THE USE OF BIOGAS GENERATED FROM SWINE MANURE AS A PRELIMINARY AGENT OF A BIOGAS PIPELINE PROJECT DEVELOPMENT

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1.BACKGROUND

Santa Catarina state is located in Brazil's southern region and has about six million inhabitants. Its economy is based on different activities as shown in Table 1.

Table 1 - Economic Activities of Santa Catarina State

Regions	*Activities*	*Regions*	*Activities*
North	Eletromechanical Industries Furniture Industries	East	Technology Companies Fishery
Valley (Vale)	Textile Companies Clothing Industries Tecnology Companies Fishery	South	Plastic Processing Plants Floor Tiles Plants Mining Textile Companies
High Lands (Planalto)	Wood Industries Pulp and Paper Plants	West	Food and Beverage Companies Agriculture and Livestock

Source: Adapted from Santa Catarina em Números (2010)[(1)]

Brazil is the largest swine producer in Latin America and the fifth largest in the world. Santa Catarina state is responsible for about 25% of national swine production estimated at 6.2 million animals [(1)]. The five largest swine based food processing plants in the country are also located in Santa Catarina. Cities such as Concórdia, located in the western region, have up to 287 swine/km², an amount as high as those found in Europe[(3)]. According to scientific research[(4), (5)], the estimated daily amount of manure production per swine is about 1 to 5 kg depending on age, while the biogas yield is about 0,10 m³ per kilogram of swine manure[(6), (7)].

The biogas produced by anaerobic digestion from animal waste is a gaseous mixture, colourless and highly flammable. Methane (CH_4) represents 50 to 70% of biogas volume and is the main energy source which allows it to be transformed to a thermal, mechanical or electrical energy form. The biogas may be upgraded to a natural gas specification, whereas in the raw state it provides a lower energetic value. Carbon dioxide, hydrogen sulphide, ammonia, water vapour, dust, nitrogen and siloxanes are the most common contaminants found in raw biogas. The presence of these compounds cause, besides a decrease in energetic value, undesirable effects such as equipment corrosion, higher SO_2 and NO_x emissions and abrasive effects in engines[(8)]. The average energetic values of biogas in its raw state lies between 5,160 and 5,590 kcal/m³, while the lower heating value for natural gas is 8,600 kcal/m³. The use of biogas with lower calorific value narrows its applications to direct-burning such as industrial burners, electric power generation units etc. However after being purified and upgraded, the biogas can be used in other segments such as automotive utilization or even it can be injected into natural gas pipelines, amplifying significantly its application. In Laholm, a Swedish city, the biogas produced from animal manure and different types of organic waste have been injected into the natural gas pipeline since 2001. According to IEA Bioenergy [(9)], after the biogas has been purified and upgraded it is injected into the natural gas pipeline, resulting in a 25% reduction in the consumption of fossil fuel. This consequently reduces about 3.700 ton per year of CO_2 emissions. The biogas injected

annually into pipelines in Laholm serves as heat generation for the villages as well as providing gas to the automotive market. Therefore, according to this and other examples in the world, biogas could be used as a renewable fuel, to supply distant places in Santa Catarina state far away from existing natural gas pipeline.

Regarding natural gas distribution, in Santa Catarina state there are over 900 km of natural gas pipe network as shown in the Figure 1. The green line shows the main transmission pipeline named GasBol, close to 400 km in length. The blue lines represents more than 900 km of the constructed natural gas distribution pipe network owned by Companhia de Gás Natural de Santa Catarina (SCGAS). This supplies the most industrialised region in the state and is located on the coast. The red lines represent the planned natural gas distribution network, while the yellow line shows the possible biogas network to be constructed.

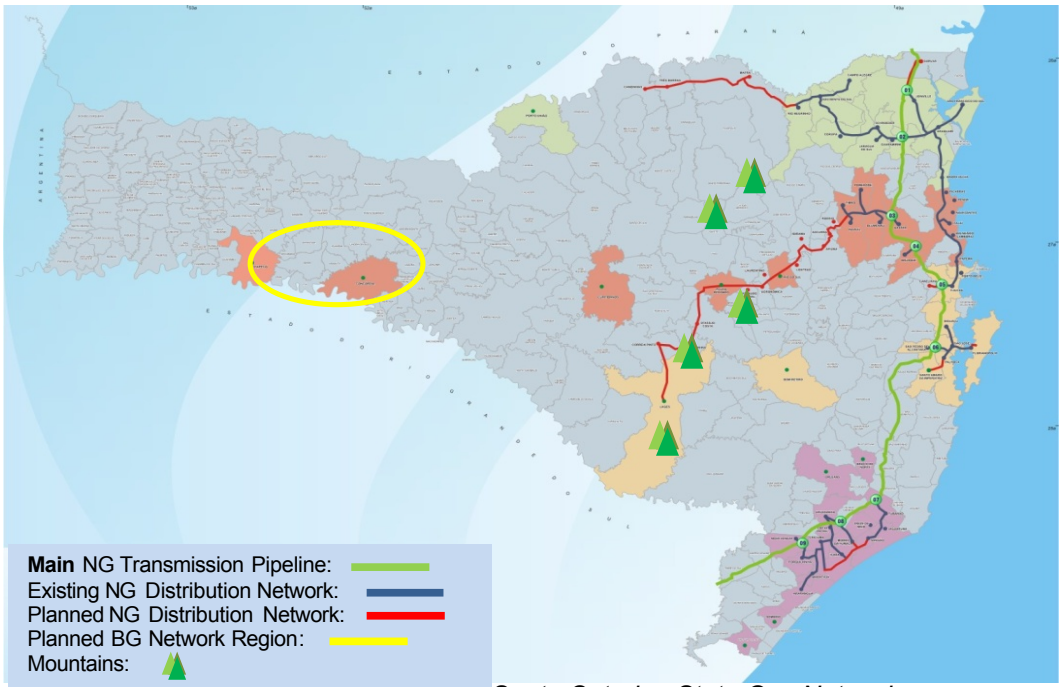

Figure 1 - Transmission and Distribution Santa Catarina State Gas Network

Due to a mountainous landscape, a pipeline construction able to supply natural gas to remote areas, such as western region, will prove difficult. Moreover in these places some of the industrial energy consumption comes from biomass such as wood, which is cheaper than natural gas. Thus, the construction of a pipeline connecting the existing networks in the east to the west region, where the swine producers are located, is not economically feasible at this time. Furthermore the potential consumption of natural gas in these areas is not significant.

Currently natural gas is supplied to distant areas from natural gas network in the form of Compressed Natural Gas (CNG) for automotive uses. This model of NG supply increases the value of natural gas by U$0.25/$m^3$ due to compression and transportation costs.

Providing a gas network infrastructure which distributes a new source of energy to remote areas could increase or even create a significant demand for fuel gas. This business model could anticipate the local gas network construction to distant regions far from existing natural gas pipeline in Santa Catarina State.

Another important issue to be addressed is about maintaining the gas company's profitability, since the contribution margin is directly connected to the natural gas network investments. In other words, the more natural gas networks that are built, the greater the contribution margin.

Therefore, this business model of biogas utilization can certainly help to develop distant regions as well as contribute to the reduction of environmental impacts which are typical of swine industry. Additionally, swine producers could benefit, since the environmental protection agencies recommend that the number of animals kept is directly related to the capacity to properly dispose of swine manure.

2.AIM

In this article an overview about the biogas usage from swine manure as support to the gas pipeline construction to distant areas will be presented.

3.METHODS

In 2009 SCGAS requested an inventory about the potential of methane production in Santa Catarina state. Field surveys [10] were performed in industrial sectors to evaluate the potential market of fuel gas in distant areas from existing gas network such as western region.

3.1.Potential for Methane Production

In order to quantify the potential for methane from biogas, the Santa Catarina Gas Company requested the Federal University of Santa Catarina (UFSC) to produce a report about methane potential in the state [11]. Through field surveys, database information [12] and by biogas software calculations[13] producer regions of biogas from animal waste, wastewater treatment plants, landfill facilities and industrial wastewater plants were identified. Due to Santa Catarina state being the largest swine producer in Brazil, studies were directed towards swine biogas production.

The equation 1 introduces the methodology [10] which estimates the potential of methane (CH_4) generated in the biogas form.

$$Q = \frac{BP * Conc * Qt * Tm}{SV} \quad (1)$$

Where:

Q = methane flow (m³/day)
BP = biogas production (kg biogas/ kg.Tm)
Conc. = methane concentration in biogas (%)
Qt = effluent generating units (nº of animals)
Tm = total manure amount (kg manure/animal.day)
SV = methane density (kg/m³)

Were adopted in the calculation some values of swine industry effluents, such as:

BP = 0.062 kg biogas/kg.Mt
Tm = 2.25 kg manure/animal.day
Conc = 66% methane
SV = 0.67 kg/m^3

3.2.Fuel Gas Potential Market Evaluation

To evaluate the biogas potential market some visits were performed in October 2009 in the largest swine producers located in western and southern regions of Santa Catarina state. During these visits the largest industrial consumer of biomass (wood), Liquefied Petroleum Gas (LPG) and fuel oil have been approached. For a better analysis, the energy contents of the fuel used in the companies were converted to equivalent cubic metres of natural gas.

4.RESULTS

Through Equation 1 and assumptions mentioned above an estimated swine methane daily production was calculated to be 0.1374m³CH_4/swine.day. According to the collected data, Santa Catarina state owns 6,021,346 swine, while the potential of methane biogas generated from biodigestion of swine manure is about 900,000 m³/day. In cities with a large potential, such as Concórdia, Seara, Iomerê, Xavantina, Braço do Norte and Videira, there is a potential of biogas production above 20,000 m³/day. Concerning the distribution of biogas production, 50% of generating potential is concentrated within 24 of the 193 municipalities. Figure 2 illustrates the potential for methane in the Santa Catarina state.

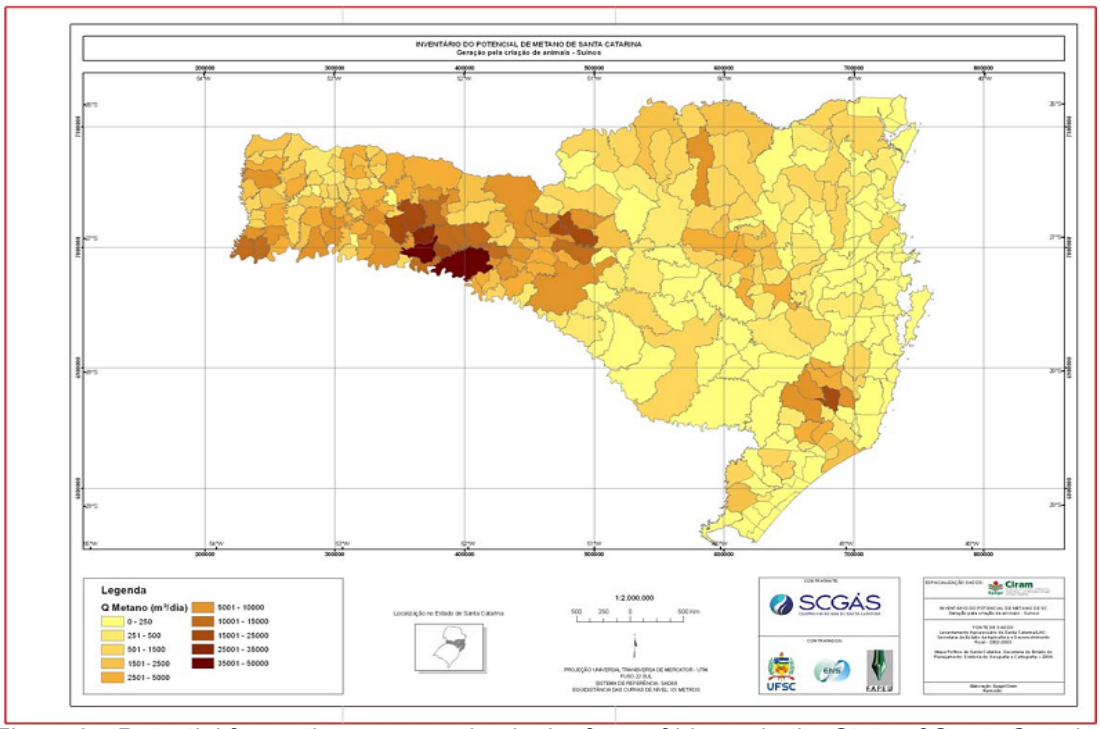

Figure 2 - Potential for methane generation in the form of biogas in the State of Santa Catarina

As shown in Table 2, there is in some western cities a potential market of natural gas from 389,583 m³ / day resulting from the consumption of wood, LPG and diesel. However, only 16,728 m³/day are displaced to biogas due to the use of expensive fuels such as LPG or diesel. Whereas the wood is a plentiful and cheaper fuel, it does not appear feasible to be displaced by biogas.

Table 2 -: Potential market and feasible methane market (CH_4) as biogas in m^3/day

City	Potential Market - GN eq. (m^3/day)	Real Market (CH_4) – Biogas (m^3/d)
Concórdia	38,300	3,500
Seara	10,068	1,068
Xanxerê	8,600	50
Xaxim	7,350	750
Chapecó	40,100	4,200
Herval d'Oeste	11,100	1,100
Joaçaba	50	50
Vargem Bonita	230,167	167
Videira	17,956	1,500
Capinzal	24,682	4,333
Salto Veloso	1,210	10
Sub Total	***389,583***	***16,728***

5.CONCLUSION

This study showed that in Santa Catarina state there is a huge potential for methane generation from pig manure estimated at 900,000 m³/day. The knowledge of raw biogas generation areas allows the identification of possible production and processing biogas units as well as planning the construction of a gas distribution network.

According to the examples mentioned the biogas can also be upgraded and injected into local natural gas pipelines. Once biogas becomes available in remote areas, a stimulus in markets based on natural gas consumption can be produced or even created. As a consequence, the reduction in payback time and the financial risks related to pipeline construction could be reduced.

The biogas business model appears to be a good alternative for fuel gas supply; however some issues such as the logistics of waste collection, gas distribution models, purification and trading costs have been quite a challenge. Although some regions are large swine waste producers there is not enough consumers to use the generated biogas. Thus, some alternatives have been studied, such as: a) compress and transport the excess upgraded biogas to other regions able to consume the gas, b) to build a large and expensive pipeline network to areas with a potential market to consume the gas.

According to SCGAS partner's research the biogas purification and upgrading process would take about 25% of capital costs. Adding this and other costs, the biogas could be 60% more expensive than the natural gas costs. The possibility of biogas to be sold as premium product is under evaluation, since its differential is to be from renewable sources. Another option which has been considered is to include the cost of biogas in the acquisition cost of natural gas.

Like other countries, the use of biogas as a fuel gas appears to be a feasible alternative for the swine farming regions of Brazil. This approach could allow the anticipation of pipeline construction in remote areas, while the environmental impacts of swine farms, such as methane and liquid effluents will be mitigated.

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