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Ethanol Outlook in the Sugar Industry

The Better Sugarcane Initiative

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CARMEN BAEZ-SMITH
SMITH BAEZ CONSULTING INC
7040 SEMINOLE PRATT WHITNEY RD STE 2538
LOXAHATCHEE FL 33470-5714

Carmen Baez-Smith

Ethanol Outlook in the Sugar Industry

To stay competitive in today's global economy, flexibility and diversity in adapting markets seems to be the key to success. As the world turns to biofuels for alternative energy supplies, ethanol from renewable sources has emerged as a transportation fuel. At the same time, ethanol has brought to the sugar industry a new frontier with tremendous opportunities to both diversify its portfolio of products, as well as participation in new markets.

Brazil, arguably the world's undisputed leader in ethanol productivity has achieved the lowest production cost per gallon of ethanol. As a result, Brazil has successfully paved the way through excellent technological advances. However, ethanol production costs and profitability can vary with geographical delineation, climate, as well as sociopolitical elements. Therefore, finding a smooth transition to the productive world of the sugar-to-ethanol distillery requires a carefully planned strategy. In finding a successful strategy, a look at the potential of ethanol production by the sugar industry can be put into perspective by analyzing several features, including ethanol production, market opportunities and policies configuration.

Ethanol Production Profile

From the perspective of sugar production, it is sucrose the valued end product. For ethanol production, all sugars, including sucrose and reducing sugars (glucose and fructose) are fermentable and suitable as feedstock. Cane-derived ethanol can be produced either from sugarcane juice, molasses, or a combination of both. In Brazil the simultaneous production of sugar and ethanol makes the sugar production easier since it is not necessary to exhaust the molasses.

Although ethanol has been made since ancient times by the fermentation of sugars, a view of the process as it exists today brings up several important production features to the forefront.

Juice Extraction and Fermentation. The process starts when sugarcane is crushed while juice is extracted and clarified as in conventional sugar production. The juice is adjusted to a concentration of approximately 19° Brix and acidified to a pH between 4 and 5, while nutrients, vitamins, and in some cases, antibiotics are added. The mash, as the acidified juice is known, is pasteurized and sent to fermentation vessels, where about 5% yeast inoculums is added. The process continues as the well-known biochemical fermentation of the mash by Saccharomyces cerevisiae yeast produces ethanol and carbon dioxide. Because the reaction is exothermic, cooling is required. In addition, the fermentation vessels require a temperature of 32° C (90° F) to maintain the fermentation yeast culture. Fermentation time ranges from 4 to 12 hours.

The mixture at the conclusion of the fermentation process is called fermentation broth, which has an average ethanol concentration ranges from 7% to 11% in volume. The carbon dioxide produced can be purified, dried and compressed for sale as an industrial gas or it can be just vented to the atmosphere.

Fermentation Broth Centrifuging. After fermentation, the broth is sent to centrifuges for separation of the yeast. The concentrated yeast is recovered and returned to the fermentors after treatment. The light centrifuge phase or "deyeasted" broth contains approximately 9% ethanol, water, and in much lower quantities, sugars, protein, bagacillo, vitamins, aldehydes, glycerol, butanol, propanol, isobutanol, and other unfermented juice components. The deyeasted broth is also known as "wine."

Distillation Columns. The "wine" is distilled by a series of distillation columns where the ethanol will be separated from most of the water mixture. In the intermediate column of the multi-column distillation process fusel oils are produced. Fusel oils are a mixture of isobutanol, butanol, propanol and other higher molecular weight alcohols, which are withdrawn and sold as heating fuel. The stream collected at the bottom of the last column is mostly water with 5% to 10% of organic and inorganic compounds, which is known as vinasse. The production of vinasse is in the range of 10 to 15 gallons per gallon of ethanol and it is disposed as a fertilizer. The stream collected at the top of the last column is a binary mixture of ethanol and water with ethanol purity of approximately 96%. This is often referred as hydrous or hydrated ethanol because it contains 4% water. The hydrated ethanol can be marketed in this form or it can undergo further dehydration.

Dehydration. Traditional azeotropic distillation that uses a third component such as benzene or cyclohexane to further separate the mixture ethanol water is gradually being replaced by newer dehydration methods featuring molecular sieve technology to produce anhydrous ethanol. Whichever method is used, ethanol purity of 99.7% to 100% is achieved at the end of the dehydration process. This is called anhydrous ethanol. Typical overall ethanol recovery obtained in the distillation and dehydration processes is approximately 99.6%.

Denaturing. Ethanol that will be used for fuel is then denatured with a small amount (2-5%) of some product like gasoline or benzene to make it unfit for human consumption. Calibrated tanks measure the denatured ethanol, which is later removed by trucks for marketing.

Fermentation Yield. Theoretically for every pound of sugar fermented 0.51 pound of ethanol is produced, as well as 0.49 pounds of carbon dioxide. However, no process is 100% efficient and yield is lost when byproducts such as glycerol and fusel oils (higher alcohols such as butanol, propanol and others) are formed. Additional yield is also lost to yeast. As a result, a yield of 91% of stoichiometric is typically achieved during fermentation.

Assuming 91% of stoichiometric conversion, calculated yield is approximately 19.51 gallons of ethanol per ton of sugarcane when the sugar polarization in cane is 13.3%. This calculation takes into account the gain in reducing sugars as well as the losses in bagasse and filter mud. Consequently, the feedstock requirement is 0.05 ton of sugarcane per gallon of ethanol produced.

Markets Drivers

High expectations for biofuels demand on a global scale, in addition to energy supply crunches and price spikes on fossil fuels are well documented as the main drivers for biofuels production. The prediction of an explosive rise of energy consumption of the so-called emerging economies, in particular the largely populated countries of China and India seems to be part of the reason for this increase.

Globally, it is expected that production growth of biofuels will come from sugar feedstock. Among world producers of ethanol, recently the United States of America (USA) became the number one producer, closely followed by Brazil, in addition to China, India, France, Russia, Germany and many others. Most ethanol in the USA is made from corn. Worldwide, most ethanol is made from sugarcane. Currently, Brazil is using more sugar cane to produce ethanol than sugar, while India, Thailand and others will follow as global use increases. Last year, the USA alone produced 4 billions gallons of ethanol, while projections for the year 2012 are over 10 billion gallons.

The selling price of fuel ethanol varies with the price of gasoline as well as geographically. In the USA ethanol price per gallon ranged from $1.88 in the state of Wyoming to $2.14 in the state of Colorado by October 2006, and is projected to be at $2.40 by May 2007.

Policies and Ethanol Program

Fuel ethanol programs are being drafted throughout the world to support and stimulate production, but like almost every aspect of fuel and energy production worldwide, these programs do not spring up on their own. Fuel ethanol programs are tightly bound by a host of local and international factors, including national energy policies, national security policies, competing interests within the energy, agriculture and transportation sectors, and the international markets for gasoline, sugar, corn and any other raw material used for the fermentation of ethanol.

Among programs with considerable incentives, are the well-documented Brazilian ethanol program, and the USA program, which recently incorporated the U.S. Energy Policy Act of 2005 with the following incentives:

- Creates a $36 million program to convert sugar cane to ethanol in Hawaii, Florida, Louisiana and Texas.
- Creates a $250 million loan guarantee program for sugar to ethanol facilities.
- Creates a $50 million loan guarantee program for sugar cane ethanol facilities.

To fully realize the potential of ethanol production and the benefits it brings to the sugar industry, carefully designed programs must be adapted to local conditions. The timing seems to be right, as governments are eagerly incorporating appropriate legislation to help in the creation of alternative sources of energy.

Opportunities for the Sugar Industry

Efforts to improve production efficiency and economic viability in the sugar industry have traditionally focused on maximizing sugarcane yield, both in the agricultural and manufacturing processes. However, innovations in the sugar and ethanol processes are needed not only in the form of advanced technology to increase productivity, but also in the form of diversification of the byproducts in the distillery. Technological advances for the treatment of vinasse are important features in configuring a sustainable sugar-to-ethanol distillery.

The useful cycle of by-products and co-products can be extended in the distillery with vinasse serving as the feedstock for the production of methane gas and fertilizers. The economics of the ethanol distillery could be greatly improved by the deduction in production costs that each byproduct represents, as large byproduct credits are essential to making the sugar-to-ethanol distillery competitive.

Author

Carmen Baez-Smith, P.E., PMP is the president and CEO of Smith Baez Consulting, Inc. Phone: 561-762-5653; Fax: 772-402-4539, Email: cbsmith@smithbaez.com

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