The Use of Municipal Solid Waste as Secondary Energy Resources on the example of the Housing Complex Novopatrushevo, Tyumen

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Abstract. The article considers the feasibility of using biomethane, obtained on the basis of municipal solid waste (MSW) for the production of thermal energy. Research suggests the possibility of using biogas directly at the place of generation. The article also proposes a solution for the processing of numerous sludge of household waste water, which allows to improve the operating conditions of domestic sewage networks. The authors carry out detailed calculations for a residential complex under construction in the city of Tyumen. This paper determines the energy efficiency of a selected waste management scheme.

1. Introduction

Since the last century, the volume of production has grown significantly, which has stimulated the introduction of new technologies in all spheres of human life. This was facilitated by engineering, chemical and biological sciences. On their basis, technologies were developed and put into operation from the production of durable materials to the processing of raw materials. Modern technological progress, thanks to the synthesis of engineering and ecology, allows the use of waste as a useful raw material, transforming them into thermal or electrical energy.

According to statistics, about one ton of waste accounts for every person on the planet Earth every year. If we add up, we get 7.7 billion tons per year. The content of the Tyumen region in the total amount of waste is about 2.5 million tons, of which only 73.5% have been neutralized [2, 4]. The main method of disposal of industrial and municipal waste on the territory of the Tyumen region are landfills, of which only 74% meet sanitary and environmental standards. The rest of the waste is located in unauthorized places.

To date, municipal solid waste (MSW) is a serious problem for Tyumen, due to their significant volumes (up to 56% of the total waste) [1, 11]. The development of the waste management system is stagnated by the inertia of the entire HLI system, as well as by the low culture of the population in the field of waste management. Therefore, MSWs are decomposed outdoors at landfills within the city or in the suburbs.
As a way out of the current environmental problem, it is proposed to process waste that is part of MSW into biogas obtained by methane fermentation of biomass. Biomass digestion occurs under the influence of 3 types of bacteria. In the food chain, subsequent bacteria feed on the waste products of the previous ones. The first type is hydrolytic bacteria, the second is acid-forming, the third is methane-forming. The composition of biogas: 55% - 75% methane, 25% - 45% CO2, minor impurities H2 and H2S. After purification of biogas from CO2, biomethane is obtained, its properties close to natural gas [3,19].

This method is universal because it allows you to dispose of almost all types of waste. As a result of waste processing under anaerobic conditions, another currently relevant problem is solved - the application of organic fertilizers to agricultural land. Namely, the reacted substrate after biogas production can be applied to the fields without any preliminary tests [17,19].

Biogas is used as a fuel for the production of: electricity, heat or steam, or as an automobile fuel. Now biogas plants are used mainly in sewage treatment plants, farms, poultry farms, distilleries, sugar factories, meat processing plants. The use of methanogenesis for the digestion of MSW is the next stage in the development of the production of secondary energy resources [3, 16].

The use of a biogas plant allows reducing the size of sanitary protection zones many times, as well as reducing CO2 emissions to the atmosphere [12, 20]. In addition, the combustion of biogas can produce both electricity and heat, which leads to savings in resources. This aspect can be taken into account in the construction of autonomous energy sources in remote regions of Siberia and the Arctic. Biogas plants can be placed in any regions of our country, they do not require the construction of expensive gas pipelines of complex configuration.

2. Materials and methods
In our case, the biogas plant is used as equipment for generating thermal energy. This facility will be able to provide with heating an entire building or a small area. The residential complex “Novo-Patrushevo” was chosen as the object for calculation and research.

The raw material for biogas production was a mixture of sorted MSW and waste collected from domestic sewage water. The latter are a serious problem for operating organizations, annually causing blockages and serious accidents in sewer networks.

Thus, the extraction and co-processing of household sewage sludge at the exit from buildings can also lead to an increase in the reliability of the sewerage system as a whole.

In the first stage, the recyclable components (plastic, glass, metal, etc.) were recovered from the waste. Sewage sludge underwent decantation, after which the waste mixture was ground. The location of the biogas plant and the boiler house in accordance with the requirements of [8-10, 12, 15, 18] is shown in Figure 1.

Figure 1. Placement of a biogas plant in the Novo-Patrushevo residential complex
3. Results
Table 1 shows the total cost of thermal energy to ensure the selected complex. The total number was 22896.3 KW (22.89 MW or 19.7 Gcal / h) [5-7,13,14].

Table 2 presents the mass of generated MSW, as well as the volumes of biogas and the approximate amount of thermal energy from its utilization. The total amount of energy produced on the basis of biomethane is 1171.849 kW (1.17 MW or 1.008 Gcal /h).

| Object name | Total area of building | Average amount of heat loss per m² | Total amount heat | Integrated indicator kWh / m² |
|-------------|------------------------|-----------------------------------|------------------|------------------------------|
| st. Fedyuninsky 62 h.1 (GP 31.2) | 24995,52 | 70 | 58 | 1449740,16 | 1971,716 |
| st. Pavla Sharova, 9 h.1 (GP 39.3) | 18194,4 | 70 | 58 | 1055275,2 | 2218,181 |
| st. Pavla Sharova, 9 (GP 39.2) | 36262,8 | 70 | 58 | 2103242,4 | 2218,181 |
| st. A. Mitinsky, 7 (GP 40.1) | 87376,32 | 70 | 58 | 5067826,56 | 1971,716 |
| st. A. Mitinsko, 5 (GP 40.4) | 25484,76 | 70 | 58 | 1478116,08 | 2218,181 |
| st. A. Mitinsky, 3/1 (GP 40.2) | 21871,08 | 70 | 58 | 1268522,64 | 2218,181 |
| st. A. Mitinsko, 3 (GP 40.3) | 60918,9 | 70 | 58 | 3533296,2 | 2218,181 |
| st. Fedyuninsky, 60 (GP 32.1) | 41772,96 | 70 | 58 | 2422831,68 | 1971,716 |
| st. Fedyuninsky, 60 h.1 (GP 32.2) | 21871,08 | 70 | 58 | 1268522,64 | 2218,181 |
| st. Fedyuninsky, 60 h.2 (GP 32.3) | 56016 | 70 | 58 | 3248928 | 1971,716 |

Table 1 - Calculation of the consumed heat energy

| Object name | Number of inhabitants | Amount of MSW tons per day | Amounts of scums tons per day | Methane amount tons per day | Produced thermal energy, MJ |
|-------------|-----------------------|---------------------------|-------------------------------|-----------------------------|-----------------------------|
| st. Fedyuninsky 62 h.1 (GP 31.2) | 448 | 0,577 | 0,023 | 0,724 | 0,188 | 249,9944 |
| st. Pavla Sharova, 9 h.1 (GP 39.3) | 392 | 0,505 | 0,020 | 0,633 | 0,165 | 218,7451 |
| st. Pavla Sharova, 9 (GP 39.2) | 882 | 1,136 | 0,045 | 1,425 | 0,371 | 492,1764 |
| st. A. Mitinsky, 7 (GP 40.1) | 1344 | 1,731 | 0,069 | 2,171 | 0,565 | 749,9831 |
Compensation of heat losses of each building in the complex due to the use of biogas is shown in Fig. 2.

**Figure 2.** Comparison of the required and produced secondary heat energy, Gcal per day

4. Conclusion
The evaluation of the results of the calculation of heat energy consumption and its production on the basis of biomethane allow us to draw the following conclusions:

- The use of biogas makes it possible to compensate for an average of 5.56% of the thermal costs of supplying a residential complex during the period of stable methane generation (Fig. 2).
- Placement of facilities for methanogenesis in residential areas is possible and meets technical, sanitary and environmental requirements.
- The proposed method allows you to dispose of up to 95% of municipal solid waste and solve the problem of placement and operation of landfills in cities.

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