RCN Conference on Pan American Biofuels & Bioenergy Sustainability

Golden Tulip Recife Palace, Recife, Brazil
July 22-25, 2014

Technical Program
Thursday, July 24, 2014: 08:30 AM - 11:30 AM

Thursday, July 24, 2014: 08:30 AM - 11:30 AM, Boa Viagem Room
Technological Innovation in Biofuel and Bioenergy Sustainability
Chair: Mark Mba Wright, Mechanical Engineering, Iowa State University, IA, USA
Co-Chair: Michael T. Timko, Chemical Engineering, Worcester Polytechnic Institute, MA, USA

8:30 AM	Small Is Better: Fostering Growth in the Biofuels Industry with Energy Manufacturing . **M. Mba Wright**, R. C. Brown, and P. Componation
8:50 AM	Small-Scale Biorefineries: Towards the Biofuel and Bioenergy Sustainability at Local Basis . R. Souza Aguiar, P. H. Sousa Baudel, R. A. Jose, C. A. M. de Abreu, and **H. M. Baudel**
9:10 AM	Alcoholic Fermentation Using Immobilized Cells in Calcium Alginate . J. C. Duarte, **J. R. Nunhez**, J. A. R. Rodrigues, P. J. S. Moran, and G. P. Valença
9:30 AM	Incorporation of Sweet Sorghum Juice into Current Dry-Grind Ethanol Process for Improved Ethanol Yields, Energy Saving, and Water Efficiency . **N. B. Appiah-Nkansah**, K. Saul, W. Rooney, and D. Wang
9:50 AM	The Continuous-Flow Solid Acid Catalyst Hydrothermal Biorefinery . **M. T. Timko** and G. Tompsett
10:10 AM	Biodiesel Production from Used Cooking Oil Using Calcined Sodium Silicate Catalyst . M. O. Daramola, **D. Nkazi**, and K. Mtshali
10:30 AM	Roundtable Discussion of Key Research Issues and Challenges

8:30 AM Small Is Better: Fostering Growth in the Biofuels Industry with Energy Manufacturing
Mark Mba Wright, Mechanical Engineering, Iowa State University, Ames, IA, Robert C. Brown, Center for Sustainable Environmental Technologies, Iowa State University, Ames, IA and Paul Componation, Industrial and Manufacturing Systems Engineering, Iowa State University, Ames, IA

Abstract:
The 2013 Intergovernmental Panel on Climate Change (IPCC) report stresses the need to reduce atmospheric carbon levels to avoid disastrous changes in global climate. Lignocellulosic biofuels are part of emerging strategies to reduce carbon emissions by replacing fossil-derived transportation fuels. We need an industry paradigm shift to have a meaningful impact on the transportation fuel market. Energy manufacturing could foster growth in the biofuels industry by enabling the economic production of small, modular biorefineries.

The topic of this presentation is the role of energy manufacturing in technological innovation for sustainable biofuel production. Energy manufacturing enables faster learning rates. Increasing learning rates has led to drastic cost reductions in feedstock production and conversion to ethanol both in the U.S. and Brazil. Sugarcane production costs have decreased by more than 60% since 1971, and U.S. corn costs have seen a similar reduction. Sugarcane ethanol production costs decreased by about 70% over a similar time period. These cost reductions occurred during a period of rapid expansion in biofuel production. We project that a similar effect will boost the nascent lignocellulosic biofuel industry. Furthermore, investing in energy manufacturing strategies could amplify the impact of learning rates on industry growth.

Most of the biofuel industry growth has been driven by first generation biofuel technologies. In the span of 10 years, global biofuel production increased from 238 thousand barrels per day of oil equivalent (BPDOE) to 1206 thousand BPDOE in 2012. Ethanol production accounted for 78.7% of 2011 global biofuel production, and biodiesel accounted for almost all of the remaining fuel. First generation biorefineries from either corn grain or sugarcane produce virtually all the commercially available ethanol.

The continued growth of the biofuel industry will substantially depend on the commercialization of advanced biofuel technologies, which face significant techno-economic challenges. Advanced biofuel technologies are those capable of converting a wide range of lignocellulosic feedstock into a variety of transportation fuels such as ethanol, gasoline, diesel, and dimethyl-ether. There has been significant investment in research and development of these technologies. However, biofuel production from advanced biorefineries has yet to meet the goals established by government policies. This lack of advanced biofuel production has prompted the U.S. EPA to reduce the annual advanced biofuel targets by more than 90% from the original mandates due to a lack of eligible supply. Recent industry developments suggest that companies may be able to increase production of advanced biofuels albeit at quantities far below the mandated targets. Two of the main constraints limiting advanced biorefinery adoption are high capital and feedstock costs.

Innovative and energy efficient technologies could overcome the high costs of pioneer facilities with sufficient commercial experience. These technologies require significant initial investments that are difficult to justify without knowledge of their earning potential. Increasing their earning potential will depend on cost reductions enabled by the deployment of facilities at their optimal scale and cost reductions from technological learning. Despite the significant literature contributions on biorefinery optimal facility sizes and learning rates, there is scarce information on their interaction particularly for

the biofuel industry. This study could lead to coordinated strategies that would result in significant economic savings and rapid technological growth.

We evaluated the impact of learning rates on the optimal scale and production costs of lignocellulosic biorefineries. Results from this study indicate that increasing biorefinery capital and feedstock learning rates could significantly reduce the optimal size and production costs of biorefineries. This analysis compares predictions of learning-based economies of scale, S-Curve, and Stanford-B models. The Stanford-B model predicts biofuel cost reductions of 55 to 73% compared to base case estimates. For example, optimal costs for Fischer-Tropsch diesel decrease from $4.42/gallon to $2.00/gallon. The optimal capacities range from small-scale (grain ethanol and fast pyrolysis) producing 16 million gallons per year to large-scale gasification facilities with 210 million gallons per year capacity. Sensitivity analysis shows that improving capital and feedstock delivery learning rates has a stronger impact on reducing costs than increasing industry experience suggesting that there is an economic incentive to invest in strategies that increase the learning rate for advanced biofuel production.

During this presentation, we will 1) describe the role of energy manufacturing in technological innovation, 2) discuss the impact of learning rates on the lignocellulosic biofuel industry, and 3) identify advanced energy manufacturing strategies with the greatest impact on biofuel production growth. The outcome of this work could lead to effective recommendations for engineering investments that accelerate the growth of the lignocellulosic biofuel industry.

8:50 AM Small-Scale Biorefineries: Towards the Biofuel and Bioenergy Sustainability at Local Basis
Rodrigo Souza Aguiar[1], Paulo Henrique Sousa Baudel[2], Reginaldo A. Jose[3], Cesar A.M. de Abreu[4] and **Henrique M. Baudel**[3,4], (1)Chemical Engineering, UFSC, FLORIANOPOLIS, Brazil, (2)Materials Engineering, UFSC, FLORIANOPOLIS, Brazil, (3)AMERICA BIOMASS TECHNOLOGIES, PIRACICABA, Brazil, (4)Chemical Engineering, UFPE, RECIFE, Brazil

Abstract:
Small to medium- scale biomass biorefineries have been identified as a promising route to the creation of local and regional agroindustrial clusters in Brazil. By delivering multiple products from starchy and lignocellulosic biomasses, a biorefinery constituted by integrated plants and processes can make feasible the economic exploitation of a myriad of low-value agricultural and industrial residues. In principle, different biomass components can be converted into sugars and other carbon-rich products, which in turn can be transformed into high-valued chemical products and high-volume biofuels, while generating electricity and process heat for self-consumption. In this scenario, the high-value products enhance profitability, the high-volume fuels contribute to support energy needs, and the power production reduces costs while avoiding greenhouse gas emissions. Hence, the biorefinery concept envisages the maximal value derived from the biomass feedstock at minimal impact to the environment. This paper describes a biorefinery constituted by integrated plants that produce ethanol, active carbon, food-grade carbon dioxide and protein extract (for cattle feed). Agricultural residues such as rice shells and straw as well as non-food energy-rice were used as starchy and lignocellulosic feedstocks. The mentioned biorefinery concept has been built on two different biomass-to-products platforms. The "sugar platform" is based on chemical and biochemical conversion processes, particularly the fermentation of sugars extracted from cellulosics, while the "carbon platform" is based on thermochemical routes with emphasis on the carbonisation of the cellulignin fractions.

9:10 AM Alcoholic Fermentation Using Immobilized Cells in Calcium Alginate

Juliana Canto Duarte[1], **José Roberto Nunhez**[2], José Augusto Rosário Rodrigues[3], Paulo José Samenho Moran[4] and Gustavo Paim Valença[2], (1)Faculty of Chemical Engineering, UNICAMP - State University of Campinas, CAMPINAS, Brazil, (2)Departamento de Engenharia de Processos, UNICAMP, Campinas, Brazil, (3)Chemistry Institute, UNICAMP - State University of Campinas, Campinas, Brazil, (4)Chemistry Institute, UNICAMP - State University of Campinas, CAMPINAS, Brazil

Abstract:
This work refers to alcoholic fermentation carried out using immobilized cells. The Saccharomyces cerevisiae cells were immobilized in calcium alginate and in chitosan-covered calcium alginate beads. Ethanol was obtained for the fermentation of both glucose or sucrose. The batch fermentations were carried out in an orbital shaker. The reaction was monitored with the use of an HPLC that assessed the concentration of products and substrate. Results show that both calcium alginate immobilized beads and chitosan-covered calcium alginate immobilized beads could be used in eight sequential fermentation cycles of 10 h each. The final concentration of ethanol using free cells was 40 g L-1 and the yields using glucose and sucrose as carbon sources were 78% and 74.3%, respectively. For immobilized cells in calcium alginate beads, the final ethanol concentration in the glucose fermentation was 32.9 ± 1.7 g L-1 with a 64.5 ± 3.4% yield. The final ethanol concentration for the sucrose fermentation was 33.5 ± 4.6 g L-1 with a 64.5 ± 8.6% yield. For immobilized cells in chitosan-covered calcium alginate beads, the ethanol concentration from glucose was 30.7 ± 1.4 g L-1 with a 61.1 ± 2.8% yield. The final ethanol concentration from sucrose was 31.8 ± 6.9 g L-1 with a 62.1 ± 12.8% yield. There was no need to use antibiotics and no contamination was observed in the batches. After the eighth cycle, a significant rupture of the beads was observed thus making them inappropriate for use in another cycle.

9:30 AM Incorporation of Sweet Sorghum Juice into Current Dry-Grind Ethanol Process for Improved Ethanol Yields, Energy Saving, and Water Efficiency

Nana Baah Appiah-Nkansah, Biological and Agricultural, Kansas State University, Manhattan, KS, Kealin Saul, Biological and Agricultural, North Carolina State University, Raleigh, NC, William Rooney, Soil & Crop Sciences, Texas A&M University, College Station, TX and Donghai Wang, Biological and Agricultural Engineering, Kansas State University, Manhattan, KS

Abstract:
Sweet sorghum is a promising energy crop due to his low fertilizers and water requirements, short grow period, and high biomass yield. However, the challenge for sweet sorghum as a feedstock for ethanol production is its short harvest period and the extreme instability of the juice. At current situation, it is difficult for sweet sorghum based ethanol industry to achieve a year-round production process. One possible way to solve this challenge and to meet the growing demand of bio-renewable ethanol is to incorporate sweet sorghum juice into current dry-grind ethanol process.

In this study, sweet sorghum juice with varying content of grain sorghum flour were liquefied, saccharified, fermented, and distilled to produce ethanol. Ethanol yield from the optimum grain sorghum flour loading with sweet sorghum juice achieved was about 28% higher than that from conventional ethanol process. It was also found that enzymatic hydrolysis with this process could be reduced by 30 minutes. The fermentation performance of sweet sorghum juice with grain flour using raw starch hydrolyzing enzyme was also investigated. The results showed that an ethanol yield was about 21% higher than that from the conventional process. This innovative technology of ethanol production by sweet sorghum juice could improve ethanol yield, save energy, and significantly decrease the use of water in the current dry-grind ethanol process.

9:50 AM The Continuous-Flow Solid Acid Catalyst Hydrothermal Biorefinery
Michael T. Timko and Geoffrey Tompsett, Chemical Engineering, Worcester Polytechnic Institute, Worcester, MA

Abstract:
A major challenges for sustainable biorefineries include adoption of continuous flow processing of whole biomasses and development of new technologies to catalyze selective biomass conversion reactions at mild conditions. Solving these problems will reduce biorefinery capital and operating costs, improve energy balances, and reduce water use. In this talk, I will share recent developments on continuous biomass processing in a hydrothermal reactor and synthesis of hydrothermally stable solid acid catalysts.

In terms of continuous hydrothermal processing, many engineering challenges remain unsolved, including how to deal with reactor plugging, whole biomass utilization, and high-pressure slurry pumping. Here, we have focused our efforts on developing a continuous flow reactor to achieve rapid heating rates in a turbulent mixer to break-up the lignocellulosic matrix, followed by reaction in a secondary zone to maximize simple carbohydrate production. We present time-on-stream data for the prototype reactor with different model feeds.

Solid acid catalysts can play important roles in economically competitive biorefineries, ranging from upstream biomass pre-treatment, to carbohydrate conversion, to bio-ethanol upgrading. A key feature of all these applications is the need for both activity and stability in water-rich aqueous environments. In this talk, I will highlight some early work to develop solid catalysts that retain activity and stability in biorefinery applications. I will describe research to synthesize and characterize bio-char catalyst supports, a class of materials that can be functionalized into strong Bronsted acids. Specifically, my lab has used a two-step hydrothermal-mechanochemical method to synthesize bio-chars for catalytic applications and characterized them using Raman spectroscopy. In a second line of work, I will share research on organic functionalized zeolites. Recent work elsewhere has shown that organic coatings can increase hydrothermal stability of zeolites; however, less work has been performed to characterize diffusion limitations associated with the organic coating. In my lab, we have synthesized several organic functionalized zeolites, characterized them using a suite of standard techniques, and performed dynamic uptake measurements to investigate molecular diffusion rates. These two catalyst vignettes showcase the range of strategies being adopted to develop solid acid catalysts suitable for biorefinery applications.

10:10 AM Biodiesel Production from Used Cooking Oil Using Calcined Sodium Silicate Catalyst
Michael O Daramola, **Diakanua Nkazi** and K Mtshali, University of the Witwatersrand, Johannesburg, South Africa

Abstract:
The recent oil crises and growing public awareness of global warming and greenhouse emissions are creating major technological, as well as social and political challenges worldwide. These challenges are related closely to energy generation and exploitation. The aforementioned problems have prompted the consideration of alternative and renewable types of energy. One of the expected key technologies for building sustainable societies and thus mitigating global warming due to CO_2emission is the production of renewable fuels and chemicals from the conversion of biomass [1]. An alternative type of energy

source that is highly favoured from an environmental perspective is biofuel of which biodiesel is a member.

Homogeneous acid and base catalysts have been extensively studied for the production of biodiesel [2,3]. But homogeneous catalysts cannot be reused or regenerated, because the catalysts are partly consumed in the reaction (during saponification). Also, separation of the catalyst from products is difficult and requires additional equipment which could result in higher production costs [4]. In addition, the process is not environmentally friendly because a large amount of wastewater is produced in the separation step [5]. Developing new solid catalysts seems to be an appropriate solution to overcome problems associated with the use of homogeneous catalysts for biodiesel production. Against this background, this study investigated biodiesel production from used cooking oil (UCO) using heterogeneous sodium silicate catalyst. The conversion of UCO to biodiesel exploited the potential of the catalyst to convert high free fatty acid (FFA) content feedstock to biodiesel directly, thereby by-passing the esterification state whereby FFA content of the feedstock is reduced prior to transesterification reaction.

The transesterification reaction was conducted in a batch reactor with 2.51 g of the catalysts and at UCO to methanol ratio of 1:6. In addition, the reaction temperature was varied between 25^{o}C to 63^{o}C, and the reaction time was varied from 0 to 180 minutes at a 30 minute step increase to understand their effects on the activity of the catalyst during transesterification of UCO to biodiesel. The fatty acid methyl ester (FAME) yield increased with reaction time and reaction temperature and the highest FAME yield of ~30% was obtained at 63^{o}C after 180 minutes. Furthermore, results of this study compare favourably with literature. However, further studies are required for in-depth understanding of the activity and kinetics of the catalyst for biodiesel production from UCO. As far as could be ascertained, this is the first open report on the conversion of UCO to biodiesel over a calcined heterogeneous solid sodium silicate catalyst. However, a more in-depth study on the activity of the catalyst and the kinetics in transforming UCO to biodiesel is required. At the same time, improvement of the synthesis protocol of the catalyst via optimization study is required. Evaluation of performance stability and optimization of the transesterification operating conditions are essential.

Thursday, July 24, 2014: 08:30 AM - 11:30 AM, Piedade Room
Bioenergy and Social Justice
Chair: Theresa Selfa, SUNY – ESF, Syracuse, NY, USA

8:30 AM	Food Security and Biofuels: Can Policy Flexibility Reduce Food Price Crises for the Poor? Part One: Global Markets and Brazil Sugar Cane Production Case . **M. R. L. V. Leal** and K. Kline
8:55 AM	Food Security and Biofuels: Can Policy Flexibility Reduce Food Price Crises for the Poor? Part Two: US Maize Production System Case . **K. Kline** and M. R. L. V. Leal
9:20 AM	Questioning the Social Dimensions of Sustainability: The Biofuel Industry and the Weakening of Traditional Communities in Brazil . **A. L. de Campos Paula** and V. Zuchetto
9:45 AM	The Sugarcane Industry and the Global Economic Crisis . **M. L. Mendonça**
10:10 AM	Roundtable Discussion of Key Research Issues and Challenges

8:30 AM Food Security and Biofuels: Can Policy Flexibility Reduce Food Price Crises for the Poor? Part One: Global Markets and Brazil Sugar Cane Production Case

M. Regis L.V. Leal, Brazil Bioethanol Science and Technology Lab, Campinas, Brazil and Keith Kline, Environmental Science Division, Climate Change Science Institute and Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN

Abstract:
Food crises are created by sudden loss of supply or, more often, sharp increases in the prices of foodstuffs on which poor populations rely for daily nourishment. Any mechanism with the potential to alleviate suffering caused by spikes in food prices is worthy of consideration. Several studies and agencies have recommended introducing flexibility into policy driven demand for agricultural biofuel feedstocks to address food price crises (e.g., report of the FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI, and the UN High Level Task Force, 2011). These proposals suggest that feedstock such as sugarcane can be diverted from biofuel production to food in order to dampen the impact of volatile cereals prices on the poor. This presentation reviews the evidence for and against temporary shifting of policies to reduce biofuel output in response to food price crises. This talk considers the experiences and data associated with the second largest producer of biofuel in the world, Brazil. The behavior of prices for Brazil sugar, food baskets (consumer price indices for food), and energy are considered along with other drivers identified to influence food price spikes. Special attention is given to periods of price volatility, including responses of the modernized sugarcane milling industry to sudden price signals such as a sharp spike in sugar prices in 2010-2011. We review data for how much time was required for industry to respond, the magnitude of the response, the effects on global prices, and a discussion of the factors that govern the flexibility and responsiveness of the industry to price signals. These data are analyzed to examine if and when biofuel feedstock could be diverted and to assess what the implications would be of such diversion in time of food price crisis. The evidence identifies many caveats to consider before implementing diversion proposals. Recommendations are offered for development pathways that could simultaneously improve food security and energy security and thereby address the needs of the populations most vulnerable to food price crises.

8:55 AM Food Security and Biofuels: Can Policy Flexibility Reduce Food Price Crises for the Poor? Part Two: US Maize Production System Case

Keith Kline, Environmental Science Division, Climate Change Science Institute and Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN and M. Regis L.V. Leal, Brazil Bioethanol Science and Technology Lab, Campinas, Brazil

Abstract:
Food crises are created by sudden increases in the prices of foodstuffs on which poor populations rely for daily nourishment. Any mechanism with the potential to alleviate suffering caused by spikes in food prices is worthy of consideration. Several studies and agencies have recommended introducing flexibility into policy driven demand for agricultural biofuel feedstocks to address food price crises (e.g., report of the FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI, and the UN High Level Task Force, 2011). These proposals suggest that grain can be diverted from biofuel production to dampen the impact of volatile cereals prices on the poor. This presentation reviews the evidence for and against temporary lifting of incentives to produce biofuels in response to food price crises. This talk will focus on the experiences and data associated with the largest producer of biofuel in the world, the USA and its corn-ethanol production system. The behavior of prices for US maize, food baskets (consumer price

indices for food), and energy are considered along with other drivers identified to influence food price spikes. Special attention is given to periods of price volatility, including the rapid rise in prices in 2007-2008 and 2010-2011, and the US drought of 2012. Relevant prior research is summarized and recent data are analyzed to examine if and when US biofuel feedstock could be diverted with beneficial results. Diversion proposals sound logical and are widely assumed to be the "right and moral thing to do." The evidence identifies many caveats to consider. Otherwise, temporary market interventions to divert feedstocks from biofuels could have significant costs and make matters worse in the long run. Areas of future research are identified and recommendations are offered for development pathways that could simultaneously improve food security and energy security and thereby address the needs of the populations most vulnerable to food price crises.

9:20 AM Questioning the Social Dimensions of Sustainability: The Biofuel Industry and the Weakening of Traditional Communities in Brazil

Ana Luiza de Campos Paula, Sociology, Kansas State University, Manhattan, KS and Vanessa Zuchetto, University of Alberta, Edmonton, AB, Canada

Abstract:
This paper focuses on the impacts on traditional Brazilian communities resulting from the expansion of the biofuel industry in the country (primarily ethanol from sugarcane and biodiesel from soy). These impacts can take the form of community displacement, dispossession of land, or loss of autonomy and control over land. Some communities have shown resistance in the face of these large-scale changes. This paper explores the vulnerability and resilience of these traditional communities, and the implications for the sustainability dimension of the ethanol and biodiesel industry.

Traditional communities in Brazil are represented by indigenous peoples, river and delta dwellers, rubber tappers, grazers, fisher-folk, peasants, and the quilombolas (descendants of runaway slave communities of African origins). They have been part of a historical process of expropriation and exploitation resulting from the development of the Eurocentric capitalist system, and they are described as 'traditional' because of their "cultural resilience and their persistence in maintaining a symbiotic relationship with nature, despite the pressures to change imposed by various modernization projects" (Fernandes et al. 2012:43). Among these projects is the biofuel industry that has been growing in the country since the beginning of 1980's (Schlesinger 2013; Tamir 2013).

Brazil is among the world leaders in ethanol and biodiesel production, most of it coming from sugarcane and soy plantations. While most of the ethanol is produced in the southeastern region, with Sao Paulo state alone producing more than half (Schlesinger 2013), production is rapidly expanding in the central west region of the Cerrado, an area that the National Energy Agency predicts will contribute to a 200% increase in the nation's current biofuels production in about 20 years (Automotive Business 2014). The central west is a region already accounting for the largest production of soy in Brazil, 32% (or 9% of the world's production) coming from only one state - Mato Grosso (Schlesinger 2013). And the preference for this region to be the center of the biofuel industry expansion concerns the substantial availability of 'idle' lands (Filho and Horridge 2014), which often involve lands occupied by those who do not have formal title to it.

Land conflicts have long been a problem in Brazil (Tamir 2013). Concerns have recently risen due to the worldwide 'land grabbing' phenomenon. As agribusiness occupies (territorializes) sparsely populated areas with sugarcane or soy, they force out (de-territorialize) traditional peoples who lose autonomy

and control over territorial access or uses (Fernanded et al. 2012). According to Tamir (2013), indigenous people and quilombolas represent more than a quarter of all people in Brazil affected by land conflicts. In this way, it makes necessary a "sociological intervention," as described by Geisler and Makki (2014:28), "to contextualize and concretize this burgeoning alienation of land rights and power contingencies across communities and continents" (p.28).

There is no standard definition of sustainability; it means different things for different people. Due to its fluidity, discourses on sustainability of biofuel systems vary. For example, while agribusiness discourses create a dominant ideology of biofuels as sustainable fuels; monocultures feed biofuel industries with their lack of biodiversity, reliance on non-renewable natural resources, and inefficient employment of rural populations. Meanwhile, those concerned with social justice issues question the centralization of these kinds of systems and their inability to include small farmers and traditional communities in biofuels markets. Contrary, many of these populations might actually be displaced by the expansion of these markets.

Food, energy, and climate issues of our time seem to be following the neoliberal model (McMichael 2014) where the dominant ideology of sustainability brought by the agribusiness world undermines the vision of an alternative, more self-reliant, environmentally friendly, and just, economic system. Many of the environmental negative consequences inherent in biofuel production can be improved by the use of technologies, but sustainability requires more diverse and less concentrated productive systems, one that difficultly will emerge without the inclusion of small farmers, peasants, and traditional communities who are deeply connected to the land and the natural resources surrounding them.

9:45 AM The Sugarcane Industry and the Global Economic Crisis

Maria Luisa Mendonça, International Relations Department, University of Rio de Janeiro (UERJ), Rio de Janeiro, Brazil

Abstract:
The presentation analyzes recent tendencies in the sugarcane sector in Brazil, and evaluates the increasing process of monopolization, particularly with the participation of multinational corporations. The study observes that the larger concentration of capital coincides with the increasing territorial expansion of sugarcane monocropping, especially in areas with access to infrastructure, in the Southeast region, and in regions with vast water resources in the Cerrado. This process of apparent "growth" is determined by the international economic crisis, in a moment of predominance of financial capital. In this context, the study shows a constant dependency of the sugarcane industry on subsidies and state credit, in addition to the permanence of labor exploitation.

Maria Luisa Mendonca is the director of Rede Social (Network for Social Justice and Human Rights) in Brazil. She has a PhD in Philosophy and Social Sciences with a focus in Human Geography from University of Sao Paolo (USP) and is currently teaching at the International Relations Department of University of Rio de Janeiro (UERJ). Her work focuses on agricultural models, rural movements and geopolitical land and natural resource systems. She is the editor of the book "Human Rights in Brazil," which has been published annually by Rede Social for the past 14 years.

Thursday, July 24, 2014: 08:30 AM - 11:30 AM, Imperial Room
Sustainability Issues in Biofuel and Bioenergy Industries
Chair: Marcelo Cunha, TBA

8:30 AM	Looking for Sustainability in Biofuel and Bioenergy Industries: Some Challenges and Opportunities . **M. Cunha, State University of Campinas**
8:48 am	Achieving Sustainable Biodiesel Production in Brazil: Challenges and Opportunities . **J. Minelli**
9:06 AM	Green House Gas Savings Produced By Argentine Biodiesel Use . **J. A. Hilbert Sr.** and S. Galbusera
9:24 AM	Bioethanol Dehydration Assessment with Environmental Issues . **M. Colombo**, F. D. Mele, M. R. Hernández, M. Kahwaji Janho, and J. E. Gatica
9:42 AM	Opportunities and Challenges Considering the Socioeconomic Dimension for Brazilian Ethanol Industries in the Recent Past . **A. Marques**
10:00 AM	Diesel Displacement in the Sugarcane Ethanol Life-Cycle: A Comparative Analysis of Different Integrated Systems . **S. P. Souza** and J. E. A. Seabra
10:18 AM	Direct and Indirect Impacts of Agricultural Land-Use Due to Increased Production of Grain-Based Ethanol in Kansas, USA: A County-Level Analysis . **J. Bergtold** and B. Lauer
10:36 AM	Roundtable Discussion of Key Research Issues and Challenges

8:30 AM Looking for Sustainability in Biofuel and Bioenergy Industries: Some Challenges and Opportunities
Marcelo Cunha, Institute of Economics, University of Campinas, Campinas, Brazil

Abstract:
The adoption of biofuels and bioenergy have been recognized as a possible sustainable alternative for replacing fossil fuels, mainly from the beginning of this century. Several countries have set policies to implement and to enlarge the use of those sustainable options. Bioethanol and biodiesel are the most important biofuels produced and used in North America and South America – United States, Brazil and Argentina are among the main countries in this field. Cosidering that there are many differences in the regulation, development, agricultural conditions and the markets in the American countries, the opportunities and challenges faced in the biofuels and bioenergy industries are regionally dependent. The objective of this presentation is to display some opportunities and challenges in this industry considering the three pillars of sustainability. In economic terms, energy policy and regulation can be an incentive to replace part of fossil fuels in domestic or international markets; on the other hand, changes on them (and sometimes the near absence of them) can create barriers to enlarge the bioenergy adoption. In this aspect, the current situation of ethanol in Brazil competing in unfavorable conditions with gasoline is an example. Still in the economic dimension, the limits of how industries of the sector can explore the production of co-products need to be careful analyzed. Considering the social pillar, special attention has to be placed on the business model adopted by a bioenergy company because there are different implications on sustainability depending on it. For example, the possible positive impacts in jobs and income generation, mainly in the agricultural phase, will be influenced by the technological level adopted in agriculture but also on the verticalization (or not) in this key phase of the production chain. A particular analysis is provided in a recent sugarcane ethanol expansion area in Brazil. Another one is the example of how the biodiesel industry has been operating with feedstock supplied by family farmers. Taking into account the environmental issues, the industry has been capable to improve, in many cases, the GHG emissions by through its production process. One of the possibilities is to use biodiesel in the agricultural phase replacing mineral diesel oil in an integrated sugarcane ethanol and biodiesel production. On biodiesel sector, the use of beef tallow (second most important feedstock in Brazil) is another other example of improving environmental benefits, as well as economics. Finally, other important issue is regard to the methods applied over biofuel and bioenergy sustainability assessment, which may (and shall) contribute to evaluate in the best possible way the benefits (or not) of this diversified sector, mainly because biofuels and bioenergy are not the same around the world.

8:48 AM Achieving Sustainable Biodiesel Production in Brazil: Challenges and Opportunities
Julio Minelli, Aprobio – Brazilian Biodiesel Producers Association, São Paulo, Brazil

Abstract:
Governments are searching for renewable energy alternatives to diminish the dependence on fossil fuel, with different commitment levels. They are fostering the use of renewable energy, but this transition has many challenges. Biofuels appears as an alternative energy resource but has, by definition, a limited flow. Moreover, it is important to have positive outcomes in Social, Economic and Ecological aspects. The impacts to the society may be managed by the right regulatory framework and assessed by indicators as employment, prices, ecological benefits, etc.
The Biodiesel production in Brazil generates employment, midland economic growth, social inclusion of more than 80 thousand families, costs comparable to imported diesel. The main raw materials used

today are soybean oil and tallow. The use of biodiesel also reduces GHG emissions and pollutants, as SOx, CO, particulate matter and hydrocarbons.
The food & fuel debate is a gut issue, normally addressed as an incompatible matter. APROBIO would see it as synergistic solution as most oilseed crops produce feed at the same time. In this sense, increasing oilseed crops increases the feed production, important nutrition element for animal protein. The limiting factor for food, feed and bioenergy production may be the land availability. The policies and efforts should seek the best resource allocation and efficiency.
Challenges and opportunities:
To increase the public awareness that bioenergy has benefits in the mid long term, to obtain a consensus on sustainability evaluation schemes, to increase the oil availability with competitive costs and endorsement to run diesel motors on B100 or at least B20.
The average income in the developing countries is rising and so is the demand for animal protein, therefore more feed demand. Excess of vegetal oil are expected to happen, and this surplus may be directed to biofuels with higher mandatory blending.

9:06 AM Green House Savings Produced By Argentine Biodiesel Use
Jorge Antonio Hilbert Sr., Ingenieria Rural, Instituto Nacional de Tecnología Agropecuaria, Villa Tesei, Argentina and Sebastian Galbusera, COmunicacion Nacional, Sec Medio Ambiente, Bienos Aires, Argentina

Abstract:
One answer to the environmental concern regarding Greenhouse gases emitions control has been the promotion of different biofuels as mandatory targets in many countries. Argentina as one of the world main producer of vegetable oils found a great opportunity to use a byproduct of its important seed processing industry to develop efficient biofuels for domestic and international markets.

The Argentinean soybean industry is extremely strong: more than 70,000 producers for 18 million of cultivated hectares and 30 million tons of products (2008-2009). The sector provides 13 billion dollars and represents an important source of foreign exchange for the State. The export taxes were 5% for biofuel and 35% for grain in 2007: this difference prompted soy exporters to invest in biodiesel plants for export. In this way, the first phase of biofuel development started. Economies of scale and the efficiency of the soy chain are exploited to make the Argentinean biodiesel a competitive product. Despite the increase in the biodiesel tax to 20% (2008), the strong international demand encouraged new investments. The production is concentrated around Rosario (province of Santa Fe), on the Paraná River, in the soybean oil exportation complex. Thus, the province of Santa Fe has 80% of the national production, against 8% for Buenos Aires and 7% for Santiago del Estero this gives additional advantages regarding GHG emitions since distances from the production area to the transforming complex and export ports don't exceed 300 km.

Large national companies (the oil manufacturers, General Deheza, Vicentin, and Eurnekian Citrusvil[1]) and transnational corporations (Dreyfus, Glencore and Bunge) build efficient industrial plants followed by medium private investors with smaller facilities in different parts of the country mainly concentrated on domestic market. The capacity 2013 is over 4 million tons per year.. Such volumes can be competitive in the global market. However, biodiesel exportation is fragile due to international and local changes in rules. The internal market is more recent and starts with an obligation to add 5%.

Since the 1970s, (bio) technological changes improve the production and productivity of the soybean chain. Now, biodiesel is diversifying its by-products, customers and locations. It also awakes the interest and creativity of engineers, chemists, and researchers since it offers an opportunity to put old and new industrial plants in operation.

Soybean production is characterized for the employment in more than 82 % of no tilling together with other modern technologies as presition agriculture. This gives an important advantage in GHG emitions savings and energy balance.

The industrial plants responsible for the principal market share of biodiesel are characterized by its high scale and efficiency. Most are located beside the processing complex and ports, which gives enormous advantages from the energy and emitions results. Raw material is coming from a radius no larger than 300 km, which also helps to increase efficiency.

In the last years, new bio refineries were developed in order to get higher value products of the biodiesel process as glycerin and sub products. This enlarges the benefits of the chain and increases the countries income.

The last eight years were characterized by huge investments in biodiesel industry using soybean oil as the main feedstock. The first investments were produced by the new emerging European market and more recently for a growing domestic one, triggered by increasing mandatory blend now reaching 10 % in the country.

In order to give an answer to increasing concerns regarding the green house savings produced by soybean oil biodiesel several international and national studies were performed giving a realistic evaluation of a very efficient transformation chain in the country.

Several studies have been completed in order to clearly calculate the GHG emissions of the Argentine biodiesel sector according to generally accepted international methodologies. Since the country has different agro-ecosystems and distances from the ports, different analyses were completed for different regions of the country. The key element to assess the Greenhouse Emission Saving (GES) was the soybean supply area. (Panichelli, 2012) With respect to GHG emissions (Kg CO2 eq/km), emissions reduction averaged 76% (0.0447 Kg to 0.0464 CO2 eq/km). The scenario that showed more GHG emissions was South East of Bs.As. (0.0447 Kg CO2 eq/km). Comparatively and percentage with conventional diesel, its reductions of GHG emissions were of 75.5 %. The scenario that showed less GHG emissions was placed in South of Córdoba (0.0464 Kg CO2 eq/km). Comparatively and percentage with conventional diesel, its reductions of GHG emissions are of 76.5%.

A deep analysis was performed of the studies looking at criteria, methodology employed, allocation factors, coproducts evaluation and data origin in order to obtain a realistic value of greenhouse savings that could represent soybean oil biodiesel produced under the particular Argentinean conditions.

A comparative analysis showed that the crop yields and the oversea transport are the main sources of variability between studies and years. The industry values are very constant and no significative difference was detected between the differen literature sources.

As methodological framework the ACM0017 (production of biodiesel to be used as a fuel) was used. Specific calculations were performed in order to obtain the total ammount of conventional diesel fuel replaced in each market.

Based on export and domestic market commercialization a national greenhouse savings calculation was performed for the last four years (2010-2013). For each case the total emitions were taken into account savings ranged 4 million tons per year.

[1] This group privileges the installation of a biodiesel plant near its oil factory (at Frías, Province of Santiago del Estero), becoming the only mega-plant located far from Rosario.

9:24 AM Bioethanol Dehydration Assessment with Environmental Issues

Mauricio Colombo[1], Fernando Daniel Mele[1], María Rosa Hernández[2], Michel Kahwaji Janho[3] and Jorge E. Gatica[4], (1)Ingenieria de Procesos y Gestion Industrial, Universidad Nacional de Tucuman, Tucuman, Argentina, (2)Ingeniería de Procesos y Gestión Industrial, Universidad Nacional de Tucuman, Tucuman, Argentina, (3)Chemical And Biomedical Engineering, Cleveland State University, Cleveland, OH, (4)Chemical and Biomedical Engineering, Cleveland State University, Cleveland, OH

Abstract:
Environmental effects and health hazards posed by fossil-fuel based technologies complemented by changes in the global economy have further demanded the need for developing “cleaner” and more efficient technologies that rely on renewable or synthetic resources. An alternative, commonly referred to as bio-fuels, has significantly matured and today’s economy recognizes the significance of being able to produce ethanol from renewable resources such as biomass. Moreover, the potential of ethanol to be further converted to hydrogen makes it a very attractive alternative to replace or complement fossil fuels as sources of energy.

Argentina has recently enacted legislation to promote the use of bio-fuels to ameliorate its ever increasing annual gasoline demand, currently bordering 4 billion liters. This new legislation (*Law 26.093 of Biofuels Promotion*) would result in a demand of over 200 million liters of dehydrated alcohol. This quota would be equivalent to produce ethanol out of all the sugar that is currently exported. With fifteen (15) active Sugar Cane processing plants, a mill capacity of 15 million tons/year, and thirteen (13) distilleries with 1.5 million liters/year of hydrated alcohol, Tucumán (located at North West of Argentina) could meet more than 50% of the ethanol demands for Argentina.

Process simulation allows a systematic analysis that leads to an advantageous combination of all the values of process variables. In particular, since they demand significant energy influx, an important subsystem for analyzing is the separation of alcohol-water mixtures. Though many techniques for ethanol dehydration are known; adsorption, distillation, hybrid processes, and pervaporation, are the most common technologies in practice. Two alternatives for ethanol dehydration technologies are considered in this work. The first is based on the combination of distillation and azeotropic distillation, while the second relies on hybrid distillation and pervaporation processes, so it was necessary to develop a simulation module for calculating the membranes performance, typically not included in commercial process simulators. Both alternatives are simulated and their optimal design and operating parameters are identified by means of rigorous simulation using Aspen Plus®.

To achieve sustainable designs process integration is a critical task. For this, we consider the dehydration step as an integral part of the overall scheme of alcohol / water separation, taking into account potential energy integration scenarios considering different concentrations of the products obtained in the different units, to analyze its impact on global energy consumption and other environmental indicators. Particular attention is given to energetic integration by performing a pinch-analysis to each of the fundamental stages to find minimum energy consumptions.

This paper uses an ad-hoc pervaporation module to assess the production of fuel-grade bio-ethanol in distillery installations complementing a sugar mill. A baseline condition is defined as a case-study to illustrate the effect of structural and parametric changes on membrane separation units.

The user-defined module is integrated in commercial process simulators to study the environmental and energetic impact of different process configurations. Different schemes meeting equivalent performance standards in terms of purity and recovery are examined in this paper. Particular attention is given to energetic demands as comparison metrics.

This paper formulates an approach that accounts for environmental issues in explicit form. The approach makes use of Life Cycle Assessment (LCA) as described by the ISO 14000 series. Unlike most common approaches that consider environmental impact by focusing on reducing effluents, this methodology also considers the impact associated with all the involved processes in the FPD. The software used to evaluate the environmental impact is SimaPro®.

Process alternatives that meets same specifications of purity and recovery in exit streams, are examined in this paper. Of particular relevance is the assessment of costs and environmental impact of these processes. A baseline case is defined in our case-study, and structural and parametric changes are made. Different scenarios with respect to economic and environmental issues taking into account the specifications of the final product are generated. The impact of different operating policies for the production of anhydrous alcohol on the environment is examined in detail.

The membrane area, the number of plates in the distillation units, the heat exchange area, and the pressure manipulators are considered as structural variables. Among the most relevant operational variables considered one can mention reflux ratio, pressure ratio, as well as compositions and flow rates of streams.

One could consider the addition of environmental aspects within energy systems optimization as a promising contribution to the energetic optimization and LCA.

9:42 AM Opportunities and Challenges Considering the Socioeconomic Dimension for Brazilian Ethanol Industries in the Recent Past
Andreia Marques, sustainability, Amarques & Associados, campinas, Brazil

Abstract:
The sugarcane sector in its evolution have a history of ups and downs that was influenced by several factors, sometimes causing structural changes, sometimes superficial in industry dynamics . However, the transformations experienced in the last 10 years have had a significant impact on the sector. In this latest expansion process, new elements and obstacles were put to groups of entrepreneurs and the new

ways to overcome those obstacles have created a new profile for the sector with significant impacts to the communities where the projects are implemented.

Among the variables to be considered on an expansion greenfield project there are elements in the agricultural , industrial and commercial steps that can be more or less aligned with the best practices of sustainability into force . The set of criteria for adoption of these elements often depends on technological factors, endafoclimáticos, legal or even structural elements of the chosen region (topography, availability of manpower).

This paper presents a description of these agricultural, industrial and commercial stages of a sugarcane company with the various technological and procedural options possible. The following focuses attention on one of the fundamental aspects of the business that has impact on the whole processing chain and in the communities where the company operates. This aspect concerns the way how the access to sugar cane has being done

In fact, the format of access to sugarcane (and so to say, land) has changed significantly in the recent expansion cycle (2000-2012). That comes to changing the role of land ownership. Before, the cultivation areas and expansion were the only states in the Northeast and São Paulo, now the crop expands to the Midwest and South. Before, planting on their own land used to be the preference and dominance of the sector who has justified by the dependence of the flow of raw materials, now, other forms of access to cane become the preference of some groups and land ownership becomes a subsidiary or complementary strategy in portfolio of raw material to be processed.

When it analyses the expansion to the state of Goiás where this author worked for 4 years, the differences leap to the eye. A simple implementation of a performance model from São Paulo to the new territory had to undergo several changes. The most striking and impactful to society differences concern the impact on agrarian structure of the region since this element brings to the company and external community consequences of long-term duration.

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This vertical integration strategy, when used for the expansion of the sector in the Midwest, this brings about the concentration of income in the hands of a few producers mill owners. Economic activity in the region decreases due to the increased use of larger suppliers capable of endereças the demands of large-scale owner / mill owner.

On the other hand, the strategy of horizontal coordination, where land acquisition gives rise to new contractual arrangements through the lease and formalizing partnerships production, causes a greater extent, the landowner and agricultural entrepreneur, continue ahead of production, and thus using more intensively local resources as manpower, suppliers of implements, products or services. The economic activity of such regions tends to be more dynamic and diverse.

But the question is what leading the adoption of vertical or horizontal strategy by sucroalcoleiras companies in the process of expanding into the region in southern Goiás? Which specificities found on the sector´s expansion to the Midwest have caused or intensified such behavior?

The hypothesis with which it works is that from the mid-2000s changed the profile of new entrants who favour new contractual arrangements in order to guarantee the flow of sugarcane production, at the expense of the vertical integration model adopted until that time by traditional entrants.

The reasons for this change is based on 2 elements: the change of profile of the owner-investor and prior presence of an established culture of using these institutes of lease and partnership that allows the new business owner to access the areas of planting without necessarily having to acquire the land
But why the new business owner profile do not accept or not prefer land acquisition anymore?
Research shows that this type of investor now has a profile of predominantly large business group , who pay attention on the scale production and at generating business cash flow instead of traditional family business which has in the real estate valuation of the land one of the attractive for the business.

The consequences of these differences for the community that receive the projects are various and belongs to social and economic dimension. To illustrate the two types of situation, the research presents two case studies of mill that expanded to the territory of Goias after 2000s - The Vale do Verdão - family management mill with access to vertical cane (sugarcane own strategy on own land acquired from the owners of the region) and the Tropical Bioenergy, a BP group business that uses horizontalized strategy, ie, does not have its own land for planting sugarcane and its supply is 100 % coming from the partnership , independent leasing and cane supply contracts .

The methodology used for the research was based on analysis of primary data collected from the companies presented, representation of business institutions. In addition, secondary data helped explain some impacts initially planned in the surrounding communities. Such analyzes and conclusions were validated with two field visits where interviews with community members and businesses surveyed supported the conclusions presented here.

10:00 AM Diesel Displacement in the Sugarcane Ethanol Life-Cycle: A Comparative Analysis of Different Integrated Systems

Simone P Souza[1,2] and Joaquim E. A. Seabra[1], (1)Department of Energy, University of Campinas (UNICAMP), Faculty of Mechanical Engineering, Campinas, Brazil, (2)Sustainability Program, Brazilian Bioethanol Science and Technology Laboratory (CTBE) – CNPEM/ABTLuS, Campinas, Brazil

Abstract:
Integrated crop systems have been proposed as an alternative to enhance the efficiency and to improve the interaction among bioenergy, food and chemicals production (Cherubini, 2010). They can be able to produce such products from different raw materials (Taylor, 2008) and, additionally, may reduce the commitment of land for bioenergy production and provide diversification and optimization of agricultural systems (Cavalett et al., 2011; Souza and Seabra, 2013).

The biodiesel and the sucroenergetic sectors in Brazil are already important model of biorefinery due to the diversity of products and the opportunities to use the residues as fertilizer, energy source, irrigation, and others. However, there is still potential for improvement and other integration alternatives for these sectors (Bonomi et al., 2012; Lombardi et al., 2009; Oliverio et al., 2007; Ometto et al., 2007;

Pereira et al., 2014). The integration in the crop and industrial systems can improve the environmental aspects over the life-cycle, such as reducing the GHG emissions and the fossil energy use.

In previous works (Souza and Seabra, 2013; Souza et al., 2013, 2012) we assessed the gains of the integrations between palm-sugarcane (PSIS), soybean-sugarcane (SSIS) and algae-sugarcane (ASIS) in terms of GHG emissions and fossil energy use. In this work, we aim to demonstrate a comparative analysis among these systems and to indicate the advantage and disadvantage of each integrated system, focusing the diesel displacement in the sugarcane ethanol life-cycle.

10:18 AM Direct and Indirect Impacts of Agricultural Land-Use Due to Increased Production of Grain-Based Ethanol in Kansas, USA: A County-Level Analysis
Jason Bergtold and Brian Lauer, Agricultural Economics, Kansas State University, Manhattan, KS

Abstract:
Applied economists have dedicated much literature to the design and specification of acreage allocation models for land use decisions. These models can play an important role in understanding how acreages might shift in the event of new policy or in a changing agricultural landscape, especially with the increasing demand for biofuel production. Furthermore, the increase in ethanol production over the past two decades has impacted markets for corn and grain sorghum in Kansas, USA, especially with the prospect of grain sorghum being classified as an advanced biofuel feedstock. The increased production of the ethanol within Kansas has had an impact on local markets and the intensity of agricultural production in these areas. The presence of an ethanol plant can impact the prices of crops in the local market; the outlets for marketing grain by farmers and elevators; and the intensity of crop production in the vicinity of the plant. The direct changes in land-use production from a stronger ethanol industry in the state will likely lead to indirect changes in the use of agricultural land, as well.

The purpose of this paper is to examine the direct and indirect impact on agricultural land-use from increased ethanol production in Kansas.

The study utilizes acreage allocation models designed in the agricultural economics literature and builds on these previous acreage allocation studies by correcting for spatial autocorrelation; spatial proximity to ethanol refineries using capacity as a function of distance to a refinery as an explanatory factor in the model; and by incorporating changes in agricultural land-use in neighboring counties to capture potential indirect land-use changes. Bioenergy is an important agricultural topic to the state of Kansas, and understanding how the presence of ethanol plants effects producers' acreage decisions is critical as the bioenergy industry moves forward and new policies are developed. This study uses a 1996-2009 Kansas county level dataset for analysis. Variables that will be examined include shifts in acreage allocated to crops in neighboring counties, expected input prices, production costs, livestock populations, government programs, site and soil characteristics, weather, and ethanol plant characteristics such as proximity to a county and size of the plant. Models will be estimated for dryland corn, wheat, sorghum and soybean. The methods in this paper will follow methods proposed by Wu and Brorsen (1995) which extended the HEAR model proposed by Kmenta (1996) to a set of seemingly unrelated equations. These methods will be expanded to take account of spatial dependence.

Results indicate that own- and cross-price effects of crops and the capacity/proximity to an ethanol refinery have had significant impacts on the crop acreage allocated to the production of corn and grain sorghum. In addition, using the spatial lags of shifts in crop production in neighboring counties allows for

the derviation of spillover marginal effects of these on within-county acreage allocation to help capture indirect effects on crop land allocation decisions. Results from the paper will help to assess the agricultural land-use impacts from the expansion of the ethanol markets in the U.S. and the impacts of U.S. bioenergy policies.