



Electric energy micro-production in a rural property using biogas as primary source

Samuel Nelson M. de Souza, Ivan Werncke*, Cleber Aimoni Marques, Reinaldo A. Bariccatti, Reginaldo F. Santos, Carlos Eduardo C. Nogueira, Douglas Bassegio

State University of West of Paraná, Cascavel, Brazil

ARTICLE INFO

Article history:

Received 18 April 2012

Received in revised form

18 July 2013

Accepted 20 July 2013

Available online 30 August 2013

Keywords:

Biodigestors

Pig farming

Renewable energy

Biogas

ABSTRACT

The generation of electric energy distributed throughout Brazil's rural area contributes in the supply and logistics of energy production all over the country. This work aimed to analyze biogas production from swine waste and the generation of electric energy using biogas as primary source. Biogas was produced in São Miguel do Iguaçu - Paraná, Brazil, in a rural property which uses two biodigesters to produce biogas, whose electric conversion is performed in an engine-generator set of 100 kVA. With an average of 4672 housed animals, 554 Nm³ day⁻¹ of biogas were used in the generation of 847 kWh day⁻¹ of electricity and the rest was incinerated in a flare. The average specific consumption of biogas in the engine-generator set was 0.68 m³ kW h⁻¹ and its efficiency was 22.21%. The cost of electric energy production using biogas was 0.12 R\$ kW h⁻¹ and the cost of the supplier's electricity was 0.14 R\$.kW h⁻¹. One can observe the economical feasibility of electricity production from biogas, even without receiving carbon credits.

© 2013 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	385
2. Biogas	386
2.1. Microgeneration of electricity with biogas	386
2.2. Motors electric power generators biogas	386
3. Materials and methods	386
3.1. Description of the research area	386
3.2. Data collection	386
3.2.1. Conversion efficiency of biogas for electricity	386
3.3. Costs of biogas production and energy	387
4. Results	387
4.1. Considerations on biogas production at the property	387
4.2. Evaluation of the generated electricity at the property	388
4.3. Efficiency of biogas conversion into electricity	389
4.4. Energy production cost	389
5. Discussions	389
6. Conclusion	390
References	390

1. Introduction

The economical development resulted in an increased demand for several kinds of energy in Brazil and around the world due to constant

machinery evolution and the popularization of equipment. Between 1973 and 2006 energy supply around the world rose from 6,115 million TOE (tonnes of oil-equivalent) to 11,741 million TOE [1].

Even though Brazil has an energy supply that depends on non-renewable energies such as oil, natural gas and coal, the renewable sources, such as biomass, hydraulics, firewood, charcoal, lye, among others, are responsible for 44.1% of the domestic supply of energy [2].

* Corresponding author. Tel.: +55 45 3220 3155.

E-mail address: ivan_werncke@hotmail.com (I. Werncke).

Pao and Fu [3] highlight that most developing countries started identifying and implementing programs and laws to improve the infrastructure of rural renewable energy markets, making them more attractive to investors, what results in bigger investments and leads to a brighter future for renewable energy.

The increase of fuel consumption rates helps to increase fossil fuel usage, strengthening its problems. Alternative energy sources, mainly biomass, tend to bring environmental sustainability, reducing part of the problems related to energy.

Biogas production from swine waste contributes to environment protection, as in the reduction of CO₂ emissions due to the substitution of fossil fuels and decrease of methane (CH₄) released in the atmosphere [4]. The substitution of fossil fuels by renewable energy sources helps the atmosphere's carbon cycle, avoiding the release of carbon stuck in geological strata.

In Brazil, the PROINFA (Program of Incentive to Alternative Sources of Energy) aims to stimulate the production of decentralized electric energy by independent and freelance producers. The extension of thermoelectric generation with biomass is one of PROINFA's goals. In that sense, there came up an opportunity for systems of electric energy generation that use biogas as primary energy source to be implemented in rural and agro industrial properties, for self-consumption and distribution to the concessionaire's network, in case of surplus [5].

Even with all the advantages of using renewable sources, its implementation is still limited normally by its technical-economical feasibility due to high costs and the maintenance of the production system and bioenergy conversion.

This work aimed to determine biogas production in a swine farm, evaluate electricity generation potential and cost of production by means of field research in a case study.

2. Biogas

Biogas is produced from biomass anaerobic biodegradation, lack of oxygen and anaerobic microorganism presence. Anaerobic digestion is a consequence of a series of metabolic interactions among several groups of microorganisms [6].

It is basically composed of 40–75% methane (CH₄), 25–60% carbon dioxide and traces of hydrogen sulfide, nitrogen, hydrogen, carbon monoxide and oxygen [7–11], its concentration and volume are influenced by the source of organic matter. Residues containing bigger organic concentration generate biogas richer in methane [12,13].

Methane's calorific value is 8,500 kcal m⁻³, therefore the concentration of methane in biogas is directly related to calorific power and biogas density. Energy potential in fuels is determined by the inferior calorific value. Highly purified biogas can achieve up to 12,000 kcal m⁻³ [14].

2.1. Microgeneration of electricity with biogas

According to ANEEL (Brazilian Electricity Regulatory Agency) [15], the distributed micro-production is the electric energy power station with capacity lower or equal to 100 kW and using renewable energy sources such as solar, wind, biomass, hydraulic or cogeneration plants, connected to the supplier's low voltage network by means of energy consumption units.

2.2. Motors electric power generators biogas

The transformation of chemical energy into biogas can be effective using internal combustion engines [16] states that thermal engines of internal combustion are equipments in which the incoming mixture is burnt and its thermal energy is transformed into mechanical energy.

A power generator must be connected to the engine axis for this result. If the power generation is connected to the supplier's network, it is necessary to install a control board to make the connection and protect the network and its equipments.

According to [17] the efficiency of biogas conversion into electricity with OTTO cycle internal combustion engines is 25%, and biogas inferior calorific power is 6.5 kWh/m⁻³ (60% CH₄).

3. Materials and methods

3.1. Description of the research area

Colombari Poultry Farm is located at Linha Marfim, in the municipality of São Miguel do Iguaçu, latitude 25°20'53 South and longitude 54°14'16 West, in the state of Paraná. It works with confined creation system. Biomass generation is directly linked to handling factors, water supply system, conditioning and cleaning systems. In the output tubing, the effluent is directed to a dunghill that stores the biofertilizers, which will be used in crops.

The generation of electric energy is accomplished with the use of a motor-generator set with 100 kVA, protection system and command board. It is interconnected to the distribution network, for the commercialization of the excesses.

3.2. Data collection

To measure the biogas burnt in the flare, a gauge model Roots Meter Series B3 was used [18], with measuring levels from 22,6 to 1,600 m³ day⁻¹. For biogas consumption of the engine-generator set (m³ h⁻¹), a thermal dispersion flow gauge model Thermalat TA2 Enhanced was used [19], with measuring levels ranging from 0.51 to 85 (m³ h⁻¹), from November 2010 to June 2011.

Data were collected at [20] referring to room temperature, to analyze the relation between housed swine and biogas production and environment temperature.

Biogas quality (methane percentage) was analyzed using Draeger X-am 7000 [21]. Quality control was registered from April 15 to May 24, with 4 daily samplings. A SMART METER T in conjunction with its SOFTWARE SMART ANALYZER T was used in the property's electricity production; it allows graphic and reports generation according to ANEEL's resolution 505 [22]; data were collected between March 1 and 14, 2011, with intervals of 15 min.

From the fuel consumption (m³ h⁻¹), active power (kW) and time (h) data it was possible to calculate specific fuel consumption in m³ kW h⁻¹ [23]. The specific fuel consumption (SFC), in m³ kW h⁻¹, is given by

$$SFC = \frac{BCH}{AP} \quad (1)$$

in which BCH is biogas consumption per hour (m³ h⁻¹) in the engine-generator set and AP is the active power (kW).

3.2.1. Conversion efficiency of biogas for electricity

To check the performance (in other words, how efficient the transformation is) of the engine-generator set, at the property, using gas as primary source, Eq. 2 was used.

$$\eta = \frac{AO}{BCH \cdot ICP} \quad (2)$$

where η is the engine-generator system efficiency; ICP is the biogas inferior calorific power (kWh m⁻³).

Data for active power (kW) in the set were gathered by means of control panel WOODWARD model GCP – 20 [24] from the generator set.

The energy efficiency test was performed on April 21, 2011 simulating the engine-generator set operating at a load ranging

Download English Version:

<https://daneshyari.com/en/article/8121037>

Download Persian Version:

<https://daneshyari.com/article/8121037>

[Daneshyari.com](https://daneshyari.com)