

Estimate of Sustainable Production for the Development of Biogas Systems from Animal Biomass

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Abstract. The research consists in the study of rural properties with the deployment of biodigesters, having as goal the biogas and energy production estimate of these properties, based on the theoretical model proposed for the development of a biogas system from animal's waste. The results obtained showed a divergence among them, where the theoretical estimates of biogas and energy are many times greater than the actual values of production, taking only in property Starmilk as real estimate greater than the theoretical. This discrepancy between results makes not viable new biogas projects. However, this is due to the lack of information about the animals and also about factors that may influence the biogas system. It is concluded that the present research showed to be satisfactory, because it is very important for the study of the real estimate generation of biogas and energy in properties with deployment of biodigesters, bringing a greater confidence to the owner interested in the aggregation of this source of renewable energy.

Key words

Rural property, biodigester, renewable energy, biofertilizer, biomethane.

1. Introduction

The concern with the environment and its limited natural resources has become a quite commented subject in the world today, mainly due to the impacts caused by the use of traditional energy sources (oil, natural gas and coal) that are fossil sources. This type of energy is considered dirty and its consumption is considered the major responsible for environmental pollution, having as main effect on environment, the greenhouse gases, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and other gases [1].

In this sense, the alternative sources of energy, such as solar energy, wind, hydro and biomass are attracting interest throughout the world, because it is a clean and renewable energy, they obtain response from nature in short periods of time [2].

Among these types of renewable energy, the use of biomass for electricity generation has been the object of several studies and applications in developing countries

and the ones already developed. This is due to the pursuit of more competitive power generation sources and the need to reduce the use of fossil fuels.

The new sources of energy produced by biomass or bioenergy can be obtained by means of combustion, gasification and fermentation from raw materials of vegetable origin non-woody (cellulose, saccharides, oilseeds), woody plants (wood), biofluids (vegetable oils) and organic waste (urban, agro-industrial and agricultural) being the last one which will be highlighted in this article.

According to Lindemeyer [3], the use of biomass in energy generation represents an alternative source of great efficiency. It is mainly used to produce electricity from biogas. The biogas is a gas originated from organic matter with high power of combustion. Currently, its use is increasingly being used in cogeneration systems and in the supply of energy for isolated demands from the electrical network.

According to the same author, in agriculture sector, the use of organic waste digesters can provide the necessary energy on farms for lighting, heating and the movement of the engines through the exploitation of this biofuel, the biogas. Furthermore, the processed organic material in the digester can be used as organic fertilizer after being digested, it's known as biofertilizer.

It is worth mentioning that agriculture sector generates a large amount of waste, among them, we can highlight the manure of animals that are considered the best food for the digesters in biogas production. However, without the deployment of biodigesters in properties, these waste end up being applied in an inappropriate way [4].

Thus, if the manure of animals is not treated properly in the environment, it will cause the pollution of rivers and lakes, and consequently, affecting quality of the water for human consumption, spread diseases, kill fishes and become a hazard for the health of the residents around the property [5].

Thus, in the rural sector, the treatment of animal manure from anaerobic digestion for biogas production, it is seen as energy easily accessible and cheap, seeking sustainability. Besides of converting a material that is considered useless and nuisance into a clean, renewable energy source. This can lead to an extra income for farmers from the sale of carbon credits due to the reduction of greenhouse gases emissions [5-6].

However, Herculano Silva [2] reports that, despite the favourable outlook for the production of biogas and bio-fertilizers on farms, the lack of knowledge about anaerobic process and information on the biodigester makes it an obstacle to its implantation in the rural sector.

Second Kotz et al. [7], another important factor for the deployment of the biodigester is the evaluation of estimated production and real biogas in property. The author himself has assessed that the results obtained in their research, the theoretical estimates of biogas are often times greater than the actual values of production. Thus, the discrepancy between the results leads the unfeasibility of new biogas project.

In this context, the research consists of the study on rural properties with deployment of biodigesters, having as goal estimate the biogas production and energy of these properties based on the theoretical model proposed for the development of a system of biogas from animal waste.

2. Justification

There is a need to cater on energy matrix in many areas, causing the least environmental and social impact. Thus, it is necessary to seek the exploitation of alternative energy and the biomass constitutes into one of the energy sources for energy production in order to avoid or minimize the use of fossil fuels [5].

Currently, among the technologies used for the production of energy through biomass, anaerobic digestion is becoming increasingly important, due to its ability to produce the biogas and use it as an energy source. In addition, helps to conserve the environment through the proper treatment of organic waste [8].

The largest sources of biomass are located in rural and agribusiness activities, where the quantity of organic waste is very high. The rural activity is widely known for its socioeconomic importance, however, at the same time, it is an activity that presents many challenges, especially for small rural properties with economic and environmental problems in its production process [9].

Another important aspect reported by Mathias [9] is that in Brazil many authors argue that the sustainability in the current model of rural production is feasible through the inclusion of agroenergy on rural properties, taking as basis the environmental sanitation technology for the treatment of residual biomass through the biodigesters, and the exploitation of the potential of the energy generation with the use of the concept of distributed generation.

Moreover, the choice of animal biomass raw material can promote the development of environmentally and economically sustainable alternative. In this context, insert the proposal for the development of sustainable design, since the production of biogas in relation to the environmental and economic aspect can transform the old problem of the inhabitants of rural properties that is the lack of rural sanitation in a new opportunity of income for agricultural exploitation. So, the biogas has generated another economic potential to the producer through the sale of carbon credits through the design of Clean Development Mechanism, Mecanismo de Desenvolvimento Limpo (MDL), provided for in the Kyoto Protocol.

However, for new deployments of biodigesters it is important that the producer has the knowledge of the amount of biogas that it is produced per day, because from this information will be carried out the sustainable production project in its ownership. Some authors such as Pereira [10] and Walker [11] suggest studies for deployment of biogas as mathematical model together with the rural properties contributing for the aggregation of this renewable energy source.

Thus, before the analysis of all these factors that make up this scenario, it becomes important to study the real estimate on rural properties with deployment of biodigesters, because there are few studies on this subject and by means of actual data becomes more specific the realization or implantation of new projects in other rural properties.

Therefore, it is relevant to study on this source of bioenergy from biomass a view to acquiring a knowledge that has as a principle the sustainability, which can be deployed across the country through the project of sustainable production, which is a source of great social, environmental and economic potential.

3. Methodology

The methodology used in this research consists of the literature and field research. For the initial elaboration of this article has been carried out a literature search to obtain the information necessary to achieve the general objective and to determine also the choice of rural property in which will be collected the data.

3.1 Bibliographic Research

3.1.1 System of biogas

The system of biogas (Fig. 1) consists of main steps that are used for its production, which is raw material for the generation of thermal and automotive power.

Animal confinement: the confinement of animals is the place where the animals are confined for the production of their waste. The withdrawal of this waste is done manually by an operator of their own property.

Cargo Tank: After being collected, the waste is channelled through gravity to the interior of the biodigester being sent along with water.

Water content: the quantity of water to be added along with the organic matter will depend on the type of deject that will be fed into the biodigester.

Biodigester: The biodigester is the equipment used in the processing of organic matter, in the anaerobic fermentation process. This equipment does not produce the biogas, it only provides adequate conditions for which a group of bacteria act on the substrate and produces the biogas.

Vertical and horizontal biodigester: The vertical biodigester is used for small biogas production. The horizontal biodigester is intended for large productions of biogas.

Biofertilizer: the biofertilizer is the organic matter processed within the biodigester, which can be used as organic fertiliser.

Biogas: the biogas is a raw gas obtained from biological decomposition of organic waste, being composed mainly of CH₄ and CO₂.

Treatment: the biogas also presents in its composition unwanted gas as H₂S that should receive treatment not to cause problems in the extended equipment lifetime, where the biogas is applied.

Filtering: The filtration is the step where the biogas is treated. The biogas go past this filtering unit to remove only the H₂S or the even along with CO₂.

Flare: The flare is also known as the burners, its purpose to transform the CH₄ in CO₂.

Biomethane: the biomethane is the gas consisting mainly of methane (CH₄), derived from the biogas purification.

Control panel: the control panel is where one has control of the production of the final product, i.e., for the biogas of first generation we have their use in the production of electrical and thermal energies. Now for the biogas of second generation, have their use intended for the production of automotive power.

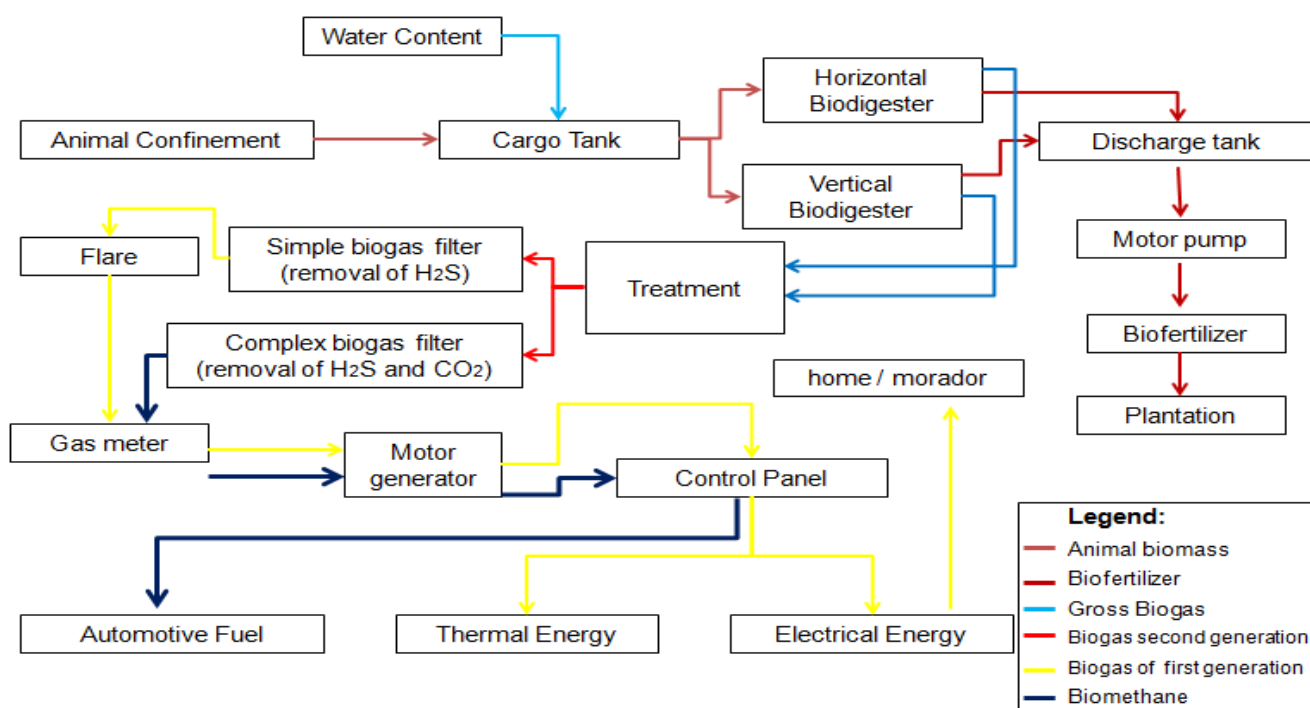


Fig. 1. System of biogas

3.1.2 Estimate of sustainable production

The literature search at research is essential to apply the estimate of sustainable production (biogas, energy, and biofertilizer), that chiefly interested the rural properties creators of animals. Thus, through the research of Herculano Silva [2] was got the formulas used for the evaluation of the estimated production of biogas from manure of animals.

Estimate of biogas production

The literature search at research is essential to apply the estimate of sustainable production (biogas, energy, and biofertilizer), that chiefly interested the rural properties of animal breeders. Thus, through the research of Herculano Silva [8], was got the formulas used for the evaluation of the estimated production of biogas from manure of animals.

The estimate of the production of biogas is very important to make possible for the owner interested in this energy source to be aware that it is possible to produce biogas in their property. In accordance with the theoretical study carried out, the following formula below may be used for the estimate of biogas for manure of animals.

$$GBiogás = Qdias \times Vc \times PBiogás^* \quad (1)$$

Where:

$GBiogás$ = Quantity of biogas produced (m^3);

$Qdias$ = the number of days that the manure is collected in the stables.

Vc = total quantity of manure produced on the property (kg);

$PBiogás^*$ = Yield of biogas per kg of organic material (m^3);

* Note: whereas 0.04 m^3 beef cattle and 0.049 dairy cattle; 0.35 m^3 pigs and 0.43 m^3 birds.

Estimate of the production of electrical energy

The estimate of electrical power generation is performed after obtaining the data of biogas production. Thus, for the achievement of the same is necessary to have the information of the concentration of methane (CH_4) of slurry of animals.

$$Genergy \cdot Electrical = GBiogás \times Conversion \cdot of \cdot biogás \quad (2)$$

Where:

$Genergy \text{ Electrical}$ = electric power generation (kWh/m^3);

$GBiogás$ = Generation of biogas (m^3);

* Note¹: Energy Conversion of biogas = whereas the energy conversion of biogas from 6.38 kWh for cattle and poultry and 7.02 kWh for pigs;

* Note²: Concentration of methane (CH_4) = Cattle and poultry (60%), and pigs (66%).

Estimated production of biofertilizer

The estimated production of biofertilizer can be used for any type of animal and biomass, this formula is based according to the quantity of total flow rate (in m^3) of organic matter diluted within the biodigester. However, before it is important to have the data of the quantity of water that was added to the biodigester according to type of manure, to determine the volume of the total mass inside the appliance.

$$Generation \cdot of \cdot Biofertilizer = Generation \cdot of \cdot waste \times 80\% \quad (3)$$

Where:

Generation of biofertilizer (m^3);

Generation of waste = (V) total flow of slurry more fresh water introduced into the biodigester.

80% = Total of all biomass used during the process of biogas (0,80).

* Note: The quantity of water used in the biodigester according to the type of deject animal:

Cattle (1 kg biomass/ 2 L of water);

Pigs (1 kg biomass / 3 L of water);

Poultry (1 kg biomass / 4L of water);

3.1.3 Rural Properties chosen for data collection

The collected data is based on information obtained in the portal of the CI Biogas [12], which is connected to the Parque Tecnológico de Itaipu (PTI).

Granja São Pedro Colombari – São Miguel do Iguaçu, Paraná - Brazil

The Granja São Pedro Colombari is located in the municipality of São Miguel do Iguaçu, west of Paraná, having as economic focus in pig farming in termination.

Unidade Produtora de Leitões (UPL) – Serranópolis, Paraná - Brazil

The Unidade Produtora de Leitões (UPL) is located in Serranópolis do Iguaçu, located in the west of Paraná. The electrical power generated by biogas is used in internal consumption of the company.

Unidade Produtora de Leitões (UPL) – Itaipulândia, Paraná - Brazil

The Unidade Produtora de Leitões (UPL) is located in Itaipulândia, west of Paraná. The unit makes the use of energy from biogas for the heating of the water used in cleaning and at the premises of the animals, reducing the use of bactericides and detergents which are used in the cleanliness of the premises.

Table 1 – Rural properties chosen for data collection

RURAL PROPERTIES	COLOMBARI	SERRANÓPOLIS	ITAIPULÂNDIA	MATELÂNDIA	STARMILK
Activity	Hog production	Hog farming	Swine – piglets production	Agroindustry Poultry slaughterhouse	Dairy Farming
Quantity of animals	5,000	5,892	6,150	270,00	550
Quantity of deject produced on rural property (m ³ /day)	45 ~ 60	140	140	960	210
Biogas production (m ³ /day)	750	1,000	1,450	1,700	1,440
Motor generator (kVA)	100	330	100	100	330
Electric energy production (kWh/day)	1,000	1,400	1,800	700	1,500
Biogas utilization	Electrical energy	Electrical energy	Electrical and thermal energy	Thermal energy	Motor
Biofertilizer utilization	Application – Croap and pasture	Directed to third parties	Offered to rural partners	Fertirrigation	Application – Crop

CI Biogás (2015)

Lar Cooperativa agroindustrial – Matelândia, Paraná - Brazil

The industrial unit of poultry of Home agroindustrial cooperative is located in the city of Matelândia, west of Paraná. The unit leverages the biogas to generate thermal energy, replacing the wood of boilers.

Starmilk – (Fazenda Iguçu) Céu Azul, Paraná - Brazil

The Iguçu Starmilk farm is located in Céu Azul, west region of Parana. Its activities are directed to agriculture, dairy farming and the reforestation. In addition to produce electrical energy by means of biogas, the property also uses the biofertilizer in the crop.

4. Results and Discussion

The equations (1 and 2) were used for the application of theoretical estimation of biogas production and energy, being fundamental for the owner interested this renewable energy. With this, you can compare the real values and theoretical estimates of biogas and energy of the selected properties (Fig. 2).

Fig. 2 – Comparison of real and theoretical estimate in biogas production (m³/day).

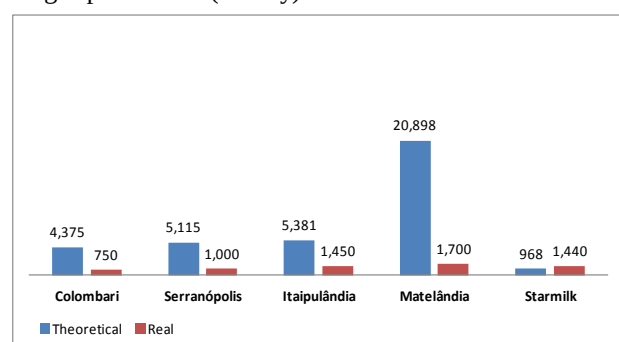
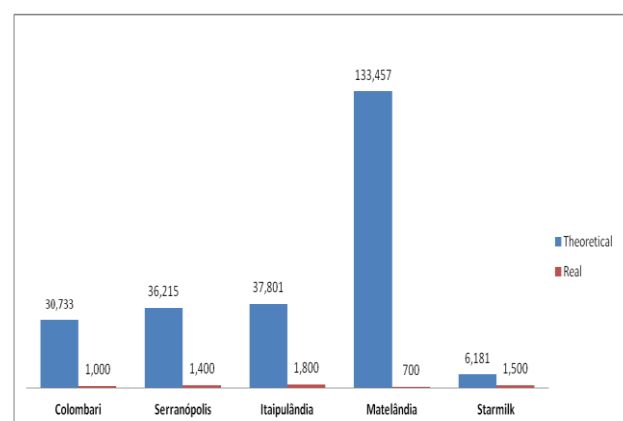


Fig. 3 – Comparison of real and theoretical estimate in energy production (kWh/day).



The results obtained show divergence in it, confirming what was quoted by Kotz et al. [7], where the theoretical estimates of biogas are many times greater than the actual values of production. Only in property Starmilk as real estimate greater than the theoretical estimate.

5. Conclusion

The discrepancy between the results theoretical and actual may be due to some aspects such as: factors that can influence the development in anaerobic biodigestion, management of biomass and different technology (biodigesters), as well as the lack of comprehensive data about the system of biogas, where time of confinement and the average weight of the animals are important data for the theoretical estimate, and they were not disclosed by the properties. Thus, all these factors may have influenced the theoretical results. It is concluded that the present research showed to be satisfactory, because it is fundamental to the study of the real estimate on rural

properties with deployment of biodigesters, because there are few studies on this subject. And in the case of actual data becomes more specific the achievement of new projects for the implementation of biogas systems in rural properties, contributing for the aggregation of this source of renewable energy.

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