ПЕРСПЕКТИВЫ ПРОИЗВОДСТВА БИОМЕТАНА В ГЕРМАНИИ И РОССИИ

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В статье говорится о производстве биометана, как одного из видов альтернативного топлива в Германии. Приводится статистика специализированного агентства возобновляемых ресурсов. Показано, что основными источниками сырья для производства биометана служат растительное сырье, жидкий и твердый навоз, биогенные отходы в сельском хозяйстве и коммунальной сфере. Рассматривается развитая инфраструктура биогазовых сетей в Германии и возможности хранения и транспортировки полученного топлива. Основными потребителями биометана в качестве альтернативного топлива являются легковой, городской и коммунальный транспорт. Актуальной проблемой производства биометана является очистка биогазовой смеси от примесей. Указаны, способы отделения метана от других составляющих элементов и стандарты для поставки биометана в газовую сеть. Авторы сравнивают состояние биогазовой отрасли в России и Германии. Отмечается, что в России основными целями производства биогаза является выработка электроэнергии и тепла непосредственно на месте его производства. В заключении рассматриваются экономические и природоохранные аспекты. Использование биометана в качестве автомобильного топлива приводит к снижению парниковых газов по сравнению с бензином и дизельным топливом. Решается проблема со вторичной переработкой отходов.

Ключевые слова: альтернативная энергетика, возобновляемые источники энергии, биогаз, биогазовые установки, биометан

PROSPECTS FOR BIOMETHANE PRODUCTION IN GERMANY AND RUSSIA

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The article deals with the production of biomethane, as one of the types of alternative fuel in Germany. It gives the statistics of a specialized agency of renewable resources and shows that the main sources of raw materials for the production of biomethane are plant materials, liquid and solid manure, and biogenic waste in agriculture and utilities. The article considers the developed infrastructure of biogas networks in Germany and the possibilities of storage and transportation of the resulting fuel. The main consumers of biomethane as an alternative fuel are cars, municipal and public transport. An urgent problem in the production of biomethane is the purification of the biogas mixture from impurities. The authors indicate methods for separating methane from other constituent elements and standards for the supply of biomethane to the gas network and compare the state of the biogas industry in Russia and Germany. It is noted that in Russia, the main goals of biogas production is the generation of electricity and heat directly at the place of its production. Economic and environmental aspects are also considered in the article. The use of biomethane as automobile fuel leads to a decrease in greenhouse gases compared to gasoline and diesel fuel. Another aim consists in recycling of secondary waste.

Keywords: alternative energy, renewable energy sources, biogas, biogas plants, biomethane

Today, humanity is increasingly turning to the search for alternative energy sources. A special place in the structure of renewable energy sources of the transport sector is occupied by biofuels. The basis for the use of biogas as a fuel is its processing with the formation of biomethane. Biomethane is a gas obtained after purification of biogas from carbon dioxide. By its chemical composition, biomethane is a complete analogue of natural gas and is used in the gas network.

The purpose of this article is to consider the development of the biogas industry and biomethane production in Germany and Russia.

Materials and research methods

The article is written on the basis of empirical material from modern scientific and journalistic sources in Russian, German and English. Research methods are an actualization of the problem in modern foreign and Russian scientific literature and a comparative analysis of the technical and economic situation in Russia and Germany. These research methods are relevant for the development of professional competencies of top-level specialists in the field of economics and energy of agriculture.

Research results and discussion

Biogas production technology is quite simple and well known. An agricultural biogas plant usually consists of:

– a pre-reservoir with a particulate feeder (where applicable),

– fermenter in horizontal or vertical position with a mixing device,

– gas storage,

– storage until the end of fermentation,

– utilization of biogas.

A mixture of silage and biowaste, which is periodically mixed, is stored in a heating tank. All this further enters the digester. The boiler has quite serious requirements: it must be waterproof, gasproof, and lightproof. To maintain good fermentation and gas formation, the mixture is constantly mixed and heated. The generated biogas goes to the gas storage, and the fermented substrate goes to the fermentation tank. After ripening, valuable fertilizer is obtained from it and used on agricultural arable land.

Bioeconomics in general and biomethane production in particular are promising areas for agricultural development both in EU and in Russia. [1]. A precondition for use of biogas as a fuel is its processing to form biomethane (also known as bio natural gas). In chemical terms, biomethane is defacto identical with natural gas and is fed into the natural-gas grid. This grid makes an outstandingly extensive infrastructure available: there are opportunities to link up to sources across large areas of Germany; at the same time the grid is connected with underground storage facilities. This enables stored biomethane to be deployed flexibly where the demand for energy is present. The biomethane can also be used not only for electricity and heating, but also as a fuel.

The quantity of biogas facilities in Germany has by now risen to 8,100, more than 180 of which produce biomethane (status: end of 2016).[2]. However, the treatment of the biogas, so as to form methane, involves resource commitment in terms of technology and energy. This is worth it, for instance, in those cases where there are not enough takers for the energy produced at the biogas facility's location. A methane-producer can conclude an agreement for supply of product with a mineral-oil trader or a fuel station operator. It is not necessary to be neighbors in terms of location, the fuel station operator obtains normal (bio-) natural gas from its grid, yet pays the biomethane producer that feeds-in the corresponding quantity of biomethane at its specific location.

The Federal Government has anchored the Gas Grid Access Ordinance in legislation, as a prerequisite for feeding biomethane into the natural-gas grid. This ordinance not only created the legislative framework but also defined goals. It provides for the feeding-in of biomethane to rise to 6 bn. m3 annually by 2020. As a comparison: in 2013 over 50 m. m3 were used as fuel.

The starting substance for biomethane is biogas: in Germany this is mainly obtained by fermentation of energy plants, liquid manure and solid manure, but also from organic waste material sourced from industry and private households. Around a half of the substrates used are renewable substances (52%), followed by animal excrement, at 43%, and biogenic waste and recycled material, at 5%. Maize dominates among the renewable resources, at 73% [3]. The Federal Ministry of Agriculture in Germany is providing support to the search for sustainable alternatives to maize, in various projects (http://energiepflanzen.fnr.de). Scientists are examining new systems of cultivation and crop rotation, and also numerous interesting old and new energy crops. In plant-breeding projects, highly-promising candidates are made ready, in terms of cultivation, for their task as energy supplier.

For the production of biomethane as a fuel, the use of waste materials and recycled materials is particularly interesting. Low GHG emissions make a case that favors this source as an option.

The biogas produced by fermentation contains a substantial proportion of carbon dioxide, alongside a methane content of 50–75%. Added to this are small quantities of hydrogen sulphide and other trace gases. Yet it is only the methane (CH_4) that is usable as a fuel: in chemical terms it is identical with natural gas. Thus, separation of the methane from other constituent elements of biogas is decisive. In Germany there are currently five different treatment procedures used in practice. These include PSA (pressure swing adsorption), compressed water washing, physical and chemical washing (e. g. amine washing), and the membrane separation procedure.

These procedures allow the methane content in the biogas to be increased to up to 98%. The orientation point for this level of methane content is the respective methane concentration in the gas grid at the place where the product is fed-in. The degrees of concentration range from 80% (so-called L-Gas from Lower Saxony, the Netherlands and the North Sea) up to 98% (H-Gas sourced from Russia) [4].

Table 1

Yield of raw materials, annual yield of biogas and methane [2]

Raw mats.-yield [t/ha] FM	Biogas yield [Nm^3/t]	Methane content [%]	Methane yield [Nm^3/ha]	[kg/ha]
ca. 50*	ca. 200*	53	4,945	3,560

Note: * Based on silo maize, medium level of yield, 12% losses in storage; Density of biomethane: 0.72 kg/m^3.

Properties and quality of the fuel Biomethane or natural gas are stored in a pressurized tank at 200 bar and sold at specialized fuel pumps. It is a mandatory requirement to state natural gas prices and biomethane prices at fuel-stations, based on mass and denominated in kg. The energy-content of a kilogram of methane ap-proximately corresponds to that of 1.5 l of petrol or 1.3 l of diesel.

To guarantee uniform quality, bringing biomethane and natural gas into circulation as a fuel is tied to compliance with the norm DIN 51624. Subject to this prerequisite, natural gas and biomethane can be mixed in any ratio.

New natural-gas vehicles are usually bivalent, i. e. equipped with an additional petrol tank, so that there are no losses sustained in terms of vehicle range or problems arising from a lack of gas fuel stations.

In the year 2015, biomethane-natural-gas mixtures were able to be tanked throughout Germany in various mix ratios at over 300 fuel stations. Of these, 150 fuel stations were already offering pure biomethane. In 2015, sales rose to 38 m. kg or respectively 53 m. m^3.

Thanks to politicians' efforts and to initiatives by the industry, in future natural gas and biomethane are to play a larger role in the mobility sector; the aim is a 4% share for natural gas and biomethane in German fuel consumption. This goal is ambitious because it amounts to a factor-of-10 increase compared to the figure for 2015. The aim is also for the number of suitable vehicles in use to grow, to a total of 1.4 m. vehicles. At present there are no more than 98,000 natural-gas-powered vehicles on German roads, of which 80,000 are cars. They have a network of more than 900 natural-gas fuel stations available to them. Yet biomethane is obtainable not only at the network of natural-gas fuel stations; there are also biomethane service stations directly at biogas facilities. In 2006 the first of these biomethane fuel stations was established in Wendland.

A reduced energy-tax rate applies to natural gas and biomethane until the end of 2018, namely 1.39 EUR-ct per kilowatt-hour. If biomethane is credited against the biofuels quota, however, the full tax rate must be paid. Yet because the prices for biomethane are still above the natural-gas prices, quota-trading for biomethane sourced from recycled material is an important mechanism used for biomethane sales.

Biomethane is an alternative, not solely for cars and small transporters; to an increasing degree, urban buses, vehicle fleets serving municipalities and also commercial vehicles are gas-powered. While the comparatively low vehicle range is problematic in the transport sector, buses and municipal vehicles can typically use the company-internal fuel-station at their operational base. First concepts tested in agriculture show that combined diesel-biomethane operation is possible with tractors. A two-tank system, similar to that used for vegetable-oil fuel, serves for starting up and switching off the vehicle using diesel fuel. The degree to which these concepts can be economically viable for farmers in the future, depends on the tractor's area of operation and on the financial support provided.

Table 2

Sales of biomethane as fuel [2]

	2010	2011	2012	2013	2014	2015
Sales in GWh	162	190	404	557	580	530

Research from BIOGASMAX (Biomethane as fuel Provider in Germany) indicated that municipalities are the strongest supporters of biomethane use in general, followed by regional, federal and national authorities. The EU is ranked lowest in terms of support for biomethane use. When asked who they consider to be the strongest supporters of their biomethane enterprise, respondents provided similar answers, shown in Fig. 1.

In Russia today, biogas plants are not very popular, but there are great prospects for their development. Processing 1 ton of manure gives 50 m^3 of biogas, one m3 of biogas produces 2 kilowatt-hours. According to statistics, the mass of agricultural biowaste per year in Russia reaches 770 million tons [6]. When calculated, we get 38.5 billion. m^3 of biogas or 77 billion kilowatt-hours.

If there is sufficient supply of natural gas, the problem of using biogas plants is more related to the need to recycle and recycle existing farm biomaterials.

The use of biogas technologies will help to solve the issue of waste processing and to obtain high-quality nitrogen-phosphorus fertilizers. One of the problems of implementing bioenergy in Russia is the need for initial investment. The construction of the «Baitsury» biogas plant in the Belgorod region costed up to 160 million rubles. Its construction was completed in 2011. «Baitsury» is one of the pilot projects in the framework of the program for the construction of a network of biogas stations in the Belgorod region with a total capacity of 10 MW. The power of the station is currently 500 kW, in the future it is planned to increase to 1000 kW. The raw material for biogas production are pig manure and corn silage. The station is connected by collectors to the lagoons of the pig complex, manure goes through pipes to the receiving part of the bioreactor, and the silage is loaded separately. The output of biogas is 4133 m3 of biogas per day [7].

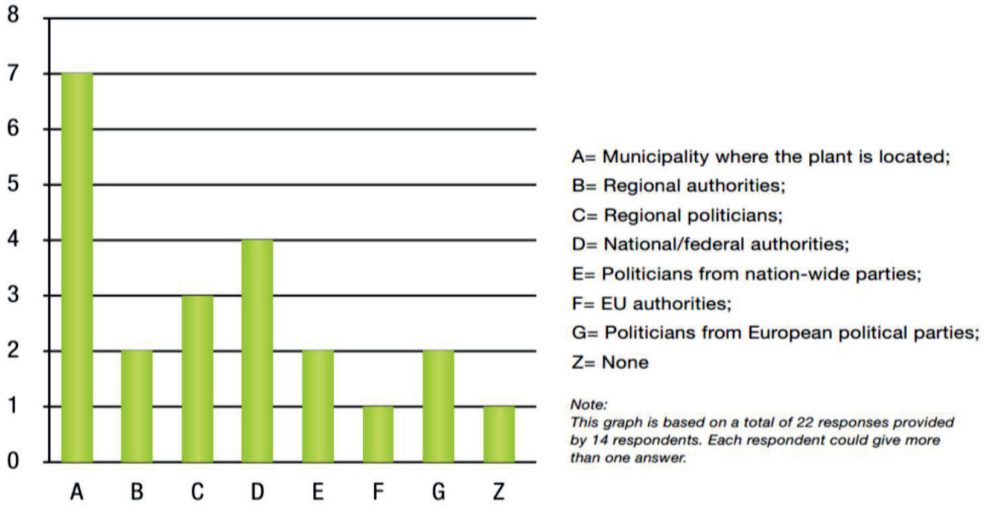

Fig. 1. Strongest biomethane supporters [5]

The bulk of biogas produced in Russia is used to generate electricity and heat. However, already today there is quite a lot of experience in the production of biomethane as automobile fuel. An example of this is the increased number of automobile gas filling compressor stations (AGFCS). Today, they are the only viable alternative to gas stations using liquid fuels. Several thousand of them have already been installed around the world, including more than three hundred AGFCS in Russia.

The main advantage of methane as an automobile fuel is, of course, high environmental friendliness and increased resource of methane engines of vehicles. But for the Russian consumer, an economic argument is also important. The cost of gasoline, diesel fuel, liquefied propane is growing not only abroad, but also in Russia.

Currently, methane fuel is becoming increasingly popular. In many countries of the world, compressed natural gas costs 30-70% cheaper than gasoline or diesel fuel. In Russia, methane costs 2.2-2.5 times cheaper than A92 gasoline or diesel fuel.

The Russian company AGNKS.com together with the St. Petersburg company AgroBioTech have developed a special proposal for the production of plants for the production of biogas from waste products of farms, silage, chicken droppings of poultry farms and other source biomass. The manufacturer declares that biomethane, as a motor fuel, has a high calorific value of 50-55 MJ / kg and an octane rating of 110. This exceeds the similar characteristics of gasoline, which, respectively, are 44 MJ / kg and 72-85. Compared to petroleum motor fuels, Russian biomethane has a higher knock resistance. This allows to reduce the concentration of harmful substances in exhaust gases in internal combustion engines and to reduce the amount of deposits in the engine. Previously, many bioreactor components were mainly imported (from Germany, Switzerland, France). The profitability of biogas refueling vehicles was positive only for large farms and livestock complexes. Now, in the production of biogas reactors of the AgroBioTech company, inexpensive components of exclusively Russian production are used. This makes biogas mini filling stations cost-effective and quick to pay even on small farms (from 10 heads of cattle and more). For example, the small «Farmer» biogas plant is designed for manure from 20 cows and 1 ton of plant substrate per day. Such a plant produces 36 m^3 of biogas per day; the volume of biomethane purified from carbon dioxide is 27 m^3 per day. A variant of the large biogas plant «Latifundist» uses manure from 2,000 cows and 110 tons of plant substrate per day. The production of pure biomethane is 2940 m^3. [8].

A fully prepared biomethane for refueling cars can be compressed for refueling cylinders of cars, tractors and other mobile equipment.

Manufacturers note the additional benefits of their biogas complexes:

– no gas pipeline is required in case of its absence;

– independence from gas and propane tariffs from natural monopolies;

– independence from gas prices;

– own biological raw materials for biogas production;

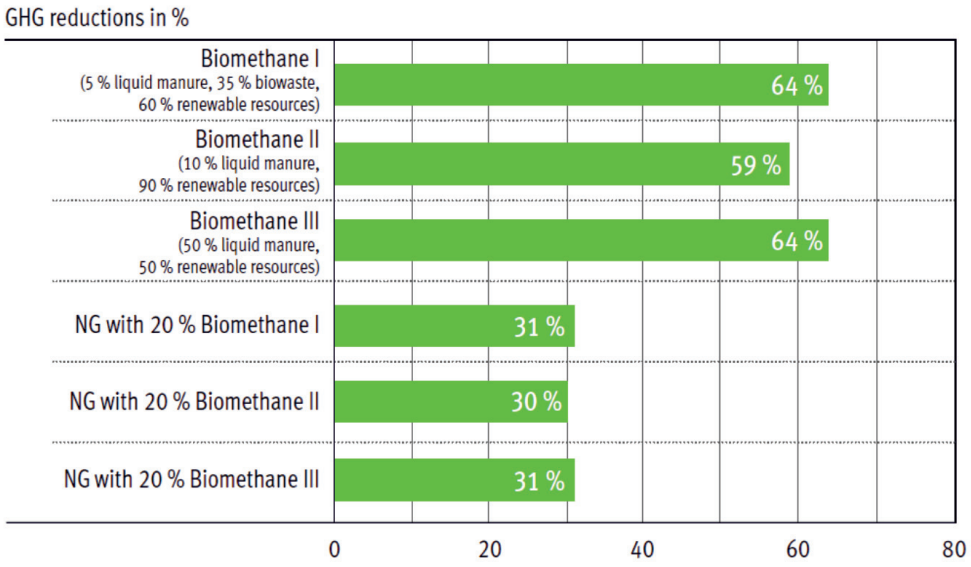

Fig. 2. GHG reduction potential using biomethane & biomethane-natural gas (ng) mixtures [3]

– savings on the disposal of farm waste (the absence of fines from the regulatory authorities for soil pollution of agricultural land with nitrates, zinc, bacteria of the E. coli group, etc.);

– obtaining a first-class liquid fertilizer from a substrate.

We consider the environmental aspect.

A key advantage of biomethane compared to diesel and petrol is the reduced level of pollutant emissions. By using bio natural gas in buses and municipal vehicle fleets, the emissions of soot and particles attributable to transport can be substantially reduced in our inner urban areas.

Depending on the raw material used, the GHG emissions for biomethane vary. The use of recycled and waste material has a positive effect because only emissions from transport and from processing are included in the balance. Overall, GHG savings of 60–80% are possible. On this basis, even taking into account various mixtures of substrate, the target value of 50% GHG saving for 2018 can be reached. After all, for natural-gas-biomethane mixtures (80:20), the GHG saving still amounts to 30% compared to petrol fuels or diesel fuels. taking into account various mixtures of substrate, the target value of 50% GHG saving for 2018 can be reached. After all, for natural-gas-biomethane mixtures (80:20), the GHG saving still amounts to 30% compared to petrol fuels or diesel fuels.

Conclusion

The production of biomethane is undoubtedly a promising area in the field of energy supply for agriculture, transport and utilities. Biological fuel allows being independent of the volatile oil and gas market. Large production costs are offset by environmental improvements and savings in the disposal of biological waste. Alongside heating and electricity, mobility is one of the fundamental areas in which people generate a demand for energy. Economic changes in the field of biomethane production can benefit rural areas. Sustainability is a topic that biofuels tackle head-on, in a very transparent way, with regard to cultivation, processing and greenhouse-gas emissions. Purposeful cultivation and processing of energy crops can make a great contribution to the sustainable development of farms and field enterprises.

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