Review of the ISSCT Co-Products Workshop

L Jean Claude Autrey1, Manoel Regis Lima Verde Leal2 and Suleiman José Hassuani3

1ISSCT Secretariat, 97 Georgetown Bldg, St. Jean Road, Quatre Bornes, Mauritius; issct@intnet.mu
2Brazilian Bioethanol Science and Technology Laboratory (CTBE), National Research Center for Energy and Materials (CNPEM), Rua Giuseppe Máximo Scofaro, 10000, PO Box 6192 – 13.083-970, Campinas, SP, Brazil; regis.leal@bioetanol.org.br
3CTC Centro de Tecnologia Canavieira, CP 162, Piracicaba, SP 13400-970, Brazil; suleiman@ctc.com.br

Abstract The ISSCT Co-Products Workshop was held in Mauritius from 30 November to 4 December 2015. The theme of the Workshop was Development of Co-Products from sugar mill streams and sugar cane biomass. It attracted 70 participants from Australia, Brazil, China, France, Germany, India, Kenya, Mauritius, Nigeria, Pakistan, South Africa, Sweden, UK, USA and Zimbabwe. The Workshop provided a platform to showcase the production and development of a range of renewable co-products derived from sugar cane and offered the opportunity for fruitful international dialogue amongst the participants from a range of countries and who had different backgrounds. The Workshop comprised seven sessions: status of Co-Products in various countries; Production diversification; Chemical and biochemical uses of Co-Products; Bagasse and additional fuels; Collection and uses of trash; Increasing biomass: Ethanol production and treatment of vinasse. Visits were made to the state-of-the-art industrial cluster of Omnicane comprising a sugar factory, a sugar refinery and a cogeneration plant and bioethanol distillery, and to Terra Group where trash collection for cogeneration was demonstrated. The Workshop demonstrated the exceptional value of sugar cane as a source of alternative products.

Key words Product diversification, biochemicals, trash, ethanol

INTRODUCTION

The ISSCT Co-Products Workshop was held at the Holiday Inn Mauritius Airport from 30 November to 4 December 2015. The theme of the Workshop was Development of Co-Products from sugar mill streams and sugar cane biomass. It was organised by the ISSCT Secretariat with the support of the Mauritius Sugarcane Industry Research Institute (MSIRI) and the Omnicane Group and was attended by 70 participants from Australia, Brazil, China, France, Germany, India, Kenya, Mauritius, Nigeria, Pakistan, South Africa, Sweden, UK, USA and Zimbabwe.

At the Opening Ceremony the General Secretary of ISSCT welcomed the Honourable Mahen Kumar Seeruttun, Minister of Agro-Industry and Food Security of Mauritius, who as Secretary Accountant of the MSIRI was the Treasurer of ISSCT from 1996 when the Secretariat was created until 2005. The General Secretary also recalled the origins of the ISSCT, its objectives, its main activities of congresses, workshops, setting up of consortia, production of documents, etc.

The Workshop was dedicated to the memory of Mr. Maurice Paturau a Mauritian who was considered the world authority on sugar cane by-products and who published in 1969 ‘By-Products of the sugar cane industry and introduction to their industrial utilisation’. This volume which has seen three complete revisions is considered to be the most authoritative text on sugar cane co-products.

The Workshop was opened by Minister Seeruttun who in his speech welcomed the initiative of ISSCT to hold the Co-Products Workshop in Mauritius at a time of low sugar prices and the pressing need to increase revenues of producers through using the entire cane biomass for the production of biofuels, bioelectricity, chemicals and biochemicals, biofertilisers, etc. Diversification, he stated, is the order of the day.

The Workshop was opened by Minister Seeruttun who in his speech welcomed the initiative of ISSCT to hold the Co-Products Workshop in Mauritius at a time of low sugar prices and the pressing need to increase revenues of producers through using the entire cane biomass for the production of biofuels, bioelectricity, chemicals and biochemicals, biofertilisers, etc. Diversification, he stated, is the order of the day.

The Keynote Address entitled Developments in biomass gasification – opportunities in the sugar cane industry was delivered by Dr Lars Waldheim, Director, Waldheim Consulting, Sweden who has been involved for many years in gasification projects of biomass including sugar cane bagasse.
The Workshop comprised seven sessions:
1 Status of Co-Products in various countries: Australia, Mauritius, USA and Brazil.
2 Production diversification
3 Chemical and biochemical uses of Co-Products
4 Bagasse and additional fuels
5 Collection and uses of trash
6 Increasing biomass
7 Ethanol production and treatment of vinasse

Visits were made to the state-of-the-art industrial cluster of Omnicane comprising a sugar factory, a sugar refinery and a cogeneration plant and bioethanol distillery, and to Terra Group where trash collection for cogeneration was demonstrated.

The final day of the Workshop was devoted to the meeting of International Sugarcane Biomass Utilization Consortium (ISBUC), which, like the International Consortium for Sugarcane Biotechnology (ICSB), is an initiative of ISSTC. On its agenda were bagasse gasification, which can more than double the present energy derived from bagasse, high-fibre cane, energy cane and new hybrids issuing from sugar cane and related genera such as Miscanthus, Erianthus, etc. The outcome of the ISBUC meeting was the setting up of four working groups in the areas of:
- Trash recovery, trash quantification, storage of biomass
- Cane cleaning, impact of trash on cane processing (extraction/ process)
- High-fibre cane and new cane germplasm
- Conversion of biomass (impact on boilers/gasification).

The technical sections were divided into specific themes and the relevant topics are highlighted below.

**PRODUCT DIVERSIFICATION**

Many important sugar-producing countries are looking seriously into diversification under different approaches and priorities, aiming to reduce the risk of relying strongly on one global commodity - sugar. In South Africa, SMRI is developing a broad and detailed methodology to identify and screen co-product alternatives. It uses several steps to identify the most promising technologies for the South African context and market perspectives. Other countries appear to focus on advanced technology to make use of cane residues and other crops to produce value-added products such as cellulosic ethanol, chemicals, plastics, microbial oils, protein, organic acids and animal feed. In Australia, the size of the national market and high costs of transport to external markets are considered limiting factors in the choice of co-products.

In USA, a biorefinery is being installed in one sugar mill in Louisiana and plans are developed to replicate this in 10 other sugar mills. Energy cane and sweet sorghum are under evaluation as a multiple feedstock and processing to biofuels and biobased chemicals; intermediate products are bagasse, syrups and molasses. The targeted products are syrups, nanomaterials, biopolymers, biobutanol and specialty products (adhesives, epoxies and chemicals).

In the beet sugar industry diversification is already a reality in the Wissington plant in UK where the concept of maximum use of the feedstock and minimisation of wastes is carried to a full extent. Several products are being produced for large markets, such as ethanol and animal feed, and for specialty markets, such as betaine and pharma/food ingredients. Other energy crops are being investigated to broaden the spectrum of possible products and gains in scale, and support to commercial developments is being provided.

**CHEMICAL AND BIOCHEMICAL USES OF CO-PRODUCTS**

It is widely recognised that today’s sugar industry needs to diversify to an industry with more products. The situation of small industries exporting sugar is even more critical. Before making product decisions, an extensive study of the alternatives is needed because they are many; just in the chemical and biochemical sector they are many with different levels of scale, price and sophistication. The starting feedstocks are many, such as sugars, syrups, molasses, bagasse, trash, and filter mud, and these can be used in many ways to produce a multitude of products: alcohols, amino acids, organic acids, polyols, polyphenols, nutraceuticals, animal feed, sweeteners, specialty sugars and many more.

Most of the more sophisticated applications are still in the development stages, but there is high interest and potential. Two examples are aconitic acid that can be extracted from molasses or vinasse in considerable quantities, and beta-glucan with its high potential use in biomedicine to control blood levels of bad cholesterol, sugars and pressure. Cane fibres can be used for energy by direct combustion or to produce special types of cellulose, pellets and charcoal briquettes.

Due to the size of the global plastic market, bioplastics are receiving a considerable amount of attention. Among them the polyhydroxyalkanoates (PHAs) seem to have a reasonable chance of becoming a big market product due to its
similarities with major petrochemical plastics, but with the advantages of being biodegradable, renewable and saving on greenhouse gases.

COGENERATION: BAGASSE AND ADDITIONAL FUELS

The sugar industry in many counties has moved or is moving to cogeneration as a new source of revenue. In Australia, the Racecourse mill is an outstanding example of things done right. The Racecourse cogeneration plant is fitted with an 8 MPa/525°C steam boiler that can burn bagasse or coal, and a condensing-extraction turbine generator set so that it can operate in the offseason. The surplus power sold is 25 MW with bagasse operation and 20-10 MW in peak and off-peak power conditions and it operates 49 weeks per year. In contrast, a plant in the Okeelanta mill in Florida, USA was designed and built by companies not familiar with fibrous fuel such as bagasse and, after a series of operational problems, the unit was shut down.

Poni Sugars in India has installed a high pressure cogeneration system based on an 80 t/h, 11 MPa/535°C steam boiler and condensing extraction steam generator producing 14-14.5 MW total power and exporting 3.5-4 MW. Bagasse is depithed at the mill and the fibres sent to a paper plant and pith burned in the boiler. Several biofuels supplement the bagasse, such as sugar cane trash, coconut residues, bark, and chipper dust. Operation with these residues deserve special attention due to fouling, corrosion and deposit problems characteristic of burning agricultural residues.

Surplus power sale by mills in Brazil is an increasing trend and today there are 177 mills exporting electricity to the grid from the 355 mills in operation. The exported power of 19 TWh in 2014 represented 4% of the total electricity production but is far from the technical potential of 127 TWh/year due to persistent technical and institutional problems. Trash recovery in quantity and quality required for year-round operation and boiler safe use is still being pursued and some regulatory barriers need to be removed to allow movement forward at a faster pace. Electricity is sold in Brazil in two commercial environments: regulated contracting environment through government organized auctions and free contracting environment where electricity contracts are negotiated directly between generator and consumers.

COLLECTION AND USE OF TRASH

There are two ways to increase the availability of sugarcane biomass: (1) collect and use the whole cane biomass including the trash; (2) cultivate high biomass varieties bred more for energy content than for sugar. Sugar cane trash represents around one third of the plant’s total primary energy content, but its use for different application, mostly power generation, is still incipient. In Brazil the interest in using trash has increased considerably in the past two years due to electricity price increases that resulted from the decrease in hydropower production in the electricity matrix, due to droughts and delays in completing new hydro power plants.

The number of mills recovering and using trash is increasing, but there are several barriers hindering the participation of this biomass as boiler fuel. Two main collection routes have resulted from the past experiences: baling, and partial cleaning system. Baling is gaining grounds due to several problems with the partial cleaning route, such as high transportation costs due to decrease in density of the cane/trash load when the harvester cleaning fans speeds are reduced and the low efficiency of the cleaning stations resulting in more fibre being milled. The bailing route is suffering with the higher mineral impurity levels in the trash arriving at the mill and its consequences on the factory operation, recovery and maintenance costs.

To identify the main problems in trash collection and use, a five-year project is being conducted by the Brazilian Bioethanol Science and Technology Laboratory (CTBE), with funding from the Global Environment Facility (GEF) and co-funding from CTBE, participating mills and UNICA. The United Nations’ Development Programme (UNDP) manages the project for the GEF. The project objective is to increase the participation of sugarcane trash in the generation of surplus power by the mills and aims at the identification of the barriers (technical, financial, information and institutional) that are holding back the increase in trash use by the mills. Four mills are participating actively in the project and are being use as references for the solution of the main problems. A sustainability analysis will be conducted to establish the criteria to define the amount of trash that needs to remain on the ground.

In Mauritius, the Terragen mill has started trash collection by baling. This is motivated by the government’s goal to increase the share of renewable energy in power generation to 35% by 2025. Today, bagasse accounts for 26% of the power generation.

In South Africa, a different approach is being tested at a pilot scale where sugarcane is harvested green and transported to the mill with only the tops removed. A specially designed furnace burns the trash adhering to the cane, cleaning the cane before sending to preparation and milling. The use of the furnace heat produced is still being evaluated.

Réunion Island is initiating a testing program with energy cane cultivated in marginal land using two different sites and 20 varieties (12 from eRcane, six from Barbados and two commercial varieties).
INCREASING BIOMASS

The interest in Mauritius in increasing the renewable share of electricity and the interest of the mills to further diversify their products has led to a study of high-fibre sugarcane varieties as a way to increase the value of the sugarcane plant through greater utilisation of its biomass for sugar, ethanol and electricity. The sugarcane varieties were divided into four types: (1) Commercial (10-12% fibre); (2) Enhanced fibre (14-16% fibre); (3) Multi-purpose (17-20% fibre) and (4) Bioenergy (>20% fibre). In this effort, the competition with sugar production is to be avoided by trying to maintain the total sugar production per hectare at the same level of the commercial varieties and testing the bioenergy cane in two marginal land sites (very humid in the uplands and under drought conditions). An economic selection index for rapid screening of high biomass cane is being developed and the high dry matter content per hectare is being used for the initial selection phase.

In Kenya, where more than 85% of the cane is produced by small farmers, the government is stimulating the diversification of products toward bioenergy applications for the sugarcane biomass. This is based on the belief that enhancing the production of renewable energy by connecting farmers to Small Manufacturing Enterprises (SMEs) would enhance the farmers’ socio-economic standards and the sustainability of the SMEs.

ETHANOL PRODUCTION AND TREATMENT OF VINASSE

Based on the successful experiences in Brazil and many other countries, ethanol was presented as a low-risk high-volume alternative that can be applied in steps in existing sugar mills. The feedstock can be final molasses, B molasses and/or juice. Depending on the degree of conversion of sugar to ethanol; minimum investment and high flexibility can be achieved by annexing the new distillery to an existing sugar factory where the ratio of sugar to ethanol can be adjusted somewhat. Depending on the size of the markets, there will be some correlation between sugar and ethanol prices and some impact of the gasoline prices in both markets, if no subsidies are given to ethanol or sugar.

Vinasse or stillage is the main effluent of ethanol production and can have a significant economic and environmental impact on the distillery depending on how it is disposed. The volume of vinasse produced depends on the feedstock (molasses or juice) and processing (ethanol concentration in the wine, recirculation of vinasse to the process, etc). The main treatment alternatives available are direct application to fields, concentration to reduce volume with addition of N and P fertilizer, concentration for burning in special boilers, biodigestion with or without purification of the biogas, and composting with filter mud. The best solution will depend on the local conditions and environmental laws, size of the distillery, and price of electricity, to name a few. Some of these alternatives are being used commercially and others are still under development. The fertilizer value of vinasse is widely recognized.

CONCLUSIONS

This Co-Products Workshop provided a platform to showcase the production and development of a range of renewable co-products derived from sugar cane and offered the opportunity for fruitful international dialogue amongst the participants from a range of countries and who had different backgrounds.

The sugarcane plant possesses exceptional photosynthetic ability, which makes it the ideal candidate as a sustainable feedstock for a large number of food and energy products.

In many countries where sugar revenues are declining the full utilization of the sugarcane plant becomes essential in order to be profitable. The diversification of revenue streams from sugar cane includes the production of electricity and steam, ethanol (potable, industrial and fuel) and other fermentation products, fertilizers, yeasts, bioplastics, animal feed, biochemicals, etc. Advances in chemistry, biotechnology, technology and engineering are leading to new-generation products that are undergoing pre-commercial testing in various laboratories around the world.

Green technologies, multiple value-added products, energy conversion efficiencies, barriers for maximum recovery, new opportunities and innovations were central to the discussions during the Workshop, thereby fulfilling its objectives.

The advances in industrial biotechnology have made sugar a superb feedstock to produce a variety of platform chemicals via the engineered microbe route. The industry needs to look at licensing technologies developed by biotech start-ups and develop in-house expertise in this emerging sector.

Compte rendu de l’Atelier de travail de l’ISSCT sur les Coproduits

Pakistan, de l’Afrique du Sud, de la Suède, du Royaume Uni, des Etats Unis d’Amérique et du Zimbabwe. L’atelier procura une plateforme pour démontrer la production et le développement de tout un nombre de coproduits renouvelables dérivés de la canne à sucre. Il offrit l’occasion aux participants qui venaient des pays et d’intérêts professionnels différents d’entamer des délibérations fructueuses au niveau international. L’atelier consista de sept sessions notamment : le statut des coproduits dans divers pays, la diversification, l’utilisation des coproduits à des fins chimiques et biochimiques, la bagasse et autres combustibles, la collecte et l’utilisation de la paille, l’augmentation de la biomasse, la production d’éthanol et le traitement de la vinasse. Des visites furent effectuées au complexe industriel de pointe d’Omnicane qui comprenait une usine sucrière, une raffinerie, une centrale de cogénération utilisant partiellement la bagasse et une distillerie de bioéthanol et au Groupe Terra où la collecte de la paille à des fins de cogénération fut démontrée. L’atelier apporta la preuve de la valeur exceptionnelle de la canne à sucre comme source de produits alternatifs.

Mots-clés: La diversification des produits, les produits biochimiques, les déchets, l’éthanol

Revisión del taller de Coproductos de la ISSCT

Resumen. El taller de Coproductos del ISSCT se llevó a cabo en la Isla Mauricio del 30 de noviembre al 4 de diciembre del año 2015. El tema del taller fue el Desarrollo de coproductos de los ingenios azucareros e de la biomasa de la caña de azúcar. Atrajo a 70 participantes de Australia, Brasil, China, Francia, Alemania, India, Kenia, Mauricio, Nigeria, Pakistán, Sudáfrica, Suecia, Reino Unido, EE.UU. y Zimbabue. El taller proporcionó una plataforma para mostrar la producción y el desarrollo de una serie de coproductos renovables derivados de la caña de azúcar y ofreció la oportunidad para el diálogo internacional fructífero entre los participantes de una serie de países y de diferentes orígenes. El taller constó de siete sesiones: Estado de los coproductos en varios países, Diversificación de la producción, Química e uso bioquímico de los coproductos, Bagazo e combustibles adicionales, Recolección e uso de la paja de caña, Aumento de la biomasa: producción de etanol y tratamiento de vinazas. Visitas técnicas fueron realizadas en los conglomerado industriales de Omnicane que comprende una fábrica de azúcar, una refinería de azúcar, una planta de cogeneración y una destilería de bioetanol, e en Terra Group donde se demostró la recolección de paja de caña para la cogeneración. El taller demostró el excepcional valor de la caña de azúcar como una fuente de productos alternativos.

Palabras clave: La diversificación de productos, productos bioquímicos, basura, etanol