DETERMINATION OF THE ECONOMIC EFFICIENCY OF BIOGAS PRODUCTION BASED ON THE USE OF AN INFORMATION AND CONTROL SYSTEM

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ABSTRACT
The article deals with the process of obtaining biogas, and also presents calculations for determining economic efficiency using the use of mathematical modeling and control of the information-measuring system. It is shown, the speed, microbiological processes occurring in a biogas plant, depending on the value of the fermentation temperature, the acidity of the processed mass, the degree of mixing, etc. Energy costs and analysis of both direct and intermediate results are discussed, which in the final types of products will have a significant impact on increasing the economic efficiency of production. Based on the indicators of economic efficiency, a comparative assessment is given before and after the modernization of equipment for the extraction of biogas.

Keywords: biogas, biogas plant, biogas production, biomass, agricultural waste, economic efficiency.

INTRODUCTION
In the Republic of Uzbekistan, animal husbandry is one of the main types of agricultural activity [1].
Keeping cattle in farms produce livestock waste, which is not disinfected and not processed, due to the lack of a system for its partial or complete utilization, which pollutes the environment of nearby settlements and the atmosphere with methane and carbon dioxide emissions, which affect climate warming and the creation of a greenhouse effect [2].
For farms, one of the unsolved problems is the lack of affordable and effective ways to process daily livestock waste [3]. Existing single biogas plants are distinguished by: a long fermentation period; primitive automation of management and high cost of biogas plants, which is unacceptable for farmers [4].
In this regard, biogas technologies with an automated control system, which ensure the intensification of the anaerobic process of fermentation into a bioreactor by obtaining biofertilizers and biogas (methane) and, moreover, solving the problems of environmental safety and the creation of waste-free production is poorly studied and scientific research has not been sufficiently conducted, which is of great scientific and practical interest [5].

MATERIAL AND METHODS
We will consider and analyze the materials of our research and the results of economic efficiency in the production of biogas, based on the use of an information and control system.

For quietpurposes, theoretical studies of thermal processes occurring in biogas plant (BP), operating in thermophilic mode, were carried out. The required thermal power is determined by the heat loss of the BP itself, and is described by the equations of thermodynamics.

The efficiency, including the rate, of microbiological processes occurring in the BP depends on the value of the fermentation temperature, the acidity of the processed mass, the degree of mixing, etc. To maintain the required nominal values of these factors, the BP contain additional functional elements that perform the functions of heating, mixing, pH control, heat recovery of the fermented product. In general, the productivity of the methane fermentation process is characterized by a change in the time of biogas [6].

To establish the optimal design parameters and operating modes of the BP, which ensure the maximum yield of methane concentration, a multifactorial experiment was conducted. Based on the data obtained, to assess the influence of variable factors on the yield of biogas (optimization criterion), regression equations were compiled using a mathematical model of thermal processes, taking into account the operating modes and design parameters of the bioreactor, in order to obtain the most accurate and complete model and simplify the process of analyzing the dynamic characteristics of the physical phenomenon of the process taking place in the object of study, subject to its verification for adequacy a real process.

To simulate the process of heat transfer, the law of thermal conductivity was used. Analytical expressions for determining the thermal resistance of heat transfer depending on the geometric dimensions of the surface of the bioreactor and energy consumption for own needs are obtained.

On the basis of theoretical studies of the processes of heat exchange and heat transfer occurring in the biogas plant, a mathematical model was obtained that allows to determine the distribution of biomass temperature over the entire volume of the bioreactor, as well as to determine the effectiveness of the implementation of the developed BP, an energy assessment was carried out [7]. Consider economic efficiency of biogas production based on the use of an information and control system.

Unlike industry, the amount of production in agriculture depends not so much on the mass of the means of labor used, but on the degree of their impact on the course of biological processes, the ability to control natural patterns, the consequence of which is the accumulation of biological mass. The difference between agriculture and industry in terms of energy consumption is that when creating industrial products, homogeneous energy is used - artificial, and agricultural - two types: artificial and natural [8].

It is the difference in energy consumed and its quantitative heterogeneity that constitute one of the specific aspects of biogas production in agriculture.

Therefore, fixed assets as potential carriers and consumers of energy, and the energy capacities themselves, do not reflect all the energy spent on obtaining biogas, but only part of it - artificial energy. It is known that the biological mass itself is formed by natural energy, and artificial energy plays the role of auxiliary energy, while in industry it is the main one.

The general basis that makes it possible to carry out the production process of obtaining biogas and biofertilizers in agriculture is land, and the common element linking all components into a single production process is energy costs.

Energy costs are divided into carriers of energy of direct and indirect use. Direct-use energy carriers primarily include the costs of process energy, and its analysis provides an idea of energy as a physical category necessary for the production of biogas and biofertilizers.

Energy analysis of both intermediate results and final types of products will have a significant impact on improving the economic efficiency of production.

The BP will be effective if the price of the resulting biogas exceeds the additional costs for the manufacture of the installation, i.e. when the following conditions are met:

$$\frac{B}{E} < \frac{B_1 + \Delta B}{E_1 + \Delta E}$$

where B is the production of biogas at an existing plant (analogue), m^3;
B_1- production of additional biogas at the developed BP, m^3;
ΔB – production of additional biogas at the developed BP m^3;
E energy costs for the production of the existing BP (analogue), mJ / m^3;
E_1 - energy costs for the production of BP-M, mJ / m^3;
ΔE – additional energy costs for the production of the developed plant, mJ/^{m3}
Energy costs for the production of the modernized BP will be determined using the coefficient of conversion of metal capacity into energy equivalent according to the formula:

$$E = MK$$

Where M is the specific metal capacity of the structure of the biogas plant, m^3 / t;
K is the energy equivalent of BP, mJ/kg year.
Evaluating the developed modernized BP, it is possible to conclude about the efficiency when the energy reproduction coefficient is greater than one (K >1), otherwise (when K < 1), then the installation will be inefficient.
Since the energy reproduction coefficient K = 1.22>1, the design of the BP for the production of biogas is considered effective.
The level of the intensification process is estimated by the efficiency coefficient

$$A = \frac{(B_1 + \Delta B)/(E_1 + \Delta E)}{B/E} = \frac{E}{E_1.}$$

With A >1, the process is effective. Since A = 1.1>1, the upgraded device for producing biogas is considered energy efficient.

Outcomes

The main task of increasing the economic efficiency of agricultural production is to reduce the energy and resource intensity of production. Energy analysis of the results of production in agriculture allows you to analyze the factors that increase production.
To determine the indicators of economic efficiency, a comparative assessment of the BP before and after modernization was carried out [8].
According to the above studies, the volume of biogas obtained for the entire processing period is 80 m3 of biogas from 1 ton of agricultural waste, and the start time of the release of commercial biogas is 11-12 days. Using these data for the calculation of the BP, with a volume of 3.5 m^3, 15.5 m^3 of biogas can be obtained, but part of this biogas is spent on heating and maintaining the thermophilic regime of biomass in the BP, and is up to 20% (3.1m^3 of biogas). And the rest can be used to generate electricity, which is 12.4 m^3 of biogas. The gas generator is capable of producing up to 3 kW from 1 m^3 biogas, therefore, from the full volume of the BP, the electricity output will be up to 37.2 kW / day. Accordingly, the annual energy output will be 13.4 MW.
Since the energy costs of the modernized BP are 25-30% less than the similar basic version, and are expressed in a lower consumption of biogas for its own heating and maintenance of the thermophilic regime, which is 14.03% or 2.33 m^3 of biogas.
The profitability of biogas production largely depends on the design advantages of the fermentation chamber. When designing a fermentation chamber, first of all, the volume of waste to be disposed of, as well as the volume of biogas that is planned to be obtained to meet the production energy needs, are considered.

Economic assessment of efficiency is necessary to determine the feasibility of optimizing the operation of the modernized BP with a heat exchanger-agitator when fermenting agricultural waste, as well as to reduce economic and energy costs in the production of biogas.

The economic efficiency is calculated for the modernized BP with a developed heat exchanger-stirrer with a volume of 3.5 m^3.

Analysis of table 1 shows that after the modernization and justification of the geometric and energy parameters of the heat exchanger-agitator, all economic indicators are reduced compared to the same basic option.

Table 1 Results of economic efficiency of the upgraded device for biogas extraction

Indicators	Формулы для расчётов	Значения
Reduction of labor costs, %	$\frac{З_{бb} - З_{м}}{З_{b}} \cdot 100\%$	33,5
Reduction of operating costs, %	$\frac{И_{b} - И_{м}}{И_{б}} \cdot 100$	34,3
Reduced costs, %	$\frac{У_{b} - У_{м}}{У_{б}} \cdot 100$	34,2
Reduction of specific capital expenditures attachments, %	$\frac{K_{ytb} - K_{ytм}}{K_{ytb}} \cdot 100$	18,6
Annual economic effect from the implementation of the BP, US dollars	$Э_{y} = (У_{b} - У_{м}) W_{cm} T$	45796,93

The results show that the annual economic effect of the introduction of the modernized BP will be 45796,93 US dollars, and the effect is achieved due to the optimal operation of the heat exchanger-agitator and uniform heating of waste in the fermentation process throughout the volume of the BP.

DISCUSSION

The developed experimental plant for the production of biogas was tested in the industrial conditions of Biogas LLC in Kashkadarin region, Republic of Uzbekistan.

As a result of the introduction of a pilot plant (a modernized version of the biogas plant) for the production of biogas, an annual economic effect of 45796,93 US dollars was obtained [9].

Biomass at a humidity of 66-85%, methane concentration was detected at a yield of 61.5-75%. In analog biogas production plants, this concentration of biogas yield is in the range of 55-65%. The difference between them was relatively high, in the range of 6.5-10% [10].

The duration of gas release by the existing method was 22 days, while the indicator of gas output in the modernized station reached about 40 days, i.e. 18 days more than the existing one.

FINDINGS

The main purpose of biogas production is to increase the economic efficiency of agricultural production is to reduce the energy and resource intensity of production. Often, energy analysis in agriculture makes it possible to analyze the factors that increase the results of production, based on the results obtained when introducing a pilot plant for obtaining biogas from agricultural waste in production, it is possible to draw a number of conclusions based on economic efficiency indicators, using the existing system and to give a comparative assessment before and after the modernization of equipment for biogas extraction.

1.According to the studies carried out and the results obtained, the volume of biogas obtained during the processing period amounted to 80 m3 out of 1 ton of manure of agricultural waste, the start time of biogas production in the bioreactor was 11-12 days.

2.Using the data obtained in the study to calculate the equipment for the extraction of biogas, in a bioreactor with a volume of 3.5 m^3, 15.5 m^3 of biogas can be obtained, but part of this biogas is spent on heating and maintaining the thermophilic regime of biomass up to 20% (3.1 m^3 biogas) in the equipment for extracting biogas. The remaining part can be spent on the production of electricity in the amount of 12.4 m^3 biogas. The gas generator is capable of producing up to3 kW electricity from one m^3 of biogas, thus, it is possible to produce 37.2 kW / day of electrical energy in full from the device for the production of biogas.

3.Accordingly, the annual volume of energy production is 13.4 MW. Due to the fact that the energy costs of the upgraded biogas extraction device are consumed 25-30% less than the basic biogas extraction device that has been applied in practice and are mainly used for maintenance in heating and thermophilicity mode, its consumption is 14.03% or 2.33 m^3 of biogas.

4.Economic calculations showed that capital investments in the modernized BP in comparison with the analog installation are 12.5% lower, and operating costs - by 13.8%.

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