

ASSESSMENT OF THE POTENTIAL OF USING BIOGAS FROM WASTE PRODUCTS (CASE STUDY OF THE TYUMEN OBLAST)

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Abstract

The development of rural areas has now reached a critically low level, but the country is the source of food. It is necessary to approach the evaluation of rural development taking into account many aspects (territorial location, available natural resources, potential resources, as well as economic, social, cultural, demographic, ecological and other indicators). With the increase in the deficit of non-renewable resources of fossil energy and the serious degradation of the environment, the strategic importance of biological resources has become even more prominent. Purpose: to determine the potential of the substance in the study. The calculations were made to identify the volume of biogas and growth ratio of the power industry in the Tyumen region. In the methodological framework anaerobic organic waste utilization including the assessment of organic waste volumes as well as the selection of the methods of used profit from the sale of electric power in the given territory, taking into account the tariff policy of the region was studied in staged manner. Results: the production of biogas from wastes will allow the region to profit not only from the sale and consuming electricity for its own needs, but also for the needs of countryside or remote settlements.

Key words: bioenergy, biogas, organic waste.

JEL Code: O13 , Q01 , Q42

Introduction

The relevance of the research is due to the search for promising renewable energy sources in the territory of Tyumen region.

At the present time organic wastes represent both environmental problem and the largest source renewable energy in the world.

However, until now, the share of renewable energy in the world energy balance is low – about 14%, whereof the share of biomass is approximately 1.8%. The evidence from practice shows that even insignificant fluctuations in the market of energy resources suppliers cause strong

price changes. This suggests that alternative energy sources will play more important role in strengthening stability in energy resource markets in the future.

The paradigm “waste as a resource” increasingly used in the scientific field, for example, led to the inclusion of the estimates of market demand for end products derived from biowaste (Lohri et al., 2017).

Further development of bioenergy can guarantee:

- significant contribution to global energy;
- reduction of greenhouse gas emissions, as well as the opportunity to gain a different environmental benefit;
- improvement of energy security and trade balance by replacing fossil fuel imports with domestic biomass;
- potential for economic and social development of rural areas;
- reduction of waste, due to its use as an energy source.

According to the studies conducted by various organizations, renewable energy sources, compared to fossil resources, create more jobs, which can be one of the sensible reasons for investing in biomass. Biogas technologies can also allow for sustainable development of regions (Khelidj et al., 2012).

On the one hand, the Tyumen region is an area where most Russia’s oil and gas reserves are located, it is the main supplier of hydrocarbon raw materials both in Russia and in Western and Eastern Europe.

But on the other hand, the dynamic development of the agro-industrial complex and the increase in population cause a new problem – wastes recycling. Different types of wastes create different environmental problems, such as greenhouse gas emissions into the atmosphere, water and soil contamination (Ghiani et al., 2014). These problems can be solved by introducing non-waste technologies, such as, for example, anaerobic methods of waste neutralization.

As a raw material for biogas production, a wide range of organic wastes can be used: wastewater, animal dung, food industry wastes (including slaughterhouse wastes), energy crops and harvesting residues (including algae) and organic solid waste fraction (Romero-Güiza et al., 2016).

The purpose of the work is to analyze the organ-containing wastes formed in the territory of Tyumen region with the prospect of using them as a source of electricity.

The Tyumen region, which includes two autonomous regions, is one of the largest Russian regions. The area of its territory is more than 1.4 million km² (8.4% of the area of Russia) that is equivalent to the area of such countries as Germany, France, Italy, Great Britain taken together. It is located in the south of the West Siberian Plain.

The main sources of organic waste include: agro-industrial complex, municipal economy, food industry enterprises.

Under the influence of anaerobic processes organic waste is converted into biogas (methane, CH₄) and its most oxidized state (carbon dioxide, CO₂). In addition to CH₄ (55-60%) and CO₂ (35-40%), biogas also contains several other gaseous “impurities”, such as hydrogen sulphide, nitrogen, oxygen and hydrogen (Cecchi et al. , 2003).

1 Research Methods

At this stage, there is no single generally accepted methodology for determining the potential for using bioenergy. The methodological framework of this paper is based on the research of anaerobic recycling of organic waste, which is a multi-level structure consisting of:

1. Estimation of organic waste volume generated on the site of the research object.
2. Selection of existing generally accepted and recommended techniques for a specific type of waste (wastewater, solid domestic waste, livestock waste, food industry waste, etc.).
3. Theoretical estimation of biogas yield from specific sources and potential profit from the sale of electric power in the given territory, taking into account the tariff policy of the region.

2 Identification of potential for biogas production from organic waste

2.1 Agro-industrial complex

Currently, the agro-industrial complex of the Tyumen region is one of the largest producers of agricultural products in the Urals Federal District. In 2014, it accounted for 23.3% of all agricultural products produced in the district. In terms of agricultural production growth rates and per capita output, the Tyumen region surpasses the rest of the regions of the Urals Federal District. The agro-industrial complex of the Tyumen region includes 410 agricultural enterprises, 26 food and processing industry enterprises and 6 flour-grinding and feed milling enterprises (Official portal of the authorities of the Tyumen region, 2018).

Today the region's agriculture is a high-tech production complex. The Government of the Tyumen region constantly stimulates the development of both large-scale commodity production and small-scale farming. In the Tyumen region agriculture is an important component of the economy and social sphere of the region. The volume of agricultural products makes up to 50% of the industrial products in the region. Currently, more than 400 enterprises of various ownership forms as well as more than 1800 peasant farms are engaged in the production of agricultural products.

Poultry farming can rightly be called the most intensively developing branch of agro-industrial production of the region. The effective cluster of large poultry meat and egg enterprises

formed in the region includes the battery farms Borovskaya, Pyshminskaya and the Tyumen Broiler enterprise (Official portal of the authorities of the Tyumen region, 2018).

The poultry is produced in large volumes, comparable with the volume of cattle meat and pork production. For reference, the volume of cattle meat production increased by 4.73% (from 43.6 to 45.7 ths tons), pork production – by 4.70% (from 40.7 to 42.6 ths tons). The essential difference is that poultry production increase maintains the livestock growth at the proper level.

For the successful stock-breeding development, we need feed production that suggests crop production increase. The situation in the plant growing in the Tyumen region as a whole can be described as stable. Despite the existence of certain problems over the past six years, the growth of crop production has amounted to more than 150%, gross collections and major crops sales have increased.

Meat and dairy subcomplexes are the most important life-supporting sectors of Russian domestic agrarian production, which have a decisive influence on the level of food provision in the region.

In 2020, the Government of the Tyumen region plans to increase the number of cows with a high potential for dairy productivity in agricultural organizations to 52 thousand heads. Dairy cattle husbandry will be presented by 45 farms with the total breeding stock of 85 ths heads. Proceeding from this, the total dairy livestock will increase by 1.5 times in comparison with 2012. The share of pedigree stock kept in the farms of all categories in the total stock will be 50%.

The implementation of the measures assumes the preservation of traditional lifestyles and the security of income and employment of individual entrepreneurs, peasant farms and agricultural organizations that specialize in sheep and goat breeding, in particular dairy goat breeding.

Dairy goat breeding is becoming very popular for consumers, whereas the production is economically profitable for producers. Thus, by 2020 it is planned to increase the number of goats to 2500 heads.

Apart from obtaining biogas, the profit can be gained from the sale of fertilizers, proximity of power plants to the consumers; location of power plants on farms that reduces operating costs (Silva et al., 2017).

The policy of the Tyumen region is aimed at increasing the volume of livestock and poultry products. This will lead to an increase in the volume of organic waste.

There are many factors that affect the amount of biogas produced from livestock wastes and its yield. They are: type of animal, body weight, the total amount of solids in manure, volatile solids ratio, wastes availability and additional waste (Özer, 2013). All the calculations to determine the output of manure and dung for farms were made in accordance with “Recommendations for the process engineering of the manure and dung preapplication treatment

systems”. Table 1 shows the integrated calculations of biogas output which were made according to the initial data retrieved.

Tab. 1: The main indicators of biogas yield from livestock.

Type of raw material	Cattle, dairy herd,	Pigs	Chickens	Goats
Livestock, heads.	197 000	102 000	6,700,000	2500
Average yield of organic waste from one head, kg / day.	35	6th	0.2	2.5
Organic waste moisture, %	88	88	75	65
Output of organic wastes t/d.	17336	8976	502500	162.5
Biogas yield l/kg	25-30	50-70	50-60	25-30
Gas yield (m ³ per kilogram of dry matter)	0.250 - 0.340	0.340 - 0.580	0,200 - 0,300	0.3 - 0.62
Biogas yield, m ³ /day.	520080	538560	27637500	4875

Source: the *author's calculations* based on the data of Recommendations for the process engineering of the manure and dung preapplication treatment systems, 2008

2.2 Food industry

According to the open data of the government of the Tyumen region, the sphere of food and processing industry involves 326 enterprises of various ownership forms, including 8 large bakeries, 3 confectioneries, 5 grain processors, 9 milk processing plants, 13 meat processing plants, 6 fish processing plants, 13 other processing enterprises (Official portal of the authorities of the Tyumen region, 2018).

The wastes from food industry enterprises are dumped to burials, transported to household waste landfills, incinerated or diverted to meat-and-bone and fish-and-bone meal. Their neutralizing implies the use of sophisticated ecologically and economically justified technologies, which include various purification methods (mechanical, physico-chemical and biological). Anaerobic biological purification technology has a number of significant advantages over the other technologies (Semenova et al., 2013).

The volumes of food industry and plant growing enterprises waste products were established according to the data of “Handbook of Research on Renewable Energy and Electric Resources of Russia and Local Fuel Types / Indices for Territories”. Calculations for determining the volume of biogas are summarized in Table 2.

Tab. 2: The main indicators of waste biogas yield in crop and processing industry.

Type of raw material	Straw, stems	Potatoes	Vegetables	Meat processing plants
Average yield of organic waste, kg/day	3201	727	221	34
Biogas yield l/kg	200 ...300	280 ... 490	400. .. 500	230
Biogas output, m ³ / day	800	290	100	8

Source: the *author's calculations* based on the data of Handbook of Russian renewable energy resources and local fuels / regional parameters, 2007

2.3 Housing and communal services

In this paper housing and communal wastes include wastewater and solid household wastes.

The region has a developed social infrastructure, here are concentrated the largest educational institutions, scientific and design organizations, cultural and medical centers, which makes it attractive for internal migration of the population from other regions of the country. The total population of the Tyumen region is 1321.8 ths people.

According to the investment passport of the Tyumen region, by 2020 it is planned that 100% of the houses will be equipped with water discharge systems, i.e. wastewater will be removed from all residential buildings (Official portal of the authorities of the Tyumen region, 2018).

The composition of wastewater is varied depending on the size of a settlement and the type of an industrial enterprise. Wastewater is cleaned and in most cases the purified sewage water is poured into the source.

The purification results in the formation of large amount of organic liquid wastes in wastewater purification plants. The processing can significantly reduce the amount of wastes at landfills and incineration plants; it will reduce the financial costs of waste management (accounting for 40-50% of the total costs of wastewater purification); will reduce electricity consumption and greenhouse gas emissions.

The production of biogas from sewage sludge in Russia is not widely spread due to the technology imperfection, sharp temperature changes, low ambient temperatures, scarcity of organic matters in domestic sewage (Kadyseva & Ivankova, 2018).

According to the calculations made on the basis of the methodology set out in "Construction Regulation 2.04.03-85. Sewerage", external networks and facilities, yield of biogas from the decontamination of sewage sludge in methane tanks will make 304 902 m³/day.

Another type of municipal wastes is solid household wastes (SHW). Year by year the problem of increasing their volumes becomes more acute. Currently, a large number of technologies for processing solid wastes have been developed (Lohri et al., 2017). SHW recycling is relevant for circular economy due to the lack of resources, for example, such nutrients as phosphorus reserves (Zabaleta & Rodic, 2015).

The composition of solid household wastes is directly related to the level of economic development and lifestyle, for this reason it is different in urban and rural areas, but in general

composition of SHW includes six categories: organic waste, paper, plastic, glass, metal, wood, various impurities (rubber, leather, fabric, etc.)

The complexity of handling SHW consists in the lack of a separate waste collection system in the territory of the Tyumen region. Basically, all the wastes are disposed in solid wastes landfills.

To determine the volume of SHW produced by people were used averaged data of Recommendations for the determination of the norms for the accumulation of SHW for cities of RSFSR (March 9, 1982) , the average daily amount of waste per capita without selection of food amounted to 1.27 kg / person / day that is equivalent to a daily amounts of wastes from the population at 1679 t / d.

The expected amount of biogas produced during anaerobic decomposition of 1 ton of SHW in one day was calculated in accordance with regulations developed by the institute of APS n. a. Pamfilov to determine the yield of biogas at the site and according to the guidelines on the calculation of quantitative characteristics of pollutants emissions into the atmosphere which take place at the sites of solid household and industrial wastes recycling. The calculations revealed that the expected volume of biogas can reach 216.6 m³/day.

The energy potential of biogas as fuel outmatches the other energy sources and amounts to 21 MJ/m³. Thus, the energy produced from the generated waste per day is 123861.8 MJ

The methane content in the biogas produced is about 50%. This biogas, used as electricity, shows energy potential of 5 kW·h/ m³, i.e. theoretically, in a day the rate of 1083 kW·h can be reached. It is necessary to consider the fact that the values obtained depend on the local conditions of each particular landfill.

3 Energy potential of organic waste

Biogas can be converted into useful forms of energy in several ways:

- Direct use in boilers (heat, hot water or steam production).
- Energy production.
- Heat and power cogeneration.
- Natural gas.
- Motor fuel after purification and compression.

At the moment, the most accessible and popular technology is the generation of electricity. The amount of electricity received from wastes and the cost of the same volume provided by centralized power suppliers are shown in Table 4.

Tab. 3: Potential amount of electricity produced from wastes processing

Indicators	Municipal wastes	Agro-industrial wastes
Volume of biogas m ³ /day	305140	287010015
Amount of electricity (kWh / day) produced by turbo-generators with a capacity of 60 kW	832200	782754586.4
Cost of the same amount electricity provided by centralized electricity suppliers*, (thb rubles per day)	1564,536	1471578,622
Also per year, mln rub.	571 055.64	537 126 197.2

Source: the *author's calculations* based on the data of REC (Regional energy commission) decree (order) No. 51 "The settlement of electricity prices (tariffs) for the population and consumers categories equated to it in the Tyumen region, the Khanty-Mansiysk and Yamalo-Nenets Autonomous Districts for 2018".

* In 2018 the tariff for rural settlements of the Tyumen region amounted to 1.88 rubles per 1 kWh.

The calculations provided the data on the prospects of biogas yield from organ-containing wastes in the territory of the Tyumen region, which is equivalent to 517,677 million rubles per year.

Conclusion

Review and analysis of the formation and use of waste showed that in the Tyumen region, as in other industrial regions, millions of cubic meters of waste have been accumulated.

The utilization of organic waste as an energy source, biogas, is one of the directions in solving environmental problems.

The calculations made to determine the volumes of biogas and electricity produced, taking into account the development prospects of the Tyumen region, showed that it is possible to derive financial benefits from wastes, so the cost of electric energy produced from biogas will be 537 697 million rubles in a year.

The production of biogas from wastes will make it possible to profit not only from the sale and consumption of electricity for power sector needs, but also will solve the problems associated with the utilization and storage of waste, environmental pollution, economic stability of the village or remote settlements.

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