Sweet Dreams are Made of This: Bioelectricity in Brazil

Sérgio Granville, Priscila Lino, Leonardo Soares, Luiz Augusto Barroso, *Member, IEEE* and Mario Pereira, *Member, IEEE*

***Abstract*— the integrated sugar/ethanol/electricity production has become the new business model – the bioelectricity industry – with a potential to become a "mainstream" energy option in the near future in Brazil. Besides being clean, it is competitive: several hundred MW of bioelectricity plants have already signed long-term electricity supply contracts with the distribution companies. These contracts have been awarded on a competitive basis (public auctions), without any subsidy policy and an agreement with the World Bank to create an "umbrella" qualifying procedure of bioelectricity plans for carbon credits – with a later auction of the credits – is already in place. The objective of this work is to discuss the bioelectricity achievements in Brazil.**

***Index Terms*-- Power system economics, power system planning, clean energy, carbon trading.**

I. Introduction

THe need to ensure an adequate generation adequacy forms the backbone of electricity markets. The availability of coal reserves and the increase of gas and oil trading has made over the last decades the fossil-fuel energy resources (such has coal-fired, gas-fired and oil-fired power plants) key resources in assuring the security of supply worldwide.

Also during the last decades, the consequent (direct) connection between the greenhouse gases[1] in the electricity generation and the increase of the average earth's temperature (global warming) has become a consensus of the scientific community for years [1]. It is also a consensus that the warming effect may be catastrophic for the poorest regions of the planet within decades (nor centuries, as imagined earlier), as the evidences presented by the Intergovernmental Panel on Climate Change (IPCC). As in the security for electricity supply, oil has a central role in the climate question. The reason is because gasoline and diesel are responsible got almost 100% of the energy consumed in the transportation sector, which in turn contributes with almost 25% of the total emissions of industrialized countries.

In this sense, the substitution of fossil fuels by clean energy (such as wind, solar and biofuels) has become very attractive recently, with many countries offering incentive programs for its development[2]. Because some of these programs are based on explicit subsidies, they have been criticized on the grounds of its economic rationale and lack of economic signals for efficiency and technological improvement.

In the case of biofuels, mainly ethanol and biodiesel, a less known facet is its integrated development process, consisted of a multi-commodity business that can generate synergies and develop clean-energy programs on a competitive basis. The Brazilian sugar/ethanol industry is a good example, where the production process is also used for electricity cogeneration (*cogen*). Brazil's plants have today an installed capacity of 2,200 MW, of which 600 MW is sold to the grid. With more efficient boilers being ordered for the new plants, sugarcane biomass cogen, known as bioelectricity, has become more competitive than "mainstream" technologies such as hydroelectric power or combined cycle natural gas thermal generation. Additional gains also apply to this cogen, such as: (a) proximity to load centers, implying in reduction in transmission losses and tariffs, (b) full complementarity with hydro resources and (c) possibility to receive carbon credits as clean developed projects.

The objective of this presentation is to describe the Brazilian bioelectricity business and its achievements obtained so far. This work is organized as follows: Section II presents an overview of the general world energy security and environment challenges, Section III discusses the role of biofuels, with Section IV describing the key aspects of the ethanol industry in Brazil. The bioelectricity program is described in Section V and Section VI draws the conclusions and perspectives for this industry.

II. The Energy Security and Environment Challenges

As the 2005 G-8 meeting has shown [2], energy supply security and global warming are critical concerns of the world's largest economies. One of the greatest challenges in finding adequate responses is that many solution alternatives address one of the concerns, but have a negative impact on the other, or require new technological developments which may delay their implementation for several years or even decades.

This dilemma is illustrated with the use of coal for power

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[1] The main GHG are CO_2 and CH_4

[2] For example, wind power being strongly developed in Germany & Denmark; the EU has launched directives on the increase of clean energy in the participant countries, etc.

generation. As it is well known, the construction of combined cycle power plants using natural gas has increased exponentially in the past fifteen years. However, as the recent examples of Russia-Ukraine, Argentina-Chile and Bolivia-Brazil illustrate, the geopolitics of natural gas are similar to those of oil[3]. Also, as shown in the Figure below, the increase of LNG production and transportation has led to a linkage of the oil and natural gas prices.

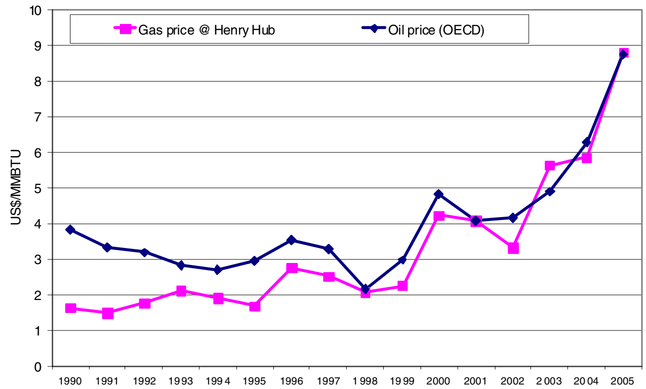

Fig. 1 – Gas vs. oil prices (Source: BP Statistic Review 2006)

In contrast, coal is relatively cheap and has huge reserves concentrated on the world's leading energy consumers, US and China. Therefore, coal-based generation looks like an attractive option to reduce dependence on natural gas. Indeed, a recent article in the science journal Scientific American [3] indicated that US and China are planning to install two million MW of coal-based generation in the next two decades.

However, this massive coal power plant construction program would have a negative environmental impact, because coal generation is a major source of CO2 emissions. In the same Scientific American report [4], it is estimated that the lifetime emissions from these new plants would equal the cumulative effective of coal burning since 1750, thus offsetting most of the world's efforts for emissions control.

Some advanced technologies, in particular carbon capture and storage (CCAS), have been proposed to alleviate the power plant emission problem, but they are still in the development stage. Also, because CCAS decreases plant efficiency, power prices may increase by 20 US$/MWh, as indicated in a recent study by the World Energy Council [5].

III. BIOFUELS

Biofuels - ethanol and biodiesel (diesel from vegetal oil and biomass) - have emerged as one of the few solutions with the potential to reduce both oil dependence[4] and emissions[5]. In addition, the technology for biofuel production is relatively simple and exists today (even the development of more advanced technologies such as cellulosic ethanol is much less capital- and technology-intensive than, for example, CCAS or hydrogen fuel cells). Finally, biofuels have the potential for being a tool for poverty reduction: the most promising production areas are in emerging countries in Latin America, Africa and Asia.

For these reasons, biofuels have attracted a lot of media attention, as well as great interest from investors and politicians. In particular, sugarcane-based ethanol production from Brazil has been getting praises from highly visible personalities such as President Bush, George Soros, Vinod Khosla, Larry Page & Sergey Brin (owners of Google) and Thomas Friedman[6].

IV. BRAZILIAN SUGARCANE-ETHANOL INDUSTRY

A. *Brazilian sugarcane-ethanol industry today*

In this context, Brazil's ethanol industry presents some figures that justify this praise:

• Brazil is the world's largest producer of ethanol volume, with US (corn-based ethanol) coming a close second.. As described in Figure 2, note that the country's ethanol production is achieved with only half of the sugarcane processed[7] – most of the remainder 50% is used for sugar, the rest being for beverages (*cachaça* - the most popular distilled alcoholic beverage in Brazil, made from sugarcane juice, *rapadura* - a traditional candy, it is essentially pure dried sugarcane juice in the form of a brick) and animal feed;

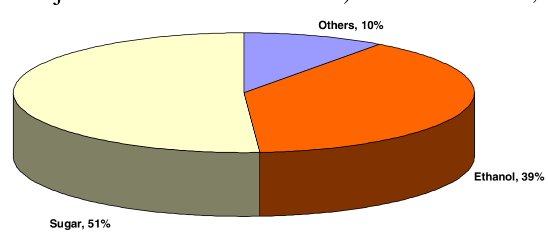

Fig. 2 – Sugarcane production destinations

• The country's ethanol has also the lowest production cost of all biofuels (0.8 US$/gallon), competitive with oil at 35 US$/barrel. In contrast, in contrast, corn-based ethanol in the US has a production cost of 1.3 US$/gallon[8], thus requiring 60 US$/barrel; and the EU requires 90 US$/barrel;

• The Fossil Energy Ratio (energy produced / fossil energy used in biomass production, such as fuels for tractors) of sugarcane-based ethanol is very high: 8.3, in contrast with 1.2 for corn-based ethanol;

• 75% of all new cars in Brazil are "flex fuel", i.e. can use any proportion of gasoline and ethanol without any adjustment;

These achievements result from decades of continuing

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[3] According to EIA's 2006 Energy Outlook, 58% of the world's reserves are concentrated in Russia, Catar and Iran. In addition, according to *The Economist*, 90% of the world's oil and gas reserves are controlled by national governments, not international companies.

[4] Biomass production, for obvious reasons, is not very abundant in the dry Middle East region or in cold countries such as Russia.

[5] Note that the burning of a biofuel does release CO_2; however, in a simplified way, the amount of carbon released is recaptured by the growing biomass in the next harvest. Therefore, biofuels are "emission neutral".

[6] See the NYT journal, September 15 and 20, 2006.

[7] Sugarcane production in Brazil (2006/2007 harvest) will be of 470 millions of tons (Mt), a historical record for the country.

[8] Ethanol from Brazil to the US gets a punitive tax of 54 cents/gallon and ethanol produced in the US gets a tax incentive of 51 cents/ gallon.

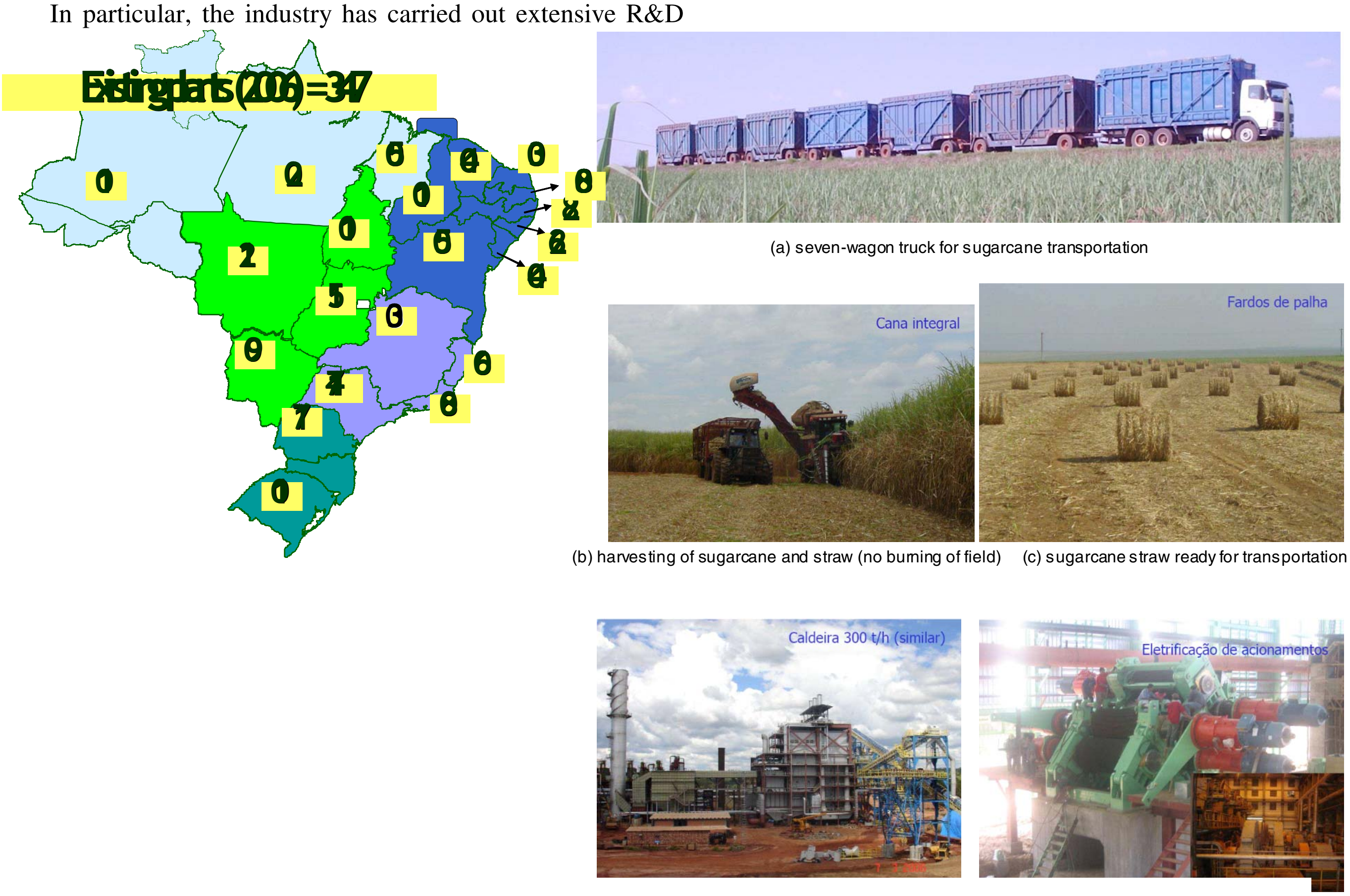
efforts from a diversified, 100% private industry, as shown in Table I.

TABLE I – OVERALL SECTOR CHARACTERISTICS (2006)

Annual Revenues	US$ 18 billion
Number of sugar cane growers	60 thousand
Producers	347 plants/distilleries
Sector jobs	3.6 million
Sugarcane production	470 million tons
Sugar production	27 million tons (17 million exported)
Ethanol production	4 billion gallons (2.5 billion exported)

In particular, the industry has carried out extensive R&D on new sugarcane varieties to optimize for micro-soil, with solid results, such as a 50% productivity increase (tons per acre) in the last 12 years. The industry has also invested heavily in the optimization of harvesting (in particular, mechanical harvest instead of hand harvest, which requires burning of the field; and processing of the sugarcane straw, in addition to the stalk) and in the energy efficiency of the processing plants (e.g. higher pressure/temperature boilers).

Figure 3 shows some pictures that illustrate some recent achievements in these areas.



(a) seven-wagon truck for sugarcane transportation

(b) harvesting of sugarcane and straw (no burning of field) (c) sugarcane straw ready for transportation

(d) high pressure /temperature boilers (e) electrical drivers

Fig. 3 – Location of existing plants & outlook of sugarcane industry

B. Brazilian sugarcane-ethanol industry - perspectives

The sugarcane industry in Brazil is currently undergoing a fast expansion. Sugarcane production is expected to increase from 400 million tons/year (Mt/y) in 2006 to 600 Mt/y in 2010; and then to 1,000 Mt/y – one sugarcane "Gigaton" [3] - by 2020. This will require the construction of 150 new sugar cane mills/distilleries, with average investments of US$ 100 millions per unit (agricultural and industry activities) – a US$ 15 billion investment.

To put this production potential into perspective, one sugarcane "Gigaton" could yield (roughly) 100 billion liters of ethanol per year (bl/y), equivalent to 70 bl/y of gasoline.

In terms of imported fuel displacement (energy security), these 70 bl/y of gasoline correspond to 1.2 million barrels/day, or 13% of US gasoline consumption in 2004. In terms of emission reductions, they correspond to 0.17 billion tons of CO2 per year, that is, 17% of a "Stabilization wedge" [9].

V. BIOELECTRICITY

A less known facet of Brazil's sugar/ethanol industry is that the production process is also used for electricity co-generation. Existing plants have low pressure boilers (21 bar,

[9] Socolow introduced the concept of a stabilization wedge in a 2004 *Science* paper; it corresponds to an average of 1 GtC/y in emission reductions over 25 years. The idea is that stabilization of emissions is achievable with 7 Wedges.

300° C), dimensioned to produce the needed power for self consumption. The objective to use this type of boiler was not energy efficiency, but to consume all the bagasse (waste) produced. Therefore, the surplus power per plant (that could be sold to the grid) is low.

Brazil's sugarcane plants have today (2006) an installed capacity of 2,200 MW, mostly for self consumption, of which 600 MW is surplus power and sold to the grid. Clients comprise essentially energy traders, via financial forward contracts.

An interesting issue was the lack of incentive of sugarcane producers to install more efficient boilers and then sell more surplus power to the grid. The electricity produced by the sugarcane cogen is seasonal (the sugarcane harvest is from May to November, so is the electricity production) and there were no mechanisms in the power sector that enabled this plants to sell *firm* yearly forward contracts (sugar cane cogen had no firm energy). Therefore, this electricity became known as "seasonal" and much devaluated by buyers[10].

This started situation started to change in 2004, with the approval of a new contracting mechanism for the Brazilian power sector, described next.

A. Electricity contracting in the Brazilian power system

As discussed in [7], the Brazilian mechanism to stimulate the entrance of adequate capacity and ensure resource adequacy lies in two main rules:

a) all consumers, both regulated and free, should be 100% contracted. The contract coverage is verified ex-post, comparing the cumulative MWh consumed in the previous year with the cumulative MWh contracted. If the contracted energy is smaller than the consumed energy, the user pays a penalty related to the cost of building new capacity;

b) all contracts, which are financial options or forward contracts, should be covered by 'firm energy certificates' (FEC). For example, in order to sign a contract for 1000 average MW[11], the generator or trader must show that it possesses firm energy certificates that add to the same amount. The FECs are tradable and can, along the duration of the contract, be replaced by other certificates; the only requirement is that the total firm energy of the certificates adds up to the contracted energy

For the regulated users, the procurement of new capacity is carried out through public auctions. Distribution companies (Discos) are required to inform their load forecast and a set of long-term contract auctions is carried out to meet the total load increase. The objective of the joint auction is to allow smaller Discos to benefit from economies of scale. Each generator (Genco) that wins the auction signs separate bilateral contracts with each of the Discos, in proportion to their forecasted loads. Note that this contracting scheme is different from a traditional 'single buyer' scheme, where a government agency signs a PPA with an energy producer. In the contract auctions, there is no government interference or guarantee; the contracts are private instruments, signed between Discos and Gencos. Another important difference is that there is no government-based load forecast; Discos are responsible for this activity, thus avoiding the 'optimistic' government bias that in many countries has led to over-capacity and expensive contracts.

B. Firm energy certificates

FEC are issued by the Regulator for each generator in the system, and reflect their *yearly* sustainable energy production capacity. For hydro plants, for example, the FEC corresponds to the (firm) energy production capacity in dry years. For thermal plants, the FEC is given by the available capacity (discounting average maintenance and forced outage rates), adjusted by a 'derating' factor that depends on the variable operating cost[12]. Yearly FEC are calculated for every equipment in the system, even for those with seasonal production, such as sugarcane biomass, or intermittent producers such as wind power. With a FEC in hands, any power producer from any technology can sell an energy contract. This mechanism allowed the determination of the FEC of an energy produced from a sugar cane mill, which started to have yearly capacity certificates that could be sold at the regulated auctions.

C. An alternative contract type: energy call options

The greatest novelty of the new market rules was the contract design: in addition to standard financial forward contracts, energy call options (described in [8]) started also to be offered in the auctions. In these contract types, the consumer "rents" the plant from the investor, paying a fixed amount – option premium (to allow investment and fixed cost recovery), reimburses the plant's owner on its declared variable operating costs (strike price) whenever the plant runs and pays the short-term market transactions: if the plant produces more than its contracted amount, the excess belongs to the buyer, who will sell it at the short-term price, while any shortfall will have to be purchased by the buyer in the short-term market.

An energy call option transfers to consumers "systemic" risks which are difficult for the individual investor to manage (e.g. hydrology or seasonality), which facilitates project finance (by eliminating risk factors) and encourages competition. This type of contract allowed the transferring of the benefits of spot sales and the risks of spot purchases to the buyers (discos). This has created a window of opportunity for

[10] Observe that even if producers decided to sell yearly firm amounts, it then becomes too risky for the individual producers to take the exposure of the risk of spot purchases during the out-of-the harvest period

[11] Average MW = GWh/#hours

[12] The idea is that an expensive plant, for example, diesel-fired, is only dispatched late in a drought situation, whereas a cheaper plant, for example combined cycle natural gas, is dispatched earlier. As a consequence, the cheaper plant's contribution to the overall 'firm supply' is more significant than that of a more expensive plant. Taken at the extreme, a thermal plant whose variable operating cost was equal to the rationing cost would have a firm energy certificate of zero average MW.

selling of cogeneration from the sugarcane biomass at the auctions, thus motivating new plants to install more efficient boilers (65 bar/520°C) and starting a program for bioelectricity.

D. The bioelectricity program

Because sugarcane production is expanding, new boilers/generators are required for the new plants. The cogen cost is only the cost of acquiring more efficient equipment (higher pressure boilers), which produce more Kw per ton of sugarcane, as shown in Figure 4.

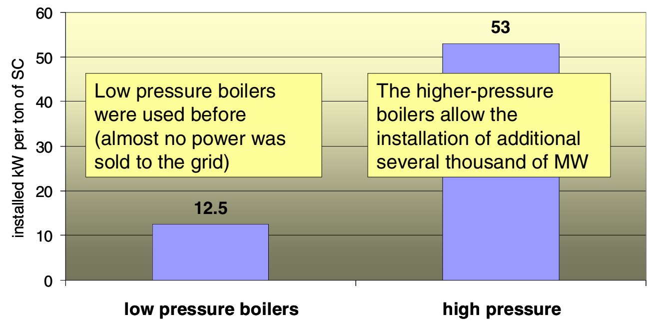


Fig. 4 – Installed kW per ton of sugar-cane (SC)

With more efficient boilers being ordered for the new plants, sugarcane biomass cogen, known as bioelectricity, has become very competitive in the auctions: their investment cost for energy sales is just the incremental cost of the efficient boiler (the remainder costs are due to the sugar/ethanol businesses).

Additional gains also apply to this cogen, such as:

(a) proximity to load centers: as shown in Figures 5 and 6, the crop areas are in the Southeast and Northeast regions. The largest crop area is in the state of São Paulo, close to the main load center, implying in reduction in transmission losses and tariffs.

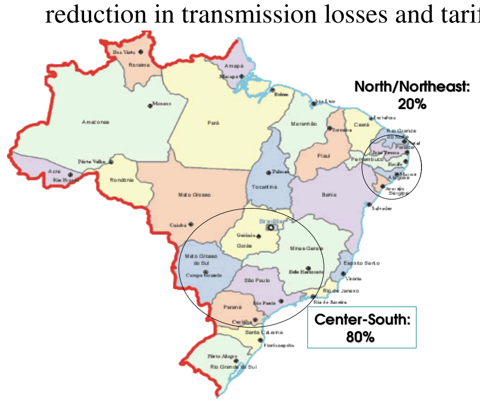


Fig. 5 – Crop area

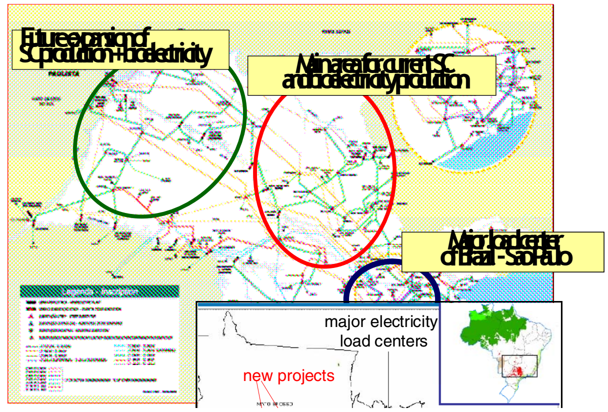
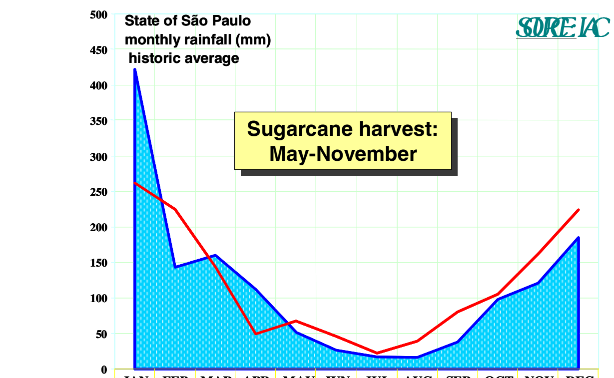


Fig. 6 – São Paulo area

(b) full complementarity with hydro resources: the crop season occurs during the dry season of hydro inflows, as shown in Figure 7, which shows an additional economic value for bioelectricity production, because it is produced when spot prices are higher:



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
- 2003	422	143	160	112	51	26	17	16	38	98	121	185
Historic	262	225	144	49	67	46	22	39	80	105	162	224

Fig. 7 – Complementarity between crop and hydro production

(c) shorter construction period: the cogen from sugarcane biomass takes (on average) 2 years to be built, instead of 5 years for hydro plants. This is important due to uncertainty in load growth (flexibility is valuable because of volatility in load growth);

(d) this cogen has a natural "hedge" with sugar and ethanol production, thus having greater competitiveness.

Hence, a joint initiative of sugarcane producers, cogen associations and equipment manufacturers was launched, with the objectives of increasing the participation of biomass cogen in the energy sector. Instead of subsidized mandatory programs, the bioelectricity initiative relies 100% on private investment and aims at competing with other sources on the same footing.

E. Bioelectricity in the energy supply auctions

The participation of bioelectricity in the energy supply auctions has been encouraging. Overall, since 2004 Brazil has carried out 3 main public auctions for 15-year energy call options for new capacity for delivery in 2008, 2009, 2010 and 2011. Sugarcane producers have offered the surplus production of their expansions in the mills (some carried out investments to retrofit their plants and offered the additional energy surplus) at very competitive prices, awarding contracts with bids that displaced "mainstream" technologies such as hydroelectric power or combined cycle natural gas thermal generation on a competitive basis (public auctions) without any subsidy policy. Table II shows the participation of the bioelectricity in the auctions, with total csapacity sold and average prices.

TABLE II – BIOELECTRICITY SALES IN THE AUCTIONS

Year of delivery →	2008	2009	2010	2011
Capacity (MW)	54	235	-	105
Average Price (R$/MWh)	110	120	-	135

*R$/USD = 2,3 as of December 2006

In particular, the lowest bid in the auction for delivery in 2008 was from a bioelectricity plant.

An important aspect of these achievements is that the sugarcane producers started to have revenue streams from the long-term electricity contracts, which can be used as collateral for private financing of additional ethanol/sugar production capacity (leverage of investment). This will, in turn, produce more electricity and can allow a higher participation of these plants in the system's expansion. This has enabled the integrated sugar / ethanol / electricity production to become a new business model in Brazil, as outlined in Figure 8.

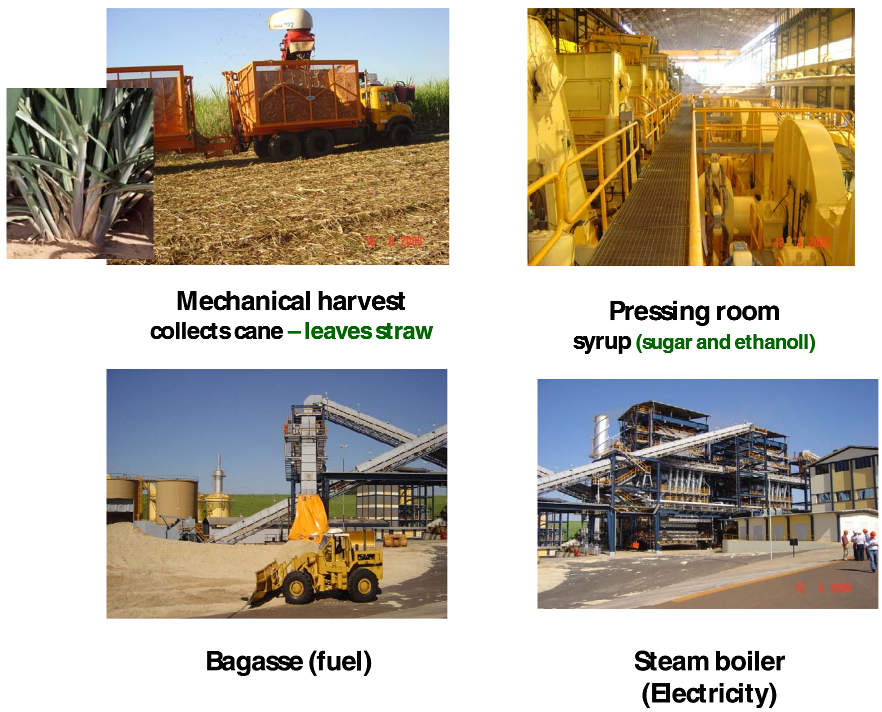


Fig. 8 – Scheme for electricity cogeneration with sugarcane biomass

VI. A STEP FURTHER: CARBON CREDITS & INCREASE IN ETHANOL PRODUCTION

A. *Carbon credits*

Bioelectricity plants can also qualify for carbon credits as clean developed project (greenhouse gas emissions cuts generated by these projects would count against the investor's own emissions reduction commitments), which can provide additional revenue streams to leverage investment in clean energy.

At the moment, the bioelectricity producers have established an agreement with the World Bank to create an "umbrella" qualifying procedure of bioelectricity plans for carbon credits and then carry out auction of the credits, which will provide additional revenue streams.

B. *Increase of ethanol production*

Increasing the crop area can expand ethanol production even further. Brazil's total land area is 2,100 million acres (Ma), of which 925 Ma are suitable for agriculture (no rainforest or other environmental areas). Of these, only 14 Ma (2%) are used today for sugarcane[13]. Given that a sugarcane Gigaton should occupy 35 Ma, and that the area suitable for sugarcane production is 280 Ma, there can be an eightfold increase in ethanol production, which would reach 9.6 million barrels of oil equivalent/day, which by coincidence is Saudi Arabia's production today.

A further increase in ethanol production can be achieved by the conversion of unused sugarcane biomass into ethanol.

[13] . As a comparison, 544 Ma are used for pasture; 228 Ma are unused; and 46 Ma are used for soy. All of Brazil's food crops (rice, beans, coffee, wheat etc.) occupy 23 Ma.

As it is well known, only the sugarcane syrup, which accounts for 1/3 of the sugarcane's total energy, is currently converted to ethanol through fermentation; the remaining biomass is burned (bagasse) to produce heat and electricity to the industrial process, or is left in the field (straw). With the so-called "cellulosic ethanol" techniques[14], this surplus biomass can also be converted into ethanol. Field experiences with a "fast hydrolysis" technique carried out by Dedini, a Brazilian equipment manufacturer [9]; indicate a twofold increase in ethanol production, thus boosting Brazil's ethanol production. Taking the increase in sugarcane production described in Section IV.B, Figure 9 next presents an example of the impact of cellulosic ethanol in terms of displacing US gasoline consumption.

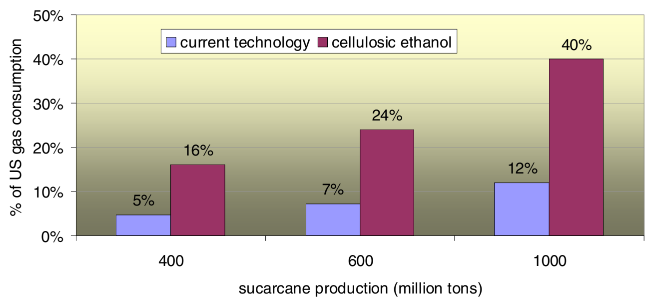


Fig. 9 – Cellulosic ethanol

VII. Conclusions and Perspectives

As discussed in this work, the integrated sugar / ethanol / electricity production has become the new business model – the bioelectricity industry - and has the potential to become a "mainstream" energy option in the near future in Brazil. This is motivated by a "window of opportunity" due to the combination of strong growth of sugar/ethanol sector, new power sector regulations and start of Kyoto initiative.

Bioelectricity presents several valuable attributes, such as: smaller size projects (typically 50 MW), which create a portfolio effect – diversifies risk of construction delays; wider range of investors (local private funds, foreign investment funds) and easier environmental licensing. It is also important to mention that some sugarcane producers are obtaining access to the capital markets including Initial Public Offer (IPO) in stock exchanges, which indicate a higher degree of maturity in the industry and possibility of long-term commitments.

In this sense, several important achievements have materialized:

- Several hundred MWs of bioelectricity plants have already signed long-term electricity supply contracts with the distribution companies. These contracts have been awarded on a competitive basis (public auctions), without any subsidy policy;
- as a consequence, financial funds of receivables tied on the energy supply contracts sold were created with the objective of leveraging investment in new plants;
- an agreement with the World Bank to create an "umbrella" qualifying procedure of bioelectricity plans for carbon credits and then carry out auction of the credits - which will provide additional revenue streams - was obtained;
- support of the Brazilian National Bank for Development (BNDES) tying more favorable financing conditions to more efficient boilers (which will produce more surplus firm energy)
- creation of integrated programs for equipment production by manufactures such as Dedini and Siemens.

The bioelectricity alternative has become a win-win situation for consumers and environment, relying on private investment and competition and illustrating the integration process of the agriculture and industrial sectors in a new sector with a large economic potential for Brazil, the industry of bioelectricity.

[14] Extraction of ethanol from the bark and leaves of any biomass (trees, waste etc.)

VIII. Conclusions and Perspectives

Authors would like to gratefully acknowledge the valuable contributions and discussions with Onório Kitayama from Unica (sugarcane producers association), Carlos Silvestrin from the Cogen association of São Paulo and Jorge Trinkenreich, Alexandre Street and José Rosenblatt from PSR.

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X. Biographies

Sérgio Granville has a PhD degree in Operations Research from Stanford University. He joined PSR in 2000 and is currently engaged in risk management for energy markets and software development for power systems, including integrated bioenergy model.

Priscila Lino has a MSc in OR from UFRJ and a MBA in Corporate Finance from PUC-RJ. She joined PSR in 2000 and has been coordinated studies in the following areas: (i) economic and financial evaluation of projects; (ii) asset valuation, including distribution, generation, transmission and trading companies; (iii) distribution tariff projection for final consumers (iv) regulatory assessment for foreign investors; (v) due-diligence studies for IADB and (vi) studies on the opportunities of an integrated bioenergy model.

Leonardo Soares has a BSc in EE (with emphasis in Statistics and Optimization) and is working towards a MSc. degree in Industrial Engineering (Finance and Investment Analysis), both from PUC-RIO. He joined PSR in 2006 and has been working on the development of computational models for the valuation of new generation plants and risk analysis involving physical and financial assets**.**

Luiz Augusto Barroso, IEEE Member, has a PhD degree in optimization from COPPE/UFRJ, Brazil. He is a senior analyst in PSR, where he has been coordinating economic studies and researching on power systems economics, planning and operation, focusing on hydrothermal systems. More recently, he has been involved on the opportunities of an integrated bioenergy model.

Mario Veiga Pereira, IEEE Member, has a PhD in Optimization from COPPE/UFRJ. He is the president of PSR and he is currently engaged in regulatory studies and the development of new methodologies and tools for risk management in competitive markets. Since 2004 he has been involved in the design of Brazil's Bioelectricity Program (aimed at developing an integrated ethanol / sugar / electricity / carbon credits business model), in cooperation with the sugarcane producers and the cogeneration association.