



# Opportunity costs for bioelectricity sales in Brazilian sucro-energetic industries

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## ABSTRACT

This study is to analyze how to extend the sugar plants by a polygeneration technology to produce sugar, bioethanol, biogas and bioelectricity. The possibility of selling the bioelectricity to the national grid in Brazil is also investigated through optimizing the energy production at an industrial plant. The viability of the generation rates for renewable energy proposed by the regulatory bodies within the Brazilian electricity sector is analyzed. The plant's short-term planning was obtained by applying non-trivial optimal solutions that allow officials to choose the best alternative for planning production employing the most economical combinations of sugar, bioethanol, biogas, and electricity. We calculated the cost of exporting electricity to the electrical grid from January 2008 to December 2009, concluding that the spot market prices were too low to stimulate the sale of the bioelectricity to the electrical grid. Moreover, the remuneration guaranteed by the Brazilian Program of Incentives for Renewable Resources (PROINFA) was not sufficient to stimulate the sale of the bioelectricity. However, the price set by the Brazilian Electrical Regulating Agency (ANEEL) in the 2009 auction was sufficient to support exporting electricity for all the months except December 2009.

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## 1. Introduction

The Brazilian sugar industry has put forth much effort in recent years to improve the qualifications of its personnel, to use equipment that increases productivity and energy efficiency, and to make the most of the production capacity of its plants. However, it is necessary to integrate into short operational times those business decisions that bear in mind the highly variable nature of the prices of resources and products in different markets. These actions would allow us to optimize the operation of industrial plants during different time periods, allowing them to achieve the best possible profits.

Cogeneration in the sugar industry has a huge potential for producing bioelectricity and contributing to the security of the country's energy supply through an integrated production with residual biomass from the processing of sugar cane [1,2]. These small and mid-sized facilities are noteworthy for their suitability for quick construction, lower operational risks, and greater ease in obtaining environmental licenses when compared to conventional electrical plants. Thus, the generation of electricity to sell to the electrical grid is a viable activity that could reap a significant financial reward. Income that can be realized from the sale of electricity to the grid is dependent on the remuneration system, which is decided by the bodies that regulate the electricity sector. In the case of Brazil, the independent producers may opt to sell by means

of bilateral contracts through ANEEL auctions (Brazilian Electrical Regulating Agency) [3], remuneration set by the Brazilian Program of Incentives for Renewable Resources (PROFINA) [4], or by selling directly on the spot market. ANEEL's function is to regulate and control the generation, transmission, and distribution of power in compliance with the legislation and policies dictated by the central government. PROINFA's objectives are the diversification of the Brazilian energy matrix and a search for regional solutions through the use of renewable sources of energy. The PROINFA program aims to increase the use of wind and biomass sources and small hydropower systems to supply the Brazilian grid system through autonomous independent producers [5]. The medium- to long-term objective of the program is that the defined sources supply 15% of the annual market growth until they reach 10% of the nation's annual electric power demand or total consumption. However, the viability of electricity from cogeneration in Brazilian sucro-energetic industries has not been analyzed yet. In this article we study the opportunity cost of the bioelectricity generated in an advanced sucro-energetic industry in Brazil.

When it comes to the technical and economic management involved in running a sugar plant, the behavior of the different markets concerning the resources used and the commodities produced is a fundamental variable in any planning, especially for plants that produce different commodities (sugar, bioethanol, biogas, electricity). The prices of these commodities are vital in terms of the results of the production program to be adapted by the industrial plant in order to maximize profits. Fig. 1 shows the schematic process of the sucro-energetic industry considered in this research.

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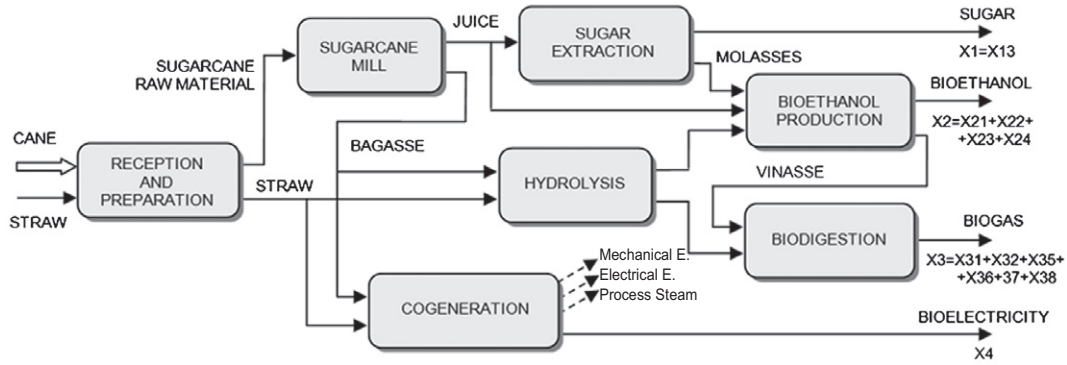


Fig. 1. Process stages of the production plant of sugar and ethanol.

The objectives of this research were to develop a model of the cogeneration of the industrial sugar plants and the optimization of energy production, as well as to examine the possibility of the plants selling electricity to the electrical grid in Brazil.

**2. Industrial cogeneration**

The production of electricity through a cogeneration process is an increasingly viable alternative that allows a region to improve

its energy consumption and the profitability of many industries. Over time, the cogeneration systems have optimized the use of the energy yielded by the fuels. It was this focus that led to the design of equipment that recaptures heat, such as the heat recovery steam generation system (HRSG) that retrieves the heat emitted by combustion fuels, which is, where we find the biggest percentage of available energy [6]. Technological improvements have allowed cogeneration to become an affordable and practical solution for a whole range of applications [7].

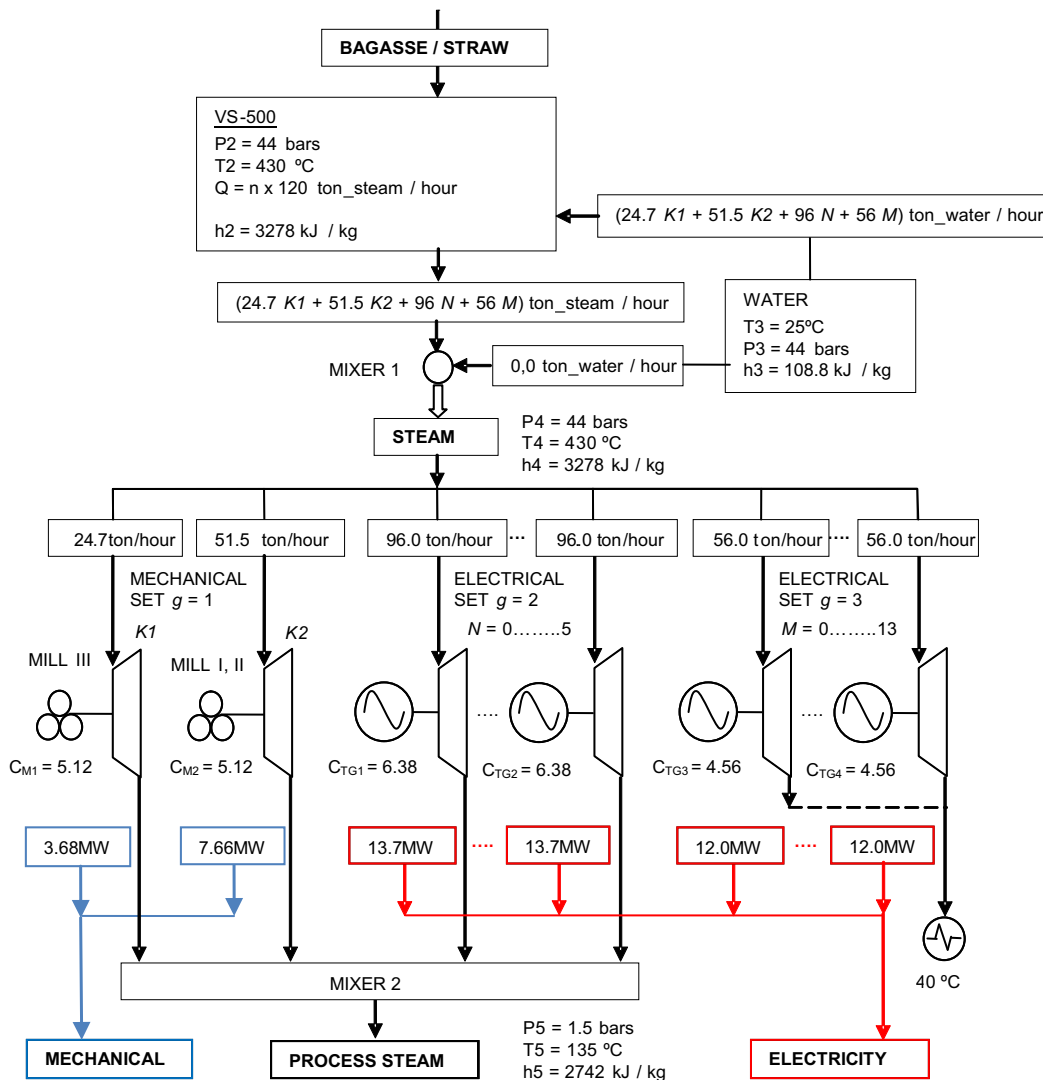


Fig. 2. Block diagram of the cogeneration stage.

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