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T.K. Bolyssov[1], Z.K. Zhanybayeva[2], B.S. Yessengeldin[2], M.K. Tuleubayeva[3]

[1]Ye.A. Buketov Karaganda State University, Kazakhstan;
[2]Kazakh University of Economics, Finance and International Trade, Nur-Sultan, Kazakhstan;
[3]Nur-Mubarak Egypt for Islamic Culture University, Almaty, Kazakhstan
(E-mail: yessen_baur@inbox.ru)

Possibilities of using biogas in agriculture

The article discusses the possibilities of using agricultural waste for biogas production. The authors pay great attention to domestic and foreign practice of generating energy using biogas plants. According to the authors, the use of biogas as an integral part of renewable energy sources will have positive economic and environmental effects in agriculture: reduction of greenhouse gases; recycling; job creation; increased energy security. The authors determined the prospects for the use of biogas industry products in agriculture: it allows you to get ready-to-use mineral fertilizers with a high content of nitrogen and phosphorus component; increases the intensity of agriculture due to the availability of cheap heat and electricity. The article highlights the main advantages of using biogas in agriculture: the widespread availability of raw materials in the form of agricultural waste; flexibility in the marketing and use of bioenergy in rural areas. The authors made recommendations on the development of biogas energy in agriculture: development of a state program for the development of biogas energy; opening of centers of expert and engineering consulting the implementation of biogas energy projects; the creation of several state agricultural enterprises for the production of biogas in different regions of the country.

Keywords: agriculture, biogas, biomass, bioenergy, biogas industry, biogas plants, agricultural waste.

Kazakhstan is a major producer of grain and other agricultural products, which indicates significant volumes of waste and residues produced, and therefore Kazakhstan has significant amounts of available waste, especially in relation to crops, manure, and municipal solid waste. The largest volumes of mixed types of agricultural waste are available in Almaty, East Kazakhstan, Zhambyl, Kostanay, Akmola, and Karaganda regions.

Agricultural waste that needs to be disposed of is itself an essential energy resource since biogas can be obtained from almost all types of agricultural waste with varying degrees of efficiency. Thus, the development of biogas energy is not only a possible solution to the waste problem, but also a solution to the energy problems of agriculture [1].

A stable source of biomass for energy production in Kazakhstan is livestock waste. Currently, the agriculture of the Republic of Kazakhstan faces with the problem of recycling a huge amount of waste exported from farms and stored. This leads to soil oxidation problems, alienation of agricultural land, groundwater pollution and greenhouse gas emissions into the atmosphere. Therefore, at the state level, it is necessary to solve the problems of agricultural waste utilization with the possibility of use in the country's energy sector.

Biomass has been used as an energy source since ancient times. Wood fuel is still the main source of energy in most parts of the world. According to experts, in Denmark, more than 18 % of the blue fuel consumed by the inhabitants of the country is biogas of its production. Germany has focused its economy on providing residents and the biomethane industry. In Germany, more than eight thousand large biogas plants have been installed, and their number is increasing every year. For several years, the Germans plan to supply the country with their own gas — up to 10 % in the energy balance due to the production of biogas. In Switzerland, municipal transport is largely converted into biomethane, and now more than 15 % of the country's total motor vehicles operate on biofuel [2].

Presently, there is no data on the total and available volumes of waste and their geographical location. Waste and residues are rarely used productively, for example, as raw materials for bioenergy projects. Therefore, the European Bank for Reconstruction and Development is implementing a project to assess the potential in the field of bioenergy [3].

The Concept on the transition of the Republic of Kazakhstan to the «green economy» [4] stipulates that by 2030 10 % of the structure of the volume of electricity production should consist of renewable energy sources (RES).

For this purpose, by order of the Minister of Energy of the Republic of Kazakhstan, a target indicator [5] was established to increase the total installed capacity of facilities for renewable energy sources up to 1700 megawatts (MW), including biogas plants up to 10 MW by 2020 (Table 1).

Table 1

Targets for the development of the renewable energy sector

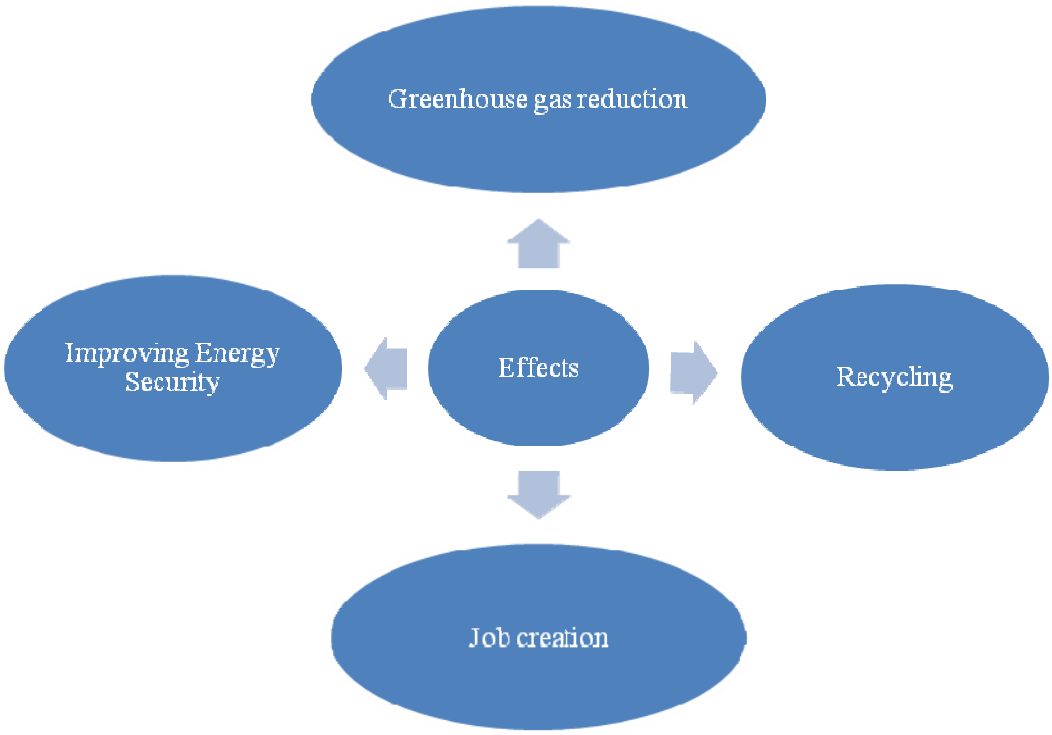
№	Name of indicators	Indicators
1	The share of the volume of electric energy generated by facilities for the use of renewable energy sources in the total volume of electricity production until 2020	3 %
2	The total installed capacity of facilities for the use of renewable energy sources until 2020, including:	1700 MW
2.1	Wind farms	933 MW
2.2	Solar power plants using photovoltaic solar energy converters	467 MW
2.3	Hydroelectric power stations	290 MW
2.4	Biogas plants	10 MW

Source. Compiled from [5].

In modern conditions for the use of biogas plants in the long term, efforts should be aimed at increasing the level of biomass output and modernizing agriculture. This can be achieved through the development of technology, as well as the spread of sustainable agriculture. It is also necessary to encourage and promote the sustainable use of residues and waste for the production of bioenergy, which poses limited or zero environmental risks.

Currently, biomass is one of the world's largest sources of renewable energy and has significant potential for expanding the production of heat, electricity and fuel for transport. However, today the share of renewable energy sources (RES) in the global energy balance is small — about 14 %, and the contribution of biomass — about 1.8 %. But, as practice shows, even slight fluctuations in the supply of energy resources in the markets cause strong changes in prices. This suggests that the role of alternative energy in strengthening stability in energy resource markets will only grow in the future. According to forecasts, the share of renewable energy sources will reach 47.7 % by 2040, and the contribution of biomass — 23.8 % [6].

In our opinion, the use of biogas as an integral part of renewable energy sources will give positive economic and environmental effects in agriculture (Fig. 1).



Source. Compiled by authors.

Figure 1. Economic and environmental effects of the introduction of bioenergy in agriculture

Further deployment of bioenergy with sound management can provide:

– reduction of greenhouse gas emissions into the atmosphere;

– solving problems associated with the disposal of agricultural waste;

– Creation of new jobs in rural areas;

– improving the energy security of agriculture.

Despite the aforementioned environmental and economic advantages of biogas technologies, for the country as a whole, obtaining energy in this way is economically insignificant and even requires certain costs. But this problem has another aspect — social, related to the interests of the population.

In the production of biogas and its further use, not only the growing demand of the population for additional energy sources is satisfied, but sometimes the very need for fuel and energy that is absent in certain territories is also met.

Biogas technologies can improve the well-being and quality of life of people in remote areas, rural areas, using local uninterrupted, cheap electricity, heat and water, using gas, for example, instead of firewood, for domestic purposes. This will save time on housekeeping, the population will be able to use household appliances, communications, have access to modern medical and educational equipment.

Using local fuel, local economic development is stimulated, and the number of jobs in the agricultural sector increases, where unemployment, migration, and social problems are highest. In the world, direct and indirect employment of workers in energy production based on biogas technologies totals 266 thousand people. (71 thousand in the EU) [7]. According to foreign studies [8], the complexity of biogas technologies is 3.71 people / MW (for construction) and 2.28 (for operation of the installation).

Using biogas technologies creates more jobs at both the construction stage and the operational stagein the area where these technologies are directly used. In the future, the process of applying biogas technologies does not require a very large number of people, which is important for farmers dispersed throughout the territory of agricultural enterprises.

Currently, no one disputes the need to build enterprises for sorting and processing household and industrial waste, since their work will certainly lead to an improvement in the environmental situation. Most experts are also inclined to support the initiatives of their governments, which seek to increase the use of biofuels in the energy sector, not only due to the introduction of quotas for greenhouse gas emissions, mainly resulting from the burning of fossil fuels, but also to reduce dependence on energy supplies from abroad. The economies of many countries have a heavy burden on energy purchases due to the continuous rise in their prices.

Another serious social problem arising from the environment is the deterioration of human health due to poor environmental conditions. Thus, the incidence rate of the population in the areas where large livestock enterprises and poultry farms operate is 1.6 times higher than its average in Russia [9]. In these places, the population is worried about the unpleasant odor caused by the decomposition of biological waste from livestock farming or the introduction of manure into the fields, and is trying to counteract the appearance of such complexes near their settlement. Biogas technologies will affect the improvement of the quality of the natural environment by reducing the amount of waste, environmental pollution, disinfection, which will lead to better human health.

Biogas is a gas mixture that mainly consists of methane (CH4) and carbon dioxide (CO2), as well as water vapor and other gases in small volumes. An overview of the average biogas composition is given in Table 2.

Table 2

The average composition of biogas derived from agricultural waste

№	Component	Concentration
1	Methane (CH4)	50–75 % of the formation
2	Carbon dioxide (CO2)	25–45 % of the formation
3	Water (H2O)	22–7 % of the formation (20–40 C)
4	Hydrogen Sulfide (H2S)	20–20 000 rt
5	Nitrogen (N2)	<2 % of the formation
6	Oxygen (O2)	<2 % of the formation
7	Hydrogen (H2)	<1 % of the formation

Source. Compiled from [10].

As you can see, biogas mainly consists of methane (50–75 %) and carbon dioxide (25–45 %). The resulting volume of methane, in this case, is mainly determined by the composition of the substrate used, that is, the percentage of fats, proteins, and carbohydrates. In this case, the specific volumes of methane production of these groups of substances are reduced in the sequence mentioned here. Reduced fats allow you to get more methane compared to carbohydrates.

Over the past decade, technologies have been developed in the world that allows decentralized generation of large amounts of energy from bio-waste. Biogas is produced in biogas plants where biowaste is available and consumed immediately. In addition to processing waste in biogas plants, it is possible to process specially grown energy crops, such as corn silage.

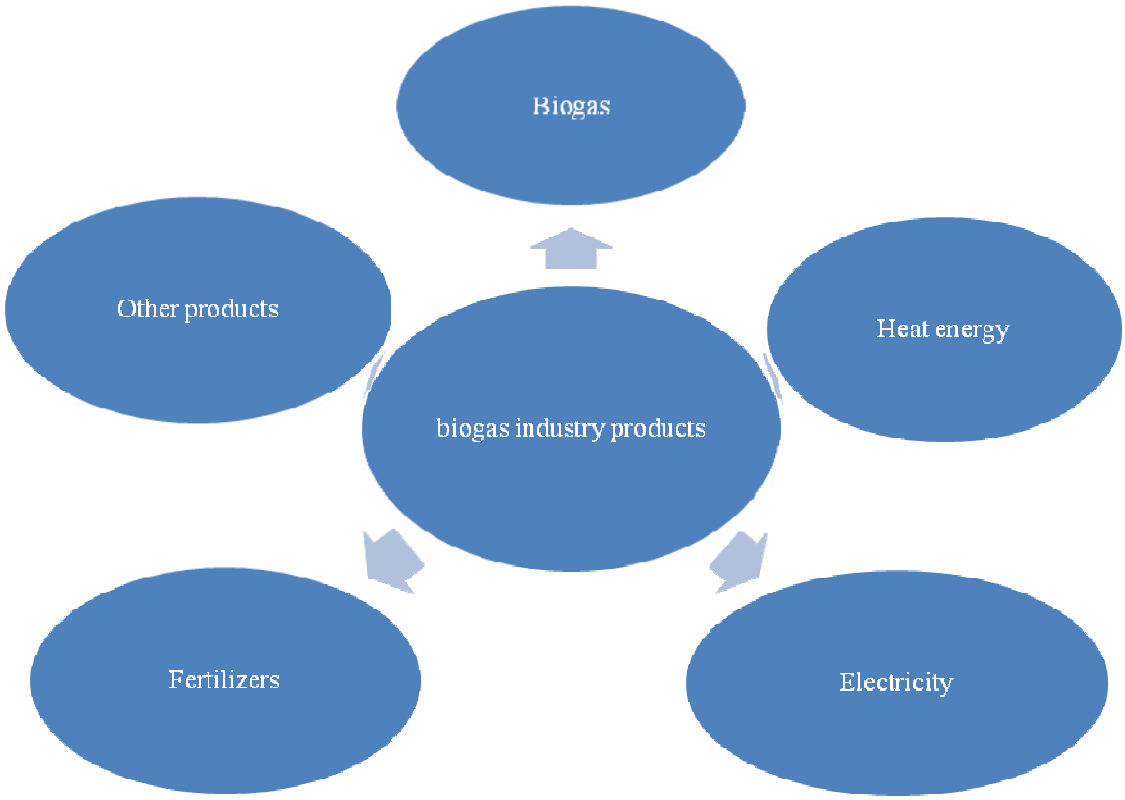
Animal wastes are of interest from their use for biogas and energy only if the animals are concentrated in confined spaces. In this case, there is the possibility of an economically sound collection of manure with minimal or no mud impurities.

The application of anaerobic digestion technology for the production of biogas and organic fertilizers will be very effective for various types of farms and peasant farms, remote from centralized energy supply systems.

The biogas industry produces not one final product, but a whole range of expensive and important products without environmental damage (Fig. 2).

When using biogas plants as the core of an agricultural cluster, the greatest economic efficiency is achieved, and it becomes possible to develop new products in agriculture. Received biogas products:

– allows you to get ready for use mineral fertilizers with a high content of nitrogen and phosphorus component;
– increases the intensity of agriculture due to the availability of cheap heat and electricity.



Source. Compiled by authors.

Figure 2. Products of the biogas industry in agriculture

Thus, biotechnology for producing biogas and related products is very promising from an environmental point of view. Consumption of environmentally friendly high-quality agricultural products when using environmentally-friendly (biological, rather than chemical) fertilizers will contribute to the health of the

whole population. Biogas energy is generally less hazardous to the environment than traditional energy sources. The positive cash flow of agricultural enterprises is formed due to:

– sales of electricity;

– sales of heat energy;

– sales of gas motor fuel (compressed methane) in the open market;

– sales of biofertilizers on the open market;

– disposal of farm waste.

The disadvantages of biogas technology for the economy are quite high capital, but one-time investments. The level of these investments depends on the capacity of the installation, equipped with modern automation and control equipment and the manufacturer of specific devices. The high cost of special equipment is also because in the absence of sufficient demand it is produced in small quantities. The installation itself is the most cost-effective when operating it on the farm as additional equipment. Drivers for the wider use of bioenergy (for example, government priorities for renewable energy) can increase demand for biomass, which will lead to competition for land that is currently used for food production. This will require government intervention, in the form of regulation of bioenergy development and/or regulation of land use, ensuring sustainable demand and production. The development of appropriate policies requires an understanding of complex issues and international cooperation on measures to ensure global sustainable biomass production.

In our opinion, the possibility of using biogas in agriculture has two key advantages:

– the widespread availability of raw materials — solid and liquid wastes of the agricultural sector, sewage sludge, food industry wastes;

– flexibility in the marketing and use of energy: the use of biogas makes it possible to simultaneously obtain several types of energy resources — gas, motor fuel, heat, electricity.

Thus, our own autonomous biogas energy in agriculture will eliminate the dependence on the rising cost of gas, heat and electricity, possible interruptions in the supply of network energy resources, increase the competitiveness of agricultural producers, and reduce the environmental burden. To do this, it is necessary:

– develop a state program for the development of biogas energy in agriculture with the involvement of funding sources;

– open centers for expert and engineering consulting on the implementation of biogas energy projects;

– create several state agricultural enterprises for the production of biogas in different regions of the country for subsequent transfer to private investors.

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Т.К. Болысов, З.К. Жаныбаева, Б.С. Есенгельдин, М.К. Тулеубаева

Ауыл шаруашылығында биогазды қолданудың мүмкіндіктері

Мақалада биогаз алу үшін ауыл шаруашылық қалдықтарын пайдалану мүмкіндіктері жете қарастырылған. Авторлар биогаз қондырғыларының көмегімен энергияны өндірудің отандық және шетелдік тәжірибесіне көп көңіл бөлген. Авторлардың пікірінше, биогазды жаңартылатын энергия көздерінің құрамдас бөлігі ретінде пайдалану ауыл шаруашылығында жағымды экономикалық және экологиялық әсерлер береді: булы газдарды қысқарту; қалдықтарды кәдеге жарату; жұмыс орындарын құру; энергетикалық қауіпсіздікті арттыру. Авторлар ауыл шаруашылығында биогаз саласының өнімдерін қолдану келешегін анықтаған: құрамында азот және фосфорлы құрамы жоғары пайдалануға дайын минералдық тыңайтқыштарды алуға мүмкіндік береді; арзан жылу мен электр энергиясының қолжетімділігі есебінен ауыл шаруашылығының қарқындылығын арттырады. Мақалада ауыл шаруашылығында биогазды пайдаланудың негізгі артықшылықтары кеңінен көрсетілген: ауыл шаруашылығы қалдықтары түрінде шикізаттың жаппай қолжетімділігі; ауыл аумақтарында биоэнергияны өткізу мен пайдаланудың икемділігі. Мақала авторлары ауыл шаруашылығында биогаз энергетикасын дамыту бойынша ұсыныстар әзірлеген: биогаз энергетикасын дамытудың мемлекеттік бағдарламасын әзірлеу; биогаз энергетикасы бойынша жобаларды енгізу бойынша сараптамалық және инженерлік кеңес беру орталықтарын ашу; елдің түрлі өңірлерінде биогаз өндірісі бойынша бірнеше мемлекеттік ауыл шаруашылығы кәсіпорындарын құру.

Кілт сөздер: ауыл шаруашылығы, биогаз, биомасса, биоэнергетика, биогаз саласы, биогаз қондырғылары, ауылшаруашылық қалдықтары.

Т.К. Болысов, З.К. Жаныбаева, Б.С. Есенгельдин, М.К. Тулеубаева

Возможности использования биогаза в сельском хозяйстве

В статье рассмотрены возможности использования сельскохозяйственных отходов для получения биогаза. Авторами большое внимание уделено отечественной и зарубежной практике выработки энергии с помощью биогазовых установок. По мнению авторов, использование биогаза как составной части возобновляемых источников энергии даст положительные экономические и экологические эффекты в сельском хозяйстве, а именно: сокращение парниковых газов; утилизация отходов; создание рабочих мест; повышение энергетической безопасности. Авторами определены перспективы применения продуктов биогазовой отрасли в сельском хозяйстве: позволяет получать уже готовые к использованию минеральные удобрения с высоким содержанием азотной и фосфорной составляющей; повышает интенсивность сельского хозяйства за счёт доступности дешёвого тепла и электроэнергии. В статье выделены основные преимущества использования биогаза в сельском хозяйстве: повсеместная доступность сырья в виде сельскохозяйственных отходов; гибкость сбыта и использования биоэнергии в сельских территориях. Авторами статьи предложены рекомендации по развитию биогазовой энергетики в сельском хозяйстве: разработка государственной программы развития биогазовой энергетики; открытие центров экспертного и инженерного консультирования по внедрению проектов по биогазовой энергетике; создание нескольких государственных сельскохозяйственных предприятий по производству биогаза в разных регионах страны.

Ключевые слова: сельское хозяйство, биогаз, биомасса, биоэнергетика, биогазовая отрасль, биогазовые установки, сельскохозяйственные отходы.

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