Biogas Equipment for Electricity and Heating

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The paper gives an example of a biogas plant used for electricity and heat production. First, the role and importance of the biogas plant is presented, then an overview of the raw materials used for biogas production is given, a project of the biogas plant with constituent elements is given, as well as a description of the technological process and elements of the biogas plant. The calculation of biogas consumption for the needs of the power plant of 0.999 MW has also been performed.

Key words: biogas plant, biogas, Power plant, Heat energy.

Introduction

The biogas plant is a complex microbiological-biological-technical system. It differs from most other types of power plants in that the combustion process, i.e. of biogas, preceded by biochemical conversion of organic matter of the substrate into biogas. In general, the biogas production and use chain can be divided into: substrate production; biogas production; use of biogas; utilization of fermentation residue [1, 2].

During the first phase, energy crops or fodder are produced to produce manure. Subsequently, the resulting biogas substrates need to be transported and stored. In the second phase, biogas is produced, and in the third phase biogas is used to generate electricity and heat [3, 4, 5]. After completion of the anaerobic process, the fermentation residue is temporarily stored and then distributed on agricultural and other surfaces, i.e. used for plant production, thus rounding the chain of production and use of biogas.

Biogas is produced by the process of microbial degradation of organic matter under anaerobic conditions (without oxygen) and in the presence of anaerobic bacterial species. Today, most commonly, the term "biogas" refers to gas produced in anaerobic fermenters and controlled conditions, that is, gas produced in biogas plants [6, 7].

The biogas composition is as follows: Methane \( [\text{CH}_4] \) _4 ca 50 - 55%; Carbon dioxide \( [\text{CO}_2] \) _2 ca 45 - 50%; Nitrogen \( \text{N}_2 \) ca 0 - 3%; Hydrogen \( \text{H}_2 \) ca 0 - 1%; Oxygen \( \text{O}_2 \) 0 - 1%; Hydrogen sulfide \( \text{H}_2\text{S} \) ca 0 - 2%.

Most of the existing biogas plants are those that use exclusively manure, substrates, manure, energy crops, harvesting and other residues from agriculture and primary processing of agricultural products [8, 9, 10]. The construction of biogas plants aims to protect the environment, as well as to decentralize electricity generation and profit [11, 12].

An example of a biogas plant

The following facilities / units are designed for the construction of the biogas power plant:

- Reception pit.
- In the receiving pit, the receiving, shredding and homogenization of the substrate that forms the mixture: manure and organic waste and maize silage is carried out. From the receiving pit, the substrate is transported to the digester.
- Anaerobic digester is a concrete structure made on the basis of patented technology, technological dimensions 22x63m, height 5 m. Organic mass (substrate) treatment is carried out in the anaerobic digester. The product of anaerobic digestion is treated organic waste and biogas.
- Container with equipment that supports the operation of the anaerobic digester, the outer dimensions of the container are 8.74x2.35 m.
- Power plant with associated substation, measuring 27x10.5 m, in which: Machine room with unit for combined heat and power production based on internal combustion engine (CHP), power 0.999 MW + 1.05 MWt, control room with power cabinets, room for separation of treated digestate and placement of separated solid phase.
- Laguna, to accommodate the liquid phase of the digestate after separation. The lagoon is earthy with foil and sloping edges, square in shape, with approximate internal dimensions of 87 m at the top and 80 m at the bottom.
- Precast concrete substation (MBTS) of transmission ratio 0.4 / 20kV, overall dimensions 5.09m x 4.3m x 3.3m.

For the purposes of the biogas plant, the substrates given in Table 1 are used.

- Table 2 provides data relevant to the digester and the substrate.
- Table 3 provides information relevant to the power system connection.
- Table 4 provides data relevant to thermal energy.

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The power of the first three sources is 580-600 kW while the power of the heat exchanger on the flue gas side is 450-470 kW which is a total of 1050 kW. The transfer of heat in the form of hot water to consumers outside the plant from all four above-mentioned heat exchangers (hydraulically...
connected) is via a central heat exchanger of 1050 kW.
In case there is no need for heat energy, an engine air cooler is located outside the facility whose capacity is adapted to the operating conditions of the CHP plant.
In addition to the engine air cooler, a turbocharger air cooler with an approximate power of 60 kW is also anticipated.
Biogas from a 10 mbar pressure digester is fed to the engine via a blower that raises the pressure to 100-200 mbar and the appropriate biogas treatment equipment.

Figure 1. Biogas plant

Figure 2. Scheme of biogas power plant

**Biogas consumption budget**

The pipeline for the transport of biogas is dimensioned in the worst case, i.e. for a minimum methane content of 50%.

Power output of CHP plant generator \( P_{el} = 999 \text{kWe} \)

Heat value of biogas with a minimum methane content of 50% \( H = 18000 \text{kJ/m}^3 \) (5.0 kWh/m$^3$)

CHP electric power efficiency, i.e. set generator \( \eta = 40.5\% \)

Engine biogas consumption

\[
B = \frac{P}{\eta H} = 493 \text{ m}^3/\text{h}
\]

The plant is dimensioned for capacities or flows of 500 m$^3$/h.

**Conclusions**

Biogas plants are very efficient in decomposing or fermenting waste. Instead of consuming energy, they produce it, and are different from all other systems.

In addition to environmental, the main advantages of biogas plants are the production of biogas and fertilizers. Additional benefits include: generation of electricity and heat, production of biomethane, and savings on the capital costs of waste management systems when constructing new facilities.

Biogas production prevents methane emissions into the atmosphere, which is the best way to reduce global warming [11, 12].

The implementation of the project achieves: reduction of energy dependence on imported fossil fuels, improved awareness of the use of renewable energy sources, increase of energy efficiency, increase of economic activities at the local level and thus local development, environmental protection.

**References**

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Biogasno postrojenje za proizvodnju električne i toplotne energije

U radu je dat primer biogasnog postrojenja koje se koristi za proizvodnju električne i toplotne energije. Najpre je predstavljena uloga i značaj biogasnog postrojenja, zatim je dat prikaz sirovina koje se koriste za dobijanje biogasa, dat je projekt biogasnog postrojenja sa sastavnim elementima, kao i sam opis tehnološkog procesa i elemenata biogasnog postrojenja. Takođe je izveden proračun potrošnje biogasa za potrebe elektrane snage 0,999 MW.

Ključne reči: biogasno postrojenje, biogas, elektrana, energana.