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**APPLICATION OF BIOGAS INSTALLATIONS AS AN  
ALTERNATIVE METHOD TO RECEIVE ENERGY**

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**Abstract**

The article proves that application of biogas installations as an alternative method to receive energy is efficient; it shows that there are certain difficulties in biogas production. The use of biogas installations in Russia is a quite new energy production method. Despite indisputable benefits of their application, there are also problems connected the half-baked process of their application, rather big investments and, as a result, not a short payback period. There are no federal methods of rate calculations for biogas energy. Besides the fact that electric power and heat received from biogas processing are very economical for enterprises, this production is ecologically friendly; it prevents methane emission in the atmosphere, which is an important thing. One more great benefit is the associated products received in the course waste conversion. The article also points out special features of biogas and biogas installations from the point of view of ecology and efficiency. We have described the project how to use a biogas installation, which characteristics considerably exceed its analogs.

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**Keywords:** Biogas; biogas installation; biogas station.

## 1. Introduction

One cannot imagine the modern world without one simple word – energy. According to the Swedish Energiläget in 2008, annual world electricity consumption was about 143 PWh, and it is increasing by 3% every year (Fallahi et al., 2016). Today, most part of energy production comes from nuclear power



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and energy received from fossil fuel (coal, gas, oil) conversion. But it is not a secret that fossil fuel deposits are limited, and the issue how to produce alternative energy sources is becoming more and more urgent (Oslaj et al., 2010). One more important point to discuss the problem of power is the environmental issue, which is nowadays not less urgent than resources deposits issue. The source which is capable to solve both problems is biogas.

## 2. Methods

Authors of the paper suggest using statistical evaluation methods of the secondary information obtained from official sources. For the article following research methods were used: observation, comparison, study and analysis of materials of scientific and periodical publications on the problem, documentary analysis, generalization of domestic and foreign practice, interviewing and interviewing experts, questionnaires using expert assessments, statistical methods. Was studied foreign and domestic experience and scientific biogas research.

## 3. Results and Discussion

### 3.1. Biogas

To understand what biogas stations are and what their efficiency is, it is necessary first to determine what biogas is. Biogas is the gas received as a result of methane or hydrogen fermentation of biological masses. The process of methane decomposition of biomass takes place under the influence of three types of bacteria: hydrolytic, acid-forming and methane-forming. In the food chain, subsequent bacteria eat waste products of the previous ones. The technology of biogas includes 4 stages:

1. Hydrolysis. Aerobic hydrolytic bacteria take part in this process, and the end products are amino acids, monosaccharides and fatty acids.
2. Acidity increase. Acid-forming bacteria are involved in this process. The end products are carbohydrate dioxide and organic acids.
3. Acetic acid formation with the help of bacteria forming this acetic acid. The received products are carbon dioxide, hydrogen and acetic acid.
4. Methane formation with the help of bacteria which produce it. At the outlet, we receive methane, water and carbon dioxide.

Biogas is the gas received in the process of biomass (organic waste) fermentation under the impact of different types of bacteria. Different types of microorganisms metabolize carbon from organic substrata in oxygen-free conditions (known as an anaerobic process). This process is also called rotting or oxygen-free fermentation and follows the food chain. Biogas is produced in the course of biowaste fermentation. This gas can be used as regular natural gas for technological purposes, heating, power generation. It can be accumulated, repumped, used for gas stations or sold to neighbors. Biogas contains 50% to 87% of methane, 15% to 30% of carbon dioxide and an insignificant share of hydrogen sulfide and hydrogen. It is hardly dissolved in water, its combustion heat is 21 to 27,2 MDzh/m<sup>3</sup>. When converting 1 ton of fresh waste received from cattle and pigs (85% humidity), it is possible to produce 45 to 60 m<sup>3</sup> of biogas; 1 ton of chicken dung (75% humidity) gives up to 100 m<sup>3</sup> of biogas. Combustion heat of 1m<sup>3</sup> of biogas is

equivalent to 0,8 m<sup>3</sup> of natural gas, 0,7 kg of fuel oil, 0, of gasoline, 1,5 kg of firewood (in perfectly dry condition), 3 kg of manure briquettes. Let us note the fact that biogas is not the finding of modern scientists. It was used by residents of modern Germany long before, in the first century B.C. (Kelebe & Olorunnisola, 2016). Thus, biogas is only a kind of fuel. Actually, within the power issue, it can be called "oil" and it cannot transform into power energy; for this purpose, biogas stations are necessary.

### **3.2. Biogas installations**

A biogas installation is a device which converts organic waste in biogas and organic fertilizers. A biogas installation solves the problem of converting organic waste. Livestock production waste is used as raw material for conversion. A biogas installation recycles vegetable and animal waste with the help of anaerobic microorganisms. All components move to reception reservoirs. After mixing, raw materials move to fermenters via heat exchangers which are in the pumping point. Under the influence of bacteria and microbes there is a fermentation process and the result of this process is biogas. It moves through pipelines to end fermentation reservoirs. A mix of fermenter components moves to the same reservoirs. Here, the fermentation process comes to the end, gas through a cooling system and cleanings moves to the block combined heat and power plant where electric power and heat are produced, and the fermentation products (biological fertilizers) move to the fertilizers storage. This is the production cycle of biogas and biological fertilizers. The amount of biogas depends on the substrata structure and the amount of organic substances they contain. 1 m<sup>3</sup> of biogas produces 2 to 4 kW of electric power. Heat energy produced by the station can be spent for its own needs and utilized. Biological fertilizers rich in nitrogen, phosphorus and potassium can be put directly into soil, they can fully or partially replace mineral and traditional organic fertilizers. The use of biofertilizers increases productivity by 30-50%.

### **3.3. Biogas stations**

A biogas station is a wider concept than a biogas installation; it includes the complex of engineering constructions consisting of devices for raw materials preparation, biogas and fertilizers production, biogas cleaning and storage, electricity and heat generation. It is the whole engineering complex which has equipment for raw materials preparation, biogas and organic fertilizers production, cleaning and storage of the received biogas; it also includes units for heat and electric power production. Within our article, it is not necessary to consider technical subtleties of biogas station construction and operation, it is important to understand only the general principle of its work. The station receives raw materials for biogas production (organic waste - manure, birds' dung, beet press, grain, any waste of fish and cattle production, household waste, grass, waste of dairy production, biodiesel; specially grown corn and seaweeds can also be used as raw materials). The end products are electric power, heat, carbonic and liquefied gas, water and fertilizers (Zaefferer et al., 2016). Biogas is used for electric generators without any cleaning. For gas stations, an additional cleaning system should be installed. After passing through the cleaning system, this gas becomes a complete analog of natural gas biomethane (90% of methane (CH<sub>4</sub>) and 10% of carbon dioxide (CO<sub>2</sub>). The second product of biogas purification is CO<sub>2</sub>. This gas can be used for profit earning too. It can be used as artificial ice, for aerated water or for technical purposes. The organic fertilizers (bioslime) produced at a biogas station are rich in nitrogen (N), phosphorus (P) and potassium (K). In comparison with mineral fertilizers, biofertilizers are almost completely acquired by

plants (only 35-50% of mineral fertilizers are acquired, the rest are nitrates); and the number of nitrates in products is minimized. There are other indicators why biofertilizers are several times better than other organic fertilizers (manure, dung, peat):

- lack of weed seeds which lead to harvest loss;
- lack of pathogenic microflora;
- availability of active microflora fostering intensive growth of plants;
- lack of the adaptation period for effective impact;
- resistance to washing nutritious elements away from soil;
- maximum nitrogen preserving and accumulating;
- ecological influence on soil.

Conditionally biogas stations can be divided into two types. The first type is simple household stations, which are intended for individual use in small farms. They are quite successfully used in European countries. The second type is industrial stations. Average cost of an industrial biogas station, including its design, construction and launch is 2 to 5 million rubles, and the expected useful life of such stations is 25 to 50 years. One installation is capable to process 2 tons of raw materials a day producing about 40 cubic meters of biogas, and heat and electric power production when using 1 ton of raw materials is about 70 kWh and 40 kWh respectively. If we have a look at the potential of biogas technology use in Russia, we will receive the following: in Russia, about 800 million tons of biological waste (from about 20 thousand agricultural enterprises) are produced. When converted they can give more than 60 billion cubic meters of biogas, about 110 billion kWh of electric power and 3 billion tons of organic fertilizers. In 2014, electricity consumption in Russia was 1014 billion kWh, so, biogas technology can potentially satisfy more than 10% of the country's electric power demand, at the same time improving the ecological situation.

### **3.4. Biogas production challenges**

However, not all raw materials can be directly converted. Chicken dung and pork drains are very toxic, therefore, buffer substances addition is required, such as silo, fresh grass or cow manure. Raw materials must not contain heavy metal admixture, chemicals, surfactants. Enterprises use huge amounts of antibiotics in production, which fact they always try to conceal (Bentounes et al., 2000). Washing and disinfecting substances can break biogas synthesis process too, but if disinfecting substances are not used at all, there can be mold (Reinelt et al., 2016). Another problem is the imperfect system of manure cleaning. Raw materials contain nuts, nails, wire and even bricks. They can be the cause of fecal pumps, mixers or pipelines breakdown. A biogas process is very sensitive to seasonal fluctuations of animal feeding. There also must be constant control of the station working hours and many other things. Some regions have quite severe climate for such technology use. The weakest point in biogas process is the low speed of biomass conversion and quality of received biogas. The process is actually unstable (Baldé et al., 2016). Huge fermenters are required because of the low conversion speed. Construction of waste conversion stations requires big capital expenditure; as a result, such projects need state grants and a long time to pay off. Governments of all countries leading in this industry such as Germany and the majority of European countries support biogas producers. The support is realized in a feed-in tariff, that is purchase of electrical and heat energy at higher prices. This important mechanism of the state support

stimulated producers at the initial stage, but later led to the industry stagnation from the technical point of view since biogas equipment producers did not care about the quality and new technologies, all their products were sold out without any additional trouble. However, the industry will be plunged into crisis as soon as state support is stopped. Many European countries have already declared that and it led to a great number of investors' suits. Therefore, in the nearest future we can expect that they will try to sell old biogas technologies to Russia, where this industry is poorly developed and needs essential state grants. It is a very dangerous thing and we must not allow it to happen. The biogas market in Russia can belong to Russian companies, but these companies should support scientific developments in order to be technically advanced in biogas production. First of all, it is because the biogas production process is considerably increasing. Russian scientists should also develop climatically adapted technology which can be used in Siberia.

### **3.5. Efficiency of biogas installation application**

The advantages of a biogas installation as an alternative method to receive energy are indisputable (Ostergaard, 2012):

- Economic advantages: energy received from biogas installations and recyclable raw materials cost much cheaper than similar traditional resources (Chu et al., 2016).
- Ecological advantages: biogas installations and livestock and poultry waste conversion involved in biogas production are ecologically friendly.
- The use of renewable energy resources (including biogas in the way we consider it in this article). The UN experts pay special attention to this fact (Pereira et al., 2015).

Now let us consider how cost efficient biogas installations are taking an agricultural farm as an example. The installation construction cost is 40 million rubles. The farm gets 50 tons of manure from one thousand head of cattle a day. One ton of manure is about 50 cubic meters of biogas. One cubic meter of biogas is 3 kW of electric power and 5 kW of heat. It should be noted that there is one more economic benefit. The farm becomes independent from external energy suppliers, which helps to reduce product costs and make it more competitive. Such project will pay for itself in 5-6 years, which is not a short period of time, but this period can be shortened. It can be done, for example, if biogas installations are used as centers of complete organic waste utilization, which has been an essential expense item for many agricultural enterprises in recent years. However, we cannot forget about financial risks of these innovations (Kalashnikova et al., 2016).

Any scientific or commercial project begins with research. After having studied foreign and domestic experience and scientific biogas research, we came to a conclusion that in the next years biogas installations will be increasingly used. There are several reasons for us to develop this project:

1. Low competition in the Russian market.
2. Low cost value of processed raw materials.
3. State interest both to recyclable raw materials conversion and ecological situation improvement. According to foreign colleagues' experience, we can draw a conclusion that such interest will be followed by project subsidizing biogas installations use. There may also be tax benefits for companies which use them.
4. There is heat and electric power cost reduction, which is quite an essential expense item for most

Russian enterprises. This economical factor makes biogas installations more attractive to potential consumers.

All the facts mentioned above show that even at quite high cost of biogas installations launch there will be a great demand for them in the future.

What do we offer? We offer a biogas installation which characteristics considerably exceed those of its analogs made by other Russian developers. To compare, we take the biogas station "Luchki" made in the Belgorod region. It is one of the most known biogas stations in Russia. Even now our pilot station receives 30% more biogas, and its operation life is twice as bigger. Even taking into account higher price of our product one can understand that being more effective and serving twice longer, it is more profitable for capital investments and will quicker pay back launch and production costs

#### 4. Conclusion

Today the use of biogas installations in Russia is a quite new energy production method. Despite indisputable benefits of their application, there are also problems connected the half-baked process of their application, rather big investments and, as a result, not a short payback period. There are no federal methods of rate calculations for biogas energy. Despite the small research period of this alternative renewable energy resource and a small amount of projected and constructed biogas installations, more and more institutes and production enterprises join their development process. The Ministry of Agriculture and the Ministry of Energy of the Russian Federation actively try to solve rate issues. Besides the fact that electric power and heat received from biogas processing are very economical for enterprises, this production is ecologically friendly; it prevents methane emission in the atmosphere, which is an important thing. One more great benefit is the associated products received in the course waste conversion, for example, effective biological fertilizers, which are possible to use in agricultural industry. All these facts show that the given technologies are not only profitable to a final consumer; they are also attractive for businesses and the state from the point of view of investments and subsidizing. So, it is possible to expect that in future, their costs will be lower and their distribution will increase.

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