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Nowadays, Brazil is facing the perspective of a significant increase in fuel ethanol demand. This forecast is based on three market realities: first, internal increase of hydrated ethanol consumption due to the success of the flex-fuel in the light automobile vehicles market; second, expansion of the Brazilian ethanol exports due to the growing world interest in the ethanol mixture to gasoline, as a way to prevent global warming; and finally, the Brazilian option for the production of biodiesel, using ethanol via the transesterification of vegetal oils.

A realistic projection foresees a significant increase of Brazilian ethanol production in the next 5-10 years. This important expansion of production is starting to become a reality through the start-up of new plants, opening new perspectives to the sugarcane agriculture. Besides, it will require a concerted effort in searching for a significant increase in productivity – liters of ethanol produced per hectare of planted sugarcane. This boost in productivity can be reached through two technological routes. The first route focuses on the agricultural area and will try, through the expansion of new varieties program and, in the future, through the use of transgenic sugarcane, to increase the present productivity level (tones of sugarcane/hectare/year). The second route, focusing on the industrial sector, will try to develop technologies for the complete utilization of sugarcane, producing ethanol or other renewable fuels, or even by means of the biorefinery concept, aggregating value to the sugarcane chain by producing new products. It will be necessary to

introduce new alternatives for ethanol use as well as concentrate efforts to improve the technology available and to develop new technologies that improve ethanol production.

The project “Guidelines for Public Policies for Sugarcane Agro-industry in the State of São Paulo” tried to establish – through workshops organized by several Institutions, and with papers written by invited specialists, the required basis to build the technological Road Map for the production and use of bioethanol in Brazil, in general, and, in the São Paulo State, in particular. This part of the project, dealing with the production and use of bioethanol, was organized in four main areas:

1. state of the art of ethanol production;
2. technological improvements within the present ethanol production context;
3. 2nd generation technologies for ethanol and other biofuels production and the biorefinery concept;
4. ethanol use.

In order to define the state of the art of ethanol production, trying mainly to establish the existing technological bottlenecks, two workshops were organized by the Engineering School of Lorena – EEL-USP. The event was attended by selected researchers, working in the area of bioenergy, especially in industrial ethanol production in Brazil. The workshops focused on aspects such as: raw material quality and its consequences for ethanol production, microbial physiology and ecology, aspects related with production operations (special emphasis on fermentation and distillation); besides

aspects related to the use of bagasse and trash for ethanol and other products, with emphasis on the heterogeneity of these materials and the need of pretreatment before use. Aiming at completing the state of the art of the production sector, a specialist, with long experience in industrial fuel ethanol production, prepared a global technological assessment.

In the assessment to upgrade the present ethanol production technology, some topics were selected for further discussion in various special workshops. The potential of bioelectricity generation using the residual sugarcane biomass was discussed in a workshop organized by Unicamp, during which the potential of this alternative was pointed out, which in the medium run could represent 20 to 30% of the installed electric capacity of the country, demonstrating as well that the major difficulties in its implementation are political and regulatory. There are still some technological bottlenecks, such as sugarcane trash combustion and bagasse and trash gasification. In order to identify technological alternatives to improve the electricity co-generation, an analysis of the optimization options for energy utilization in sugar, ethanol and electric energy plants was performed. The instrumentation and automation of ethanol plants were discussed in a workshop organized by embrapa-Instrumentação, in the city of São Carlos, covering the two major areas of the production chain, the agricultural phase (report included in Part 3) and the industrial phase. In this part of the workshop, the following aspects were shown. The development of mathematical modeling and simulation tools, in order to implement modern, advanced and robust techniques for the processes and unit operations control, considering also the future integration of the 2nd generation ethanol production and the diverse operations and technologies included in the biorefinery concept. The optimization of water consumption, an issue that is becoming important due to the shortage of this natural resource, was presented in a workshop organized by Nipe-Unicamp. The workshop dealt mainly with the environmental aspects (report included in Part 2), during which a significant reduction in water consumption in the mills – from

5 to 1 m³/tone of cane observed in the last decade, was pointed out. New reductions, as well as the possibility of the mill becoming a water exporter, will require significantly much larger investments. The use of stillage to produce energy, an issue that will be considered when optimizing the Biorefinery, was discussed in a technological workshop on stillage organized by FCAV of Unesp in the city of Jaboticabal, São Paulo state. The application of to agricultural (report included in Part 3) was also dealt with in this workshop. The fact that the biodigestion of stillage is not used on a large scale was justified by the large investment and operational costs required, when compared with the ferti-irrigation alternative. A paper was prepared in order to analyze and give further details of R&D requirements associated to the production and use of stillage, identifying the alternatives that will reduce the amount of stillage/liters of ethanol ratio, as well as assessing the techniques to be used e.g. biodigestion, concentration, and combustion or incineration. The increasing level of development reached by the sugarcane industry in Brazil associated with the concept of integral sugarcane use, has generated an attractive incentive to the use of the agricultural residues of the sugarcane. With this focus, a paper was prepared to elaborate a technical and economic evaluation of some of the possible routes to collect the trash, the most important physicochemical and energetic characteristics, as well as its application in energy production through combustion. Still, within the context of assessing the technological improvements in the present production chain, Dedini S/A Indústrias de Base, prepared a paper detailing the integration possibilities of biodiesel production with sugar and ethanol plants, which present several advantages with regard to the reduction of operational costs and investments. Dedini has designed such an integrated operating plant – Usina Barralcool, in the state of Mato Grosso, Brazil.

In the new industrial model for bioethanol production, a major emphasis has been given to the so-called 2nd generation ethanol, considering the chemical and biochemical route, as well as the thermo-chemical route for the ethanol production from lignocellulosic material (excess bagasse and

trash). The chemical and biochemical route was dealt in the workshop “Hydrolysis of lignocellulosic material” organized by IPT, during which some aspects were considered to be of considerable relevance to make this technology viable e.g. requirement to establish standard analysis to measure the most important fractions of lignocellulosic material; importance of using all the fractions of the lignocellulosic material, including penthoses fermentation and lignin combustion; comparison to the chemical routes. The enzymatic route for hydrolysis was considered as a more adequate alternative for the production of ethanol from bagasse and trash, producing a hydrolysate with large sugar yields and contents, and low toxicity. Besides these technical aspects, the requirement of planning and following the technological development, through technical-economic assessment studies of pretreatment, hydrolysis and fermentation technological alternatives, was also pointed out. Due to the importance of this topic, two additional papers prepared by international experts – Dr. Guido Zacchi (Chemical Engineering Department of Lund University in Sweden) and Dr. Rodolfo Quintero-Ramirez (Natural Science and Engineering Division of Universidade Autônoma, Cuajimalpa Unit, Mexico) were included in this analysis.

Regarding the thermo-chemical route, fast pyrolysis of the lignocellulosic material as a precursor of the BTL (“*Biomass to Liquid*”) process was analyzed and identified as a viable technology that must be commercially proven through the construction of demonstration plants. The workshop “BTL Technologies” was also organized by IPT, and several bottlenecks were identified, starting with the pretreatment and biomass feeding in pressurized reactors, continuing with the development of new gasification technologies, and finally, in the requirement of adapting the produced synthesis gas and the development of catalytic routes, for the production of liquid fuels, adequate to the BTL technology.

In order to complete the analysis of 2nd generation ethanol production, various papers were prepared aiming at detailing new concepts such

as “energy cane”, to quantify the relative importance of the increase in sugar and fiber content in sugarcane, as well as “biorefinery”, listing the new routes and products produced from renewable raw-materials, especially sugarcane. Closing the assessment of the 2nd generation technologies and derived new concepts, a paper was prepared to evaluate their economic and environmental perspectives. This paper shows that the considered alternatives (hydrolysis and gasification technologies) present a great potential for integration in the Brazilian sugarcane mills, due to the large availability of low cost biomass. Besides, they represent an important environmental contribution, collaborating with the sustainable development of the sector.

In relation to bioethanol use, the logistic problem associated with its distribution was assessed. From this analysis, it was clear that the expansion of ethanol production should be planned in order to minimize transport costs and the resulting social and environmental impacts. Still considering the bioethanol use, the required importance of its quality, a fundamental issue as it becomes a world commodity, was included in the analysis. Therefore, a paper was prepared to evaluate the aspects related to regulation of the production, commercialization and use of bioethanol in Brazil, and the harmonization of the world specification for fuel use. Regarding quality, another paper analysed aspects related to the official methods of analysis and certified reference materials used in the validation and control of the quality assays methods. In the specific case of bioethanol use, papers were prepared presenting the historical background (past, present and future) of its use in Otto cycle engines and its future use as a fuel, the situation bioethanol in new engines, comparing it with new fuels, besides presenting the ongoing programs of its use in Diesel engines. Finally, a paper was prepared to evaluate ethanol use in the vegetal oils and animal fats transesterification, for the production of biodiesel, a viable alternative in Brazil that should increase the importance of the integrated production of these two biofuels.

