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ABSTRACT
The re-organization of the energy matrix is the aim of several countries that heavily invest in sources of renewable energy. The bioelectricity generated from sugarcane residues in Brazil can be considered as an alternative for the shortage of hydric resources that occurs during periods of drought due to its climate characteristics. The objective of the present study was to evaluate the Brazilian market of electrical energy co-generated from sugarcane biomass by analyzing its macro-environment and competitive forces, thus highlighting the system's main threats and opportunities in terms of political-legal (institutional), economic, environmental, socio-cultural and technological variables. The main result of this study demonstrated that there are important issues to be solved in order to develop this new market, highlighting the creation of a strategic agenda to overcome challenges and to take advantage of opportunities in the Brazilian sector.

Keywords: *bioenergy; biomass; sugarcane; energy; Brazil.*

1. INTRODUCTION

Regards to world demand for energy, data from *MAPA* (Brazilian Ministry for Agriculture, Livestock and Supply) indicate a mean annual increase of 1.7% between 2000 and 2030, reaching consumption of 15.3 billion tons of oil equivalent (toe) per year (MAPA, 2011). If the world energy matrix remains unchanged, fossil fuels will account for 90% of this increase. The world petroleum reserves reportedly amount to 1,137 trillion barrels (not including the potential Brazilian pre-salt reservoirs), 78% of which can be found in the subsoil of members of the Organization of the Petroleum Exporting Countries (OPEC), according to data from the Brazilian Ministry of Mines and Energy (MME). The volume mentioned above allows for global demand to be met for approximately 40 years at current levels of consumption, but increases in demand are predicted, and many variables may influence the projections of future sources of energy (MME, 2009).

In order to meet current and future energy demands, Brazil has made a number of investments in the past decades to modify its national energy matrix and reduce its dependence on oil. However, the fact is that many structures are not compatible with meeting these objectives, including the lack of specific legislation on alternative sources of electrical energy. Despite this context, the co-generation of electrical energy by sugarcane-ethanol mills from production residues represents an opportunity to further stimulate the desired and needed changes in the national energy matrix.

The Brazilian sugarcane energy industry represented approximately 2% of the country's Gross National Product in 2008 (SOUSA; MACEDO, 2010) and it can effectively contribute to the generation of clean energy by using bagasse and sugarcane straw, which are residues from the ethanol and sugar production processes. It is important to note that sugar cane bagasse is the most abundant residue generated in Brazilian agricultural production (FELFLI et alli., 2011).

According to data from UNICA (Brazilian Sugarcane Industry Association), Brazil is currently the world leader in sugarcane production, having processed about 487 million tons in the 2008/2009 (UNICA, 2009). Sugarcane was historically almost exclusively used for the production of sugar, but in the past 30 years, it has gained strategic importance in the energy sector, initially through *Pro-Álcool* (National Ethanol Program) and, more recently, through the generation of electrical energy from bagasse (fibrous residue resulting from juice extraction) and sugarcane straw (leaves and tops).

Considering that up to 6 harvests are generally possible during the useful life of a sugarcane crop, mills produce enough bagasse to fuel their boilers following the first crushing, thus becoming self-sufficient industrial units in terms of electrical energy (AMARAL, 2009). In fact, the co-generation of electrical energy by sugarcane-ethanol mills is a traditional practice, but a change can be observed in this practice: mills now sell their energy surpluses rather than merely being self-sufficient producers of electrical energy. Some factors, however, still represent challenges for the production of energy surpluses, and investments in technology will be needed because in the majority of cases, bagasse is inefficiently burned in boilers that are still in operation in older plants, which is not optimal for the process of generating electrical energy.

By virtue of its large territorial area, the use of land for energy agriculture in Brazil would not influence the land used for food agriculture; that is, there would be minimal, if any, impact on traditional agriculture in terms of volume and competitiveness because the raw material for energy in Brazil is considered to be a by-product rather than a food crop. According to data from the National Bank for Economic and Social Development (*BNDES*), Brazil has a series of advantages that qualify the country to lead the large-scale energy agriculture and bioenergy market (BNDES, 2009).

2. MATERIALS AND METHODS

The employed methodology was qualitative in nature. With regard to the research model, a non-experimental transversal study was chosen; that is, variables were not manipulated but observed as such within their natural context for later analysis. Macro-environmental analysis techniques were used in the present study by addressing the main threats and opportunities of the system as well as the political and legal (institutional), economic, environmental, socio-cultural and technological variables involved. Similarly, by analyzing Porter's five forces, it was possible to evaluate customers, competitors, suppliers and substitutes.

3. RESULTS AND DISCUSSION

3.1. Macro-Environmental Analysis

Box 1 was elaborated for sugarcane mills that co-generate electrical energy and lists the main, non-controllable factors that impact the development of their activities to establish a general panorama of the sector.

3.1.1. Political and Legal Factors

Although Brazil possesses several sources of energy, legislation on the electrical sector has been consolidated over almost 70 years and is still flawed in terms of regulation. The changes defining the current energy matrix occurred only in 2004, but the main hallmarks in the modernization of the sector, including company privatization and the decrease of the government's role as the only investor, have been observed since the 1990s with the February 1995 Act on Public Services Concession and Law 9427/1996 on the creation of the National Electrical Energy Agency (*ANEEL*) (MME, 2009).

According to data from ANEEL (2009), basic legislation on the electrical energy sector consists of constitutional articles, complementary and ordinary laws, decrees, inter-ministerial regulations, decrees by the Ministry of Mines and Energy, including those from the now defunct National Department of Waters and Electrical Energy, joint resolutions from *ANEEL* and the National Environment Council. With regard to regulations on the trading of electrical energy, which guide the activities of the Electrical Energy Trade Chamber (*CCEE*), some normative resolutions are in force (CCEE, 2011).

It is important to note that since 2010, few relevant changes have occurred in this industry. In 2011, normative resolution no. 456 was approved to guide the activities of the New Accounting and Liquidation System (BRASIL, 2011). This new system aims to develop a new accounting and liquidation system that is more flexible and dynamic for the short-term energy market. The main objectives are to simplify the rules of the sector, use upgraded and independent technology platforms, reduce the time required for system certification, reduce processing time, and retain, disseminate and clarify knowledge, visibility and transparency with regard to the accounting and liquidation processes for the entire market as well as for the organizations (CCEE, 2012). Moreover, ANEEL is reviewing the distribution policy through module 3, named Access to Distribution System. Normative resolution no. 482/2012 is now in force after 4 older versions (ANEEL, 2012).

With regard to policy on electrical energy transmission and distribution, regulations on connection-related costs were elaborated only a few years ago, with such costs being passed on to the mill (which was responsible for power line construction as well as electrical connection adjustments). *ANEEL* normative resolution no. 312/2008 established that the main connection costs are related to the central power generator that wishes to access the electrical network, leaving few costs for the distributor (PALOMINO, 2009).

In addition to the rules dealing with the production, trading, transmission and distribution of electrical energy, an obstacle to be considered is the difference liquidation price (DLP). The DLP is the electrical energy price negotiated on the spot market (short-term transactions), and is thus used to adjust the differences between contracted volumes and those effectively consumed in the free market (ANEEL, 2009). The value of the DLP is determined on a weekly basis for each load level based on the marginal operation cost and is limited by the maximum and minimum prices in practice for each period and submarket (CCEE, 2009).

Both consumers and energy providers are subject to the DLP through either positive or negative liquidations, so that if the amounts bought by the consumer are less than the generated volume (energy surplus), the consumer can either negotiate them in short-term contracts or even positively liquidate them. However, if the generated amounts of energy are not enough to fulfill the contract terms, the provider can either purchase the energy or negatively liquidate the missing amount (PALOMINO, 2009).

Therefore, it can be stated that the DLP represents a risk for both consumers and free-market energy providers, mainly because hydrological projections are incorporated into its formation process (PALOMINO, 2009). Because the electricity generation matrix is predominantly hydroelectric in Brazil, mathematical models are used to calculate the DLP, whose aim is to determine an optimal balance solution between the current benefit of using water for energy and the future benefit of its storage (CCEE, 2009).

Due to the current problems related to heavy dependence on hydroelectric sources, even in periods of drought, the Brazilian electrical system requires a rapid transition toward the hydrothermal model (SOUSA; MACEDO, 2010). After the blackout of 2009, the National Electrical System Operator (*ONS*) increased the production of thermoelectric units in order to improve the security of the national electrical system and reduce dependence on Itaipú, currently the world's largest hydroelectric plant, which accounts for 19.3% of the energy consumed in Brazil (ITAIPU BINACIONAL, 2009).

Another important legal factor is State Act no 11.241/2002, which focuses on the gradual elimination of the burning of sugarcane straw, distinguishing mechanized plantations from non-mechanized ones (areas with slope above 12% and smaller than 150 hectares) so that burning will be entirely eliminated by 2021 for the former and 2031 for the latter. In addition to state intervention, Decree no. 2.261/98 also addresses the gradual elimination of sugarcane straw burning (AMARAL, 2009).

In addition to federal law no. 5.889/73, which legislates rural labor relations, there are also labor unions throughout the country that support workers' demands. It is important to note that because of the exploratory characteristics of this type of economic activity, this sector's workers are supported by the Ministry of Labor as well as by the Consolidation of Labor Law (*CLT*). According to Article 13 of Decree Law no. 5.452/1943, which establishes the CLT, "social security and work registration is required to carry out any job as an employee, including those of rural and even temporary nature, or as a liberal professional".

Finally, with regard to the current taxation laws, it can be said that the incidence of taxes indirectly affects the production of co-generated energy. On October 8th, 2009, the Brazilian Senate's Commission on Infra-structure Services approved law-project no. 311/2009 (still to be approved by the Economic Affairs Commission for publication), establishing the Special Taxation Regime for Incentives to Develop and Produce Alternative Sources of Electrical Energy and measures for boosting the production and consumption of clean energy so that eligible companies will be exempted from the following taxes: PIS/PASEP (Social Integration Program and Formation of the Public Server Patrimony) and COFINS (Contribution to Social Security Financing), both of which are levied on gross revenue (BRASIL, 2009). However, sources of clean electricity include only solar, wind, and marine energy.

It is also necessary to mention that a regulatory policy is being considered by the Brazilian Ministry of Agriculture, as well as investments to boost sugarcane production between 2012 and 2015 (MAPA, 2012).

3.1.2. Social-Cultural Factors

With regard to social-cultural factors, it is important to emphasize the demographic aspects. According to data from ANEEL (ANEEL, 2009), approximately 95% of the Brazilian population had access to electrical power in 2008, meaning that there were 61.5 million units in 99% of the country's cities and towns, mostly for domestic consumption (85%).

According to data from the Brazilian Institute of Geography and Statistics (IBGE), the population growth rate decreased from 3.04% between 1950 and 1960 to 1.05% in 2008. In that same year, the Brazilian population reached 189.6 million; this figure would have been 295 million had the average population growth rate been maintained at 3%. Based on projections, the Brazilian population can potentially grow until 2039. It can be observed that Brazil has a new demographic pattern that is characterized by a reduction of the population growth rate and deep changes in the composition of the age structure, meaning an increase in the elderly population (IBGEa, 2009).

Another factor that may impact the consumption of electrical energy is the increase of people living alone. Individual consumption units grew continuously in the past ten years, reaching nearly six million in 2005. A reduction in the number of marriages and their durations (mean time of 12.1 years) is also observed (IBGEc, 2009).

There is also a direct relationship with the population's purchasing power; that is, the prevalence of people living alone is more frequent in those regions where families have higher incomes. The Southern states present the highest rates of empty-nest families (couples without children and people living alone represent 47.7%). In addition, the number of elderly people who live independently was high, a fact that may be relevant because the majority of those individuals living alone were more than 60 years old (40.6%) and female (50.1%) (IBGEc, 2009).

The factors relating to the current transformation in the sector's labor composition should also be taken into consideration. The use of seasonal workers has decreased because of the pressures exerted by new technologies. Two other typical characteristics of the sector are that workers are mostly migrants and have very low educational levels. Therefore, re-inserting or re-locating these workers into agricultural activities within or outside the sector will require the following measures: motivating them to be aware of the importance of seeking another job; re-qualifying them, including teaching them to read and write; and, finally, providing them access to qualification courses so that they can work in other functions (LIBONI, 2009).

The Agro-environmental Protocol (UNICAa, 2011) aims to further improve working conditions in this sector. Another equally important project is the Project *Agora* (Project Now), which was created in 2009 and is currently supported by more than 20 associations and sugarcane-ethanol companies. Its objective is to develop initiatives for the generation of knowledge, dissemination of positive social-environmental impacts and awareness of public opinion with regard to industry issues related to sustainability (UNICAb, 2001).

3.1.3. Economic and Environmental Factors

Agricultural lands have appreciated in value due to the competitiveness of several cultivations per area and the high prices of commodities. Because sugarcane cultivation requires large volumes for producers to achieve positive results, the industry is naturally highly concentrated (AMARAL, 2009). In fact, a shift toward tenant contracts or agricultural partnerships involving cultivable lands has become more frequent in the past few years. The sugarcane produced by suppliers in São Paulo increased by 156% between 1992 and 2008, from 40 million to approximately 90 million tons (UNICA, 2009).

Data reported by the United Nations (UN) reveal that there is an upward trend in food prices because many countries are using food grains for the production of energy, which is also a concern given the global food supply crisis. Although agricultural activity is quite intense in Brazil, the country possesses large swaths of cultivable lands that are still available (agricultural border) (MME, 2009).

Within the economic context, the fiscal incentives that the Brazilian government has provided for consumption of electrical appliances (tax reduction) and electronic devices (informatics law) are worth emphasizing, in addition to increases in the population's purchasing power (IBGEa, 2009) and credit, which have an indirect impact on the consumption of electrical energy.

Moreover, technological development has greatly impacted the economic environment for both the sugarcane production sector and the communities in which mills operate, with several regions of the country being provided with work opportunities for hundreds of thousands of people. To produce the same amount of energy, ethanol production involves 152 times more workers than oil (IBGEb, 2009), thus facilitating the economic development of entire regions (i.e. communities and industries).

An unfavorable economic aspect affecting energy co-generation is the cost of installing a co-generation plant that is capable of producing an energy surplus, which can vary depending on the employed technology, with the investment being recovered by the sale of the energy surplus. Another unfavorable aspect resulting from the transmission and distribution policy has to do with high investments in the installations used by producers to generate energy surpluses, which often make the co-generated energy unviable, even when the sugarcane mill is located next a distribution substation (as mentioned above, this is a recurrent fact addressed by law, the so-called distributed energy generation). Finally, the producer also has to pay a tax for using the power line – the distribution use tariff, which is different from the transmission use tariff, although both represent energy transmission costs (PALOMINO, 2009).

With regard to environmental factors, the search for renewable and sustainable sources of electrical energy has been increased in light of recent world energy problems. Several countries have implemented many energy efficacy programs as important measures of controlling atmospheric pollution, for example (MME, 2009).

A positive point related to the sustainability of the sugarcane industry that contributes to the concentration of sugarcane suppliers is the trend of eliminating the burning of sugarcane straw, which is often linked to global warming. This practice has been addressed by the Agro-environmental Protocol mentioned above through a series of measures aimed at improving the agricultural and environmental practices of the sector (AMARAL, 2009; UNICAa, 2011).

Another environmental concern has to do with deforestation, specifically of tropical rainforest. The cultivation of sugarcane has been spreading into degraded pasture areas in the states of São Paulo, Minas Gerais, Mato Grosso do Sul and Goiás, meaning that the major production regions are 2,000 to 2,500 km away from the Amazon Rainforest (AMARAL, 2009).

The relationship between economic and environmental factors currently represents one of the main opportunities in the sugarcane alcohol industry through the selling of carbon credits. The global amount of carbon credits negotiated in 2008 was the equivalent of 389 million tons (tCO_2e), corresponding to USD 6,519 million (NEVES; TROMBINI; CONSÔLI; 2011).

Participation in the carbon credit market occurs through clean development mechanisms (MDLs) established by the Kyoto Protocol, thus being the only way to allow developing counties to voluntarily participate. In 2008, the 68 Brazilian projects registered by the United Nations Framework Convention on Climate Change (UNFCCC) in the carbon credit market generated an estimated reduction of 3.45 million tCO_2e, corresponding to USD 25.35 million. Of these projects, 24 came from the sugarcane energy sector, which accounted for an estimated reduction of 473.94 thousand tCO_2e (USD 3.48 million) during the same period (NEVES; TROMBINI; CONSÔLI; 2011).

In order to further strengthen this type of sustainable production project, some initiatives for the social-environmental certification of biofuels have been carried out by national governments, private sector companies, non-governmental organizations, and international organizations.

3.1.4. Technological Environment

Due to technological evolution, the bagasse burning process (generation of thermoelectric power from sugarcane biomass) generates fewer polluting emissions than other thermoelectric sources (e.g. natural gas, fuel oil, vegetal coal), in addition to their absorption by sugarcane crops. Water is also re-used by mills to wash the sugarcane, resulting in 98% efficacy in this treatment, which also includes dry washing processes (AMARAL, 2009), thus demonstrating the strong role the technological environment plays in improving the sector.

Despite being ineffective, Brazil's sugarcane biomass has significant energy generation potential. From a long-term perspective, biomass, for general energy purposes and for the generation of electrical energy in particular, is one of the renewable sources of energy that is most likely to grow not only in terms of nature and origin, but also in terms of technology for energy-converting products (MME, 2009).

3.2. Analysis of Threats and Opportunities

By analyzing the macro-environmental factors (non-controllable) influencing electrical energy co-generation from sugarcane biomass, Box 2 was elaborated in order to present the threats and opportunities according to the main strengths and weaknesses of the sector.

Sugarcane plantations occupy approximately 7 million ha, or 2% of all cultivable land, in Brazil, which is the leading global producer of sugarcane, followed by India, Thailand and Australia, according to data from (UNICAc, 2011). In addition, in the central-southern region, cultivable lands for the current sugarcane harvest (2008/09) were estimated at 6.53 million ha, corresponding to an increase of 15.7% (917.9 thousand ha) compared to the previous harvest, according to data from the CANASAT Project, which is responsible for sugarcane mapping (UNICA, 2009).

Because the main factors related to threats and opportunities have already been addressed in this study, it is important to highlight the influence of the Agro-environmental Protocol on both. The Agro-environmental Protocol, in terms of production, has great relevance for both environmental and social factors in the State of São Paulo (UNICAa, 2011). Nevertheless, at the same time, the protocol may represent a threat to the small producers who supply the large groups, thus causing production to become concentrated. The next section will analyze Porter's five forces.

3.3. Analysis of Porter's Five Forces

3.3.1. Suppliers

As previously mentioned, sugarcane is a crop that demands high production volumes, thus involving great extensions of land for plantation. In fact, the number of sugarcane suppliers is beginning to increase, ensuring the participation of a greater number of agents throughout the production chain and promoting a better distribution of income (AMARAL, 2009).

Considering only the sugarcane suppliers (independent producers), given that there are also herbicide product suppliers among others in the sector, it can be said that their bargaining power is only moderate because approximately 25% of the total sugarcane volume comes from them, with the remaining volume being produced by mills on their own or rented lands (AMARAL, 2009).

Although sugarcane is just the raw material, it is actually invaluable for the productive processes in which the bagasse, which results from the crushing process, is the main by-product for energy co-generation.

3.3.2. Clients

The bargaining power of free consumers is considered to be low because changing costs mean breaches of contracts and fines, including those related to investments in power transmission networks. The bargaining power of domestic consumers, who are subject to the electricity distribution monopoly in their regions, would be virtually nonexistent if the concessionaries aggregated the co-generated energy to the electrical network. In addition, if the federal government were considered to be a potential client because of its energy auctions, then it would have great bargaining power because the energy co-generated from biomass is only part of the reserve energy system, thus limiting its expansion.

3.3.3. Substitute Products

Brazil's electrical sector has traditionally relied on hydroelectric power plants, whose broad exploration dominates the alternative sources of electrical energy. In recent years, however, the concentration of this type of source has proven to be inefficient (e.g. blackouts in several regions of the country, electrical network overload), mainly during periods of drought, when water reservoirs reach low levels. Therefore, a shift toward a hydrothermal model can be observed in which thermoelectric units can be used during periods of drought. However, this type of energy generation ends up resulting in higher costs, including the use of fossil fuels and pollutant emissions (SOUSA; MACEDO, 2010).

It should also be emphasized that thermoelectric units were employed to be used occasionally, as expected, because of the admittedly high costs involved. Therefore, if they are to be more regularly used to overcome the sector's structural deficiencies, then these high costs will be imposed on society (SOUSA; MACEDO, 2010).

3.3.4. New Entrants

The barriers to entry and exit from the sector are enormous, indicating the high profit potential permeating the activities to be performed. The risks of entering this sector mainly involve the high investments needed to set up a complete plant (crushing, co-generation, industrialization of sugar and alcohol, etc.), including cultivable lands, machines for planting and harvesting, irrigation systems (for periods of drought), and transportation equipment, among others. Similarly, the exit risks are related to the lack of liquidity of these investments. In light of such barriers, the majority of sugarcane mills currently belong to large national and foreign groups that can exploit economies of scale.

3.3.5. Competitors

In 2009, there were a total of 282 entrepreneurial operations using electrical energy co-generation in the sugarcane ethanol sector, but the majority of mills used co-generated energy only for their own consumption (self-sufficiency). Among the sixty co-generation thermoelectric plants in operation, that is, those that are supplying the market with electrical energy, only 19 used sugarcane bagasse as fuel. During the same period, the electrical energy potential of the co-generation mills using bagasse as fuel corresponded to approximately 3.9% of the national energy matrix, although about 7% of them had sold their power surpluses (ANEELb, 2009).

As a result, the sector is initially seen as unattractive because of the great number of active organizations or groups, with a strong trend toward consolidation of the sector's activities. At second glance, however, the sector becomes more attractive when opportunities and expectations regarding the electrical energy market are analyzed (search for alternative energy sources, renewable and sustainable fuels, complementation of the amount of energy offered, increase in the amount of non-supplied energy, etc.)

Bioelectricity is a form of complementary energy in the energy matrix because it contributes to the GGE reduction and is close to urban centers, with both the maturity of the sugarcane industry and cost competitiveness also playing important roles in this respect (CASTRO; BRANDÃO; DANTAS, 2009). Therefore, the production of energy surpluses to sell becomes attractive to the players who want to maintain and expand their activities in the sugarcane alcohol industry. There are also benefits, such as reduced construction and implementation times (compared to hydroelectric plants), ranging from 24 to 30 months; smaller projects requiring neither large areas nor water dams while involving more investors – a fact that eliminates the risks of delay and construction problems; the strengthening of the national machinery industry; and the generation of jobs and income (SOUSA; MACEDO, 2010).

The lack of competitiveness of bioelectricity in generic energy auctions (i.e. those open to projects involving several sources) is actually a false impression. Because unfavorable results occur due to both methodological failures and project selection rules, the issue of seasonal complementarity has not been recognized and evaluated in the auctions (CASTRO; BRANDÃO; DANTAS, 2009). However, thermoelectrical projects have been improperly favored because they add little to the electrical system, thus being a consequence of a failure of the project selection rules.

The criteria that are currently being used in electrical energy auctions place the biomass projects of electrical energy co-generated from sugarcane bagasse at a disadvantage. Cost evaluations are performed on the basis of energy prices, which do not take production seasonality into account at all (i.e. energy value is higher than the annual-average value for drought months, thus not being perfectly translated into higher prices). In addition, the DLP is calculated on the basis of hydric factors, and the methodology used to measure the guarantees of the new investors underestimates the benefits of bioelectricity, presenting a strong bias toward thermoelectric generation (SOUSA; MACEDO, 2010).

The majority of the biomass contracts in the energy matrix were obtained by means of alternative energy incentive programs, such as the Incentive Program for Alternative Energy Sources (*PROINFA*), alternative source auctions and reserve energy auctions, the last of which is exclusively for bioelectricity, as cited above. In regular auctions (long-term contracts with distributors), bioelectricity has been neglected, which can at least partially explain the poor participation of biomass in the energy matrix (low performance of co-generation projects) (SOUSA; MACEDO, 2010).

Despite the obstacles to the commercialization of electrical energy surpluses, including the enormous exit barriers and inconsistent governmental policies, this industry can be assessed as having a high attractiveness within the national scope, although this attractiveness was found to be relatively lower because some large groups are established in the South-eastern region of Brazil.

4. CONCLUSIONS

The development of a consistent energy matrix should be regulated according to the various available sources, including a well-defined policy for long-term objectives, so that incentives for such activities could be guided. Based on the performed analyses, there are noteworthy obstacles to the development of bioenergy in the sugarcane energy industry, mainly relating to the commercialization of its surplus. However, the lack of both structure and opportunities to boost the sector might be resolved through the adoption of specific regulations that are in the development process, thus making it more competitive and ensuring a safe electrical system.

Bioelectricity is a real alternative to the concentration of hydric sources for the generation of electrical energy in Brazil. In addition to the possibility of complementing the energy matrix, the development of energy co-generation activities using sugarcane bagasse has economic, social and environmental advantages. Economically, it can be stated that the main advantage is the use of a by-product as a raw material, thus decreasing both resource extraction and costs related to the setup of a production unit. Finally, among the main environmental benefits, the reduction in the greenhouse gas emissions and the possibility of selling carbon credits can be cited.

REFERENCES

AMARAL, R.O. Análise da transação de suprimento de cana-de-açúcar e os relacionamentos inter-organizacionais. Ribeirão Preto: Dissertação de Mestrado. Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto – Universidade de São Paulo, 2009.

ANEEL. Agência Nacional de Energia Elétrica. Atlas da Energia Elétrica. 3rd ed. Brasília, 2008. Available at: http://www.aneel.gov.br/visualizar_texto.cfm?idtxt=1689. Accessed: November, 2009.

ANEELa. Agência Nacional de Energia Elétrica. Available at: http://www.aneel.gov.br/biblioteca/pesquisadigitres.cfm. Accessed: April, 2009.

BNDES. Banco Nacional de Desenvolvimento Econômico e Social. Available at: http://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/conhecimento/bnset/Set2901.pdf. Accessed: November, 2009.

BRASIL. Projeto de Lei do Senado n° 311, de 2009. Institui o Regime Especial de Tributação para o Incentivo ao Desenvolvimento e à Produção de Fontes Alternativas de Energia Elétrica – REINFA e estabelece medidas de estímulo à produção e ao consumo de energia limpa. Available at: http://legis.senado.gov.br/mate-pdf/62455.pdf. Accessed: November, 2009.

BRASIL. Resolução normativa nº 456, de 18 de outubro de 2011. Aprova as Regras de Comercialização de Energia Elétrica aplicáveis ao Novo Sistema de Contabilização e Liquidação – Novo SCL. Diário Oficial da União, Brasília: 2011; 148 (209); p. 112, Available at: http://www.aneel.gov.br/cedoc/ren2011456.pdf. Accessed: November, 2011.

CASTRO, N.J.; BRANDÃO, R.; DANTAS, G.A. Importância e Perspectivas da Bioeletricidade Sucroenergética na Matriz Elétrica Brasileira. Available at: http://www.unica.com.br/downloads/estudosmatrizenergetica/pdf/matriz_bioeletricidade_castro5.pdf. Accessed: November, 2009.

CCEE. Câmara de Comercialização de Energia Elétrica. O Projeto Novo SCL. Available at: http://projetonovoscl.ccee.org.br/display/blogscl/O+Projeto+Novo+SCL. Accessed:

July, 2012.

FELFLI, F.F.; MESA, P.J.M.; ROCHA, J.D.; FILIPPETTO, D.; LUENGO, C.A.; PIPPO, W.A. Biomass briquetting and its perspectives in Brazil. Biomass and Bioenergy, 35(1): 236-242, 2011.

IBGEa. Instituto Brasileiro de Geografia e Estatística. Available at: http://www.ibge.gov.br/home/presidencia/noticias/noticia_impressao.php?id_noticia=1272, Accessed: November, 2009.

ITAIPU BINACIONAL. Available at: http://www.itaipu.gov.br/index.php?q=node/157&foto=geracao.jpg. Accessed: November, 2009.

LIBONI, L.B. Perfil da mão-de-obra no setor sucroalcooleiro: tendências e perspectivas. Tese de doutorado. São Paulo: Faculdade de Economia, Administração e Contabilidade - Universidade de São Paulo, 2009.

MAPA. Ministério da Agricultura, Pecuária e Abastecimento. Available at: http://www.agricultura.gov.br/vegetal/noticias/2012/02/governo-lanca-plano-para-a-expansao-da-oferta-de-cana. Accessed: February, 2012.

MME, Ministério de Minas e Energia. Available at: http://www.mme.gov.br/spe/menu/publicacoes.html. Accessed: April, 2009.

NEVES, M.F.; TROMBIN, V.G.; CONSOLI, M.A. (Coord.). Mapeamento e Quantificação do Setor Sucroenergético. Ribeirão Preto: Markestrat; 2009. Available at: http://www.unica.com.br/multimedia/ documentos. Accessed: November, 2011.

PALOMINO, J.M.G. Formação de preço de energia elétrica gerada por biomassa no Ambiente de Contratação livre brasileiro: uma abordagem computacional baseada em agentes. Ribeirão Preto: Dissertação de Mestrado. Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto – Universidade de São Paulo, 2009.

SOUSA, E.L.; MACEDO, I.C. (Coord.). Etanol e bioeletricidade: A cana-de-açúcar no futuro da matriz energética. São Paulo: LUC Projetos de Comunicação, 2010.

UNICA. União da Indústria de Cana-de-açúcar. Available at: http://www.unica.com.br/downloads/estatisticas/canasat_2008.pdf. Accessed: May, 2009.

UNICAa. União da Indústria de Cana-de-açúcar. Protocolo Agroambiental do Setor Sucroalcooleiro. Available at: http://www.unica.com.br/content/show.asp?cntCode={BEE106FF-D0D5-4264-B1B3-7E0C7D4031D6}. Accessed: May 2011.

Political and Legal Factors	Economic and Environmental Factors
Legislation on the electrical and energy sector	Business life-cycle
Legislation on the sale of electrical energy	Increase in the consumption of electrical and electronic appliances
Policies on energy transmission and distribution	Increase in purchase power
Policies on energy pricing (purchase and sale)	Easy credit availability
Policies for hydroelectric system expansion	Economic development (industry and commerce)
Policies incentivizing non-renewable sources of energy	Installation costs
Legislation on petroleum	Transmission and distribution costs
Absence of biofuel legislation	Renewable and sustainable sources of energy
Environmental policy	Global warming and burning
Taxation policy	Impacts of soil utilization
Labor and union laws	Clean development mechanism

	Climate problems
Socio-Cultural Factors	**Technological Factors**
Human population growth	Government and industry investments in research and development R&D
Increase in the number of people living alone	Rapid adoption of new technologies
Increase in the consumption of electrical and electronic appliances	Costs and implementation of new technologies
Consumption habits	
Labor market formalization and qualification	

Box 1 – Macro-environmental factors interfering with sugarcane co-generation.
Source: Elaborated by the authors.

THREATS	OPPORTUNITIES
Lack of coherent national energy policy	Increase in sugarcane production (area and productivity)
Incentives and substitute sources	Stock of production
Climate factors	Selling of carbon credits
Agro-environmental protocol	Agro-environmental Protocol
Costs with technologies	Energy gaps
Investment in transmission network	World trend towards changes in energy matrix
Energy pricing policy	Sustainable model
Energy trading policy	New sugarcane products and by-products

Box 2 – Threats and opportunities of energy co-generation.
Source: Elaborated by the authors.