The Development of the Brazilian Bio-electricity Market: An Historical Analysis of the Institutional Changes in the Sugarcane and Electricity Markets

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INTRODUCTION

The emergence of bio-energy markets have been studied all over the world (CBES, 2009). Questions regarding government programs and interventions in the development of bioenergy markets are the main focus of researchers. Specifically, commentators argue that bioenergy programs have adversely distorted the economics of agricultural markets (Business Week 2007). Brazil provides an instrumental case for analyzing how the deregulation process in the sugarcane industry creates new opportunities for alternative energy production, such as biomass electricity. Institutional interventions and the privatization process in both the sugarcane and the electrical sectors have linked capacity for clean energy production with increasing demand for alternative electricity.

This study is divided into seven sections. First, it describes the sugarcane and energy sectors from the early 1900's through 1990 when New Economy concepts started being implemented worldwide. Second, this paper presents how the national government has gradually decreased its intervention in the sugarcane industry. The third section tackles how institutional changes in the electrical sector have created opportunities for alternative energy production. In the fourth section an integrated approach is made in order to associate the sugarcane industry and its opportunities in the bio-electricity market with the new organization of the electrical sector. The fifth section discusses current national government's interventions. The sixth section briefly describes future studies. Finally, the seventh section concludes the paper.

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HISTORICAL BACKGROUND

Government programs and institutional reforms have always been part of the Brazilian energy sector. After 1929, the federal government intensely regulated the energy sector as a way to relieve the harm caused by the global economic downturn. While the world was trying to rebuild its economy, many governments assumed the position of players in the most important sectors of the economy. In the mid 1930's, the United States government announced the well-known Smoot-Hawley Tariff Act which raised the tariffs on international goods in defense of U.S. national recovery (IRWIN, 1998). Starting after the economic collapse of 1929, countries explicitly assumed nationalist positions as a response to the crisis and imposed national programs of revitalization. Brazil focused its efforts on domestic market protection and job creation.

As one of the strongest agricultural exporters in the world, Brazil was vulnerable to the international downturn. Trying to reorganize its internal markets and looking at the most important exports, among them sugar, the federal government established the Sugar and Ethanol Institute (IAA) in 1933. IAAs' role was to plan and control the annual sugar and ethanol production as well as the amount of sugarcane delivered to each plant. According to the IAA act, no sugarcane processor could be established without authorization. The institute regulated the amount of ethanol and sugar to be produced in each state. Between 1933 and 1990, the IAA was the main vehicle for the national governments' intervention in the sugarcane sector. Depending upon the historical period, the IAA and other federal organizations either supported ethanol and sugar production or limited it at the national or the state level.

As both sugar and ethanol are derived from sugarcane, the government programs had a major impact on the agricultural sector. In the 1970's, well-known programs such as the National Sugarcane Breeding Program, National Facility Modernization Program and *Proálcool* (Ethanol

Program) were announced in order to increase sugar exports and decrease dependency on foreign oil.

Proálcool was the first bioenergy program which had large impacts on the domestic market and consumers' choices. During the thirty years after the initiation of *Proálcool*, the ethanol production increased 30 times, yield per hectare increased 60% and production cost declined by 75% (Nass et al., 2007). By December 1980, ethanol car sales represented 76% of total car sales. The main purpose of the program was to motivate the production of and demand for alternative fuel as a reaction to the increasing price of oil on the international market. However, increasing federal debts and lack of support for new investments ended the program in 1989 when international oil prices started stabilizing after the end of the Iran-Iraq war (1980-1988). As a result, people who had invested in ethanol cars (E-100) were unable to find fuel and changed consumption back to gasoline cars. Ethanol was no longer competitive to gasoline given the international prices for sugar and oil. When *Proálcool* ended, ethanol cars were no longer economically efficient. Consumers again embraced ethanol as a fuel only in 2003 when flex-fuel technology was first introduced in Brazil.

The electrical sector has followed a slightly different sequence of government interventions until 1990's when privatization measures started being adopted on both sectors. Market protection for the electrical sector began in 1943 when the federal government started investing in transmission improvements and intervening in the electrical sector as a whole. Before 1943, transmission and distribution services were concentrated in two foreign companies. *Brazilian Traction Light & Power Co.* (a Canadian company) and *American & Foreign Power Co.* (an American company) were responsible for 70% of the capacity for electricity generation in Brazil (LEITE, 2009). The national intervention took place with the establishment of

Eletrobrás in 1961, a state-owned company which became responsible for managing generation, transmission and distribution activities across the country. State intervention in the electrical sector ended in April of 1990 when the National Privatization Program was launched through Law 8,031.

Since 1990, new patterns have been traced by the federal government supported by the Federal Constitution of 1988. Based on democratic and open economy principles, the Brazilian government decided to minimize its interventions. The nationals' role has changed since 1988: it moved from interventions to the establishment of free-markets and regulation measures where free-markets cannot properly operate.

THE PRIVATIZATION OF THE SUGARCANE SECTOR

Initiated by the National Privatization Program, the Brazilian economy began following New Economy concepts in 1990. Due to the complex interaction between ethanol/sugar markets and government interventions, the deregulation program was rescheduled several times. During the national intervention period, the agricultural market for sugarcane was related to the market for ethanol and sugar. The Sugar and Ethanol Institute (IAA) decisions were first based on market predictions and stock levels for food and energy security purposes. Then seasonal plans were released informing farmers and processors of the amount of sugarcane to be processed and the price to be paid. Describing how sugarcane prices and acreage moved from government-level to firm-level decisions can only be explained by presenting the changes in the sugarcane industry as a whole.

The first move towards the privatization was the termination of IAA in 1990. In 1991, national organizations and ministries became responsible for IAA tasks. At first, the Ministry of Economy dealt with prices for sugarcane, ethanol, sugar and petroleum-based fuel; the Secretary

of Regional Development (SDR) was responsible for production aspects of sugarcane, ethanol and sugar; the National Fuel Department (DNC) was responsible for supply mechanisms of petroleum-based fuels and ethanol. Besides the high complexity observed in the sugarcane sector, the fragmented administration postponed the deregulation process even more. Effective measures regarding ethanol and sugarcane prices were taken only after 1997 through the Sugar and Ethanol Interministry Council (CIMA). Given social, economic and environmental issues associated with the sector, sugarcane and related products had their prices totally deregulated after February of 1999 (MORAES & SHIKIDA, 2000). Although the National Privatization Program has been completed, the Federal government still partially intervenes in the fuel market. The current federal and state interventions in the fuel market will be briefly discussed in the fifth section.

In 1990, sugar was the first product to be deregulated because of its low input on national security. In May of 1997 the price of anhydrous ethanol (used as oxygenate on gasoline) was completely deregulated. Hydrated ethanol prices and production were deregulated by the State two years later (MARJOTTA-MAISTRO, 2002). Since then, ANP (Petroleum National Agency) has been controlling the anhydrous and hydrated ethanol standards. Both anhydrous and hydrated ethanol are now traded through competitive markets. With the development of the world-wide ethanol market, anhydrous ethanol is negotiated mainly through BM&F/BOVESPA and CME/Chicago whereas hydrated ethanol is traded as contracts between buyers and sellers.

The most important reason that sugarcane market deregulation had been postponed several years was the lack of information on the raw-material pricing. In 1997 UNICA was established as a sugarcane processors' organization in the Central-South region of Brazil. Along with ORPLANA (Sugarcane Growers Association), UNICA presented a new model of payment

for the sugarcane crop in April of 1998. The payment model called CONSECANA has substituted for the state-defined price in the majority of the transactions between growers and processors since May of 1998. Few farmers and processors still prefer to set up contracts of raw-material price and quality. However, the CONSECANA model is designed to engage all potential factors of variation in quality and estimate a fair price in terms of Kg of ATR/metric-ton of sugarcane[1].

With the agricultural market completely deregulated, firms started looking for new enterprises. The successful cases of organic sugar and biodegradable plastic production are examples of opportunities in which sugarcane processors can invest. The most common enterprise adopted by sugarcane processors is bio-electricity generation based on residuals (bagasse and recovered trash[2]) from the sugar/ethanol production process. Many factors such as availability of technology, incentive programs promoted by the government, environmental pressures and the increasing demand for alternative power have pushed decision makers toward bio-electricity generation. However, institutional and legal changes in the electrical sector are needed to make this diversification in production possible.

The next section will tackle the deregulation and legal changes that the electrical sector has gone through and will explore how these changes have created opportunities for bio-electricity producers. Table 1 describes the main events that have readied the sugarcane sector for bio-electricity market creation.

[1] The appendix A briefly presents the current CONSECANA model
[2] Agricultural residue recovered at the field after the harvest of sugarcane

Table 1: Events in the sugarcane sector in Brazil

Event	**Year**	**Details**
Law 8,031	1990	National Privatization Program launched
Law 8,029	1990	Sugar and Ethanol Institute (IAA) expires
Rule n^{o}. 79	1990	Sugar production has become deregulated
Administrative reform on Fernando Collor mandate	1991	Ministry of Economy, Secretary of Regional Development (SDR) and National Fuel Department (DNC) responsible for IAA tasks.
Formal organization of Sugarcane processors	Apr 1997	Establishment of UNICA
Rule n^{o}. 294	May 1997	Anhydrous ethanol production deregulated
Decree (DOU 08/22/1997)	Aug1997	Sugar and Ethanol Interministry Council (CIMA)
Law 9,478	Aug 1997	Establishment of ANP
UNICA presentation at BM&F Board of Trade	Apr 1998	CONSECANA methodology released
	May 1998	Sugarcane production deregulated
	1999	Hydrated ethanol production deregulated

Source: MORAES & SHIKIDA (2000), MARJOTTA-MAISTRO (2002), and Brazilian Government website.

DEREGULATION AND LEGAL CHANGES IN THE ELECTRICAL SECTOR

Following the National Deregulation Program, legal and institutional changes were made in the electrical sector. Because of the New Economy perspective, electricity prices had to be deregulated where a competitive market could fairly operate.

Moving from a protected market, the first step toward openness was Law 8,987 released in 1995. It settled concession rules that the Brazilian Privatization Plan (PND) followed from 1996 to 2000 when conceding rights for private companies to provide basic services. Although the privatization process of the electrical sector did not properly affect the bio-electricity market creation, its related laws have certainly created conditions for the establishment of a competitive market.

Between 1996 and 1998, the federal program (RE-SEB project) took place in Brazil with the specific objective of instituting perfect competition for the product (electric power) and

regulating the services (distribution and transmission services). According to ALMEIDA (1995), the finest consequence of the RE-SEB project was the separation between product and services. As cited in PND, federal Laws 8,631/1993 and 8,987/1995[3] introduced the first changes that founded the current electric energy sector. Law 8,631 eliminated the system of price equalization and guaranteed remuneration, and made it obligatory for generators and distributors to sign contracts defining prices. Law 8,987 deals with conditions of competition in tenders for electricity generation and transmission projects. It also establishes rules for public service concessions, and provides assistance for the privatization process. In addition, it classifies as free consumers those with a load equal to or higher than 10mW and voltage greater than 69kV. Accordingly, free consumers can openly choose which electricity producer (or concessionaire) and related source of electricity they will be supplied with. This law also creates the legal entity of independent electricity producers which in some sense founded the primary scenario for the competitive bio-electricity market. An independent electricity producer is defined as one allowed to consume either all or part of the energy produced and sell the remaining product.

At this point, two market environments were created: (i) a free contracting environment where free consumers choose their suppliers and the related source for energy production; and (ii) a captive environment where consumers cannot choose which company supplies their electricity. As enacted by Law 9,074, new consumers (those established after 2000) with power demand greater than 3mW were also qualified as free consumers and could integrate the free contracting market regardless of their demanded voltage.

Some commentators argue that all the measures taken before 1997 were inconsistent and uncoordinated (PIRES, 1999). From this perspective, the new institutional model was first introduced by Laws 9,427/1996 that established the National Electricity Agency (ANEEL) and

[3] implemented through Law 9,074/1995

9,648/1998 which defined rules for entry, taxes and market structure. The creation of an independent agency represented a milestone in the regulatory reform of the Brazilian electrical sector. According to these commentators, the previous Laws had no effective changes because a neutral party was missing in the resolution of disputes and adoption of measures. Law 9,427/1996 established ANEEL's legal nature as an autonomous body and defined its roles as (i) introduction of competition into the electricity generation and commercialization segments; (ii) creation of regulation mechanisms that prevents market concentration; and (iii) mediation of disputes arising from diverging interests of the government, utility providers and consumers.

ANEEL's subordinate agency, the Electric Power Commercialization Chamber (CCEE) has become responsible for electricity marketing through Law 10,848/2004. CCEE has been responsible for both captive and free contracting environments and for the spot market. In the captive environment, CCEE holds least-price auctions and validates transactions between generators and distributors. In the free contracting environment, the chamber certifies quantity and price of electricity settled between generator and consumer. CCEE also holds spot market auctions to guarantee the liquidity of contracts between generator and final consumer[4]. Although the greatest portion of the consumers (residential homeowners) is still unable to join the free contracting environment, the first steps towards an entirely competitive market have been made.

The electrical sector became attractive for bio-electricity suppliers when Law 9,427/1996 (and related decrees) defined the special consumer. According to the Law, special consumers are free customers interested in buying electricity from non-polluting sources such as windmills, solar power plants, small hydroelectric mills or biomass generators. In 2002, Law 10,438 decreased the minimum power requirement for special consumers purchasing alternative energy

[4] The spot market is better detailed in the appendix B

to 500kW. This Law has broadened the bio-electricity market since medium-sized firms, shopping malls and hotels may now qualify as special consumers (ALMEIDA, 2006).

The government has also stimulated the bio-electricity market by easing taxes paid by alternative energy suppliers and special consumers. Affecting the supply side, ANEEL rule 281/1999 has created a discount on the bio-generators' bill. Law 9,991/2000 has enacted that the Research and Development tax will no longer be charged to alternative energy producers. On the demand side, Law 9,648 has created a discount in part of the special consumers' electricity bill regarding the use of the distribution system.

Beyond these government incentives, government programs have facilitated the development of bio-based energy production due to the unbalanced energy demand and supply profiles. As examples of the national concern, in 2001 the federal government imposed a maximum electricity use per house to better match supply and demand structure. In November of 2009 eighteen states of Brazil suffered with 5 hours power cut. Sao Paulo, Rio de Janeiro, Espirito Santo and Mato Grosso do Sul state had five hours of total power outage. The other fourteen states were partially affected. The unbalanced electricity profile has forced the federal government and several state governments to explore innovative programs to maintain the energy security across the country (SAMPAIO et al, 2005). Commentators argue about the effectiveness of these programs and which laws have been useful in the sense of creating the new electricity sector (PIRES, 1999).

The most important program has perhaps been the *Proinfa* (Program of Incentives for Alternative Electricity Sources) created through Law 10,438/2002. This government program was first introduced in 2002 and it has provided financial opportunities for all kinds of alternative electricity enterprises. As proposed in the program, *Eletrobrás* guarantees the

purchase of the alternative energy. However, alternative energy producers have preferred contracting directly to a final consumer (assisted by a broker registered at CCEE) because they may reach better returns. Under the same program, the government has also supported up to 80% of the investments in windmills, biomass generators and small hydroelectric mills through BNDES loans (National Development Bank). Table 2 summarizes the major Laws and ANEEL rules related to the establishment of the Brazilian bio-electricity sector.

Table 2: Legal and Institutional Changes in the Electrical Sector

Law/Rule	**Year**	**Details**
8,631	1993	electricity price no longer set by the State; price defined by the conceded companies.
8,987	1995	formalization of the Brazilian Privatization Plan setting conditions of competition in the electrical sector definition of free consumers definition of independent electricity producers
9,074	1995	rights and obligations of conceded companies;
	1996	RE-SEB Project
9,427	1996	establishment of ANEEL; definition of special consumer.
ANEEL 281	1999	abolish part of the distribution system use tax (TUSD) for alternative energy producers
9,648	1998	creation of a 50% discount on the distribution system use tax (TUSD) for special consumers definition of rules for entry, taxes and market structure. Veto Law 8,631
10,438	2002	decrease of the minimum power requirement for special consumers to 500kW regardless of the voltage.
		creation of *Proinfa*
9,991	2000	waiver of R&D tax
10,848	2004	establishment of CCEE.

Source: ALMEIDA (2005) and Brazilian Federal Constitution

BIO-ELECTRICITY GENERATION: THE INTEGRATED APPROACH

Although institutional and legal changes have created opportunities for biomass processors to diversify its production, most of the sugarcane mills did not truly join the

electricity market until 2001. In the electrical sector, Law 9,074/1995 founded bio-electricity market by defining free consumers and independent electricity producers. In the sugarcane sector, industry deregulation allowed players to explore new opportunities beyond sugar and ethanol. However, alternative producers had no economic incentives to join the market due to the well-structured hydropower supply and the balanced energy demand and supply profiles.

The first alternative energy projects were launched when *Proinfa* guaranteed the purchase of bio-electricity production and offered low interest rate loans. Until the early 2000's sugarcane mills had not invested in high pressure boilers and turbines for electricity production purposes, though they have had bagasse at their disposal. Along with *Proinfa*, greenhouse gas emissions, global climate change, local air pollution, and sustainability issues affected biomass processors' decision of whether or not to start producing bio-electricity. At that point, the legal and institutional environment was set up for alternative electricity producers. Given the increasing demand for clean energy and the government financial support, sugarcane mills have found the economic incentive that was missing. Since 2003, firms have traded electricity directly with free consumers (assisted by CCEE) or *Eletrobrás*, under the auspices of *Proinfa*.

Most of the sugarcane processors joined the electrical sector after 2007 when the *1st Auction of Alternative Energy* was held at CCEE. The auction indicated that bio-electricity generators have finally become a reliable source of power. At that time, eight sugarcane processors and one generator using sawdust traded large-scale contracts with average revenue of R$14.2 million/year (US$8.08 million/year) and average price of R$138.93/MWh (US$79.02/MWh)[5]. These contracts became official in January of 2010 when sugarcane firms started delivering electricity to distributors. Table 3 shows the results of the *1st Auction of Alternative Energy* pointing out sellers, final prices, and revenue per year.

[5] Exchange rate: BRL 1.758 = USD 1 (04/06/2010)

Table 3: Auction report, 2007

Company	Project	Region	Contracts	Price (R$/MWh)	Revenue (R$/year)
FENIX	Xanxere	S	25	138.50	27,484,500.00
FLORALCO	Florida Paulista	SE	8	139.12	10,025,088.67
GDA DEDINI	São João da B. Vista	SE	23	138.60	28,440,702.93
LDC BIO R PRATA	Louis Dreyfus	SE	13	139.12	16,326,160.69
LDC BIO R PRATA	Louis Dreyfus	SE	6	139.12	7,554,276.95
LDC BIOENERGIA S/A	Louis Dreyfus	SE	10	139.12	12,558,585.15
LDC BIOENERGIA S/A	Louis Dreyfus	SE	12	139.12	15,059,129.69
PIONEIROS	Pioneiros II	SE	12	139.12	14,995,616.47
USC STA CRUZ	Santa Cruz AB	SE	6	138.75	7,520,648.22
USC STA CRUZ	Santa Cruz AB	SE	14	138.75	17,548,180.18
USINA Ester	Ester	SE	7	138.90	8,740,027.84
UTEIAC IACANGA	Iacanga	SE	4	138.94	4,923,696.00

Source: CCEE (2010)

Brazil has 423 sugarcane mills spread out across the country but 290 firms (69%) are regulated at ANEEL as power generators. Together those firms represent 4.75 GW of capacity of generation (4.11% of the Brazilian electric matrix). However, the actual share of bio-electricity traded through CCEE is smaller. Bio-electricity producers must also be regulated as sellers and registered at CCEE in order to be allowed to trade it. During the sugarcane harvesting season, facilities consume electricity as an input for sugar and ethanol production and trade the remaining part. In the off-season, facilities do not produce sugar or ethanol due to weather constraints and maintenance reasons but keep producing electricity based on the bagasse accumulated over the season. Depending on the generation technology used, the amount of energy produced over the season and off-season may not differ significantly. A study proposed by CTC (Sugarcane Technology Station) shows that the generation capacity of an individual plant in the harvesting season and off-season are 25MW and 26.3MW, respectively. The study considered an integrated generation plant using loose bagasse and recovered trash as inputs (LINERO et al., 2005).

There are roughly 70 sugarcane mills that currently sell electricity to the grid. There are another 21 bioelectricity generators under construction, and 7 new projects of bio-electricity production based on sugarcane biomass are being registered in Brazil (CCEE, 2010). The prediction for the largest biomass project being built is to generate 136 MW that can supply a city of 1.8 million people (RECCHIA, R. & ZAGO, 2010). Studies have also shown that if the whole sugarcane industry had efficient generators already installed, the capacity of production would reach 7,000 MW during the harvesting season which coincides with the shortage in hydropower supply (rainfall driven) (NEVES & CONEJERO, 2010).

Estimations made by UNICA (2010) show that only 1% of the processors' total revenue came from bio-electricity sales in 2008/2009. The small share of bio-electricity in the total revenues can be partially explained because it is priced as a substitute for hydropower energy. It is expected that the biomass electricity will be better priced after 2012 (when the second run of the *Kyoto Protocol* happens) when Brazil ratifies the new international framework. If the ratification happens, companies will have their carbon emissions limited and they will have to find non-pollutant sources of energy in order to reach the national goal. Using bio-electricity will let them decrease their current carbon emissions and may give them opportunities to join the carbon market. Given these perspectives for alternative power, it is expected that the share of total revenues will increase to 16% by 2015/2016 (NEVES & CONEJERO, 2010). Sugarcane companies will also have a chance to sell climate credits (CER – *Certified Emission Reductions*) due to their capacity for carbon mitigation.

REMAINING STATE INTERVENTIONS

As presented in the second and third sections, the national government has decreased its interventions in the sugarcane industry and the electricity industry. However, federal and state-level interventions are still being used as regulatory tools to promote bioenergy use.

The oil industry is also very influenced by government decisions. Under Brazilian Law, the government owns crude oil and natural gas reserves and concedes the right of exploring and refining Oil to *Petrobrás*. Although *Petrobrás* is a public company, the Brazilian government holds the majority of *Petrobrás* voting stock. In this sense, the federal government has autonomy to impose taxes or contributions to the oil industry in order to promote other sectors of the economy. The former tax called PPE (Specific Price Rate) was an example of the national government intervention. It was added to petroleum-based fuel prices and used as a subsidy to stimulate the production and consumption of hydrated ethanol which could be offered at competitive prices. PPE was terminated in August of 2000 due to oil industry pressures but a slightly modified tax (CIDE) was created through Law 10,336/2001 which has been imposed since then. Another national government intervention in the bioenergy market is the regulating amount of anhydrous ethanol to be mixed with pure gasoline across the country. This regulation has to be followed by retailers in order to stay in business. The current gasoline fuel offered at gas stations is 25% anhydrous ethanol.

In the state level, government interventions are also found when analyzing the ICMS tax (good & sales tax) which can differ among the states. The ICMS tax for ethanol sales vary from 12% in São Paulo state and can reach 25% in the northern states. Although sale taxes are not considered a market distortion, they can affect the flow of goods among states and be classified as local government intervention.

The CIDE tax and ethanol proportion rule for gasoline fuel are government tools used to promote bioenergy usage. While few commentators may classify these government tools as market distortions (Business Week 2007), we believe that the creation of sustainable markets based on non-polluting inputs has to be regulated until the complete establishment of the new sector.

FUTURE STUDIES

Over the past twenty years both the electrical and sugarcane sector have shifted from the national regulated markets to competitive markets. However, investment decisions have been made at a faster pace than the deregulation process has been done. The CONSECANA model proposed by UNICA and ORPLANA in 1998 had considered only sugar and ethanol as final outputs. In this way, sugarcane has been valued through the proposed model without considering any other final output like bio-electricity.

Since 2007, an increasing number of sugarcane mills have joined the bio-electricity market by using part of the fiber content of the residual from sugar and ethanol production. This means that the current CONSECANA model may be underpricing the sugarcane value when it is delivered at the processors' gate.

Since sugarcane has not been traded as a commodity, its prices are not affected by diversified demands (i.e. ethanol production as a factor of changes in corn prices). Future studies may tackle the sugarcane valuation model by comparing gross margins (total revenue over sugarcane price) over time. The results may suggest interesting insights to better value alternative energy inputs.

CONCLUSION

Within the last twenty years Brazil has gone through legal and institutional changes in both sugarcane and electrical sectors. Concerned with international dependency and unbalanced energy supply and demand profiles, the national government has created programs to meet the increasing demand using clean sources of energy. In the 1970's *Proálcool* (the first bioenergy program promoted by the Brazilian government) supported the ethanol production and demand to avoid international dependency for oil. Recently, *Proinfa* supports alternative electricity supply and demand by facilitating investments and easing taxes for consumers. The establishment of national organizations such as ANP, ANEEL and CCEE are also extremely important to guarantee the improvement of renewable energy markets.

This paper contributes to the discussion of how government interventions have founded markets for renewable energy and how Brazil has become one of the most self-sustainable energy users in the world. This discussion makes us reevaluate the criticism against institutional interventions that are usually pointed out as market distortions.

APPENDIX A: THE CONSECANA MODEL

The ATR (Total Recovered Sugar) is a technical measure of sugarcane quality as a function of sugar contents (SILVA, 1998).

$$ATR = 9.26288*PC + 8.8*AR$$

where,

ATR = Total Recovered Sugar;

PC = Pol % sugarcane (amount of saccharose in the extracted juice);

AR = Reducible sugar % cane:

$$AR = (9.9408 – 0.1049*Pr)*(1 – 0.01*F)*(1.0313 – 0.00575*F)$$

where,

Pr = Purity of extracted juice;

F = Fiber % cane

Then, the price for a metric-ton of sugarcane is defined by the formula:

$$VTC = kg\ of\ ATR / (t*P\%*VATR)$$

where,

VTC = price paid for a metric-ton of sugarcane;

P% = percentage of sugarcane used for sugar + ethanol production or anhydrous + hydrated ethanol;

VATR = ATR price monthly defined by the CONSECANA council

APPENDIX B: THE SPOT MARKET HELD AT CCEE

As presented by ALMEIDA (2007), let us assume the following situation:

A qualified consumer (C) is operating through the free contracting environment and he or she is located in the region where the distributor (D_1) provides electricity. The same qualified consumer has contracted for electricity with generator (G) that is located in the region where the distributor (D_2) is the energy provider. Then, the electricity is supplied from D_1 to C that pays for the service of distribution to D_1. G also pays for the service of distribution to D_2.

Every month C will publish his or her energy consumption. If the energy consumed is greater than the amount of energy contracted from G, C buys the difference of electricity through the spot market. If the energy consumed is lower than the amount contracted from G, C sells the difference using the same auction system in the spot market.

The electricity itself flows from D_2 to D_1 based on an agreement between both.

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