SESSION 2: Ethanol Programs in Brazil and other Countries

Ethanol: Renewables Fuel Evolution in Brazil

Luiz Carlos Corrêa Carvalho
Alto Alegre Mill

Brazil learned how to produce and use ethanol in the early 20th century, during World War I. Ethanol began to be produced in a more planned and systematic manner in large scale in the 1970's, with the creation of the PROALCOOL, the National Alcohol Program, when this renewable fuel became extremely important to the sustained development of the sugarcane agro-industrial sector.

The different phases of the Program are presented along with their main conditioning factors and components up to the present day. We also seek to project possible scenarios with the expected development and implementation of public policies and the greater harmony among all stakeholders in the industry's production chain.

The analysis is based on actual historical data and the projection model, which point out, among other aspects, the positive strategy of the Brazilian agro-industrial model flexibility, as well as the key policies and laws that assure the sustained development of the sector.

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Bioethanol as an Oxygenator for Automotive Gasoline: Still a Possibility in Colombia

C.O. Briceño
Cenicaña, Colombia
E-mail: cobricen@cenicana.org

The Sugar Sector, located into the Geographic Valley of the Cauca River, has considerable investment potential, with the capacity for implementing a bioethanol pilot project for the entire country. It brings together the raw material, the geographic and agroclimatic conditions, the organizational capacity, research programs, a capacity for investment and long-term commitments and the development of an agroindustrial cluster in the region. This pilot program would serve to determine the actual costs of bioethanol production in Colombia and the sustainability of the project over time. Once the results of this project have been obtained in the Cauca Valley, this scheme could be expanded to several strategic regions of the country, with the technical support of the Colombian sugar sector, together with the other sectors involved in the program. Asocaña, the Sugarcane Cultivators Association of Colombia, has undertaken a series of studies related to the technical, economic and environmental feasibility of alcohol fuel production. Cenicaña, the Sugarcane Research Center of Colombia, is developing a project to establish the management and use of vinasse. The high incidence of Law 693 - 2001* requires the design and implementation of clear and precise regulations so that the investors are guaranteed security at the moment of carrying out the respective investments that a project of this nature demands. It is essential, therefore, that it become a stimulating factor and not a constraint for the development of this agroindustry; and most importantly, that the country as a whole benefits. The ethanol producers will need to be exempt from taxes including the sales tax as well as the other taxes that are applied to gasoline so that the distillery industry will be economically feasible. The supply of anhydrous ethanol must be ensured notwithstanding the fluctuation in the prices of sugar in order to prevent mistrust among the consumer public. An ethanol-based gasoline oxygenator program must be treated as a project for the nation, which means that the different public entities such as the ministries of Mines and Energy, Environment, Treasury, Agriculture, Transport, Development, Labor and National Planning have an important role to play, as well as those private-sector entities that wish to develop a sustainable and eco-efficient agroindustry.

* This law was promulgated by the Colombian Congress on the production, distribution and use of fuel alcohol blended with domestic and imported gasolines.

Keywords: fuel alcohol, vinasse, country, taxes, feasibility.

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Introduction a new Alcohol & Yeast Complex in Iran

E-Rezaee & M. A. Parsafar
Sugar Cane & Products Development Co., Iran
E-mail: btic-scbpd@yahoo.com

Islamic republic of Iran hás vast potential capabilities of sugar cane production, specially in Khuzestan province with extremely high yield per unit área of the land. The average yield in this province is about 100 t/hectar sugar cane and 11 t/hectar sugar respectively and the maximum yield is a high as top sugar cane producing countries in the world such as Brazil, South Africa and United States. This province has long term history of sugar cane production butmechanized cultivation of sugar cane in Khuzestan started about 40 years ago in Haft-Tappeh and followed by Karun Agro-Industry inco and Sugar Cane & By Products Development Company respectively.

As a result of country demands for more sugar productions and consumption as source of energy, urged the government of Islamic Republic of Iran to develop sugar cane cultivation areas. The Sugar Cane & By Product Development Co. that can be called the greatest

sugar cane development project in this region took place in the area of 84000 hectar virgin lands of Khuzestan province for establishing seven new sugar cane Agro-Industrial units.

This project is the biggest national project sugar cane Agro-Industry in history of Iran.

The main objective of this project is:

- To achieve economic independence.
- To achieve sugar supply need by the country sufficiently.
- To meet a main pant of national requirement in the field of paper, fodder, industry boards & Bio-technological products through 7 units of cane agro-industry.
- Following the overall operation of these agro-industries more than billion dollars annual income will accrue to the country.

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Potential for Fuel Ethanol in the Guyana Sugar Industry

Harold Davis & Lawrence Stuart
Guyana Sugar Corporation, Guyana
E-mail: HaroldD@Guysuco.com; LawrenceS@Guysuco.com

Sugar cane in Guyana is cultivated along the Atlantic Coast on some 50,000 Ha. Annual production is between 320,000 to 350,000 tonnes from 8 mills. Domestic consumption is 35,000 tonnes. The Industry is as a consequence heavily dependent on exports. At an average cost of production 17ë per pound, the industry is only profitable at the preferential price agreements the major proportion of its production is currently sold. It is now readily apparent that these preferential prices may be reduced significantly in the medium term and at worst disappear in the long term.

In the circumstances, the Industry has embarked on a number of initiatives aimed at improving productivity of sugar. These efforts have seen productivity increase from approximately 6 tonnes sugar per ha to over 7 tonnes sugar per ha over the last 5 years. The industry has also embarked on a programme of modernisation of plant and modest area expansion, which is expected to produce over 475,000 tonnes by 2010. Notwithstanding the cost of production of raw sugar is unlikely to sustain the Industry.

This study is one a number directed at exploring the potential of our sugar cane as a source of energy. These include co-generation for electricity and production of anhydrous ethanol for fuel. The studies centre around co-generation and distillery options centred around mills of 2600TCd to 4100 TCD capacity.

The production of anhydrous alcohol from final and hi test molasses for gasohol containing up to 24% ethanol has been indicated to be potentially advantageous for the Guyana sugar Industry, given the low prices currently paid for molasses and the fact that all petroleum products are imported. The requirement for a state subsidy is not indicated at this stage. Guyana would be able to pursue this option while at the same time providing adequate feedstock to the country's profitable Rum Industry.

Keywords: molasses, anhydrous alcohol, co-generation, gasohol

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SESSION 3: Automative use of ethanol

Vehicular Application of Ethanol Fuel

Henry Joseph Junior
Wolkswagen do Brasil, Brazil
E-mail: henry.joseph@wolkswagen.com.br

The ethanol utilization as vehicular fuel is increasing around the world. Many countries are introducing the ethanol in their energy matrix, due to environmental or economic problems. Frequently, this ethanol introduction is done through the blending with gasoline, but the straight use is also intended in some places. Since ethanol and gasoline are different compounds, chemically speaking, depending of ethanol content in the blend is necessary to adjust the vehicle fuel system and motorization for this new condition, in order to keep the good performance, drivability, durability and exhaust emission characteristics. This paper shows the main technical changes adopted by Volkswagen for their ethanol fueled products, for the Brazilian market, as well as reports the results and brings some comments on what is necessary to do for different ethanol level introducing.

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Environmental Aspects of Fuel Ethanol Use in Brazil

Alfred Szwarc
UNICA - União da Agroindústria Canavieira de São Paulo, Brazil
E-mail: alfreds@terra.com.br

Ethanol is a source of energy that can be used in various applications such as neat automotive and aviation fuel, it can be blended with other fuels like gasoline and diesel oil and it can be used also as a feedstock for hydrogen generation in fuel cells and biodiesel production. When produced from biomass, like it happens in Brazil, it can be classified as a renewable product, a plus in terms of sustainable development. Ethanol has also been classified as a clean fuel because of its environment-friendly characteristics. Ethanol from biomass can help to mitigate the greenhouse effect and its use as a fuel or blending component can contribute to reduce air pollution. Combustion of ethanol does not generate sulfur compounds, produces virtually no particulates and reduces emissions of carbon monoxide and unregulated toxics. Although aldehyde emissions increase with ethanol use they are mostly acetaldehyde, a species that is considerably less toxic and photochemically reactive than formaldehyde, which is a by product of gasoline and diesel combustion. Because ethanol is biodegradable under normal ambient conditions, ethanol does not represent a serious problem if compared with similar spills and leakages envolving oil or hydrocarbon fuels. It can be claimed that the large scale of ethanol use in Brazil has contributed significantly to halt air

pollution growth in urban areas, to avoid carbon emissions that otherwise would be release into the atmosphere and to lessen the negative impacts of accidental release of fuels into the environment.

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Specification and Quality of Fuel Ethanol

José Felix Silva Junior
Copersucar Technology Center, Brazil
E-mail: felix@copersucar.com.br

Brazil is the biggest producer of ethanol for fuel use in the world, and the average for the last 10 crop season was 12.8 million m3 , with 5.0 m3 for anhydrous and 7,842 million m3 for hydrated.

Brazilian specification for fuel ethanol is presented and the main parameters are discussed related to their use as fuel. The average quality of Copersucar hydrated and anhydrous ethanol are presented and shown that it complies with the specification.

The specification includes characteristics that are simple to measure and that needs equipment as densimeter (glass), titration, pHmeter and conductivity meter; and complex to measure that uses flame photometry, ion chromatography, specific titration, and atomic absorption spectrophotometry. The mill laboratory and major part of the distribution companies are not capable to measure all parameters, because the required investment to buy all the equipments is too high. In the sugar/ethanol mill, that costly equipment for the complex measurement are not needed, because there is no use for the results, provided by them, for the operational control of the factory.

Correlation of sodium and sulphate with pH and conductivity were significant and shows that the simple measurement is more than adequate to qualify the product for use as fuel.

Data of the percentage of anhydrous ethanol in gasoline and quality of hydrated ethanol at the pump station is presented and discussed.

Other parameters like surface tension and low heating value for different alcoholic strength are presented.

Since not all characteristics are measured by the factory and distribution system, suggestions are made to improve the specification and turn it more operational using only simple measurements that are possible to be measured on line.

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Fleet Test of Ethanol/Diesel Blends in Cane Transportation Trucks

Armando José Dal Bem and Gilberto H.Azevedo Koike
Virgolino de Oliveira S.A. Catanduva Unit, Brazil
E-mail: armando@gvo.com.br

This study has as objective the evaluation of the technical viability of anhydrous ethanol and diesel blends to be used as fuel in vehicles of load transport. The evaluation involves determination of behavior of the blend as for stability, vehicle performance regarding to power and fuel consumption and evaluation of the durability of components of the injection system. The experiment was developed through the blend of 7% of anhydrous ethanol and diesel, without the use of additive. The blend is submitted to agitation for a brief initial period and made available for fueling of a test fleet used in the transport of sugar. cane The test fleet used is composed by 5 vehicles Scania model R113E and 4 vehicles Mercedes Benz model LS 2635. A reference fleet of same models and amounts are used for comparison of results. The test fleet accumulated almost 3 million km, that represents an average of 310 thousand km for each vehicle. The fuel consumptions for the vehicles Scania R113E operating with the blend and with pure diesel were, respectively, 1.09 km/l and 1.13 km/l. For Mercedes Benz LS2635 the consumptions were 1.05 km/l and 1.10 km/l, respectively, for blend and pure diesel. It was observed, during the operation of the vehicles, a small loss of torque felt by the increased need to shift of gears. Regarding the durability of the components a great variation of results was observed not allowing, until the moment, a reliable statistical analysis. Considering the results reached until the moment it can be stated that the use of the 7% blend of anhydrous ethanol alcohol and diesel without the use of additive, for this type of engine that uses in line fuel injection pumps is technically viable.

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SESSION 4: Alternative raw materials for ethanol production

DHR - DEDINI Hidrólise Rápida (DEDINI Rapid Hidrolysis) - Revolutionary Process for Producing Alcohol from Sugar Cane Bagasse

José Luiz Oliverio, Antonio Geraldo Proença Hilst,
DEDINI, Brazil
E-mail: jose.oliverio@dedini.com.br; antonio.hilst@dedini.com.br

The DHR-Dedini Hidrólise Rápida (Dedini Rapid Hydrolysis) - process consists of using the hydrolysis process to convert sugarcane bagasse into sugars which, fermented and distilled, result in alcohol.

The revolutionary feature of DHR is due to the reduced hydrolysis reaction time - only a few minutes - in a continuous process enabling higher yields, few unit operations, minimum investment and reduced operating costs.

The process was developed from the end of the 1980's, in the laboratory, and then on a pilot scale, its technical-economic feasibility having been confirmed. At present, a semi-industrial plant of 5,000 liters of alcohol/day is installed at Usina São Luís, Pirassununga, São Paulo State, sugar and alcohol mill from Dedini Group and a affiliate to Copersucar. The resources for that joint Project came from Dedini, COPERSUCAR and the São Paulo State Fund for Supporting Research - FAPESP ("Fundo de Amparo a Pesquisa do Estado de São Paulo").

On reaching its full potential, DHR will have a large impact on the sector, making it possible to:

- almost duplicate the current alcohol production per hectare of sugarcane harvested;

- International competitiveness of alcohol with gasoline, at petroleum prices lower than US$20/barrel.

The following items shall be presented:

- what the DHR process is and what its main features are;
- current stage and potential;
- impact on production and productivity;
- economic impact;
- environmental impact.

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Estimates of Ethanol Production from Sugar Cane Feedstocks

B.P. Lavarack and R. Broadfoot
Sugar Research Institute, Australia
E-mail: r.broadfoot@sri.org.au

The continued low price for raw sugar on world markets has led to the investigation of alternative products for the Australian cane sugar industry with the overall aim of ensuring the long term viability of the industry. One of the potential major alternative products for the cane sugar industry is the production of ethanol for use as a blend in fuel for the domestic market in Australia.

This paper does not assess the marketing aspects of ethanol, but focuses on the calculation of yields and potential production of ethanol from various feedstocks available in the Australian sugar cane industry.

Yields of ethanol

There are numerous methods for reporting the yields of ethanol and some of these are discussed.

The preferred overall ethanol yield is the product of the Gay-Lussac yield for fermentation and the distillation efficiency and is on a mass basis. However, since the production of ethanol is normally reported (and sold) on a volumetric basis and overall production yields are preferred, the practice of quoting Gay-Lussac yields and distillery efficiencies are not often used in day to day factory operations

. Production levels for various feedstocks from Australian sugar industry production

The overall yield for the production of ethanol is assumed to be 87.1% which is regarded as good and assumes (i) a distillation efficiency of 99.0% and (ii) a fermentation efficiency of 88.0%. The equivalent overall yield in litres of ethanol (100%) per tonne fermentable sugar is 564 L/t fermentable sugar.

The potential production levels of ethanol (100%) from the fermentation of various feedstocks available in a sugar factory are assessed for the whole of the Australian sugar industry and are reported in the table below.

Table: Potential ethanol production rates for various feedstocks for the whole of the Australian sugar industry

Feedstock	**Approximate potential ethanol production, million L per annum**
Final molasses	280
B molasses	680
A molasses	1560
Raw sugar	3100
Evaporator supply juice	3400
Secondary expressed juice and final molasses from first expressed juice	750

The total petrol demands in 1989-1999 for Queensland and for Australia are 2887 million L/y and 16027 million L/y respectively. The required make of ethanol for the production of E10 blend for the Queensland market is approximately 290 million L/y and for the whole of Australia is 1600 million L/y. The Australian cane sugar industry will find difficulty in supplying the potential market demand for ethanol required for the E10 petrol blend in Queensland, with ethanol produced solely from final molasses. Alternate feedstocks will be required. The potential for the production of ethanol from secondary express juice should be explored as an additional carbohydrate source as it can increase the potential production to approximately 750 million litres per year, assuming all factories in Australia convert to this source.

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SESSION 5: Energy balance in ethanol production

Energy Reduction in Distillation

Frank Seemann
IPRO Germany
E-mail: seemann@ipro.de

A typical distillation scheme for the production of bioethanol from sugar cane products is shown and commented in relation to its steam requirements (both quantitatively and qualitatively) and technology employed.

Modern distillation schemes employed for producing bioethanol from sugar beet and grain products currently employ approx. 50 % less steam than typical sugar cane distilleries. Some of the modern distillation schemes are shown and the main differences (multiple usage of distillation vapours, temperatures, connections between columns, types of columns and plates etc) are highlighted.

Several schematics of energy efficient distillation schemes from different suppliers are shown, including main characteristics like total volume, types of plates and steam consumption.

Some suggestions on improving the typical "cane distillation scheme" are made with a view to reducing significantly its steam consumption.

Keywords: Steam requirements, distillation column technology, multiple vapour usage.

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Integration of Ethanol Production with a Sugar Factory Producing Maximum Cogeneration

Pedro Avram
IPRO Germany
E-mail: avram@ipro-bs.de

Cogeneration (meaning generation of electrical power for export to consumers outside the factory) has come in greater demand in recent years, due to more favourable prices for electrical energy of biomass origin. The paper shows basic characteristics of a factory redesigned for producing maximum generation, i.e. employing high pressure steam boilers, condensing-extraction turbines and electrified drives where possible.

The case examined also refers to a factory where approx. 50% of the sucrose (respectively ART) recovered from the entering cane is sent to the annexed ethanol distillery. In order to increase the cogeneration potential of the sugar factory, it is worthwhile examining possibilities to reduce the steam consumption in the distillation process. When employing low pressure steam and multiple vapour usage in the distillation plant, the steam consumption there can be reduced to approx. 50% of conventional schemes widely in use.

The combined effect of a cane sugar factory designed for maximum cogeneration coupled with an energy efficient distillery appears to be a financially attractive proposition, especially at price levels paid for selling electrical energy in some major sugar producing countries like Brasil and Guatemala.

Keywords: Factory steam requirements, high-pressure boilers, electrified factory, energy-efficient distillery.

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Life Cycle Analysis of Energy Use in Sugar / Ethanol Production

I.C. Macedo and M.R. Leal
NIPE/UNICAMP
Copersucar Technology Center, Brazil
Email: regis@copersucar.com.br

The sugar cane plant has a considerable energy content but only about one third of the potential is converted in useful renewable energy under today's practices. Nevertheless, even with the inefficient technology used today to produce ethanol from cane the energy balance is highly favorable when the renewable energy output is compared with the fossil energy input.

This work presents a life cycle analysis of the energy flows in the process of sugar cane production and processing to produce sugar and ethanol. Three energy levels are considered in the analysis:

- Level 1: Fuel and electric energy directly used in the production process (agricultural and industrial).
- Level 2: Energy used in the production of chemicals, lubricants, fertilizers.
- Level 3: Energy required for the fabrication, erection and maintenance of equipment, structures and buildings.

The results of the analysis are presented for each level and green house gas emissions reductions are estimated for the present use of bio ethanol in Brazil.

Alternatives to improve the energy balance and the GHG emissions are indicated, using the sugar cane trash to generate electric power.

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SESSION 6: ethanol production technologies

PDE Process for Beer-Enrichment-Based Lowering of the Steam Consumption in an Azeotropic Dehydration of Ethanol.

Sergio Barreira and Antonio D'Ávila
DEDINI, Brazil
E-mail: sergio.barreira@dedini.com.br; antonio.davila@dedini.com.br

The PDE process for lowering of the steam consumption in an azeotropic dehydration of ethanol, is based on the fact that beer with higher ethanol contents requires less energy per unit of alcohol produced in the plant. Basically, it consists in an alcohol content enrichment of the plant feed beer, as long as the process of enrichment provides energy enough to the dehydration column demands.

The main features of the PDE process can be resumed by an optimal engineering system, where controlled beer enrichment in a PDE-specific distillation column is attached to the dehydration column, in order to provide energy enough to find the dehydration column demands, using the latent heat of condensation of the product of alcohol enrichment.

This process has been developed in a 400 klpd plant, where all of modifications, improvements and optimization has been accomplished since 2001, when was born the project concept at Dedini S/A Ind. de Base. Since then, a careful engineering has been developed in order to enable the attachment between enrichment system and dehydration column energy demands.

The process represents a flexible, good solution for systems where 1 - beer alcohol content is not economically advantageous, in an example below 6oGL; 2- in case of higher alcohol contents, where the process requires lower steam consumption; 3- It is necessary to increase the production of alcohol, but no further steam are available at plant.

We intend to introduce the following PDE process topics:

- What is the PDE process - Process diagram including.
- The main features of PDE process.
- The proper applications for PDE process.
- Impact of PDE process on the steam consumption of a typical ethanol plant.
- Present stage of development and perspectives.

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Ethanol Dehydration by Zeolite Membrane

Kori Yamada
Bio Nanotec Research Institute - BNRI, Japan
E-mail: k-yamada@BNRI.co.jp

BNRI (Bio Nanotec Research Institute) Inc. - Mitsui & Co subsidiary, having in mind the growing anhydrous alcohol market, has developed this technology for dehydration of ethanol, which presents: high energy savings, simple operation, no risks of product contamination.

The ethanol dehydration is performed by zeolite membranes, which are supported on porous ceramic tubes and housed in steel vessels. The process receives 93 wt% ethanol as a feed and produces 99.5 wt% (minimum) ethanol. The feed is vaporized and compressed to 150 kPa (absolute pressure) before feeding the membrane modules. Due to the cavity (pore size : 0.4 nm) of zeolite, the membranes allow only water to permeate into the ceramic tubes, where a 0.7 kPa (absolute pressure) vacuum is kept.

Then, the ethanol-enriched vapor is condensed, and this energy is recovered by heat exchangers to heat the ethanol feed.

The permeated water is discharged from the membrane modules, and is condensed and cooled by chilled brine.

This is a continuous process, that is, all the membrane modules work in series, and don't need to be regenerated, because the water is not adsorbed into the zeolite.

t present, there is a 100 L/h pilot plant in operation at "Usina Costa Pinto" (Cosan group - Piracicaba-SP). The test will be performed during almost 6 months (from April/2003 to September/2003), and we already have great results. In a 5 hour daily operation, this pilot plant is producing 99.65 wt% ethanol, even when there are small variations in the feed ethanol content.

Keywords: Ethanol, Dehydration, Zeolite Membrane, Anhydrous.

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Survival in a Raw Sugarmill through Cogeneration and Ethanol Production

David Heck
Rocky Point Sugar Mill and Distillery, Australia
E-mail: davidheckgroup@ozemail.com.au

Rocky Point Sugarmill is the smallest mill in Australia, as such it can not rely solely on the income from the production of 'industrial' sugar utilizing 'traditional' milling techniques. Due to this inability to take advantage of economies of scale it has embarked on a number of value adding and by-product ventures, one of which is a study into the use of alternate high impurity sugar streams and different ratios of molasses within its distillery operations.

Last year, with the installation of a new 70bar.a 30MW cogeneration plant by a GOC, the mill converted all steam prime movers on its milling train with electric/hydraulic/mechanic independent drives, including six roll mills first and final, and two x two roll intermediate mills.

All process steam was supplied from the vapour of a new 2500m^2 modified Roberts (BFEL, Wright, et.al) first evaporator in a quin set. This vessel was driven by a 2.7 bar.a extraction from the generator turbine.

Steam on cane was reduced from 52% to 41% in addition to 6 tonnes per hour to its distilling operations, which until now have used

molasses as the only source of fermentables.

The mill crushes on average 350,000 tonnes cane each year. Breakeven for last years operations was 400,000 tonnes at AUD $250/tonne sugar. With current prices below this, the mill must increase its annual average production to over 400,000 tonnes and reduce its unit costs. The groups distillery produces on average 2M LAL's per annum (240LAL's/tonne molasses using saccharomyces yeast).

Findings from last year to embark on increasing ethanol production at the expense of producing crystal sugar showed there was no definite fuel alcohol market, and the small sales available were at unacceptable prices, linked to a Platts95 and exchange rate.

Back then this price was around 60cpl and today it is more like 55cpl, or the effective breakeven for the distilling operations.

A study was undertaken in any case to determine from bench top trials and juice stream analysis, the financial effects of alcohol production and energy savings in diverting a filtrate stream to batch incremental feed fermentation.

If the research theory was correct, the steam saving, that normally used to evaporate the filtrate should reduce by 3-5 tph, crushing rate should increase due to reduced impurity recirculation by 10-20tph (the mill is pan and fugal capacity limited) and season length should correspondingly reduce by almost 4 weeks, critical to reducing unit costs and ensuring the longest growing season and tonnes cane (400,000+ tonnes) for the following year. Ancillary benefits include lower colour and better quality sugar for local markets.

The biggest benefit envisaged from the joint cogeneration's year round operation, burning woodwaste as the alternate renewable fuel to bagasse, is year round steam for the distillery, using either stored molasses, maize or sorghum as the fermentable.

The trial involved taking a side stream of filtrate from the rotary vacuum filters, cooling to 35degC and incremental filling of a fermenter while keeping the brix below 30, and temperature below 32degC. The fermenter was set to achieve a 10% ethanol yield adjusting fermentables according (90% fermentation yield), approximate ratio 1:5 molasses:filterate. Fermentables in filtrate was 10% and molasses 48%.

An area to watch is cleanliness of the filtrate side stream, particularly the elimination of bagacillo. We found considerable fouling of PHE's from not screening the side stream trial, spending 2 hours filling a fermenter and 2 days reinstalling the plates! As such, the remainder of the trial was done small scale in the laboratory.

Results of the study confirmed the initial research theory, in addition to showing it better to sell molasses throughout the season when prices were over AUD$140/tonne and use a grain giving DDG's as the by-product rather than incur disposal costs for dunder out of season.

The other interesting outcome was that rather than use ground water for diluting the molasses to below 30 brix and obtaining 7.5-8.5% random ethanol yields in the fermenters, using filtrate reduce the yield losses from bacteria and high TDS (limiting osmotic pressure) in the groundwater, allowing more consistent yields of 8.5-9.5%. What was not confirmed and needs further study is the potential to reset a molasses fermenter using the dunder from a filtrate first run fermenter.

One disadvantage with utilising the latest technology for the co-generating plant was that there was a considerable increase in mill effluent (high BOD) to dispose of or treat. Using filtrate reduced this load considerably. Similarly, with cogeneration, there is the added revenue stream of the renewable fuel (bagasse) as well as sugar, molasses and ethanol. HPLC cane maturity test indicate that although early cut cane was lower in CCS (sucrose content) certain varieties still have high total sugars (fermentable) levels, allowing the mill to start early on crushing cane to produce ethanol, then switch to crystal sugar as purity increases.

Keywords: energy efficiency, capital utilisation, season length, alternate fermentables.

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Antibiotics Use Reduction in Continuous Alcoholic Fermentation

Idalina Spina,
Santa Adélia Mill

Santa Adélia mill, since 1988 makes ethanol using a Copersucar Continuous Fermentation process, that has a production capacity of 710 m^3ethanol/day, presently making 515 m^3 ethanol/day.

Due to the increase in sugar production, the proportion of ethanol production was reduced from 75% to 45%, what lead to the use of a lower purity molasses (today around 55% purity). In these new conditions some problems of the continuous fermentation were amplified and aggravated, making the antibiotics use to reach 18.1 g antibiotics/ m3 ethanol in order to keep the bacterial infection below 25% (25 bacteria/ 100 yeasts).

In order to solve these problems, several modifications in the process were tried such as avoiding solids accumulation, increasing the turbulence in the tubes, elimination of dead zones, replacing low efficiency cleaning systems by better ones, putting CIP procedures to work in the heat exchanger section (for cooling the substrate and the fermentation mash), avoiding solids accumulation in the molasses tank and also many other details of the process and the operation were optimized to diminish or eliminate places where the bacteria could grow.

Following the 2002 crushing season, it was possible to see significant improvements due to the use of better process and operational procedures. The antibiotics use was only 5.5 g antibiotics/ m^3 ethanol and the bacterial infection dropped to 18.5%, with a molasses purity of 57.8%. In the present 2003/2004 season, the antibiotics use is around 4.5 g / m^3 ethanol and the infection at 12.2 % but with a better molasses purity, of 68% (due to an increase in the ethanol production and corresponding reduction in sugar production).

The continuous fermentation process, as presently managed, is showing good operational results but has not reached (till now) a higher level of final ethanol concentrations, since it is being operated at 6.9-7.5 oGl (% ethanol, v/v).

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Evolution of Ethanol Production Process in Brazil

Jaime Finguerut
Copersucar Technology Center, Brazil
E-mail: jaime@copersucar.com.br

In this work it is shown that there has been significant improvements in several important features of the brazilian ethanol production process such as the final alcoholic content, the yeast concentration, the fermentation time and the ethanol yield, all them highly related to the production cost.

It is also clear that the raw material, molasses and / or sugarcane juice, interferes significantly in the overall performance, being much easier having better results with a greater purity substrate (more sugar cane juice and / or a greater molasses purity).

In terms of ethanol separation, concentration and purification, the process of distillation, the conventional, typical, brazilian process is not optimized in terms of steam and water use These points will be subject of great improvements in the near term mainly because now it is much clearer that bagasse will have better uses than burning with a relatively low efficiency to generate steam that will be used with low efficiency in the distillation process.

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Productive Diversification of Guabira Sugar Factory

Américo Vera
Ingenio Azucarero Guabirá S.A. Bolivia
E-mail: destileria@guabira.com

Why was the Project Implemented?

- Adaptation need to markets opening, because the next agreement of free-market in the south American area . Therefore is essential to implement of effective politics of cost reduction.
- Hold trends of decreasing sugar prices in scale worldwide.
- Missing utilization of agricultural potential.
- European demand of alcohol proceeding from Pacto Andino countries.
- Imminent increase of alcohol demand for fuel use in local and international market.

How is the project being implemented?
First-phase. Year 2002

a. Increase fermentation capacity.

b. Installation of a distillery for production of high quality alcohol. 150.000 l/day capacity.

Second-phase. Year 2003

Increase sugar milling capacity and modernization.
Old capacity. 7.000 TM/day (with two tandem of mills).
New capacity. 10.000 TM/day (with one tandem of mills). Third Phase. Year 2004

a. Steam generation capacity enlargement.

b. Installation of an anhydride alcohol distillery for fuel use.
200 000 lts/day capacity.

Fourth phase. Year 2005
Energy cogeneration

Until 2001, we assign the 18% of sugars from sugarcane to alcohol production. During the present harvest, this percentage has been increased to 40%. When the Bolivian government authorize anhydride ethanol for automotive use, we will give up to a 50% of sugars from incoming sugars to alcohol distillery.

Results:
Although the project has not been realized in its totality, until this date obtain results are the following:

1. Increase in sugar cane crops. Benefits of scale economics for farmers, owners from our factory.
2. Increase in sugarcane milling and improvement of efficiency.
3. Increase of processing capacity of sugar factory.
4. Cost reduction due to:
   - Less operative costs in milling.
   - Optimization of energy use.
   - Better quality products.

- Upper levels of milling and efficiency.
- Scale economics for Guabira factory.

Conclusions:
The objective for improve our reliability has not been accomplished in its totality. Implementation of diversification politics to ethanol and modernization of our processes have generated important savings, principally for effect of scale economics.

The implementation of energy-fuel politics based in fuel alcohol by the Bolivian government is an essential aspect for improve our competitive position that will have direct effect in our agricultural development.

Our Company is conscious that every technological development in sugar and alcohol conversion process, or another derivate products, is very important in order to maintain us in the market. Therefore, research and investment in technology are taken as priorities for the Directory.

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SESSION 7: BY-Products of the ethanol production

Alternatives for the Use of Yeast and its Products

Karl Heinz Leimer
Copersucar Technology Center, Brazil
E-mail: karl@copersucar.com.br

The production of distiller´s yeast has been increasing during the past 20 years utilizing the excess-yeast from the ethanol production. There is still a big potencial for an increase of the yeast-production, since only part of the distilleries are recovering yeast at rather low levels.

Practically all this yeast has been directed to the market for animal feed supplement.

New routes for producing yeast autolysates, yeast cell wall, yeast extract and concentrated yeast protein from the untreated yeast cell may open new possibilities for utilizing yeast for different applications in animal feed and human food , as well.

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Sugar Plant Bases Co-Products & Co-Generation

Narendranath Mullapudi
Andhra Sugars Ltd. India
E-mail: asltnk@vsnl.com

The Andhra Sugars Ltd located in South - Eastern India started operation in 1952 with sugar production and diversified into the production of various products based on the Sugar Plant.

In fact, nothing goes waste at The Andhra Sugars Ltd. MOLASSES which is a by-products from the sugar plant is used to produce INDUSTRIAL ALCOHOL & ETHANOL. The CARBON DIOXIDE that is a by-product at the Alcohol Plant is collected, scrubbed and used in the production of SALICYLIC ACID - an intermediate for ASPIRIN and also used in the sugar plant.

From Alcohol ACETIC ACID, ACETIC ANHYDRIDE, ETHYL ACETATE AND BUTYL ACETATE are produced. ASPIRIN is also produced in this complex using ACETIC ANHYDRIDE and SALICYLIC ACID as raw material. The SPENT WASH from the Alcohol Plant is put thru a BIO - DIGESTER. The METHANE gas is collected and used as FUEL in the BOILER. The liquid that leaves the bio - digester is sprayed on the PRESS MUD that comes from the VACCUM FILTERS at the Sugar Plant and a COMPOST is produced. This Compost is given to the Cane Farmers to use on their Farm.

BAGASSE which is another by - product from the Sugar Plant is used as fuel in CO - GENERATION to produce ELECTRICITY. With the use of a Cane Diffuser - Bagasse Dryer and High Pressure Boilers, our Sugar Unit - II generates surplus power by using bagasse and cane trash as fuel. This helps to produce lower cost electricity and generates a third of the revenue of this Sugar Unit.

At The Andhra Sugars Ltd. EIGHT products and Electricity are produced based on by - products from the Sugar Plants.

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Vinasse: A Liquid Fertilizer

Jorge L. Donzelli, Claudimir P. Penatti andSérgio A.V. de Souza
Copersucar Technology Center, Brazil
E-mail: donzelli@copersucar.com.br

Vinasse is a byproduct of alcohol distillation process. On average to produce one liter of alcohol 13 liters of vinasse is produced. This value ranges from 10 to 15 liters, depending on cane quality and the industrial process.

Presently Vinasse is applied in sugar cane fields through a process called ferti-irrigation as a partial or total substitute for mineral fertilizer (potassium). Vinasse applied at adequate rates is a soil physical and chemical ameliorant that increases sugar cane yield.

Depending of Vinasse potassium concentration, soil type and fertility, rates of 100 to 300m3 ha/ha are environmentally safe for Brazilian conditions.

The main methods for Vinasse application are: Direct application by truck, trucks for transport and application through self-propelled sprinklers and/or canal transport and application through sprinklers.

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SESSION 8: Other Co-products from sugar cane

A Review of Sugar Cane Potential for the Poduction of Chemical Products

Carlos E. V. Rossell
Copersucar Technology Center, Brazil
E-mail: rossell@copersucar.com.br

In this work it is shown that there is a great potential for producing chemical products from sugar cane associated to the current Sugar, Ethanol and Energy production at the Sugar Mill. Mill can provide thermal and electrical needs as well as utilities. Sugar, Ethanol, Bagasse and Filter Mud are the more important raw materials.

Chemical and Biochemical routes are combined to produce valuable chemicals such as organic acids, amino acids, polymers, solvents, flavoring agents, manitol, sorbitol, furfural, xilitol, ethanol derivatives, waxes, sterols and many others.

Some examples of commercial production of these chemical products are shown.

The work emphasizes the advantage of producing these chemicals from agricultural renewable materials, without increasing carbon dioxide emissions.

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Biodegradable Plastic (PHB) from Cane Sugar- CTC Production Process

Paulo Eduardo Mantelatto and Carlos E. V. Rossell
Copersucar Technology Center, Brazil
rossell@copersucar.com.br

Polyhydroxibutirate, a polyester of 3-hydroxybutiric and its derivatives are natural thermoplastic polymers which show biodegradable and biocompatible behavior.

They can be produced from cane sugar by aerobic fermentation of Ralstonia Eutropha.

CTC has successfully developed an Industrial Process for the production of this bioplastic. The goal of the process is to integrate it to a Sugar Mill producing sugar, fuel ethanol and the PHB. The raw material sugars as well as Steam for electric power and heating duties are provided by the Sugar Mill.

The process involves a biological step in which a pure culture of Ralstonia microorganism is multiplied in several steps from a stock tube to a prefermentor.

At the final fermentation step cell biomass is grown at a high density and then inverted syrup is fed with the aim of accumulate a high percentage of intracellular polyester.

This is followed by physicochemical step which involves biomass inactivation, harvesting and washing. This biomass sludge is submitted to countercurrent solvent extraction with Isoamilic Alcohol. Raw extract is clarified, PHB precipitated after cooling. The PHB Gel suspension is concentrated by microfiltration and organic solvent is removed by multistage evaporation. The resulting PHB size controlled particles are dewatered and dried.

The economical feasibility of this process has been proved; CTC has licensed PHB Ind. SA for the commercial use of it. Actually the process is running at a demonstration plant.

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Biocomposting of Sugar Mills Effluents

Zahid Mehmood
Shakarganj Mill Limited, Pakistan
ssugar@jmg.pakmet.com.pk

Sugarcane after harvest finds its way to the crushing mills, where Juice is extracted from the cane. Juice, in turn, is clarified and evaporated to turn it into sugar crystals. Filter cake and Molasses are produced after clarification and centrifugation as co-products.

Sugar in Molasses is converted into ethyl alcohol through Fermentation process at Distillery. The liquid waste obtained after primary distillation of fermented mash is drained as stillage or spent wash. Filter cake, a solid waste of sugar factory and stillage a liquid waste of distillery if composted together, the stuff can be turned into a useful product, Biocompost, containing all the non-sugars which the sugarcane brings from the soil.

At Shakarganj filter cake is transferred to the composting plant to provide organic matter and phosphates. Stillage, a rich source of potash, nitrogen, phosphate, iron, manganese, zinc, copper, boron and single cell protein (SCP) is sprayed on the filter cake.

Conclusions

a. Biocompost increased the efficiency of nitrogen, phosphorous and potassium thus saving in the use of costly chemical fertilizers through complimentary effect.

b. Utilization of Biocompost was the best way to exploit the environmental polluting effect and to improve the soil and plant health.

Keywords: Fermentation, Mash, Distillation, Biocomposting, Single cell protein.

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SESSION 9: integration of co-production with the sugar factory and energy cogeneration

Sharing of Revenue from Cogenerated Bagasse Energy in Mauritius

Dr. Kassiap DEEPCHAND
Mauritius Sugar Authority, Mauritius
E-mail: msatm@bow.intnet.mu

In Mauritius, export of electricity from sugar factory based power plants to the public grid started in 1957 when one sugar factory sold 0.28 GWh of electricity in an intermittent form to the grid. The price obtained was Mauritian Rupee (MRs) 0.165 (1 US$ = MRs28 in 2003). All the revenue from this export accrued to the miller.

From then on, more and more sugar factories started to export intermittent electricity to the grid and the amount exported reached 25 GWh by late 1970's. The same kWh price was paid to the producers and the revenue accrued to the miller only.

The other milestone in bagasse energy generation was in 1980 when one factory, Médine, operating at 170 TCH entered into an agreement with the utility for continuous (crop season only) power export (6 MW) to the grid. In 1985 another factory (FUEL) operating at 250 TCH commissioned a firm power plant of 21.7 MW using a condensing-extraction turbo alternator operating on steam at 44 bars. Bagasse was used during crop season and coal was the offcrop fuel. With these 2 additional plants, the amount of electricity exported from bagasse reached 70 GWh. The revenue from sale of power again accrued in toto to the millers.

Significant development on electricity export from bagasse occurred thereafter. The electricity export from sugar factories to the grid increased to 700 GWh in 2002 of which 300 GWh was from bagasse with the implementation of an additional 112 MW installed firm power capacity and 200 MW of continuous power capacity.

Concurrently as from 1982 cane growers started lobbying for benefits from the proceeds of the electricity sales and in 1985, growers were given Rs100 (US$3.50) per tonne of bagasse used for electricity export to the grid. A Bagasse Transfer Price Fund (BTPF) was created and proceeds from this Fund was distributed to growers and subsequently a sharing of formula was enacted which made provision for accruals to the BTPF to be shared to the power companies, the small growers and the corporate (or miller-planters). The evolution of the sharing formula over time will be presented in details at the Workshop.

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Factors Influencing Surplus Electricity Production in Bagasse Co-generation Plants

A.F. Lau, K.T.K.F. Kong Win Chang and D. Gunness
Mauritius Sugar Industry Research Institute, Mauritius
E-mail: skong@msiri.intnet.mu

Bagasse cum coal co-generation plants, in partnership with the sugar cane industry in Mauritius are becoming major players in the electricity production sector. Power sales to the utility, using bagasse and coal as fuel has reached 300 GWh and 447 GWh, respectively. This represents 43 % of the country's total electricity demand in 2002. With an annual cane production of 5.8 million tonnes, surplus electricity production using bagasse as the sole fuel can potentially attain 800 GWh with the conventional steam cycle.

The large disparity between the output of the most and the least efficient co-generation plants is not solely a matter of technological superiority, e.g., high pressure boilers. Factors such as fibre % cane, moisture % bagasse, boiler efficiency, process steam consumption and electricity consumption in the mill, influences surplus electricity production. It appears that cane with a high fibre content, when burnt in an efficient boiler, not necessarily at very high pressure, can achieve a satisfactory performance, in terms of surplus electricity. Typical figures from Mauritian co-generation plants are used to benchmark the surplus electricity production for plants with low, medium and high pressure boiler. Achievable targets ranged between 76 kWh/t cane to 143 kWh/t cane (433 to 815 kWh/t fibre) for the low and high pressure boilers, respectively for a factory without distillery.

Should all the molasses produced by the factory be converted to ethyl alcohol by an annexed distillery, then the achievable targets ranged between 72 kWh/t cane to 139 kW/t cane (408 to 792 kWh/t fibre) for the low and high pressure boilers respectively.

Keywords : Energy, bagasse, co-generation, electricity, alcohol.

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Energy Balance in the Combined Production of Sugar and Ethanol

Celso Procknor
Procknor Engenharia, Brazil
E-mail: celso@procknor.com.br

The Brazilian experience in the production of fuel ethanol during the last 25 years has shown that the combined production of sugar and ethanol is, most of the times, more advantageous than the individual production of sugar or ethanol. The main benefits are the better sugar quality, the more adequate energy balance and the smaller effluent disposal requirements for a given sugar cane production. This paper presents the comparison of the basic energy requirements for plants with some different production combinations of sugar and fuel ethanol."

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Integration of DHR Process (Fast acid Hydrolysis Dedini) with a Typical Sugar and Ethanol Factory

Djalma Lahr Filho, Carlos E. Vaz Rossell and Helcio M. Lamonica
Centro de Tecnologia Copersucar, Brazil
E-mail: rossell@copersucar.com.br

The DHR process can widely increase the ethanol production using the sugar mill bagasse surplus and sugar cane trash. This work study DHR process integration with a typical sugar and ethanol factory and its impact on biomass needs and electric power production.

The DHR process is characterized by the use of a solvent that efficiently dissolves lignin, exposing cellulose to a more efficient acid attack. At high temperatures and short residence time the sacharification reaction is very fast and efficient.

The bagasse is fed to the hydrolysis reactor. The water-solvent solution is heated up to reaction temperature and introduced into the reactor together with sulfuric acid. The mixture of the bagasse with the warm acid solution remains into the reactor enough time to provide lignin dissolution and hydrolysis of hemicellulose and cellulose. Residence time is short enough to limit the degradation of sugars, mainly glucose. The reaction mixture leaves the reactor, being cooled by fresh hydro-solvent solution entering to the system. This heat regeneration step reduces the thermal requirement of the process. In practice the heat demand of the process could be balanced by the amount of heat obtained after burning lignin in the steam boiler.

The reaction mixture is fed to a distillation column in which the solvent is recovered on the top. Lignin precipitates when the solvent is removed during distillation. Liquor containing the sugars and suspended lignin is recovered at the bottom of the column.

The liquor free from solvent and lignin is pumped to a neutralization step with lime. Liquor is clarified by settling removing calcium sulfate precipitate, and then it is filtrated. To this clarified liquor nutrients are added to formulate the fermentation must.

Fermentation process is the traditional MELLE-BOINOT fed-batch with yeast recycle process for ethanol production.

At the present time only the hexoses fraction is fermented to ethanol discarding the pentoses.

The final wine after fermentation is submitted to distillation producing either hydrated or anhydrous industrial and fuel grade ethanol.

The integration study considered a 2 million tonnes of cane per year sugar mill and a DHR module for 22.9 t/h of bagasse (100,000 t/year at 50% humidity) operating 4,366 h / year, producing 2.3 m^3 /h of ethanol (10,000 m^3/year).

For this integration a 2 million tonnes sugar cane mill would have a bagasse deficit around 23,000 tonnes/year, than the sugar mill would need to buy bagasse or recover sugar cane trash. To integrate this module without buying bagasse or recovering trash the sugar mill has to process at least 2.6 million tonnes of sugar cane/year (596 t/h).

Keywords: Hydrolysis, sacharification, sugarcane bagasse, ethanol, cogeneration.