

RATIONAL ENERGY USE AND ALTERNATIVES SOURCES USE OF BIOGAS AT USP – PUREFA

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ABSTRACT

The PUREFA (Rational Energy Use and Alternative Sources Use Program) is a project that is implemented by USP and financially supported by FINEP (Financier of Studies and Projects), and has as main objective to implant measures of management and action of energy efficiency in order to increase the distributed generation at USP from the renewable resource and not conventional energy and to introduce incentive permanent politics to the efficient and rational energy use.

This project is subdivided in 14 purposes. The execution of purposes 11 and 12 is a responsibility of CENBIO (Brazilian Reference Center on Biomass).

Purpose 11 has as objective to capture, to purificate and to store the biogas originated from the treatment of residential sewage from CRUSP (Residential Set of the Sao Paulo University), produced by a biodigestor model UASB (Up flow Anaerobic Sludge Blanket) located in the Technological Hydraulically Center (CTH – USP).

Purpose 12 is to use this stored biogas as fuel in an Otto engine to generate electric energy.

1. INTRODUCTION

The biogas results from organic material anaerobic fermentation, that occurs inside the UASB biodigestor (Figure 1), and its chemical composition depends on several parameters, such as the biodigestor employed, the kind of organic material and the constancy of the feeding process of the biodigestor. Anyway, the most important biogas components are methane (CH₄), carbon dioxide (CO₂) and sulfuric components (H₂S). The biogas composition is an essential parameter, because it allows identifying the appropriate purification system, which aims to remove sulfuric gases and decreasing the water volume,

contributing to improve the combustion fuel conditions. Other data obtained from biogas analysis refers to the low heat value, that combined to the efficiency and biogas consumption is important to estimate the electric generation potential.

However, the biogas production is much variable because it depends on several parameters, such as the kind of organic material.



Figure 1 - Biodigestor Model UASB (Up flow Anaerobic Sludge Blanket)

2. THE BIOGAS PRODUCTION PROCESS

The biogas production involves three steps: fermentation, which includes hydrolysis and acid genesis, acetone genesis e methane genesis.

In fermentation process, during the hydrolysis the organic material is converted in smaller molecules and this material is transformed in soluble acids by acidogenesis process. After that it is initiated the acetanogenesis process, transforming the products obtained in the first step in acetic acid, hydrogen and carbon dioxide. The last step is referent to metanogenesis process, through anaerobic bacteria action, producing methane gas.

3. ANALYSIS AND PURIFICATION OF THE BIOGAS

As the biogas chemical composition is extremely important, two analyses were required. One before the purification process and another after. The most important biogas components are methane (CH₄), carbon dioxide (CO₂) and sulfuric components (H₂S). The table 1 shows the biogas composition before the equipment used in the purification.

Table 1 – Biogas Composition Before the Purification Process

| Chemical Components | %Vol or ppm |
|--|--------------------|
| O ₂ (Oxygen) | 1,23% |
| N ₂ (Nitrogen) | 15,5% |
| CO ₂ (Dioxide Carbon) | 4,75% |
| CH ₄ (Methane) | 75,8% |
| H ₂ S (Sulfate de Hydrogen) | 649 ppm |

| | |
|--------------------------|-------|
| H ₂ O (water) | 2,62% |
|--------------------------|-------|

At the purification process was used an adsorbent material, a molecular sieve and iron chips, the first one is to reduce the percentage of the present water, the second and third one are to react with the sulfate hydrogen and so, do the purification of the biogas. This system is possible because the biogas production is very inconstant and due to the low mass flow of biogas produced, estimated in 4 m³/day. This estimative was made using an electronic measurer of low outflow.

Table 2 shows the biogas composition after this equipment used in the purification.

Table 2 – Biogas Composition After the Purification Process

| Chemical Components | %Vol or ppm |
|--|-------------|
| O ₂ (Oxygen) | 0,89% |
| N ₂ (Nitrogen) | 13,2% |
| CO ₂ (Dioxide Carbon) | 4,07% |
| CH ₄ (Methane) | 80,8% |
| H ₂ S (Sulfate de Hydrogen) | < 1,0 ppm |
| H ₂ O (water) | 0,98% |

The appropriate purification system contributes to improve the combustion fuel conditions. Other data obtained from biogas analysis is referent to the low heat value that combined to the efficiency and biogas consumption is important to estimate the electric generation potential, as showed in equation 1

$$\eta = \frac{W}{M_b \cdot LHV} \quad \text{[EQUATION 1]}$$

W – Estimated Power;

M_b – Biogas mass flow consumption;

LHV – Low heat value;

η - Efficiency

To procedure the calculation above it is necessary to admit the efficiency, which depends on technology used in biogas conversion, basically including three different technologies: gas turbines, microturbines and Otto Cycle engines.

In this project, due to the low mass flow of biogas produced, estimated in 4 m³/day, Otto Cycle engine has been pointed as the appropriate technology, according to the power calculated as showed in equation 1.

This engine has an national technology.

4. PROJECT INSTALLATIONS

After the biogas has passed in through the tubing, the water accumulator, adsorbent material, the molecular sieve and the iron chips, it is ready to be stored in a pillow tank (flexible tank made with PVC). That pillow tank is also an national technology. This

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storing is necessary because of the variable production of the biogas like mentioned before, it provides that the functioning of the engine lasts more, so more data can be collected. A complete previous project scheme is present in figure 2, jointly with the equipments description on table 3:

Table 3 – Equipments employed description

| Equipamento | Número | Quantidade |
|---|--------|------------|
| Tubing | 1 | 1 |
| Sewer Measurer of Outflow | 2 | 1 |
| Biodigestor | 3 | 1 |
| Water Accumulator | 4 | 1 |
| Valve Sphere | 5 | 6 |
| Adsorbent Material and Molecular Ciever | 6 | 1 |
| Iron Chips | 7 | 1 |
| Biogas Measurer of Outflow | 8 | 1 |
| Pillow Tank | 9 | 1 |
| Engine/Generator | 10 | 1 |

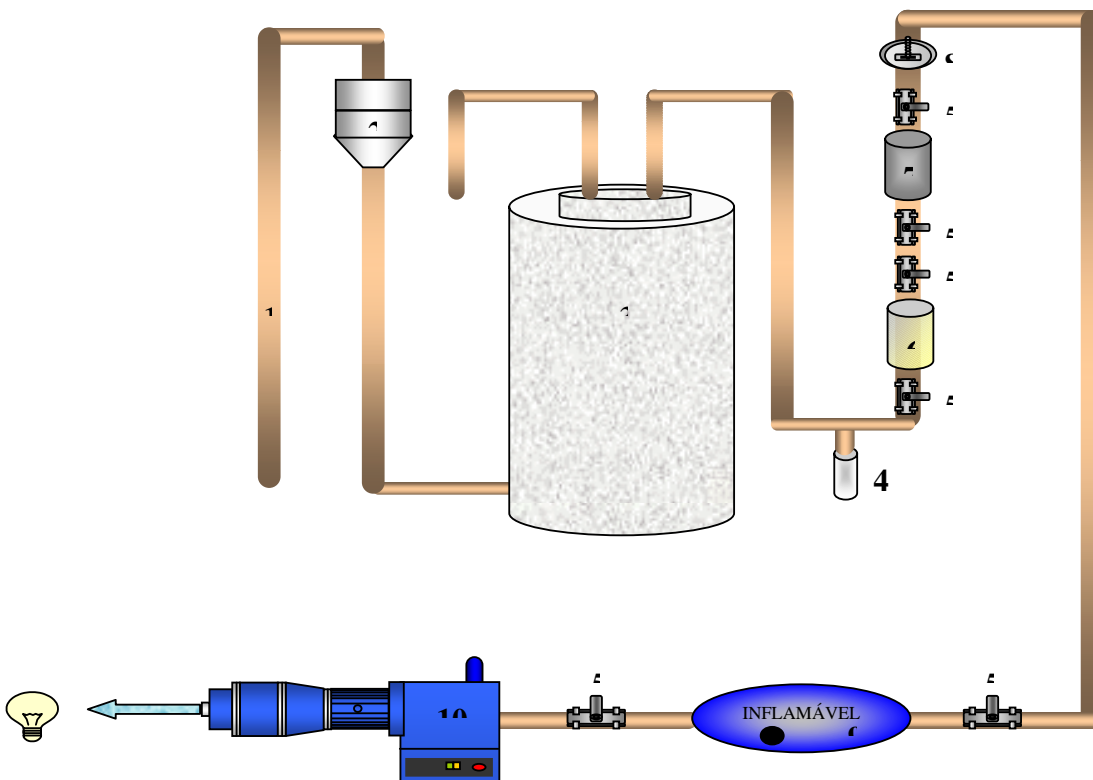


Figure 2 – Previous project scheme

5. CONCLUSIONS

Despite the fact that this project has been developed experimentally in Sao Paulo University's campus, thus in urban area, one of the expectations is that the results obtained provide information about biodigestor's operational conditions. This allows defining appropriate areas where this project could be applicable.

Especially in rural areas, the use of sewage as fuel to produce electric energy is able to contribute with electrification programs already structured in Brazil. Focusing the social aspects, the implementation of this project also increases the job offering, the agricultural productivity. It creates important benefits to the country, as lower expending of fossil fuel importation and a good investment return rate. Once that each real R\$ (correspondent around tree dollars) invested in rural area, represents tree R\$ in entire economy of Brazil (Energy and Mines Ministry, 2003). Those benefits are important especially to isolated communities; the most of them located at north in Brazil.

The most important environmental contribution associated to this project is the mitigation of greenhouse gases (GHG) emissions, especially verified trough methane conversion in carbon dioxide, which presents a dangerous level around twenty five times lower than methane.

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