Ethanol Production in Brazil: A Successful History

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Abstract

The Brazilian experience, regarding the use of ethanol as automotive fuel, began in 1923 by the addition of ethanol to gasoline. Since then, the proportion of ethanol to gasoline has changed throughout the years mainly due to fluctuations in sugar and alcohol prices in the international market. In 1975, the Federal Government launched the "Proalcool" program to reduce the country's dependence on oil importations that some years before had reached 80 percent of its oil needs. Nowadays, ethanol, sugar and bioelectricity have opened new perspectives and transformed Brazilian mills and distilleries into bioindustries for food and energy. The aim of this paper is to show the positive impact of the Brazilian ethanol program on the economy, engines, energy, employment and environment, as well as, price stability making sugar and ethanol, the role of bioelectricity and the forecast to next years.

Ethanol Production: Impact in Brazil

Since the beginning of the "Proalcool" program, the country has saved more than 140 billion dollars with imported oil and interests, while sugarcane production increased from 91 to 406 million tons per year in 2005. Nowadays, sugarcane is cultivated by more than 70,000 farmers in an area of 6 million hectares corresponding to less than 3% of the total cultivating area in Brazil. In the same period, ethanol production jumped from 0.56 to 16.8 million m^3/year while sugar production increased from 6 to 27.5 million tons/year. The development of new cane varieties, better soil practices, control of plagues and diseases, as well as new harvest systems, increased the field productivity from 53 tons per hectare/year in 1977 to 90 tons per hectare/year in 2005. During this period, the percentage of sugar in sugar cane was increased from 9.5% to 14% while the sugar extraction was improved from 88% to 96-98%. Moreover, by measuring and monitoring industrial parameters of alcohol fermentation processes, it was possible to improve the fermentation yield from 75-78% in 1977 to 90-92% in 2005. Today, there are 370 distilleries in the country, and the sugar and alcohol sectors employ more than one million people.

Some years ago, automobile industries developed new engines and launched flex-fuel vehicles, which are designed to operate on pure ethanol, pure gasoline or any combination of both. They have become quite popular in Brazil because of the high gasoline prices. Nowadays, there are more than 30,000 gas stations to attend to 16 million cars powered by gasoline blended with 20 to 25% of ethanol as well as more than 2 million cars running on hydrated ethanol only or in any combination of gasoline and ethanol (flex-fuel vehicles).

Concerning the environmental impact, the main benefit of ethanol use as a fuel has been the reduction of carbon dioxide, heavy metals and other toxic pollutant emissions in large cities like Sao Paulo and Rio de Janeiro. Ethanol is a clean fuel, and the production process is almost entirely sustainable because carbonic gas is recycled by sugarcane without releasing fossil CO_2 into the atmosphere in the same proportion as gasoline or diesel oil. Considering the entire production chain, there is a positive balance resulting from ethanol production processes because for each energy unit consumed, another nine units of energy are generated (Ometto, 2004). Furthermore, sugar cane removes CO_2 from the atmosphere, which is immobilized in organic matter in the soil. Because of its renewable process of production the distilleries have been considered potential candidates to receive carbon credits from the Kyoto Protocol.

Fermentation Process: Main Characteristics

Ethanol production in Brazil is done during a continuous sugar cane harvest season of 200-230 days. These industrial processes are based on large-scale fermentations of sugar cane juice, molasses or a mix of both in different proportions. Alcoholic fermentations have been carried out in very large fermentors with capacity from 0.4 to 2.0 million liters each. Despite differences among distilleries, there are two main fermentation systems: feed-batch and continuous fermentation (Amorim and Lopes, 2005). Approximately, 75% of the distilleries have used the feed-batch system. Moreover, the industrial fermentations are well characterized by their high yeast cell concentrations (8-17%), very short fermentation times (6-10 hours) and alcoholic concentrations between 6-11% (v/v). After the end of each fermentation cycle, yeast cells are centrifuged off from the beer and treated with diluted sulfuric acid for 1 – 2 hours at pH 2.0-2.5 to kill bacteria. After this treatment, the yeast cells are returnd to fermentation vats to start a new fermentation cycle. Yeast strains such as PE-2 and CAT-1 (Fermentec) or BG-1 and SA-1 (Copersucar) were selected from industrial fermentations by karyotyping techniques and evaluated in the laboratory for many years (Wheals, *et al*., 1999). These strains are adapted to industrial processes and show high resistance to stress conditions. In 2006, more than 190 distilleries began the fermentation process with selected yeasts strains.

Price Stability

Nowadays, the prices of sugar and ethanol have a strong mutual influence in Brazil. When the sugar prices in the international market are more profitable than ethanol, more sugar cane is milled to sugar production, while the molasses is sent to fermentation and ethanol production. In the last 30 years the percentage of cane sent to sugar production has been variable (from 26.5% to 86.3%) but has been around 50% in the last 5 years. Another aspect to be considered is international oil prices. When oil prices are above US$40, ethanol is competitive in Brazil (Carvalho and Oliveira, 2006). Ethanol production cost in Brazil is US$1.00 per gallon, while

the cost of ethanol production from corn (dry milling process) has been very close - US$1.05 per gallon (Shapouri, *et al*., 2006).

Bioelectricity

Many Brazilian distilleries are based not only on sugar and ethanol but also on bioelectricity production. Sugarcane leaves and bagasse can be burned to produce steam and electrical power for the industry as well as to be sold to electrical companies. Because sugar and ethanol are made during the dry season, it is advantageous to produce electricity during the driest period in the year, when water reservoirs are low. Sometimes there are problems with the electricity supply from hydroelectric plants during the dry season, but distilleries can supply this energy during critical periods.

Forecasting

Brazil has met appropriate conditions to develop its ethanol industry including economic and political stability, a large market and distribution nets for sugar, ethanol and bioelectricity, crop area, sugar cane varieties, know-how in alcoholic fermentation and specialized technical staff. Moreover, Brazil has all necessary technology and industries to build new mills and distilleries.

There are three important centers of plant/design builders in the State of Sao Paulo: Piracicaba, Ribeirao Preto and Sertaozinho. They supply projects and equipment such as samplers, milling tandems, diffusers, decanters, evaporators, centrifuges, distillation columns and any other equipment needed to build a mill.

Because of these favorable conditions, the forecast for the next six years is to expand sugar cane areas on to pasture land (Goldenberg, 2006). The total sugar cane area in Brazil will reach 8 million ha by 2012 (Biagi, 2006) while more new 89 mills will begin to produce ethanol and sugar. Brazilian production will reach 560 million tons of sugar cane, 27.3 billion liters of ethanol, 35 million tons of sugar and 6,000 MW of bioelectricity (Biagi, 2006).

Then, we have been witnesses that many mills and distilleries are building a successful history looking to new horizons based on ethanol, sugar and bioelectricity production.

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