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Scenarios for the second generation ethanol in Brazil

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ABSTRACT

The objective of this paper is to build scenarios for the ethanol industry in Brazil, considering the technology of the second generation ethanol. The theoretical framework draws on the field of studies of the future, scenario construction methods and concepts of stakeholder analysis. The method for constructing the scenarios employs techniques of environmental analysis, stakeholder analysis and consulting with experts. The variables "Creating subsidies for consolidation of second generation ethanol" and "Price of oil" formed the axes of the scenarios. Four scenarios were developed based on the contrast of the variables and on checking their internal consistency, as follows: "Cellulosic integration," where the second generation ethanol is the world fuel; "Bioelectrical world" with no investments on the production of second generation ethanol, "Fossil World" that shows the decline of the ethanol market, and "Apocalypse," which features an energy crisis. For each scenario, the respective plots and logic diagrams are presented. This paper presents two types of contributions: the first are the scenarios that can be used in the development of public policy and as a tool for decision makers working in the energy sector, the second contribution is to the knowledge of future studies to provide an orderly construction of scenarios.

1. Introduction

In Brazil, in the '70s and '80s, oil shocks led to a deficit in the balance of payments, causing the government to initiate an ethanol production program to replace gasoline usage. The Pró-Alcool, as it was called, aimed to produce ethanol as a vehicle fuel. The raw material chosen to produce ethanol was sugar cane (*Saccharum officinarum L.*) in light of Brazil's geographic features. The program lasted for three decades and managed to create a market for ethanol as well as a productive infrastructure of such a magnitude and scale that made ethanol production economically competitive with gasoline prices. Plants, research centers, universities, public and private companies, and a whole myriad of organizations were mobilized from the Pró-Alcool, finally resulting in the bioenergy program of São Paulo, currently the largest renewable energy program in the world (in joules of energy produced).

The technological development needed to establish this renewable energy matrix proved crucial. In agriculture, genetic improvements ensured the production of varieties of sugarcane that were more resilient and contained more sucrose.

Advances in biochemistry in recent decades provided the envisioning of a new way to produce ethanol. The possibility of producing ethanol from the cellulose of vegetables was discovered, in this case, transforming the timber of the sugarcane (bagasse) rather than its juice in ethanol through an enzymatic hydrolysis process. This new mode of production is called the production of second generation ethanol, or cellulosic ethanol.

The importance of taking the second generation production of ethanol to scale in times of global warming is easy to recognize. Nonetheless, if many technical studies have been and are being conducted for the development of second

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generation ethanol, no study was found in the literature that would forecast the future of second generation ethanol in Brazil in terms of industry. Thus, this study seeks to fill this gap and aims to build scenarios for the ethanol industry in Brazil, considering the technology of the second generation ethanol (cellulosic) with a horizon extending to 2020.

1.1. Historical background

Brazil has produced ethanol since its settlement in the 16th century. In addition to historical reasons, such as the demand for sugar and alcohol from the colonizing countries, geographical features, such as suitable land and favorable seasonal rains contributed to the cultivation of sugar cane in Brazil (*S. officinarum L.*) [1]. Although sugarcane is a vegetable originating from Southeast Asia, Brazil, over the centuries, became the world's largest producer of both ethanol and sugarcane [2].

Ethanol is a fuel whose technology for obtaining it is relatively simple and therefore its use has been observed from as early as the pre-Industrial Revolution. The first prototypes of the internal explosion engine, created by Samuel Morey in 1826 and Nicolas Otto in 1876, among other biofuels, were powered by ethanol [3,4]. However, with the industrial revolution and the discovery of oil, the use of biofuels as a source of motive power remained in the background.

In Brazil, programs to produce ethanol for automotive use began tentatively in 1927, the year the first alcohol pump was installed to supply vehicles for the civilian population [5]. However, most of the fuel used by Brazilian fleet came from petroleum derivatives. In the 30s, although both the quantities of ethanol produced and the automotive fleet circulating in the country were still small, the Brazilian government introduced a 5% blend of ethanol in gasoline [6].

In the first half of the 1970s, the Brazilian automobile fleet (mainly fueled with gasoline) already had a significant amount of cars, and it was in this context that Brazil suffered the first "global oil crisis" where the barrel had an increase from U.S. $ 2.70 to U.S. $ 11.50. This increase impacted the Brazilian trade balance since the cost of imported oil in the balance went from $ 469 million in 1972 to $ 2.8 billion in 1974. In response to this condition in the balance of payments, the Brazilian government launched three major projects: 1) the exploration of new oil fields, 2) the expansion of hydropower generation and 3) the substitution of petroleum products, especially gasoline, to ethanol [7]. Also in this phase, the compulsory mixture of ethanol in gasoline reached 24% [8]. In this context, the first phase of the "Pro-Alcohol" was implemented, in response to the first oil crisis, establishing a series of government incentives to consolidate ethanol as a vehicle fuel in Brazil [9].

In the early 1980s, due to the Iranian revolution, the "second oil crisis" began, with the price of oil rising from $ 24–26 in 1979 to $ 40 in 1981 [2,7]. This scenario made the Brazilian government intensify subsidies for the expansion of the "Pro-Alcohol" program, which entered its second phase. In the period 1980–1983 there was a vast expansion in the productive capacity of sugarcane and investments in industrial plants [10]. In the second phase, the cars were produced to work with hydrated ethanol, so that 96% of Brazilian automotive fleet, sold in 1985 was filled with a mixture of ethanol and water (92.6% ethanol), called "bioethanol" [7].

Fig. 1 shows the evolution of ethanol production in Brazil in the period between 1975 and 2009.

However, the late 1980s marked a period of crisis for the Pro-Alcool. At that time, the price of sugar had increased considerably, and the Brazilian government encouraged the export of sugar, making the production of this input increase at the expense of ethanol production. The stagnation of ethanol production, low ethanol prices (caused by the facility including in importing methanol), the political uncertainties regarding the Pro-Alcohol and increased oil production in the domestic market, led the Pro-Alcohol to a crisis in credibility. Due to this situation of uncertainty about supplies, the population stopped buying vehicles powered by ethanol [12].

The solution to this crisis came in the early 1990s, with the engines called "Flex-Fuel". In 2003, the combustion technology of different proportions between ethanol and gasoline in automobile engines hit the market. Thus, consumers are able to choose how to fuel their cars, regardless of the "blend" of fuel that was already in their car tank.

In the context of high oil prices, the "Flex-Fuel" technology gained ground. In the first year of its launch 48,000 "Flex-Fuel" vehicles were sold (4% of sales). In 2007, sales had totaled 86% of the light vehicle market in Brazil. The phase initiated by the "Flex-Fuel" technology ended the old government program "Pro-Alcohol" and gave rise to the "Bioenergy Program of the State of São Paulo." The State of São Paulo concentrates many of the almost five hundred existing plants in Brazil, which produce, in addition to ethanol, electricity derived from burning the remains of the harvest and milling of sugar cane [7,12].

Currently the total production of sugar cane in Brazil is around 560,000 tons (2012), and the production of São Paulo accounts for more than half that amount. Table 1 illustrates the situation of the 2012 harvest, as well as the Brazilian ethanol production reaching about 23 million cubic meters of input.

The sector is expected to increase production of 27 billion liters to 104 billion liters by 2025. However, to achieve this there must be a reduction of logistic costs, opening of international markets and development of new plant varieties through natural breeding and genetic improvements in sugarcane.

1.2. Technological aspects

The evolution of the cultivation and processing of sugar cane can be divided into two major phases: the agricultural and the industrial phases.

In the agricultural phase, there was the gradual mechanization of the field [14], with their harvest without burning the straw, i.e., when the sugar cane was mechanically harvested, it was not necessary to burn the straw from planting to harvest it manually. This aspect greatly increased efficiency in agricultural processes of ethanol production.

Genetic improvements in varieties of sugarcane were also observed. In the last thirty years, varieties of sugarcane were crossed in order to obtain production gain and quality. In this sense, genetic strains more resistant to pests and adapted to the climate and soil for various regions of Brazil were selected

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