the needs of the domestic market, but also allow them to successfully compete in foreign markets. Therefore, great importance is attached to attracting investments in fixed assets of machine-building enterprises.

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METHODOLOGY OF CALCULATING THE COST OF PRODUCTION OF BIOFUELS FROM AGRICULTURAL WASTE, SHARE OF REPLACEMENT OF TRADITIONAL FUELS BY THEM AND ECONOMIC BENEFITS FROM SUCH SUBSTITUTION

Abstract.

A characteristic feature of the current stage of human development is the search for alternative energy sources and the development of bioenergy production. The article considers topical issues of biofuels production from organic waste produced by agricultural enterprises. The life cycle of agricultural biomass (waste) generation, its processing into biofuels and use for energy purposes is analyzed. An algorithm for calculating the cost of biofuels from agricultural production waste is presented. It is substantiated that the main research methods used in studying the raw material potential of waste are desk research and the method of business contacts. It is proved that raw materials make up a significant part of the cost of biofuels from agricultural waste, and since the cost of waste is a fairly conventional value, further research is needed in the formation of methods for their evaluation. A method for calculating the share of traditional fuels, which can be replaced by biofuels from crop waste, is proposed. The peculiarity of the proposed method is the calculation of the share of waste (by-products), which should be used for the production of solid biofuels, as part of the waste must remain in the fields to preserve soil fertility. A method for calculating the share of natural gas, heat and electricity, which can be replaced by similar products obtained from livestock waste by bioconversion. The peculiarity of the proposed method is that it takes into account that biogas is inferior to natural gas in terms of energy output and there is a need to enrich it to the level of biomethane, if a direct target replacement is envisaged. A method of calculating the economic benefit from the replacement of traditional fuels with biofuels from the company's own waste is proposed, which provides for the comparison of the cost of biofuels with the price of traditional energy sources

Key words: *biofuels, waste, organic waste, cost, methodology.*

Introduction. The governments of many countries are taking radical measures to conserve traditional forms of energy and develop bioenergy production. So-called “green quota” has been introduced in European countries, which provides the mandatory use of energy produced by alternative methods: 20% of the total energy consumed must be provided by renewable energy sources and in the amount of 10% – for biofuels. There is also growing interest in the use of unconventional energy sources from government, business and scientific circles, and from agricultural producers in Ukraine. The Law of Ukraine "About Alternative Fuels" defines the legal, social, economic, environmental and organizational foundations for the production of alternative energy sources and sets the goal of increasing their share of use to 20% of the total fuel consumption in the country until 2020 [1]. Thus, the study of the cost of biofuels production and replacing traditional energy sources by them is extremely relevant.

The word "biofuel" consists of two parts "bio" and "fuel". "Bio" is the first part of complex words, which indicates their connection with life and life processes, such as biology, biography, biosphere [6]. "Fuel" – combustible substances that emit a significant amount of heat during combustion, which is used in technological processes or converted into other types of energy [16]. Thus, biofuel is a fuel that has a biological origin.

According to Kaletnik G.M. biofuels are solar energy accumulated through photosynthesis. Their advantages are environmental friendliness and the ability to produce energy resources from renewable raw materials. Biofuels in the form of bioethanol, biodiesel, biogas are the most cost-effective, and therefore promising [9].

According to the Law of Ukraine "About Alternative Fuels" biological fuels (biofuels) - solid, liquid and gaseous fuels made from biodegradable raw materials (biomass), which can be used as fuel or a component of other fuels [1].

Today, the role of biofuels from waste of organic origin is growing in the world (biomass). It is customary to define biomass as all organic substances of both plant and animal origin, the source of which is the current biosphere of our planet [15].

The most familiar source of renewable energy is wood, namely wood waste: sawdust, wood chips, sawdust, plywood waste, pruning, rails, bark, branches and pruning of trees and shrubs, etc. For many wood processing enterprises, these are constant unproductive expense, as it is necessary to spend money on removing waste from the territory. Open burning of wood waste on the territory of the enterprise is inadmissible - it falls under the sanctions of regulatory authorities.

Modern technologies make it possible to turn wood waste into a source of income. To do this, they need to be pressed. Pressing solves two problems: it reduces transport costs by almost 5 times by reducing the volume of waste and removes water from the waste. The perfect fuel for boilers is obtained. When receiving 1 ton of pellets or briquettes, a place of 7-8 cubic meters of sawdust is cleared.

Until recently, everyone attributed straw to waste, but now there is another approach to it - a source of energy. When growing one ton of grain, from 1.5 tons (barley) to 2.4 tons (corn) of straw are obtained. Part of the straw is stored in the fields, part is plowed. But there are many cases of burning in the fields, that is completely unacceptable. , The straw is pressed into rolls or bales for transportation, storage and subsequent use.

Straw has many ways to be used, the most profitable is being used as fuel. Straw usually has a relatively low relative humidity (no more than 25%) and a fairly high heat of combustion: wheat straw has 17-18 MJ / kg, rape straw has 16-17 MJ / kg, and corn straw has about 18 MJ / kg.

Straw pellets are an efficient and, most importantly, cheap fuel that can be used for grain drying and space heating. When burning one ton of straw, about 3 MW of thermal energy is released, which means replacing 333 cubic meters of gas. Straw is well granulated and briquetted. It can be fed into boilers with automatic feeding in pressed form.

When obtaining sunflower seeds, rice or buckwheat, they get the husk, which has become a raw material for solid biofuels – pellets and briquettes. In Ukraine, such opportunities are available at oil plants, which have several dozen large capacities and more than 500 small productions. In the southern regions of Ukraine, it is advisable to produce pellets and briquettes from the husk, which can be transported over long distances for sale to power plants.

Literature review. Kaletnik G., Prutska O., Pryshliak N. studied resource potential of bioethanol and biodiesel production in Ukraine [10]

Kolyadenko S.V. noted that the production of biofuels has become widespread ,in the world in recent decades. The reasons for such rapid growth were, first of all, the reduction of fossil resources, the complexity of their extraction, environmental pollution, economic and political unrest. She substantiated theoretical aspects of ecological and economic efficiency of biofuel production, and also investigated the synergetic effect of their combination in the information economy [11].

Recent developments and key barriers to advanced biofuels were studied by Oh, Y. et al. [13]

Berezyuk, S. studied resource potential of waste usage as a component of environmental and energy safety of the sate [5]. In his work [4] he tried to solve the problems of recycling in Ukraine, as the accumulation of waste every year becomes more and more threatening. According to his research waste, accumulated in landfills, occupies 7 percent of the territory of Ukraine (more than 43 thousand km^2), which simultaneously leads to pollution of water, soil, air and the deterioration of the ecological and economic situation in general.

Geletukha, G.G., Oliynyk, E.M., Antonenko, V.O., Zubenko, V.I., Radchenko, S.V. studied organizational and technical solutions for using agricultural residues for energy [8].

Vis, M., van den Berg, D. et al in the frames of Biomass Energy Europe (BEE) project tried improve the accuracy and comparability of future biomass resource assessments for energy by reducing heterogeneity of terms and definitions, increasing harmonization of data and calculations and exchanging knowledge on methods and approaches [19].

Aim of the research. Investigate and improve methodological approaches to the analysis of the cost of biofuels production from agricultural waste of organic origin, the methodology of calculating the share of replacement of traditional energy sources by biofuels derived from waste and the economic benefits of such substitution for agricultural enterprises.

Materials and methods of the research. In the course of the research the methods of statistical and economic analysis were used: the abstract-logical method that provided theoretical generalizations, formation of conclusions; statistical and economic methods, comparison and juxtaposition of quantitative and qualitative indicators; tabular and graphical methods – to display analytical information; monographic method.

Results of the research and discussion. Today, waste is not just a concept from the natural, technical or geological sciences, but an economic category. And this category follows not only from accounting terminology. Waste is an economic object and the development of economic systems of individual enterprise and the country as a whole, in some cases – individual regions depends on its the management. After all, waste is an integral part of production and interaction of the enterprise with the environment.

Waste is a powerful internal reserve for increasing the efficiency and competitiveness of agricultural enterprises in the domestic and international markets. Analysis of international practice proves that the development of an integrated system for handling waste from agricultural industries allows not only to increase the efficiency of using reserves of material resources and the effectiveness of the company as a whole, but also to reduce the anthropogenic load on the environment by returning waste to production cycles as a secondary raw material.

A general definition of "waste" is contained in the Waste Framework Directive 75/442 / EU: "…Waste means any substance or object which the holder disposes of or is required to dispose ... " [14]. Since this definition is too general, an annex to the Directive contains a list of specific substances and items that may be considered waste. This list is constantly being supplemented and changed: today it contains more than 600 types of waste.

Definition of the term "waste" in different documents is shown in Table 1.

Having ratified the Association Agreement between Ukraine on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other hand, Ukraine has undertaken the obligation to gradually adapt the Ukrainian legislation to European compliance with the directions defined in the agreement.

Table 1

Definition of the term "waste"

Document	Definition
Law of Ukraine "About waste" [2]	Any substances, materials and objects that are formed in the process of activity and do not have further use at the place of formation or detection and which their owner must get rid of by disposal or removal
Ukrainian State Waste classifier ST 005-96 [18]	1) Waste – any substances and objects formed in the process of production and human activity, as a result of man-made or natural disasters, which have no further purpose at the place of formation and are subject to disposal or recycling to protect the environment and human health. or for the purpose of their repeated involvement in economic activity as material and raw material and energy resources, and also the services connected with waste; 2) Waste – any substances, materials and objects that are formed in the process of human activity and have no further use at the place of formation or detection and which their owner gets rid of, intends or must get rid of by disposal
Basel Convention [3]	Substances or objects to be removed, are intended for disposal or are subject to disposal in accordance with the provisions of national law
Directive "On waste and repealing certain Directives" [14]	Any substance or object which the holder disposes of or is required to dispose

Cooperation in the field of the environment, aimed at developing a green economy is among them. Accordingly, changes were made in the Ukrainian legislation to the existing ones and new regulatory documents were adopted. In particular, on November 8, 2017, the Cabinet of Ministers of Ukraine adopted the National Waste Management Strategy in Ukraine until 2030, which focuses on identifying problematic areas of waste management policy in Ukraine and defining the main European norms that are advisable to implement into Ukrainian legislation based on the experience of countries - EU members.

To choose a rational type of agricultural waste for energy use, it is necessary to take into account the specifics of the project site [17], the provisions of the Energy Strategy of Ukraine for the period up to 2035 "Security, Energy Efficiency, Competitiveness" [7].

The main advantages of organic waste as a raw material for biofuels production:

- is a local fuel. In the process of energy production from biomass, the available local resources of the region are used, including labor. Thus, the use of biomass leads to: the development of the local economy; recoverability, neutrality in relation to greenhouse gas emissions; relative ease of extraction and use;

-is a renewable fuel, and therefore, when used rationally, is essentially an inexhaustible source of energy, the use of which contributes to the sustainable development of the region, and does not create the risks of gradual consumption typical of traditional energy sources (corresponding price increases) due to depletion of natural deposits;

-is an environmentally friendly fuel compared to other solid fuels such as coal. As a rule, biomass contains little sulfur, and its combustion at relatively low temperatures does not lead to the formation of nitrogen oxides. In addition, due to the inclusion of biomass in the natural cycle of absorption, storage and release of CO_2, the burning of biomass does not lead to an increase in the greenhouse effect and reduces the negative anthropogenic impact on the environment;

- as a rule, it is a cheaper fuel per unit of energy than other types of traditional energy resources; at the same time, the trends of the last twenty years show a faster growth rate of prices for traditional energy resources than for renewable ones, and this difference is increasing every year;

- energy use of organic waste reduces its amount in cities, and in the case of using biogas, it leads to the disposal of hazardous waste from solid waste landfills, contributes to the cleansing of contaminated areas, the return of biodiversity, and a general improvement in the environment;

- the introduction of biomass generation facilities contributes to the attraction of modern, advanced technical solutions in the field of heat supply, the renewal of technological parks of existing equipment, the development of the production of new equipment, activities for its installation and maintenance.

Table 2 shows the classification of organic waste by origin in accordance with the recommendations of the Best Practices and Methods Handbook of the BEE - Biomass Energy Europe project, which aims to harmonize estimates of biomass resources in Europe and other countries.

Table 2

Classification of organic waste by origin [19]

Main type	Sub-type	Examples
I. Forest biomass	Stemwood	Biomass from pre-commercial and commercial thinnings and final fellings, available for energy production, including whole trees and delimbed stemwood from pre-commercial thinnings
	Primary forestry residues	logging residues, stumps.
	Secondary forestry residues	Residues resulting from any processing step: sawdust, bark, black liquor, etc.
	Woody biomass from short rotation plantations on forest lands	
	Trees outside of forests	Trees in settlement areas, along roads and on other infrastructural areas
II. Agricultural residues - he by-products of agricultural practice	Primary or harvesting residues, by-product of cultivation and harvesting activities	Wheat straw, etc.
	Secondary processing residues of agricultural products, e.g. for food or feed production	Rice husks, peanut shells, oil cakes, etc
	Manure	Pig manure, chicken manure, cow manure, etc.
III. Organic waste	Tertiary residues, released after the use	Biodegradable municipal waste, landfill gas, demolition wood, sewage gas and sewage sludge

Organic waste can be used for energy purposes by direct incineration, as well as in recycled liquid (rapeseed oil esters, alcohols, liquid pyrolysis products) or gaseous biofuels (biogas from agricultural and crop waste, sewage sludge, solid waste, gasification products solid fuels).

Conversion of organic waste into other types of energy or final energy (thermal or electrical) can occur by physical, chemical and biochemical methods.

According to the production process and options for possible further use, biomass is divided into the following groups:

1) organic and organ-containing waste from processing industries and utilities, the disposal of which is a problem for the producer;

2) secondary raw materials of agricultural production, which are used or in the future should be used for the production of organic fertilizers and restoration of soil fertility (animal waste, non-commodity part of the crop, etc.);

3) biomass, which is specially grown for energy needs (energy crops, rapeseed for biofuels production, algae cultivation, phytomass cultivation, etc.) [11].

It is worth noting that the biomass of the 1st group (according to the classification above), which the manufacturer at the first stage agrees to provide free of charge or pay for its disposal in order to avoid environmental problems, after the introduction of an effective method of using it as an energy source, will give rise to the status of secondary raw materials. This, in turn, naturally prompts the former waste producer to demand payment for new raw materials.

For the production of solid biofuels, biomass of group I, woody and herbaceous crops of group II, primary and secondary residues of group III are most often used. In Ukraine, wood biofuel (firewood, wood chips, pellets and briquettes from wood) is mainly used in heat power engineering and in recent years - sunflower husks, grain straw, rapeseed, soybeans in the form of bales, granules and briquettes. The areas of energy plantations of willow, poplar and miscanthus are growing rapidly. The stalks and other wastes of corn and sunflower seeds are not yet actively used (except for husks), but they are a promising source of biomass for energy use in Ukraine.

Several industries are involved in the biomass-biofuels-energy chain. So, in systems on agricultural biomass (Fig. 1), resources are involved: agriculture for the production and harvesting of biomass, transport for its transportation of biomass and distribution of biofuels, processing of biomass into biofuels and heat power engineering, where raw materials are burned and electricity and / or heat are generated.

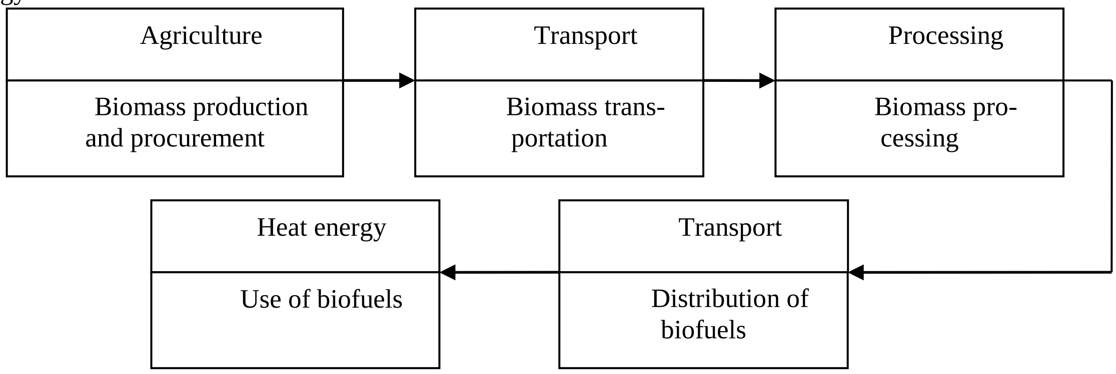

Fig 1. Life cycle of agricultural biomass generation (waste), its processing into biofuels and use for energy purposes

The input cost of various types of biofuels depends on the interaction of participants in the procurement, processing and logistics process. Therefore, it is important to determine the scheme of its delivery to the bioenergy facility, ensuring diversification, if possible.

The mechanism for calculating the cost of various types of biofuels includes an estimate of their cost. It is convenient to track costs according to the stages of the production process. The initial data for this is the volume of biofuel and the scheme of stages of its production. The amount of biofuel is estimated in mass tons or volumetric units: m^3. Although for consumers, given the different moisture and ash content and the varied chemical composition of biofuels, the key characteristic is the lower calorific value. However, its constant control leads to additional financial costs. Therefore, in practice, the price of biofuel is adjusted depending on its moisture content.

Production costs for biofuels are divided into three groups:

- capital investments;
- direct production costs per unit of output {including raw materials, basic materials, basic salary and accrual of electricity, fuels and lubricants, thermal energy, other costs);
- fixed production costs: expenses for the maintenance and operation of equipment (salaries of maintenance personnel and payroll, spare parts and auxiliary materials, repair services of third-party organizations, equipment rental) and general production costs (salaries of production management personnel and charges for it, inventory, repairs and maintenance of buildings and structures, depreciation, other business expenses).

The algorithm for determining the cost of biofuels from waste is shown in Fig. 2.

At the initial stages of determining the feasibility of a bioenergy project, it is difficult to fully estimate the cost of biofuels due to the lack of information.

Specialized literature and the Internet allow to establish the technological scheme and stages of the production process. In the brochures of technological equipment, it is possible to find only general and data and some characteristics.

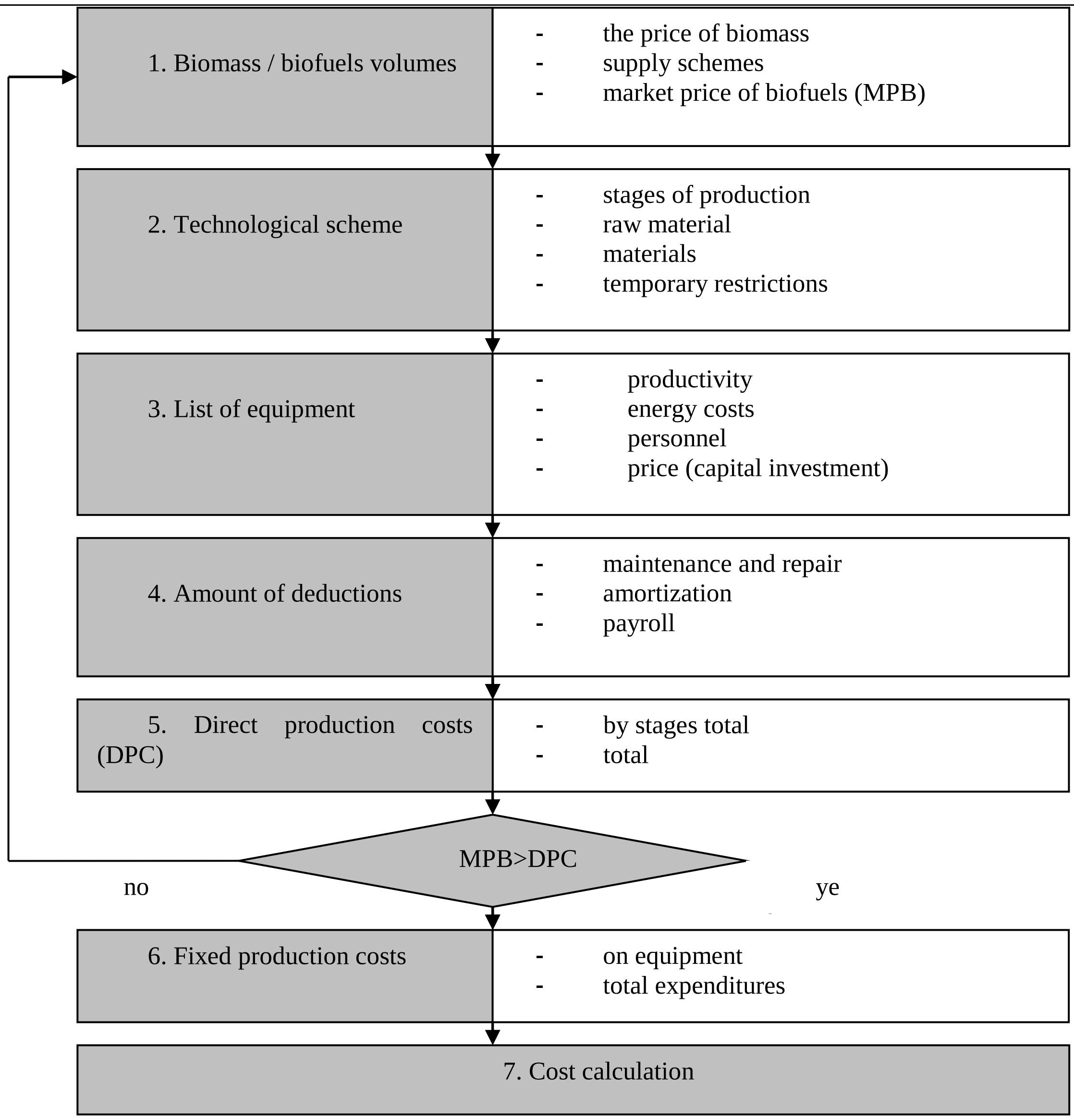

Fig. 2. Algorithm for calculating the cost of biofuels from agricultural waste

Manufacturing plants and dealers provide a commercial offer with a price upon request. But this information is enough to determine the volume of investments and estimate direct production costs, the analysis of which allows to formulate a specific project proposal in more detail.

The calculations of the cost of biofuels are being clarified and a feasibility study is being prepared for the project on the energy use of agricultural waste in the future.

So, the algorithm includes determination of volumes, approximate prices and all stages from harvesting biomass to supplying it in the form of biofuels to a bioenergy facility, a basic list of equipment, number of personnel, transportation distances. Further, the calculations of cost items are performed at each stage. The total costs determine the cost of t or m^3 of biofuels, their analysis by stages and items allows you to optimize the production process.

Marketing research plays a significant role in organizing the use of waste for energy purposes, in particular, in determining the energy potential, on which the efficiency of this activity and the production cost directly depend.

The main research methods that are used in studying the raw material potential of waste are desk research and the method of business contacts.

Desk research involves the collection and analysis of secondary information, the main sources of which are publications, Internet sources, information databases of enterprises, and statistical data.

The method of business contacts involves obtaining primary information directly from agricultural producers.

Thus, experience has shown that it is advisable to assess waste raw materials for energy needs at two levels:

1. district level (desk research);

2. the level of the agricultural enterprise (method of business contacts).

At the district level, it is advisable to establish cooperation with regional, district and city (settlement) authorities, in particular to gain access to statistical information and establish contacts with large local agricultural producers.

Desk research allows you to:

- to determine the general characteristics and production potential of crop production in a particular area: data on the total arable land; the structure of sown areas; yield and gross yield of individual crops;
- get a list and contact details of agricultural producers.

The advantages of desk research include its efficiency and low cost. But the generalization and analysis of information requires special professional training of experts. In addition, there is a risk of obtaining outdated, incomplete or inaccurate information in such studies. Correct organization of desk research and systematic analysis of the data obtained can significantly reduce the number of responses, save time and money for the next stages of research, involving direct communication with potential waste suppliers.

For the purpose of preliminary acquaintance, it is advisable to conduct a survey of agricultural producers. The essential questions of the questionnaire are: the area of agricultural land in the context of individual crops, yields, gross harvest by crops, the total potential for the production of agricultural waste, in particular, grain straw, the volume of straw use for own economic needs, the potential for the supply of straw, features of agricultural technology and the level of technical equipment enterprises, the possibility of organizing temporary storage of straw, the distance to the bio-boiler house, etc.

When processing questionnaires, it is necessary to pay attention to agricultural technologies that are used by agricultural producers, since modern technologies used by large enterprises, in particular, provide for the use of stabilizers for the growth of straw stalks, can significantly affect its yield.

The next step in research is the organization of working meetings. The issues covered in the questionnaire are discussed in detail, the level of interest in cooperation, the essential conditions for cooperation are determined, and the idea of forming a price for waste is discussed. As a result of negotiations, Memorandums of Cooperation or Agreement of Intent may be signed.

This stage of research is the longest, as it involves several meetings with each potential supplier of straw. The following problems are possible at this stage: receiving incomplete information from the agricultural producer, unwillingness to communicate, the problem of pricing. The last problem is that the market for straw as biofuels in Ukraine does not actually exist. Some farms sell straw in small household bales weighing about 10 kg for private farms, or supply it (usually in small or rolled bales) for mushroom pickers, but this does not correspond to industrial volumes.

To estimate the cost of straw it is necessary to determine the cost components: straw in rolls, baling, cargo operations, transportation, storage.

The approximate cost structure of harvesting and logistics of baled straw is shown in Fig. 3.

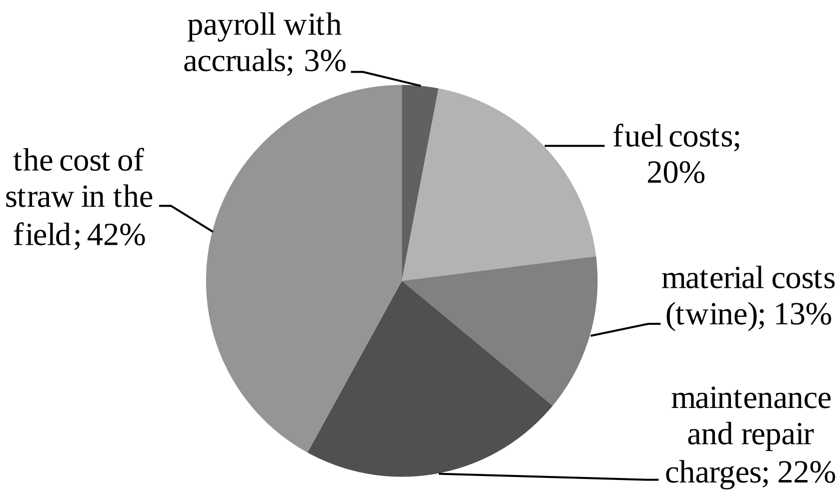

Fig. 3. Cost structure of harvesting and logistics of baled straw,%

Considering that the straw rolls are formed by the farmer's combines, the following stages of work can be distinguished:

1) straw baling
2) collection and loading of bales;
3) transportation of bales;
4) unloading and storing for storage [12].

Cost components: wages, fuel, maintenance and repairs, and for baling straw it is still necessary to use a consumable material – twine. For more accurate calculations, it is necessary to take into account taxation, overhead costs, depreciation of equipment, other specific costs for specific conditions, including food and transportation of workers, non-working movement of machines, etc. It is convenient to determine all costs per ton of baled straw.

The cost structure of harvesting and logistics of baled straw by stages is shown in Fig. 4.

It should be noted that the burning of plant residues is strictly prohibited in Ukraine. Burning stubble, meadows, pastures, areas with steppe, wetland and other natural vegetation or its remnants in the right-of-way of roads and railways without the permission of state control authorities in the field of environmental protection or violation of such a permit entails administrative responsibility and provides for fines sanctions.

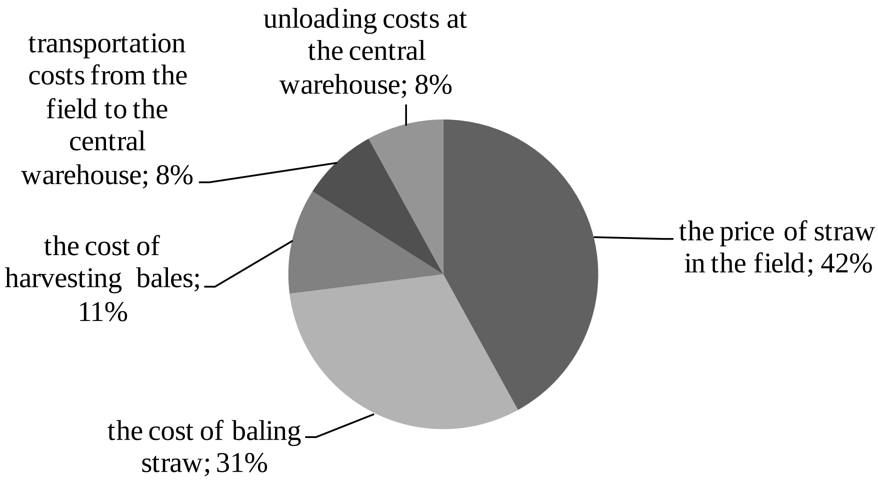

Fig. 4. Cost structure of harvesting and logistics of baled straw by stages,%

In addition, according to Article 245 of the Criminal Code of Ukraine, the destruction or damage of forests, green spaces around settlements, along the railways, as well as stubble, dry wild herbs, vegetation or its remains on agricultural land by fire or in another generally dangerous way – are punishable by a fine from three hundred to five hundred tax-free minimum incomes of citizens or by restriction of liberty for a period of two to five years. In the case that people died as a result of this crime, or there was a mass death of animals or other grave consequences, it is punishable by imprisonment for a term of 5 to 6 years.

But some farmers in Ukraine, despite the prohibitions, annually with enviable consistency burn stubble or straw in the fields after harvest, which reduces the cost of technological operations associated with the incorporation of plant residues into the soil and in order to destroy pests and pathogens of agricultural crops.

In agricultural enterprises, in the presence of livestock farms, straw is used as bedding and roughage. In crop enterprises, by-products of grain growing are used as organic fertilizers. Therefore, the collection and removal of straw from fields, in particular for energy use, is possible only if it is replaced by other fertilizers to ensure soil fertility.

The straw market in Ukraine today is not formed, in particular, straw in rolls in the field. Therefore, the cost of biomass is set individually by agreement between the seller and the buyer. The estimated price can be determined by the cost of mineral fertilizers that need to be applied to the soil to compensate for the removal of nutrients contained in the straw. It is necessary also to take into account the reduction in costs for farmers to perform technological operations for spreading straw over the field and tillage. In addition, the ash formed after burning straw is a valuable fertilizer, but it has a number of peculiarities in use due to its chemical composition. Therefore, for its application, it is necessary to obtain an opinion from the agronomic service on the efficiency of waste use in agriculture, then conduct a hygienic assessment of fertilizers and obtain a conclusion from the state sanitary and hygienic inspection.

An important task for agricultural enterprises is to develop a methodology for calculating the share of replacing traditional fuels consumed in the process of production and economic activities with biofuels based on their own waste. The calculation algorithm for crop waste is shown in Fig. 5.

Stage 1. Calculation of the amount of waste (by-products) of crop production generated at the enterprise

↓

Stage 2. Calculation of the amount of waste (by-products) of crop production, which should be used for biofuels production

↓

Stage 3. Calculation of the amount of solid biofuel that can be obtained from available for energy use crop waste

↓

Step 4. Calculation of the share of energy (electricity and / or heat) from traditional sources that can be replaced by energy from the combustion of solid biofuels

Fig. 5. Algorithm for calculating the share of replacement of traditional energy sources with biofuels obtained from waste (by-products) of crop production

At the first stage, the yield of crop by-products (waste) is calculated, using reference information on the ratio of the main and by-products when growing individual crops.

At the second stage, it is necessary to calculate what amount of crop waste should be used for energy purposes, and what – to leave in the field to preserve soil fertility or use as litter for animals. Taking into account the recommendations of the Bioenergy Association of Ukraine, the coefficient of energy use is 0.25-0.40, depending on the culture.

At the third stage, the volume of solid biofuel (pellets or briquettes), which can be obtained from crop waste available for energy use, is calculated.

At the fourth stage, the share of energy from traditional sources is calculated, which can be replaced by energy, acquired from burning solid biofuel.

To determine the economic efficiency of replacing traditional energy carriers with biofuels obtained from crop waste, using reference books, the cost of a mass or volume unit of the produced biofuel is converted into the cost of a unit of thermal energy. Further, a comparison with the price of a unit of thermal energy obtained from traditional sources is carried out, allowing to analyze the efficiency of its production from different energy carriers.

The algorithm for calculating the share of replacing traditional energy carriers with biofuels obtained from animal waste (by-products) is shown in Fig. 6.

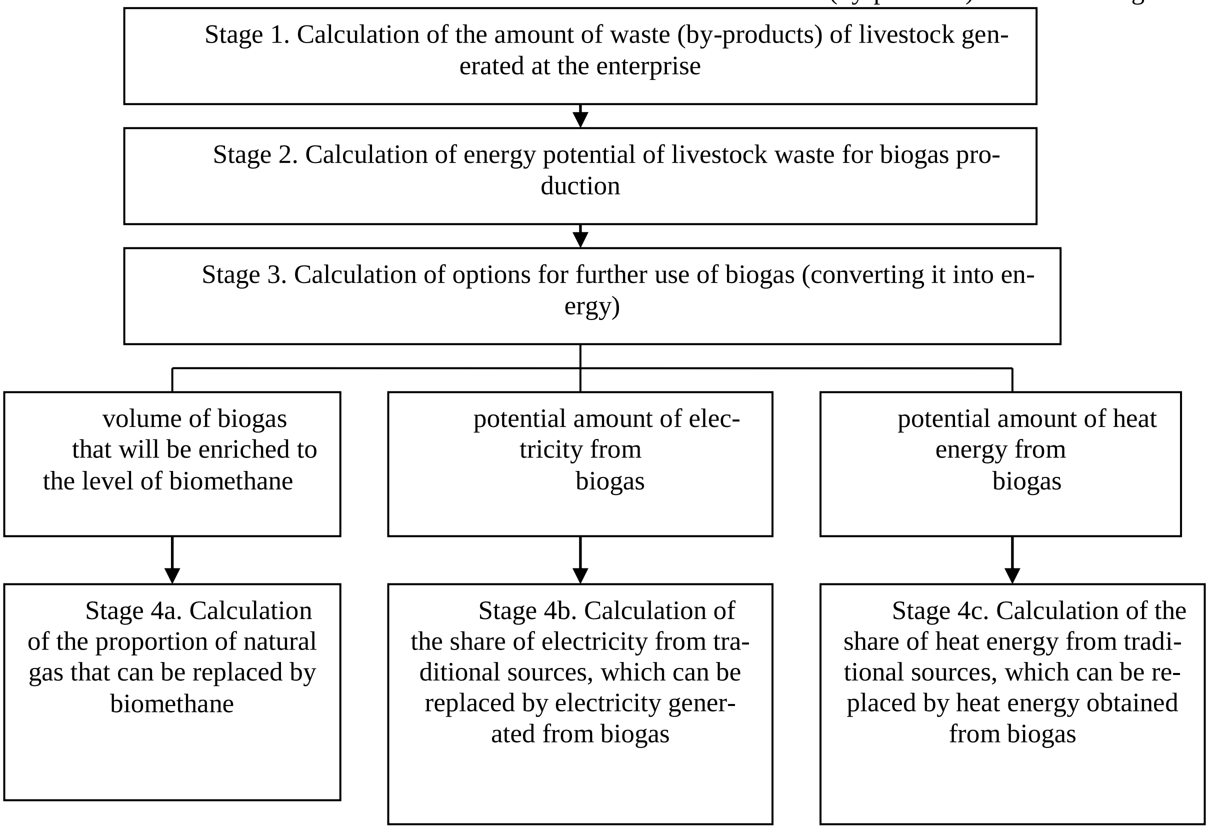

Fig. 6. Algorithm for calculating the share of replacement of traditional energy sources with biofuels obtained from animal waste (by-products)

At the first stage, the volume of waste (by-products) of animal husbandry generated at the enterprise is calculated. Manure from livestock, pigs, poultry droppings, etc. are taken into account.

At the second stage, the energy potential of animal waste is calculated, that is, the potential amount of biogas production. In contrast to the algorithm for calculating the share of replacing traditional energy carriers with biofuel obtained from crop waste, it is advisable to subject all animal waste to bioconversion. This is due to the fact that in addition to energy carriers, a biogas plant provides organic fertilizers, which are then used to increase soil fertility.

At the third stage, options for the further use of biogas (converting it to energy carriers) are calculated, which includes:

- enrichment of biogas to the level of biomethane for targeted replacement of the latter, since biogas is inferior to natural gas in terms of energy output;
- production of electrical energy from biogas;
- production of heat energy from biogas.

At the fourth stage, the share of traditional energy carriers is calculated, which can be replaced with energy products based on biogas.

To determine the economic efficiency of replacing traditional energy carriers with biofuels obtained from animal waste, compare:

- the cost of biomethane obtained and the cost of natural gas;
- the cost of electrical and thermal energy obtained from biomass and from traditional sources.

Conclusions. The main components of the potential of organic waste are primary agricultural waste (straw, waste from the production of corn for grain and sunflower), which remain in the fields as by-products after the harvest of primary crops. The most important type of primary agricultural waste available for energy use is straw. Secondary agricultural waste is produced and accumulated when crops are processed for food and feed production. These include: sunflower husks, rice hulls, nutshells, bean waste and other types of biomass of a similar type suitable for biofuels production. Animal manure and poultry droppings are classified as organic animal waste.

The algorithm of calculating the cost of biofuels from waste is developed that provides calculating the volume of biomass, technological scheme, forming a list of equipment, calculating the amount of deductions, direct and fixed production costs. It is determined that raw materials play an important role in the cost of biofuels from agricultural waste. Since the market value of waste is mostly not established, the is a need to calculate it for a specific use case, incl. for energy purposes. The methodology for calculating the economic efficiency of using biofuels instead of traditional energy carriers has been substantiated.

The algorithm of calculating the share of replacing traditional energy carriers with solid biofuels obtained from crop waste is presented. It is envisaged to take into account the share of waste that is advisable to use for energy purposes, and the share of waste that should be used for plowing in order to increase soil fertility. The methodology for calculating the share of replacing traditional energy carriers with biofuels obtained from animal waste (by-products) by bioconversion is proposed.

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