Biogas Energy in Southern Brazil: Swine Waste, Power Generation and Carbon Credits

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RESUMO : O Brasil tem preocupações históricas relacionadas aos recursos renováveis, que são fonte de energia devido a suas excepcionais condições de solo e clima, pela imensa biodiversidade e vasto território. As atividades agrícolas representam 2/3 da economia brasileira. Muitas destas atividades produzem biomassa, as quais podem ser utilizadas como fonte renovável de energia e como boas práticas na gestão de resíduos agrícolas. Este artigo explora o potencial da biomassa em áreas tropicais, focando a produção suína. Para tanto, são apresentados os modelos de gestão ambiental aplicado em uma propriedade suinícola em Santa Catarina. Esta propriedade desenvolve suas atividades deforma distinta das demais propriedades da região e tem sido considerada uma referência nacional na produção de suínos com bases sustentáveis. Os dejetos suínos são transformados em energia elétrica e créditos de carbono em um projeto de Mecanismo de Desenvolvimento Limpo (MDL). A geração de energia elétrica tem, atualmente, capacidade de 500 kW e, devido ao seu sucesso operacional, pode ser expandido para 1MW. Os resultados indicam que a produção suína pode ser desenvolvida em bases sustentáveis, ou seja, economicamente viável, socialmente responsável e ambientalmente adequada. Este estudo foi desenvolvido em cooperação com a Granja São Roque, Itaipu Binacional e Universidade Federal de Santa Catarina.

Palavras-chave: Gestão Ambiental, Cadastro Técnico Multifinalitário, Suinocultura, Bioergia, Biogás.

ABSTRACT : Brazil has historical concerns about renewable sources of energy, mainly because it has exceptional soil and climate conditions, a huge biodiversity and a vast territory, which contributes to this scenario. Agriculture activity represents 2/3 of Brazilian economy and many of these activities produce usable biomass, which can mean renewable source of energy and best practices in agriculture residues management. This paper explores the potential of biomass in tropical areas, focusing on swine production activity. It will be presented an environmental management model performed in a swine production, located in Santa Catarina, Brazil. The property develops its activity in a different way, being considered a national reference in swine production with sustainable bases. Swine wastes were transformed into distributed power generation and carbon credits, as a Clean Development Mechanism project. The power generation capacity is 500 kW and due to the successful operation, the project can be expanded to 1MW. The results indicate that the swine production can be developed on a sustainable basis, i.e., economically viable, socially responsible and environmentally sound. This study was developed in cooperation with São Roque Farm, Itaipu Binacional and Federal University of Santa Catarina.

Key Words: MTC, renewable sources, swine waste, environmental management, power generation.

1. INTRODUCTION

The interest in energy from renewable sources is increasing due to its ecological and environmental benefits. This growing interest is prompting governments, power utility companies and private individuals to evaluate technologies for generating energy from a wide range of renewable sources, which previously were considered economically not viable (Lantz et al, 2007; Mwakaje, 2008; Patterson et al, 2011; Svensson et al, 2005).

Biogas is a renewable and high-quality fuel, currently produced in many developed countries (Lantz et al, 2007; Patterson et al, 2011; Svensson et al, 2005). Despite its advantages and favourable conditions for its production, biogas energy used in developing countries remains low due to technical, economic and political impediments. Different incentives and barriers, including energy, agricultural, and environmental policies affect biogas systems (Cowley & Wase, 1981; Gunnerson & Stuckey, 1986; Lusk, 1998).

This source of renewable energy can be produced from a wide range of raw materials, from organic waste to agricultural and forest residues, and can be used for a lot of energy services such as heat, electricity or as a vehicle fuel (Cowley & Wase, 1981; Gunnerson & Stuckey, 1986; Lusk, 1998; Patterson et al, 2011). On-farm biogas energy production is a possible source of income for farmers, besides promoting environmental benefits with the liabilities reduction (Yiridoe et al, 2009).

The swine production is a large and representative economic activity in Brazil, which is the fourth largest producer in the world, behind China, the European Union and the United States.

In Brazil, Santa Catarina State is the biggest producer. Despite its polluter potential, the activity can, through an efficient land management, reduce its impacts on the environment and generate profits for producers. This paper analyzes economic and environmental feasibility of on-farm biogas energy production in a best practice project placed in Videira, Santa Catarina State, denominated São Roque Farm.

2. Objectives

1) Analyze the economic, ecological and social viability in the production of biogas from swine manure;

2) Verify the implementation of São Roque Farm Project, which uses swine waste for distributed generation of electricity and obtain carbon credits;

3) Show the results obtained in the farm, through field survey data in São Roque Farm, reliable documents and reports of economic, environmental and productive areas of the property.

3. Biogas Economy: a source of power generation and carbon credits

An analysis of a best practice project could provide relevant information to on-farm biogas production and its effects on economy, ecology and society. The implementation of biogas systems on developing countries can leads to significant improvements concerning resource efficiency and environmental impacts compared to current agricultural production practices. Swine production generates a large amount of residues that can be used to biogas production and avoid water and air pollution (Lusk, 1998).

Biogas is a renewable on-farm produced fuel and its production could be a significant contribution to the fulfilling of national and international policy objectives (Yiridoe et al, 2009). However, in spite of the multiple benefits of biogas systems, current Brazilian production is very low and utilizes only minimal part of the potential (Brasil, 2011). Thus, it demonstrates that present incentives are not strong enough to increase the biogas production. In order to expand biogas projects in Brazil is necessary to reinforce the incentives and/or weaken barriers. The promotion of biogas systems is relevant to energy agricultural, environmental and waste management policies.

After 1970 there was a large increase in the scale of swine production in Brazil. Consequently, there was a considerable increase in the generation of waste resulting from the activity that, when not properly treated, become serious environmental liabilities (Brasil, 2011). The treatment of these liabilities has only begun to

be relevant with the creation of the National Environmental Policy (NEP), which was established by Federal Law No. 6.938/81. The NEP recognized mechanisms of protection, improvement and restoration of environmental quality, aiming to ensure development and respect for nature.

Brazilian energy matrix is composed primarily of renewable energy sources (44.7%), and of this total, 29.7% corresponds to the energy generated by biomass. In the rest of the world, renewable sources account for only 13.3% and 11.2% biomass, demonstrating that the Brazilian energy matrix is very clean compared to other countries (Brasil, 2011).

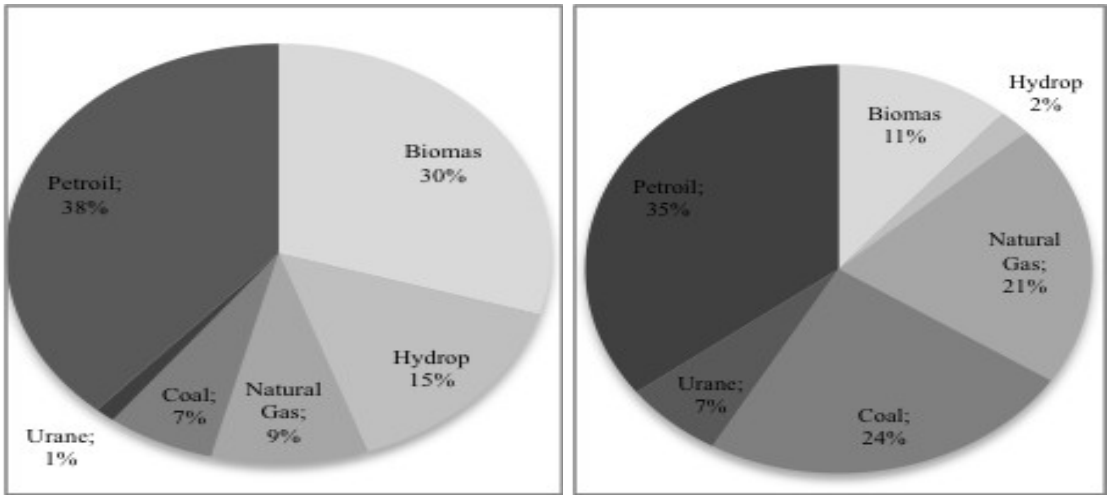

Fig. 1. Composition of Brazilian energy matrix (Brasil, 2011)

Besides its big biomass potential as renewable source of energy, Brazil occupies the third position in Clean Development Mechanism projects (behind China and India) (Brasil, 2011). Making an analysis by sector, the predominance of CDM project activities in Brazil is in the energy sector (51.4% and 245 projects under development) and swine activity (15.9% and 76 projects), representing the importance of biomass. Carbon credits are certificates issued in the emission reduction of greenhouse gases (GHG).

These projects support the growing energy demand in Brazil (due to the economic growth) and improve the electricity supply, contributing at the same time, to the environmental, social and economic sustainability. This is possible through the increased participation in sustainable energy relation to the total electricity consumption in Brazil, substituting, the construction of power plants using fossil fuels. Studies show that long-term use of biomass energy is more advantageous to employ the land for the cultivation of forests for carbon sequestration (Larson & Kartha, 2000).

One of the most abundant sources of biogas in Brazil is from livestock waste. In this scenario, it is important to examine the way in which the swine properties use the biogas generated by the animals and how they manage the treatment of swine's effluents. This study was realized in the city of Videira and it was concluded that, for lack of resources or even lack of environmental awareness, most properties perform this treatment in a rudimentary way, with serious consequences to the environment and not using the biomass as a new income. In contrast, it was noticed that some properties are already trying to change the environmental scenario in which the pigs are inserted, demonstrating that it is possible to implement actions that combine the creation of animals to environmental conservation. An example is the Unit Piglets Producer, denominated São Roque Farm.

4. Environmental management of São Roque Farm – From environmental liabilities to the sustainability

Since 2003 a daring plan of modernization began to be implemented in São Roque Farm, including an increase in the production scale - the 3.400 sows that existed before were increased to 8.500 sows. Nowadays, the property has 100 employees and a population of 45,500 swines, following to strict sanitary controls, always focusing on the animal welfare.

Due to the large amount of swine waste generated daily (about 3.500 m3), the property had to find a viable solution to this material. Following to the Environmental Management criteria of ISO 14001, São Roque Farm created the Swine Waste Treatment System (SWTS), which aimed to improve the environmental treatment of waste generated on the property, reducing the incidence of pathogenic vectors and the bad odor and improving the quality of final effluent treated.

The wastes generated in the swine's facitilies are transported, through pipes, to the decanters. The solid part is retained in the decanters and the liquid part is sent to the digesters. This process is very important in order to avoid the silting up of the biodigesters. The liquid of the biodigesters follows to the final effluent treatment and the biogas is used for two purposes: Distributed Energy Generation (DEG) and Carbon Credits trade (CDM Project), composed as the image below.

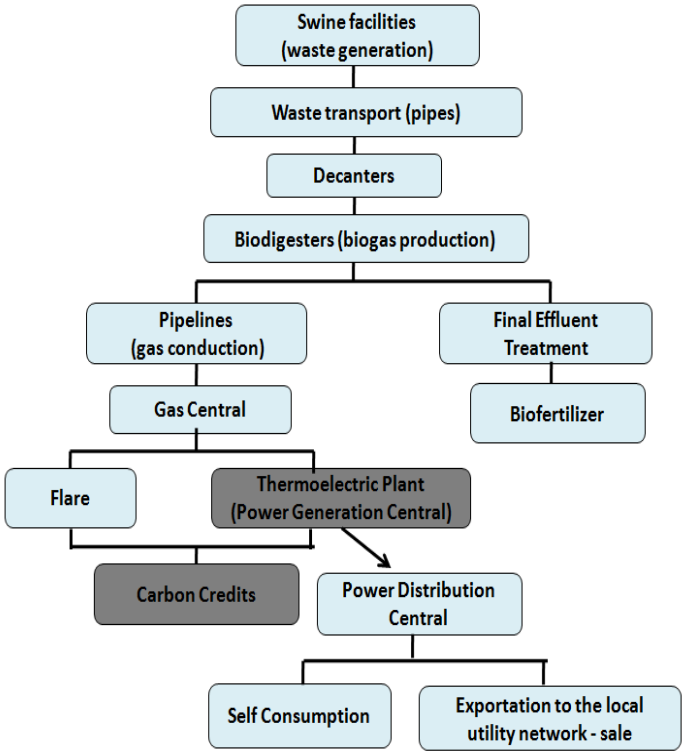

Fig. 3. Flow chart of the operation of Swine Waste Treatment System in São Roque Farm

4.1 Distributed Energy Generation trough Swine Biogas

The DEG of São Roque Farm is being developed in partnership with the Power Plants of Santa Catarina (CELESC). It is a mode of energy production that enables the creation of small generating units based on renewable energy - such as biogas. It allows the producer to consume the energy in his own property and sell the exceed energy to the local utility.

In São Roque Farm, the biogas derived from swine manure is produced and stored in anaerobic biodigesters, covered by semi flexible plastic sheeting. There are five biodigesters installed, which capture the biogas for electricity generation.

Fig. 2. Biodigesters of São Roque Farm.

The biogas arrives to a Gas Central, by pipeline, where 3 moto-generators are operating (2 generators of 100 kva and 1 of 330 kva), transforming the biogas into electrical energy. The current installed capacity of energy generation is of 0,5 MW, which will be expanded to 1 MW in a few months.

The generation of electricity consists in the burning of CH4 in the motor generator, avoiding the emission of this gas to the atmosphere. Filters of iron filings are used to extract hydrogen sulfide from the biogas before its arrival to the motor generator, which reduces the corrosion of the equipment and increase its life cycle.

This energy is directly connected to the local distribution network under technical standards of the Brazilian Electricity Regulatory Agency (ANEEL) and under specific protections. To be allowed to generate electricity in the distributed system, the property should be authorized by ANEEL. In April 2010, ANEEL approved the register of São Roque Farm, with permission to generate up to 1 MW of power, being the first register in the state of Santa Catarina. After that, the property applied its project for the announcement of CELESC, in the category “Purchase of Electricity from Farms that Uses Biogas from Animal Waste. The property was the winner and since June 2011 it’s selling electricity to the local utility.

Besides providing the generation of electric energy in renewable sources, the project of São Roque Farm reduces the greenhouse gases (GHG) emissions and contributes to the improvement of the life quality in the region by the upgrading in the air quality.

4.2 Carbon Credits

Swines are managed in confinement system in São Roque Farm, which generates a large amount of methane gas (CH4). As the largest part of SWTS is anaerobic, ie without the presence of oxygen, the GHG reduction emission is obtained through the burning of CH4 in the moto-generators for the production of energy and the burning of the remaining gas is made in a flare. In this case the biogas is converted to CO2, preventing methane emissions, which have a global warming potential 21 times higher than the CO2 one. Therefore, one ton of methane reduced corresponds to 21 carbon credits.

The CDM project of São Roque Farm began to be designed with the bioenergy project. The biogas that is burned in motor generators, and thus transformed into energy, is directed to a flare (burner), in order to ensure complete elimination of CH4. In this case, the reduction of GHG emissions is achieved in two ways: through the combustion of this gas in the motor generator to produce electricity and/or by burning in the flare (burn up to 4,500 m3/day).

The CDM project is framed in category AMS III.D - Version 14: "methane recovery systems in animal manure management", established by the United Nations Framework Convention on Climate Change (UNFCCC). The baseline emissions were calculated using the quantity of swine waste that decompose anaerobically in the absence of the project.

CER are calculated by the difference between baseline emissions and emissions verified as a result of the CDM project activities, including trails. Since there is no significant leakage of biogas systems in the treatment of swine waste, this item was nullified in the calculation of emission reductions.

The project, in addition to positive effects on the local environment, will reduce emissions of greenhouse gases in tCO2e/year 9154.04, as shown below.

Year	Estimation of the annual reductions due to the project activities (tCO2e)	Estimation of the annual baseline emissions reductions (tCO_2e)	Estimation of the annual leakage emissions reductions (tCO_2e)	Estimation of the annual emission reductions (tCO_2e)
2010	2,397.71	10,026.07	0	7,628.36
2011	2,877.25	12,031.29	0	9,154.04
2012	2,877.25	12,031.29	0	9,154.04
2013	2,877.25	12,031.29	0	9,154.04
2014	2,877.25	12,031.29	0	9,154.04
2015	2,877.25	12,031.29	0	9,154.04
2016	2,877.25	12,031.29	0	9,154.04
2017	2,877.25	12,031.29	0	9,154.04
2018	2,877.25	12,031.29	0	9,154.04
2019	2,877.25	12,031.29	0	9,154.04
2020	479.54	2,005.22	0	1,525.68
Total emission reductions estimated (tCO_2e)	28,772.50	120,312.90	0	91,540.40

Fig.4. Estimated amount of CER – São Roque Farm

The Project Design Document (PDD) of São Roque Farm was elaborated and it is published on the website of United Nations (UNFCCC). The property has received the visit from the Designated Operational Entity (DOE), which performs two basic functions: validation and subsequent application for project registration. Within the next few months the property will be selling the CER.

It should be noted that for this whole process to achieve the desired result, the operating procedures must be in constant improvement, in order to adapt environmentally the entire production chain, since the initial management of swine manure until the electricity generation through biogas.

5. Analysis of economic feasibility of bioenergy and carbon credits projects

The projects of São Roque Farm were initially based on the need for proper treatment of wastes generated from 45,500 animals that exist on the property. This amount is highly representative, about 360,270 liters a day.

Through the economic analysis conducted at the beginning of the projects it was concluded that the treatment systems for swine manure through anaerobic biodigesters are recommended when there is a large number of animals. Thus, it was concluded that the number of animals of the Granja San Roque was sufficient for the implementation of DEG and CDM projects, generating enough amount of biogas to become viable.

The property invested a total of U$ 1,800,000.00, using their own resources and financing of public and private institutions, which 68% was allocated to the project of DEG and 32% for carbon credits.

The property generates electricity for own consumption since September 2009, which represents a monthly saving of approximately U$ 9,411.00, considering 77,420 kWh per month generated for self consumption.

From June 2011, the power grid of the property was connected to the CELESC network. Since that São Roque Farm started to sell the power generated exceed to the local utility, having an income of U$ 5,882.00. This value is calculated assuming that the utility uses the Annual Reference Value (ARV) established by ANEEL for payment of electricity generated, which corresponds to U$ 75,02/MWh (based on August 2009).

From the total power generation, 52.2% is used for self consumption and 47.8% is sale to the local utility.

It is important to know that the self consumption of electricity is much more profitable than the sale of surplus, since the self-consumption represents a saving of approximately U$ 0.16 kWh and the energy surplus is sold at U$ 0.07 kWh.

Regarding carbon credits, it is expected that within a few months the financial return will be about U$ 13,503.00 per month, corresponding to 763 credits.

Both projects presented the Net Present Value (NPV) of U$ 600,828.52, being considered a recommended project.

NPV	U$ 600,828.52
IRR	21%
PAYBACK- Years	4
PAYBACK- Months	4
Tax of Attractiveness	10%

Fig. 5. Economic analysis of bioenergy generation and carbon credits projects.

With the analysis presented, it is concluded that the projects of energy generation and carbon credits are enable and become more attractive when developed concurrently. As the projects are innovative they have a certain degree of risk, which must be offset by favorable results in the shortest time possible. It is important to highlight that the results being obtained in São Roque Farm serve as a reference and stimulus for several properties and show a high degree of replicability in other sectors.

On-farm biogas projects have been reasonably successful by providing clean and renewable source of energy and afford environmental benefits. Standard analysis of the economic feasibility of on-farm biogas energy production shows that electricity generation or carbon credits individually are not economic feasible, but the combination of these aims produce direct financial benefits to farmers and raises nonmarket co-benefits to society as a whole, like ecosystems services. Moreover, improvement of biogas is technically feasible and could be undertaken at local and regional scales on developing countries, like Brazil.

6. Conclusion

Brazil is recognized worldwide as a potential producer of biofuels, because it has exceptional soil and climate conditions, a huge biodiversity and a vast territory. These features allows the country to develop an agriculture and livestock effectively, thus producing a substantial amount of waste derived from animals, especially swine, which can be used as renewable sources of energy.

The bioenergy generation from biogas is an alternative that has emerged as beneficial to the environment, replacing fossil fuels by renewable sources. At the same time, it contributes to the reduction of global warming and create a new revenue streams for rural properties, through self-generation of energy and carbon credit trading.

Since it is a traditionally recognized as polluting, the swine production has to change this paradigm and make progress in the implementation of environmental systems suitable for their wastes. This was the main objective that led São Roque Farm to adopt projects that align swine production to the environment conservation, such as bioenergy projects and carbon credits.

The property is generating energy for self consumption and the excess is selling to the local utility, being the first property in Santa Catarina to obtain this results. The current installed capacity of energy generation is of 0,5 MW, which will be expanded to 1 MW in a few months.

Therefore, it is possible to align the maintenance of a growing economic activity, as the swine production, to the mitigation of climate change and environmental balance.

Moreover, standard analysis of the economic feasibility of on-farm biogas energy production shows that a combination of electricity generation and carbon credits can produce direct financial benefits to farmers and ecosystems services to society.
The results obtained on the property indicate that the swine production can be developed on a sustainable basis, i.e., economically viable, socially responsible and environmentally sound.

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