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CONTENT

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STATE AND LAW

Methodology for calculating the ECONOMIC EFFICIENCY OF WASTE USE FOR THE PRODUCTION OF BIOFUELS IN COMPARISON WITH THEIR TRADITIONAL USE

Tokarchuk D.
PhD in Economics, Associate Professor, Vinnytsia National Agrarian University, Vinnytsia
Prishlyak N.
PhD in Economics, Associate Professor, Vinnytsia National Agrarian University, Vinnytsia
Palamarenko Y.
Ph.D in Economics, Vinnytsia National Agrarian University, Vinnytsia

Abstract

One of the important tasks of the energy complex of Ukraine is to maximize the use of renewable energy resources, in particular, biomass for biofuel production. The methodological approaches to calculating the economic efficiency of waste for biofuel production compared to their traditional use Have been analyzed in the article. An own method of calculating the indicator of ecological and economic efficiency of waste processing at the state level and at the enterprise level was proposed. This methodology covers 5 main stages and is unique in comparison with existing analogues. The developed methodology can be applied at enterprises that intend to process their own waste in order to obtain biofuels, in particular biogas, which will increase the economic profitability of production and reduce the harmful impact on the environment.

Keywords: economic efficiency, waste, methodology, evaluation methods, biofuels.

Introduction. In recent years, due to the tightening of environmental requirements, the expansion of the field of application of renewable energy sources is considered an important direction worldwide. A significant part of the Ukrainian industry is unprofitable, which is caused by structural political and economic crises, outdated equipment, high energy intensity and energy dependence of industrial facilities. To solve these problems, it is necessary to make changes in many areas, namely in the political, economic and social. In modern economic conditions, the economic and environmental components of the activity take the leading place. Analysis and assessment of environmental and economic efficiency as an important determinant in the transition to sustainable development is essential for the further development of the Ukrainian economy.

Literature review. In connection with the global trends towards the transition to renewable technologies, reuse of resources and recycling, as well as issues related to efficient waste management, are actively reflected in scientific research, both from an environmental and economic point of view (Berezyuk S. [3], Antonenko V. [2], McConnell C.R. [12] et al.).

Waste from the agricultural sector has its own characteristics, in particular, it is predominantly organic and has a significant energy potential. The works of V. Denysenko [4], G. Kaletnik [8, 9], S. Romanchuk [18], C. Zulauf [26], Yu. Kernasyuk [10] reflected the issues of using agricultural waste as raw material for biofuel production.

The paper is a continuation of the authors` research [16; 17; 20-23] in accordance with R&D "Development of the latest concept of the use of agricultural waste to ensure energy autonomy of agricultural enterprises" of Vinnytsia National Agrarian University.

At the same time, despite the significant contribution of foreign and domestic scientists to the study of the problems of effective agricultural waste management, a comprehensive and detailed analysis of possible directions for the effective use of organic plant and animal waste from agricultural enterprises is necessary.

Formulation of research objectives. The purpose of the research is to develop methodological approaches for calculating the economic efficiency of waste use in biofuel production in comparison with their traditional use. The proposed methodology will have an integral character of assessing environmental and economic efficiency.

Results. Waste recycling has a double purpose: on the one hand, it reduces the environmental burden on the environment, on the other hand, it has a positive effect on the financial condition of the enterprise, therefore we are talking about environmental and economic efficiency.

According to research, in the modern economic literature, the concept of economic efficiency has a different interpretation, and such a concept as environmental and economic efficiency is not fully disclosed. In its broad sense, environmental and economic efficiency is the ratio of total economic and environmental costs to the integrated environmental and economic effect, a comprehensive assessment of the space and time of interaction of economic activity and the environment [5]. As a rule, environmental and economic efficiency is calculated using the appropriate indicator (E) (1):

$$E = E0 - (A + B + C), \quad (1)$$

Where: $E0$ – general economic effect of the business entity;

A – the cost of environmental measures;

B – losses from damage to the environment;

C – cost of natural resources [25, p. 167].

However, this indicator is not complete and takes into account only economic and ecological criteria of ecological and economic efficiency. At the same time, it is not necessary to take into account intangible effects, which are not always possible to present in monetary terms.

When assessing the environmental and economic efficiency of biofuel production from biomass waste, it is necessary to take into account a set of components, including economic, environmental, social, energy and political (Fig. 1).

In addition, in the process of assessing the environmental and economic efficiency of waste processing, it is important to observe the consideration of the issue in two planes: at the state level and at the level of a separate enterprise.

In the EU countries, the processing of industrial waste in order to increase production efficiency takes an important place in terms of the volume of activity and socio-economic sense in the system of economic development. Thus, in European countries, production waste is now a very important resource, and their loss is a direct factor in reducing production efficiency at an enterprise or in the industry as a whole. [18, p. 323].

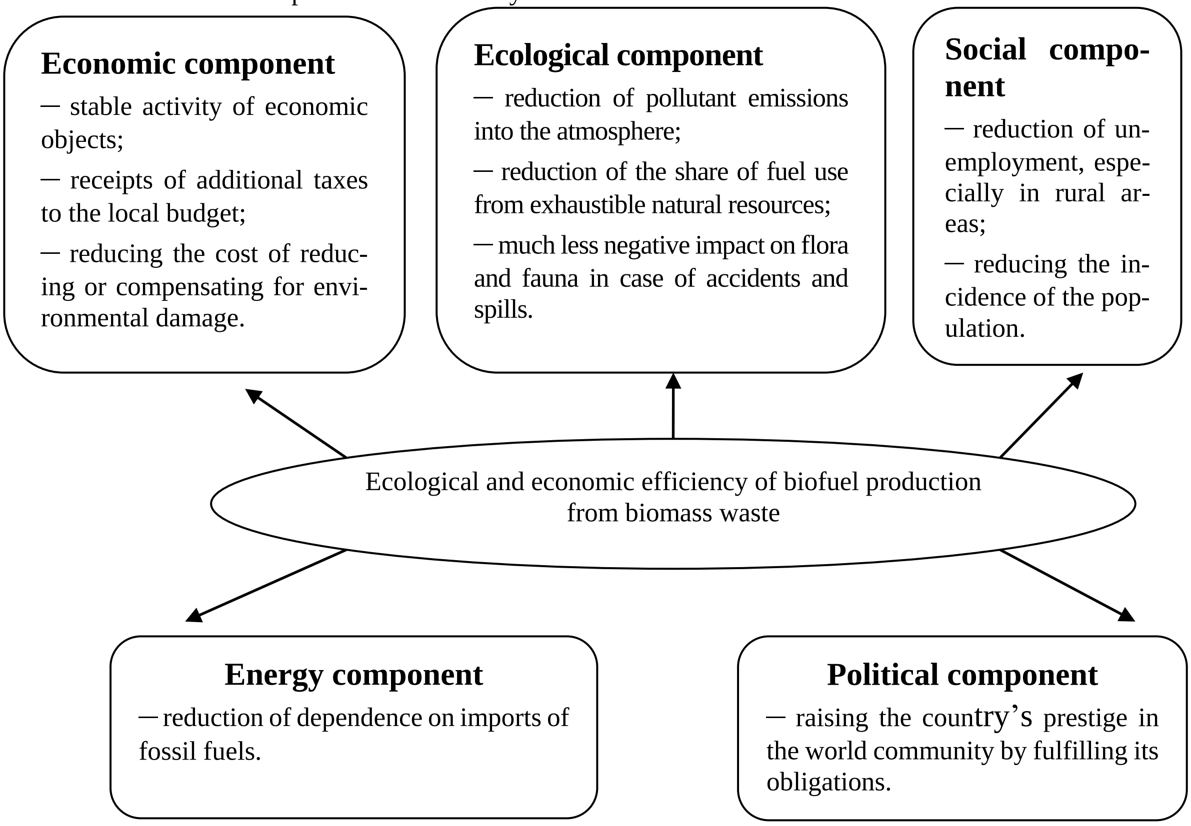

Fig. 1. Components of the system of ecological and economic efficiency of biofuel production from biomass waste
Source: formed by the authors on the basis of the analyzed literature

Given the significant population growth rates (according to UNDP (United Nations Development Program) forecasts [14] by 2024 the world's population will grow to 8 billion, and 10 billion people by 2056), the issue of providing mankind with energy resources is becoming especially urgent. At the same time, the high cost of traditional energy resources leads to an increase in the cost of food products obtained in agricultural production. The problem of rising prices for food, which is associated with the rise in prices for fuel and energy resources, can be largely solved by the use of biomass of agricultural origin as biofuel. Under these conditions, agricultural production solves a threefold problem: food production; production of energy resources; improving the ecological situation by utilizing organic waste and ensuring a positive balance of humus in the soils of crop rotation.

At the same time, a comprehensive solution to this problem is impossible without increasing the energy and environmental efficiency of technical and technological processes of energy production from biomass [19]. Currently, interest in alternative energy sources is growing in proportion to traditional fuel prices, the oil crisis and the fight against global warming have greatly contributed to the fact that the development of bioenergy has become part of the political and economic plans of many countries.

At the same time, Ukraine, despite the significant energy potential of biomass, is behind the world leaders in the field of bioenergy. Ukraine is the only large agricultural country whose biofuel production has declined since 2010. The reason for the slow development of bioenergy in our country is the imperfect regulatory framework, insufficient level of state support for innovation and development of bioenergy, lack of public awareness in the field of biotechnology and lack of credit and financial support.

It should be noted that agricultural enterprises can produce gaseous fuels – biogas, biomethane, generator and pyrolysis gases; liquid fuels – diesel biofuel and bioethanol; solid fuels – straw, tops, wood waste, as well as fuel pellets and briquettes based on them. In this case, biofuels can be used directly or as a source for the production of electricity and heat.

The undeniable advantage of biofuels made from vegetable or animal waste of agricultural origin is the ability to ensure energy autonomy of agricultural enterprises, redirection of energy for sale to third-party consumers, a significant reduction in greenhouse gas emissions.

At the same time, in the conditions of agricultural production the use of biofuel energy requires significant optimization of technical and technological processes of biofuel production and use, as well as improvement of scientific and technical parameters of machines and equipment used for biofuel production and energy production. Also, there is a need to develop a methodology for calculating the economic efficiency of waste for biofuel production compared to their traditional use.

The methodology of the economic efficiency of waste use in biofuel production in comparison with their traditional use at the state level provides (Fig. 2):

Stage 1. Determining the energy intensity of GDP, the needs of the state in energy resources and areas of their provision; analysis of the formation of agricultural waste in the areas of their management.

↓

Stage 2. Analysis of waste potential for biofuel production.

↓

Stage 3. Calculation of the investment attractiveness of using biofuels from waste as a source of electrical and thermal energy.

↓

Stage 4. Analysis of possible solutions to problems that may arise during the implementation of bioenergy projects.

↓

Stage 5. Calculation of environmental benefits from the energy use of waste.

Fig. 2. The main stages and characteristics of the methodology of economic efficiency of waste use for biofuel production at the state level

Source: formed by the authors

In the world community, the main priorities of energy policy are energy efficiency, the use of renewable energy sources and reducing the negative impact on the environment.

One of the tools to guarantee Ukraine's energy security is to expand the use of all types of renewable energy. Thus, according to the forecast balance of the total primary energy supply until 2035 (Table 1), the share of renewable energy will grow in 2035 to 20% of the total primary energy supply.

Achievement of such results is planned to be obtained due to a significant reduction in coal consumption – by more than 57% by 2035 of natural gas – by 27% by 2035.

Table 1

Forecast balance of the total primary energy supply for the period up to 2035, the share of renewable energy sources in the total primary energy supply and the level of energy efficiency of the national economy

Consumption of primary energy resources, million tons of oil equivalent	**2013**	**2020**	**2025**	**2030**	**2035**
Coal	41.4	32	28.8	24	17.7
Natural gas	39.5	33	30	29	28.8
Petroleum products	9.85	13	12.5	12	11
Nuclear energy	21.9	26.7	27.8	28	28
Biomass, biofuels and waste	1.56	3.6	4.5	6	8
Solar energy	0.07	0.5	1.5	2.8	5
Wind energy	0.08	0.4	1.6	2.3	4
Hydraulic energy	1.14	0.9	1	1.2	1.2
Environmental energy	0.05	0.3	0.7	1.1	2.3
Net exports of fuel and energy resources	– 0.35	– 0.9	–1.3	–2.2	–2.6
In total, including	115.2	109.5	107.1	104.2	102.6
Renewable energy sources	3.13	5.7	9.3	13.4	20
Realizing Energy Efficiency Potential					
Energy consumption, t of oil equivalent / thousand dollars USA	0.32	0.26	0.2	0.15	0.12
Realized potential to increase energy efficiency, million tons of oil equivalent	–	36.6	65.6	98.7	144.6
Expanding the use of renewable energy					
Share of renewable energy sources in the total primary energy supply,%	2.7	5.2	8.7	12.9	20

Source: formed by the authors according to the data from Ministry of Energy and Coal Industry of Ukraine [13]

Proved reserves of traditional natural gas in Ukraine at the beginning of 2018 amounted to 11.19 trillion m^3, predicted natural gas resources were 3.49 trillion m^3, and potential gas resources were estimated at up to 6 trillion m^3. However, 43% of the projected volume of natural gas falls on the Eastern region of our state, where due to the current political situation, the search and development is rather difficult. Moreover, more than 50% of the deposits are located at a depth of 4000 m and deeper.

The projected volumes of unconventional gas in Ukraine are estimated at 1.2 trillion $m^3$of shale gas, 8.5 trillion m^3 of gas from dense reservoirs and more than 12 trillion $m^3$of methane from coal seams. These data are quite promising in terms of providing the state with its own energy resources and, as a result, reducing the level of energy dependence of Ukraine. A prerequisite for this is to carry out sufficient volumes of geophysical research and exploration drilling.

Another way to reduce energy dependence is to reduce gas consumption. It should be noted that over the past decade this indicator has undergone a significant decrease. The main reason for this is the drop in production both in industry and in other sectors. The least (only 12%) decrease in gas consumption by the population is a consequence of changes in the country's demographic situation.

In the current conditions of the imminent threat of depletion of minerals as sources for obtaining traditional fuels, the need for the production of alternative types of energy to meet energy needs is becoming increasingly important. A particularly urgent task of the national energy sector is the search and use of alternative fuels that will have signs of environmental friendliness and renewability.

The main factor now complicating the active implementation of the production and use of fuel is the disparity in prices between traditional and renewable energy sources.

The National Renewable Energy Action Plan has proposed an ultimate goal for the development of this sector in Ukraine by the end of 2020. According to it, the share of renewable energy sources in gross final energy consumption in 2020 should reach 11% (in accordance with the obligations of Ukraine as a member of the Energy Community). Biomass is an important component of renewable energy sources, according to the National Action Plan, its main contribution is provided in the heating / cooling sector – 5,000 thousand tons of oil equivalent per year in 2020, which will be 85% of the contribution of all renewable energy sources (Table 2).

Subtracting from the total planned volume of natural gas substitution (7.2 billion m^3 / year) the amount of reduction already achieved today due to biomass (1.93 billion m^3 / year), we obtain the volume of gas (5.27 billion m^3 / year), which should be additionally replaced by biomass by the end of 2020 according to the National Renewable Energy Action Plan.

Table 2

National indicative target for renewable energy sources in gross final energy consumption by 2020 and estimated trajectories of its achievement

Indicator	2009	2014	2015	2016	2017	2018	2019	2020
Renewable energy sources: heat production, %	3.4	5.7	6.7	7.7	8.9	10	11.2	12.4
- biomass, thousand tons of oil equivalent	1 433	2 280	2 700	3100	3 580	4 050	4 525	5 000
Renewable energy sources: electricity production, %	7.1	7.6	8.3	8.8	9.7	10.4	10.9	11
- biomass, megawatts of thermal energy		40	250	380	520	650	780	950
solid		28	175	260	360	455	540	660
biogas		12	75	120	160	195	240	290
Total share of renewable energy sources in gross final energy consumption, %	3.8	5.9	6.7	7.4	8.3	9.1	10.1	11.0

Source: formed by the authors on the basis of the analyzed literature [1]

The energy potential of biomass, according to 2016 estimates, is more than 21 million tons of conventional fuel / year (Table 3). The main components of the potential are primary agricultural waste (straw, waste from corn and sunflower) and energy crops, the cultivation of which on an industrial scale is actively developing in the country in recent years. In general, the economic potential of agricultural waste is 12.2 million tons of conventional fuel / year, energy crops – 10 million tons of conventional fuel / year.

Currently, the transition of energy systems of countries to renewable energy sources is an important aspect, since the reserves of minerals are exhaustive. Accordingly, the issue is a certain percentage of "green energy" in the country's energy balance. In particular, for example, in 2019 in Germany 55% of available electricity is produced on the basis of renewable energy sources (8.9% based on biofuels), in Austria – 70% (3.3%), Portugal – 84% (3.4%), Hungary – 27% (3.07%), Czech Republic – 11% (3%), Lithuania – 29% (4.3%), Latvia – 18% (8.8%), Estonia – 26% (7.2%), Finland – 34% (6.3%). Therefore, the use of renewable energy sources in the energy balance of European countries is an important component, since the fate of renewable energy sources is 30% of electricity production, which has increased significantly over the past 20 years (12% in 2000) [4, p. 85].

Table 3

Energy potential of biomass in Ukraine

Type of biomass	Theoretical potential	The share available for energy	Economic potential
	million tons	%	million tons of conventional fuel
Rapeseed straw	2.2	40	0.29
Waste from the production of corn for grain (stems, rods)	36.5	40	2.79
Wastes from sunflower production (stalks, baskets)	25.9	40	1.48
Secondary agricultural waste (husk, pulp)	2.0	87	0.71
Wood biomass (firewood, logging residues, wood processing waste)	6.6	94	1.55
Biodiesel (from rapeseed)	–	–	0.16
Bioethanol (from corn and sugar beet)	–	–	0.66
Biogas from waste and by-products of agro-industrial complex	1.6 billion m^3 of methane (CH_4)	50	0.68
Biogas from landfills	0.6 billion m^3 CH_4	34	0.18
Biogas from sewage (industrial and municipal)	1.0 billion m^3 CH_4	23	0.19
Energy crops:			
– willow, poplar, miscanthus	11.5	100	4.88
– corn (for biogas)	3.0 billion m^3 CH_4	100	2.57
Total	–	–	21.00

Source: formed by the authors on the basis of the analyzed literature [4, p. 85]

At the same time, conclusions regarding the available energy potential of biomass in Ukraine are based on a theoretical assessment based on statistical data on the level of agricultural production (yield of main crops, structure of agriculture, coefficient of waste generated), level of forest cover in the region, amount of final felling and waste wood, formed at woodworking enterprises, the level of firewood procurement in the region and the total capacity of producers of biofuels of plant origin (pellets, briquettes), woodworking and processing enterprises and other enterprises using biomass, including for energy needs.

Table 4 shows examples of the successful application of biofuel (by its major types) in the municipal power system, which actually shows its economic viability for solving the key problems. Savings are generated by replacing expensive natural gas with cheaper biofuels that can be directed towards a return on investment.

Table 4

Technical and economic indicators of boiler houses and thermal power plants in district heating systems

Indicator	Boiler room 10 Mega watt			Heat power plant, 6 megawatts of electricity + 18 megawatts of heat		
	Straw in bales	Corn stalks	Granules from sunflower husk	Straw in bales	Corn stalks	Granules from sunflower husk
Volume of electricity supply, million kilowatt hours	–			40.18		
Volume of thermal energy supply, thousand Gcal	38.25			68.85		
Fuel price with delivery, UAH / t without VAT	750		1440	750		1440
Fuel consumption, thousand tons / year	13.5	14.1	13.5	14.1	13.5	14.1
Gas savings, million m^3 / year	5.2			9.6		
Investment needs, million euros	2.5	2.2	2.5	2.2	2.5	
Simple payback period *, years	4.4	3.4	4.4	3.4	4.4	3.4

Source: formed by the authors on the basis of the analyzed literature [2, p. 34]

The analysis showed that the simple payback period of such projects, even with a high fuel cost of UAH 950 / t without VAT, is 2.4-4.6 years [2, c. 32].

However, there are factors that hinder investment processes in these projects: for example, the need for insurance in the bioenergy sector to attract significant funds, since foreign investment companies have strict insurance requirements. Fig. 3 shows the main elements of the successful implementation of bioenergy projects.

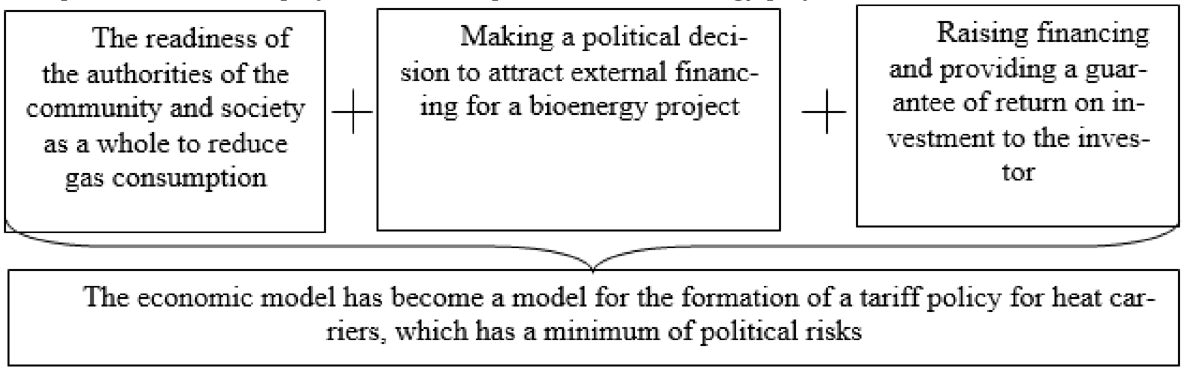

Fig. 3. Formula of a successful example of a project with gas substitution with local fuels
Source: formed by the authors on the basis of the analyzed literature [24, c. 110]

The environmental benefits of using waste for biofuel production at the state level include: reduction of greenhouse gas emissions into the atmosphere; solving problems of waste accumulation in landfills; fulfillment by Ukraine of its environmental obligations.

We have proposed a methodology for calculating the ecological and economic efficiency of waste use for biofuel production in comparison with their traditional use at the level of an individual agricultural enterprise, which is progressive and consists of a set of stages (Fig. 4).

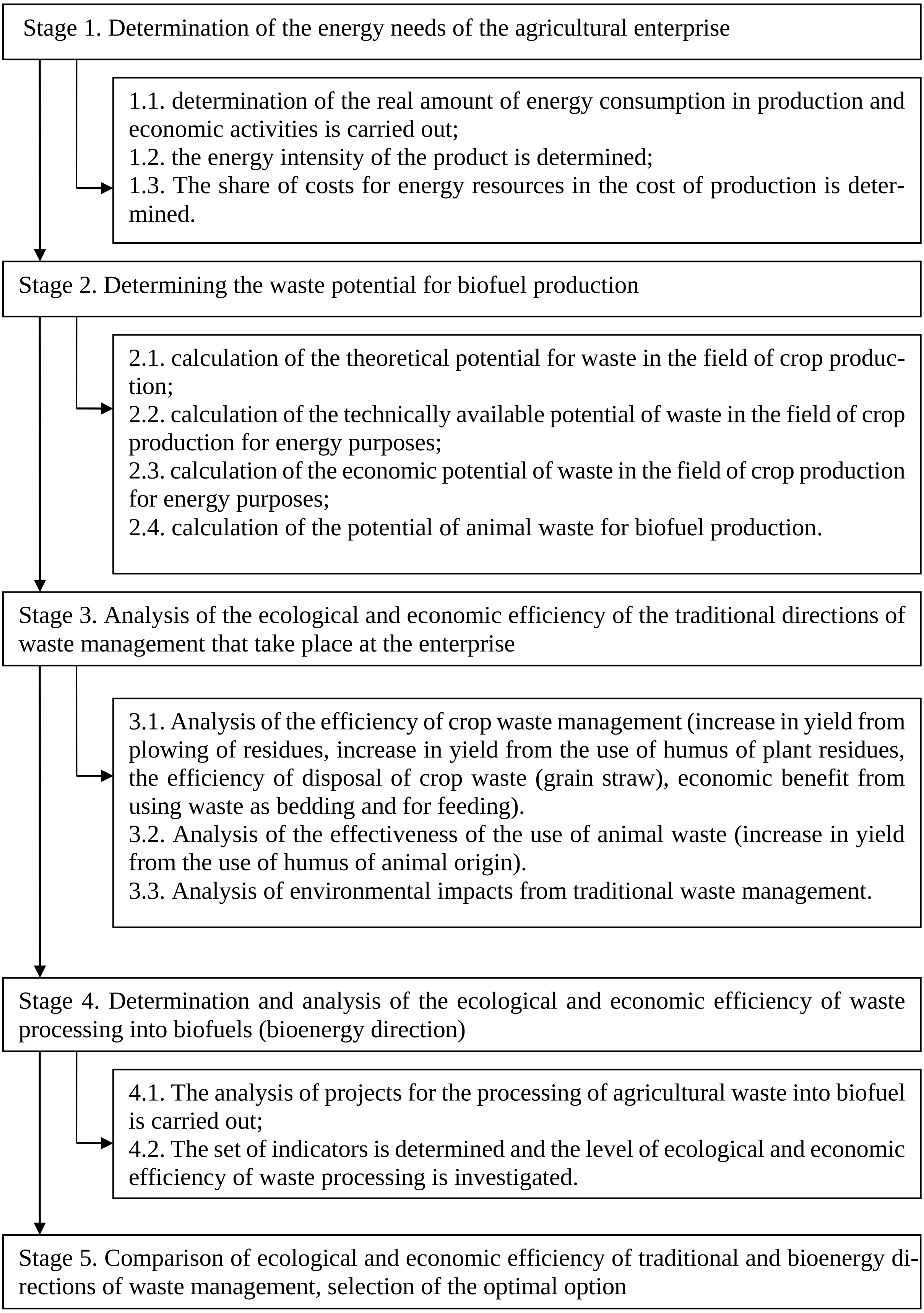

Figure: 3. Stages of determining the ecological and economic efficiency of waste use in biofuel production in comparison with their traditional use

Source: formed by the authors on the basis of the analyzed literature

Stage 1. Determination of the energy needs of the agricultural enterprise

The first stage involves analyzing the energy consumption of agricultural enterprises and determining the energy demand. The total energy intensity of production of products, works and services in agriculture has the following components:

– direct energy consumption of fuel and electricity;

– energy intensity of the use of agricultural machinery;

– energy consumption for output technological materials (seeds, fertilizers, pesticides, feed, bedding, etc.);

– energy intensity of fixed assets of production;

– energy consumption for irrigation;

– energy consumption for the restoration of soil fertility.

The efficiency of the use of energy resources can be judged by the indicator of the energy intensity of production, which is calculated by the formula (2):

$$e = E/Q, \quad (2)$$

where: e – energy intensity of production;

E – consumed energy resources;

Q – volume of production [11].

Stage 2. Determining the waste potential for biofuel production

An important prerequisite for the successful use of agricultural waste for energy needs is the correct assessment of its potential.

There are three main types of biomass potential: theoretically possible (theoretical), technically accessible (technical) and feasible (economic).

Theoretical potential is the total maximum amount of terrestrial biomass theoretically available for energy production within fundamental biophysical limits. When it comes to the biomass of agricultural crops, energy crops and forests, it represents maximum productivity with theoretically optimal management, taking into account the constraints arising from temperature, solar radiation and precipitation. In the case of various types of waste and residues, this potential is equal to their maximum generated volume.

Technical potential – the proportion of theoretical potential available under certain technical and structural conditions and current technological capabilities. In addition, spatial constraints due to competition between different land users are taken into account, as well as some environmental and other non-technical constraints.

Economic potential – the share of technical potential that meets the criteria of economic feasibility under existing conditions [6].

The methodology for assessing the energy potential of crop waste includes the following types:

– primary – straw of wheat, barley and other cereals; rape straw; waste from the production of corn for grain and sunflower;

– secondary – sunflower seed husks.

The general formula for assessing the economic potential of wastes from the production of a particular crop is (3):

$$P_e = c_r \cdot \kappa_r \cdot \kappa_t \cdot \kappa_e \cdot \kappa_{ce}, \quad (3)$$

where: P_e – economically feasible potential, thousand tons of conventional fuel;

c_r – gross harvest of agricultural crops, thousand tons;

κ_r – waste ratio, which is different for each plant species;

κ_t – coefficient of technical availability of agricultural waste, which characterizes the amount of straw that can be obtained with the available collection technology. The coefficient of technical reach for all types of agricultural plants is taken equal to 0.8;

κ_e – waste energy factor, which characterizes the fraction of waste (straw) that can be used for energy production;

κ_{ce} – conversion factor to fuel equivalent [24, p. 52].

A feature of determining the energy potential of animal waste is that the theoretical, technically accessible and economic potentials are the same in the presence of financial resources for organizing biofuel production.

Stage 3. Analysis of the ecological and economic efficiency of the traditional directions of waste management that take place at the enterprise

Evaluation of the effectiveness of traditional directions of waste management includes:

– analysis of the dynamics of the yield of the main crops, for which the plowing of plant residues was carried out, the effect of plowing on the yield level;

– analysis of the dynamics of the yield of the main crops, for which humus was introduced; the influence of the application volume on the yield level;

– analysis of the growth of animals at the enterprise, which are fed with straw as feed and assessment of the effectiveness of such use;

– analysis of the volume of straw required for use as bedding;

– study of the technology of storage and traditional use of waste at the enterprise and their impact on the environment.

Stage 4. Determination and analysis of the ecological and economic efficiency of waste processing into biofuels (bioenergy direction)

Modern trends in the development of scientific and technological progress and innovation require an increase in the level of strategic development of enterprises. At the same time, the priority is the problem of effective use of development components (financial, technological, managerial, marketing and innovative components). Increasing the efficiency of the specified development components used, their effectiveness is one of the main conditions that ensures the effective development of an enterprise, will contribute to increasing competitiveness and the strategic level of development of the economy as a whole [15].

The total yield of biomass suitable for conversion into electrical and thermal energy can be expressed as (4):

$$Ns = \Sigma \text{ si ui } [ka - (kb + kc)] - \Sigma \text{ nj } N \quad (4)$$

where: Ns – yield of crop by-products (straw), which can be used to increase the level of energy autonomy, tons;

ka – the coefficient of the by-product yield of the i-th culture;

kb – coefficient taking into account the loss of by-products during harvesting;

kc – coefficient taking into account the input of by-products for composting;

si – the area allocated for growing and-and crops, hectares;

ui – yield of the i-th crop in crop rotation, tons / ha;

m – number of species of livestock and poultry;

nj – livestock of animals and birds of the j-th species;

N – the need for crop by-products for the relevant species of animals or poultry, tons / head per year [7, p. 86].

As noted above, the economic component of efficiency is the expression of additional benefits when a certain capital is invested in waste processing. For the ecological and economic efficiency of waste processing, its economic component is the actual saving of funds on energy resources obtained by processing our own waste. That is, when determining this component, it can be noted that the difference in the price of natural gas and the cost of producing own biogas is a decrease in direct material costs in the structure of the cost of the main product. The cost of producing own biogas is a complex category and requires a detailed analysis [18].

The components of the cost of processing waste to obtain biogas are:

– raw material costs;

– depreciation deductions;

– salary (basic and additional)

– repair costs;

– costs for auxiliary materials, services of own and third-party auxiliary production;

– general station costs, etc [10].

Methodological approaches to the concept of environmental and economic efficiency remain not fully defined, therefore, we believe that it is necessary to apply the following approach, which comprehensively covers the problem of increasing the environmental and economic efficiency of waste processing. This indicator consists of 3 main components and is calculated by the formula:

Romanchuk S. proposes a general approach to the methodology for determining environmental and economic efficiency by structure (5):

$$EE = a \cdot ((P - CB) \cdot GC) + (b \cdot EK) + (c \cdot RC)/TC \cdot 100\% \quad (5)$$

where a, b, c – indicator weights;

P – selling price of natural gas, taking into account all taxes and fees, transportation, UAH / 1 thousand m^3;

CB – cost of production of own biogas, taking into account operating and capital costs for its production, UAH / 1 thousand m^3;

GC – total gas consumption required for the operation of the plant, thousand m^3;

TC – total production costs, UAH;

EK – savings on storage, transportation and disposal of waste, UAH;

RC – reduction of carbon dioxide emissions due to the use of biogas, ineligible costs, reduction of fines and payment of environmental taxes, UAH [18].

In the conditions of transformation and structural changes of economy weight coefficients for different types of the enterprises, branches and comparison of this indicator for different types of the analysis are applied for this indicator. Typical weights are given in table 6.

Table 6

Weight coefficients of ecological and economic efficiency indicator

EFFICIENCY	Economic component	Social component	Ecological component
Implementation for the improvement of the economic condition of the enterprise	5	3	1
Implementation for the improvement of environmental situation	1	3	5
No specific slope	1	1	1

Source: formed by the authors on the basis of the analyzed literature [18, p. 326].

At the same time, the economic component is the calculation of alternative benefits obtained as a result of obtaining our own energy resources, the social storage is a decrease in the environmental and economic burden with a decrease in the amount of waste, and the environmental component is a decrease in air emissions due to the use of biofuels.

Stage 5. Comparison of ecological and economic efficiency of traditional and bioenergy directions of waste management, selection of the optimal option

In modern market conditions, the requirements for economic measurements and economic justifications for decision-making on innovative projects in the field of waste management are increasing, which can be financed only after an economic assessment of each of their possible options. It should be borne in mind that enterprises are building their activities in the direction of achieving their local goals, primarily with the aim of successfully operating in the market.

The methodological approach to substantiating the feasibility of implementing innovative projects with bioenergy waste disposal as organizational components of innovation activities that are conducted in the selected areas of market opportunities, which is based on the use of the proposed project success indicator, depends on five main factors: human, financial and time resources, support state and compliance with market needs. So, we can conclude that the success of an innovative project for the use of waste for the production of biofuel depends on the main five groups of factors, given by the formula (6):

$$Sp = f(M, T, H, S, C) \quad (6)$$

where: Sp – project success;

M – monetary resources, which include both own and borrowed or borrowed funds;

T – time parameters;

H – human resources, that is, all specialists of the appropriate level of qualification and professionalism necessary for the implementation of the project;

S – state support, which covers all possible actions of state governing bodies, both direct and indirect, contributing to the innovative activities of enterprises;

C – compliance with market requirements, that is, satisfaction of hidden or insufficiently met market needs, or the ability to create new needs. At the same time, a methodological approach to elucidating the integral influence of a certain set of innovations on the key indicators of the production and economic activity of an enterprise for a certain period of time is proposed.

It should be noted that one of the most promising ways to obtain energy from crop by-products is its gasification using combustible gas generators. In particular, in the technological process of the production and use of biomass, it is proposed to collect a mixture of manure and litter along the area where animals are kept, separating them into mud and litter manure, and removing them from the livestock building. At the same time, the mud is used for anaerobic digestion to produce biogas. Waste substrate and bedding manure are used for composting. The resulting compost is used as organic fertilizer [7, p. 88].

The general criterion for the effectiveness of the implementation of energy saving measures is the increase in profit remaining at the disposal of the enterprise. The change in the indicator of profit remaining at the disposal of the enterprise in the 1st billing period as a result of the introduction of innovative measures for energy conservation is determined by the expression, taking into account the change in costs for individual items (7):

$$\Delta P_i = \sum_{i=1}^{n} \Delta \mathrm{Pr}_{i,t}^{f} + \Delta \mathrm{Pr}_t^{T} + \Delta \mathrm{Pr}_t^{E} + \Delta P_t^{X} + \Delta E_t^{0} + eK \quad (7)$$

n – the number of fuels used in the enterprise;

$\sum_{i=1}^{n} \Delta \mathrm{Pr}_{i,t}^{f}$ – change in the cost of the i-th type of fuel consumed;

$\Delta \mathrm{Pr}_t^{T}$ – change in the cost of purchased thermal energy;

$\Delta \mathrm{Pr}_t^{E}$ – change in the cost of consumed electricity;

ΔP_t^{X} – change in the amount of payments for environmental pollution;

ΔE_t^{0} – change in operating costs for maintenance of process equipment;

e – internal efficiency rate;

K – capital expenditures related to the implementation of innovative energy saving measures.

The presented model fully characterizes both the economic and environmental components of this indicator. Considering the blocks, it can be noted that the economic efficiency of waste processing is a fairly significant indicator, because the efficiency cannot be calculated without a direct impact on the financial result. Any project can be implemented if there is a high probability of obtaining future benefits, which should be greater than alternative investments with the same investment risk.

The choice of the optimal direction for the use of waste depends on many factors, including the needs of the enterprise itself for a particular product (fertilizers, energy resources, etc.).

Conclusions. As a result of the study, it was established that to calculate the ecological and economic efficiency of biofuel production, it is necessary to take into account the economic, environmental, social, energy and political components. This list includes the whole range of effects – from the stage of plant construction to the use of the final product.

Rational bioenergetic utilization of organic animal waste solves a number of complex problems of agricultural production. First of all, this is a decrease in environmental pollution with hazardous substances, including rare and solid waste from livestock farms, and a limitation of methane emissions into the atmosphere. The economic component consists in the possibility of obtaining additional cash income, which will contribute to an overall increase in the efficiency of animal husbandry, reducing the level of unprofitable production of beef and other types of products.

The adoption and implementation of a special state program, which should be properly substantiated and structured in terms of financing, insurance and responsibility for its implementation, can significantly stimulate the production of biofuels in Ukraine. The main ways to interest consumers in the domestic market in the use of biofuels are awareness, economy, environmental friendliness and energy efficiency of this product.

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THE ROLE OF INNOVATION IN THE DEVELOPMENT OF ORGANIC PRODUCTION

Khaietska O.
PhD in Economics,
Associate Professor of Economics Department,
Vinnytsia National Agrarian University
Ukraine, Vinnitsa

Abstract

The article considers the features of organic production, stages of formation and introduction of organic products in domestic and foreign markets. The benefits for producers of organic production and the current state and prospects of development of the market of organic products are given. It is noted that the purpose of ecologically oriented innovative activity of enterprises is the introduction of ecologically clean waste-free and low-waste technologies. Innovative measures are proposed for a set of internal and external factors that affect the eco-innovation activities of enterprises.