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Potential of the Bagasse Sugarcane to Electric Power Generation

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***Abstract* — An important renewable sources in the Brazilian energy matrix is the biomass, which is all organic matter, either animal or vegetable origin, used to produce energy such as is the case of the sugarcane bagasse. The bagasse is the fibrous residue after the sugarcane (*Saccharum officinarum*) harvest and the extraction of its juice. The excess of electricity generated in industries through the sugarcane bagasse burning can be exported to the electricity grid in a process of cogeneration. This work presents the potentiality of bagasse sugarcane in such important process in Brazil.**

***Keywords* — Bagasse Sugarcane; Cogeneration; Electricity; Energy; electricity grid.**

I. Introduction

Despite the Brazil having peculiar tradition in the cultivation and processing of sugarcane, initially for the sugar production and latter, in the early twentieth century, for the production of alcohol (ethanol) fuel, cogeneration from sugarcane bagasse is a newer idea. The future projections indicate the trend for significant increase in the production of sugarcane in Brazil for the period 2010-2030 going from 518.4×10^6 t /year to $1{,}141.2 \times 10^6$ t /year [1].

The sugarcane plant presents high bioconversion by photosynthesis, causing large amount of atmospheric carbon fixation in the biomass. After harvesting of the sugarcane, it rests residues that may represent up to 30% in weight of green matter and can provide an excellent source of animal feed and a valuable source of energy.

These residues are usually left in the field after the harvest of sugarcane, or sometimes the waste is separated and used, for example, for paper and fertilizer production. However, part of the waste of harvested sugarcane must be left in the field for agronomic reasons.

In Brazil there are currently hundreds of industrial plants producing fuel from sugarcane and the vast majority of them are of the type "mixed", that is, they can produce both ethanol and sugar [2]. Brazil is on the position of second largest producer of ethanol and the first largest producer of sugarcane in the world. However, in Brazil the distribution of the production is not homogeneous since more than 60% of all sugarcane produced in the country is located in the Southeast region (see Brazil map in the Figure 1).

II. Sugarcane Bagasse For Electric Power Generation

Brazil dominates the complete cycle of production of sugar and ethanol, since the crop productivity until the installation of the necessary equipments [3]. The bagasse generated can be used efficiently for power generation through cogeneration for energy use in the own plant that processes the sugarcane or inefficiently, to return to the cultivated fields as fertilizer, or simply burned, resulting in irreparable damage to the environment, with direct effects to the air pollution [4]. In addition, the bagasse is a source of organic matter, and it can contaminate the groundwater in cases of deposition of this bagasse directly in places where geomorphological factors facilitate such contamination.

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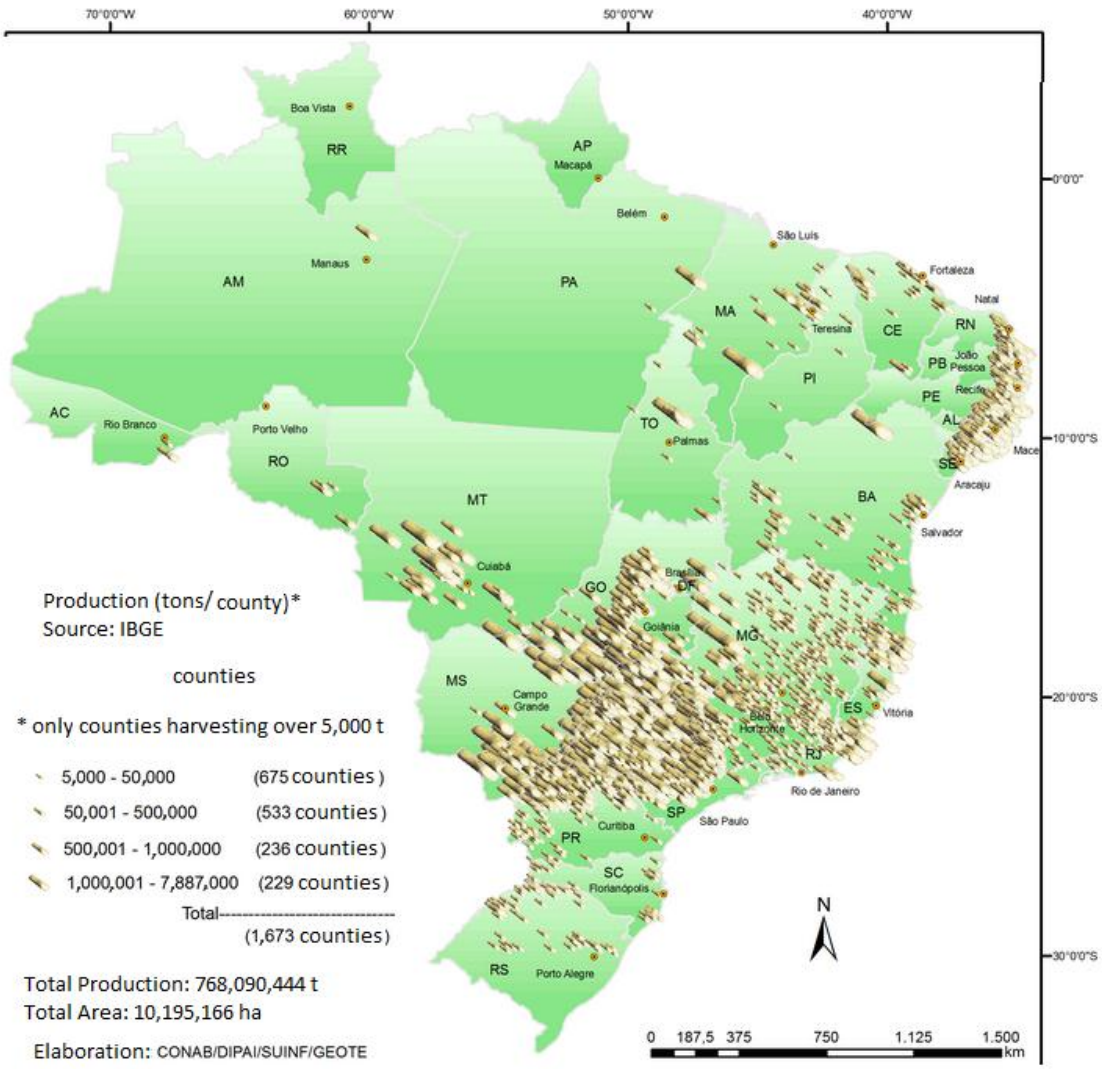

Fig. 1. Brazilian sugarcane production – Crop 2013. Adapted from [10].

In many cases, the bagasse, which is used for power generation to the sugar mill and/or alcohol, produces more energy than is required for the same. In this way, the excess energy can be exported to the electric grid [5].

In Brazil, cogeneration from bagasse and the use of ethanol fuel generates a net reduction of greenhouse gases, which allows the exportation of carbon credits. Figure 2 presents the basic steps of a cogeneration process. The net total of bagasse produced varies from 24% to 27% of the sugarcane processed [2].

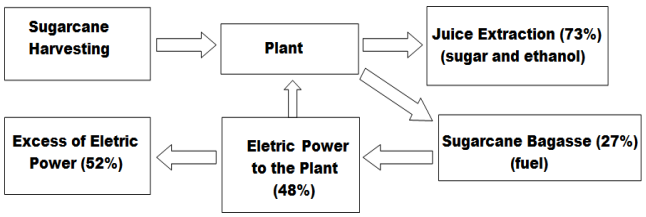

Fig. 2. General Cogeneration scheme using sugarcane bagasse. Source: Self elaboration

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III. Valuation Of The Sugarcane Bagasse Energy Potential In Brazil

According to [1] there is an expectative of increase in Brazilian sugarcane production for the period 2010-2030 reaching production of about 1,141.2 x 10^6 t / year. This represents about 308.12 x 10^6 t of sugarcane bagasse in one year if considering 27% of the total weight.

Obviously, there are several elements to consider that can affect the electricity production by the bagasse burning, such as the presence of humidity in the same. The bagasse drying techniques are expensive and must be carefully investigated. An experiment related bagasse calorific value according to the humidity present in the same concluding that it is possible to reduce the humidity to about 20% and, consequently, increase the energy performance of bagasse to u_b = 3,641 kcal/kg = 15,244.14 kJ/kg [6]. Therefore, considering that the annual bagasse production in Brazil will be about M_b = 308.12 x 10^6 t and the calorific value of the bagasse as u_b = 3,641 kcal/kg, the thermal energy generation, E_{th}, would be:

$E_{th} = M_b \times u_b$ = 308.12 x 10^9 kg x 3,641 kcal/kg = 1.1219 x 10^{15} kcal = 1.3 x10^6 GWht.

Moreover, it is necessary also to consider that at least about 52% of the total energy produced could be commercialized and also the fact that the industrial plants for cogeneration in Minas Gerais have an average efficiency to conversion of 30%. Then, it is possible to conclude that the total electrical energy, E_e, provided by the 308.12 x 10^6 t of sugarcane bagasse considered in these calculations is:

$E_e = E_{th}$ x 52% x 30% = 1.3 x10^6 GWh x 0.52 x 0.30 = 202,800 GWh.

These calculations were made considering that all the bagasse produced were converted into energy, therefore a theoretical estimate maximized. The aim is show the potentiality of this type of biomass and its importance to Brazil.

For a more realistic assessment of the situation it is necessary to investigate the current scenario. The analysis of installed capacity of cogeneration in the sugar-alcohol sector must initially to consider the number of industrial plants in this sector and also the prospects of introduction of new installations and/or extensions of existing ones.

The performance of the plants should be evaluated from the point of view of energy and exergy analysis, taking into account various technical characteristics of systems that compose the plants such as boilers, turbines, valves, condensers, etc as, for example, in the study done by Saint-Martin [7, 8].

IV. Using The Sugarcane Bagasse As Renewable Source

The use of sugarcane bagasse for power generation reduces carbon emissions into the atmosphere, as it replaces more polluting sources such as fuel oil and natural gas in power plants. In this case, the reduction of emissions is of the order of 0.55 tonnes of CO_2 equivalent for each ton of used sugarcane bagasse. In addition, sugarcane bagasse contributes to diversify the energy matrix, since the harvest of sugarcane corresponds to the dry season, where there is less hydroelectricity capacity - the main source of the Brazilian energy for electricity generation.

The burning of sugarcane bagasse has an extremely important role in the sugar and alcohol sector; at the same time, gives a destination to this residue, and takes advantage of its energy potential. In addition to meeting the energy needs of enterprises, since the 1980s, bagasse has allowed the generation of electric power surpluses that are provided to the Brazilian electrical system.

Sugarcane bagasse can have your energy potential availed through a so-called cogeneration technology as calculated before.

However, despite the renewability of sugarcane bagasse as a source of electricity generation, we must raise the question of the sugar and ethanol industry has air emissions during the production cycle of sugarcane. Manual harvesting, for example, involves burning emitting gases into the atmosphere. In addition, there is the use of fossil fuels on the steps of the production cycle, which is present in the operations of enterprises through specific machines to perform the collection, cutting and transport of sugarcane. In this way, the entire production of this sector process occurring atmospheric emissions. The difference is, however, in the type and amount of these emissions occur.

V. Conclusions

The production of electric energy from the cogeneration using sugarcane bagasse as fuel is characterized as a sustainable proposal to reduce the problems resulting from the electric power supply, which in turn is practically all attended, in Brazil, by hydroelectric plants. Nevertheless, while the two sources act as an integrated system, since the harvest of sugarcane coincides with the time of drought, there is the issue of minimization of social, economic and environmental impacts related to the construction of hydroelectric plants. On the other hand, Brazil cannot give up of the construction of large hydroelectric, even in the Amazon region.

And, still, the hydroelectric plants to be built must have reservoirs, in order to regulate the electrical system. The recent water crisis in Brazil is worrying and affects directly the hydroelectric power plants.

In this study, it was verified the great potential of the sugarcane bagasse to electricity production. Unfortunately, only a very low percentage of this potential is currently used in cogeneration. However the production of surplus electricity from burning sugarcane bagasse to feed the Brazilian energy network would be drastically increased if it would be considered the modernization of the installed plants in operation and, and in parallel, improvements of the techniques of bagasse drying and storage, that is, depending of the cost-benefit of each industry.

The theoretical calculation, considering the conversion of all produced bagasse in electrical energy, has shown that it would be possible to reach values still higher, demonstrating that it would be possible to increase the electricity production by means of an efficient use of sugarcane bagasse in Brazil. It can be concluded then that still there is a very high potential to be explored in the sugarcane bagasse cogeneration. In addition, the use of the bagasse for energy potential brings important economic and environmental gains.

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