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The Brazilian energy matrix: Evolution analysis and its impact on farming

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HIGHLIGHTS

- We analyze the impact of Brazilian energy matrix on farming.
- We highlight the socio-political-economic impact on the agricultural sector.
- We highlight the biofuels potential.

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ABSTRACT

This work proposes a technical and economic analysis of the Brazilian matrix energy evaluation, aiming at the evaluation of impacts inherent to technological innovation involved on energy matrix and the sectoral development. Particular attention is given to biomass energy, natural gas, and conventional fuels, considering their impacts on agricultural activity, identifying the highest potential for investment in this sector. As a result, a clear view of the importance of agricultural sector participation in the context of the Brazilian energy is obtained, not only as a consumer, but mainly through self-production energy policy of waste reuse as biomass and of biofuels.

1. Introduction

A major input of industries is energy. The productive capacity of the segment can be determined by crucial features of energy such as its availability, price, and quality. However, the cost of energy to the Brazilian productive sector has grown consistently above inflation rates (CNI – Confederacao Nacional da Industria, 2007).

A tendency of large industries to invest in technologies related to alternative sources of power generation is encouraged by this aspect, especially those sources based on biomass, in order to take advantage of solid waste from their own production processes. Moreover, the use of waste, or its use for biogas generation, in the agricultural sector is a broad and propitious scenario for its application (DIEESE – Departamento Intersindical de Estatistica e Estudos Socioeconomicos, 2007; Rathmann et al., 2008).

The share of ethanol in the Brazilian energy matrix is increasing, which shows a trend of the Brazilian market acceptance of renewable energy sources. According to data from the Brazilian energy balance, sugar cane based energy increased from 13.8% in 2005 to 14.4% of domestic energy supply (Margarida, 2007).

This participation is one of the factors that contributed to the decline in share of oil in the Brazilian energy matrix in the last 30 years. Other three factors stand out with the ethanol in this restructuring of the energy matrix: the policy of construction of large hydroelectric power plants, the growing share of natural gas in gross domestic supply, and restrictions on use of firewood and charcoal from deforestation, followed by its replacement by other more efficient sources, such as LPG (Barbieri, 2002; Campos, 2002; Alves Filho, 2003; Pires, 2006; Landau, 2008).

The search for new alternatives for energy generation has contributed to the evolution of the Brazilian energy matrix. Albeit slight, initiatives such as the development of biofuels are gaining space and they have gathered support and subsidies, especially from the Federal Government (CETESB – Companhia de Tecnologia de Saneamento Ambiental, 2006; Marques et al., 2006; Dabdoub, 2006).

The environmentalist point of view should also be considered when talking about reform in the Brazilian energy matrix, considering that even renewable energy sources are eventually impacting the environment. According to recent studies (CETESB

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– Companhia de Tecnologia de Saneamento Ambiental, 2006), which highlight the representativeness of renewable sources, including hydropower, such sources have decreased their share in the energy matrix due to limitation in capacity expansion of hydroelectricity and to the priority of the Federal Government. Such policy would increase Brazil's emissions of greenhouse gases and pollutants today such as NO_x and SO_2 (Jacomo, 2006). It should be noted that from the beginning of 2006, thermoelectric power plants represented significant part the energy matrix, about 85%, of which using natural gas as primary fuel.

An overview of the availability and affordability of energy sources and generation potential in Brazil, highlighting the Brazilian public strategy for the following years, concentrates on the promotion of more efficient energy utilization in different sectors of the society and also on diversifying its energy matrix, is given in several works, such as Goldemberg et al. (2002), Gomes (2009), Bajay and Nogueira (2010), Schaffel and La Rovere (2010), Gomes et al. (2012), Santos (2013), Pottmaier et al. (2013).

The potential of the Brazilian sugar cane industry as an electrical power supplier and the impact of modifications in the cogeneration plant on the costs of production of sugar and ethanol have been reported in many works, such as Pellegrini (2011), Vane (2012).

The efforts and perspectives in Brazil for sugar cane ethanol and bioethanol have been reviewed by several authors, such as Soccol et al. (2010), Khatiwada et al. (2012), Kostin et al. (2012).

The emergence of the biodiesel industry in Brazil has also been characterized and analyzed, and an assessment of the extent to which the goals established by the National Biodiesel Production and Usage Program have been reached in works such as Garcez (2009), Silva et al. (2010), Padula et al. (2012), Queiroz et al. (2012), Watanabe et al. (2012), Cunha Junior et al. (2013).

Salomon and Silva-Lora have evaluated the organic residues coming from the sugar and alcohol industry (vinasse, molasses and bagasse) and livestock residues (chicken, bovine and swine manure) in Brazil and estimated the electrical power generation potential of biogas from these sources (Salomon and Silva-Lora, 2009).

The Brazilian energy matrix is usually presented in a general way and without highlighting specific considerations about the technologies involved, industry characteristics, regionalism etc. In order to assess the impacts inherent to technological innovation involved in the energy matrix and to the sectoral development, technical and economic analysis of the evolution of the Brazilian energy matrix with the participation of biomass energy, natural gas, and conventional fuels, considering its impact in agricultural activity, identifying the greatest potential for investment in this sector, is proposed.

2. Materials and methods

The information that will be used in this analysis will be obtained from data queries to documents containing the necessary information for this study. The compilation of these data will allow reporting the trend with socio-political-economic of the Brazilian energy matrix, specifically considering their impacts on the agricultural sector.

3. Results and discussion

Recent researches, especially related to the sugar and alcohol sector, specifically within the scope of the agricultural sector, have been highlighted by enabling the reuse of environment aggressive residues, like sugar cane bagasse, molasses, wood chips etc., as energy sources and, in some cases, providing some energy autonomous supply, both electrical and thermal.

A source analysis of Brazilian energy balance shows two major energy sources directly or indirectly linked to the agricultural sector: sugar cane products and charcoal.

The former is represented mainly by ethanol production showing an increase of 17.9% in 2011 relative to 2010, while the final consumption increased by 11.0%. Moreover, sugar cane bagasse consumption as a heat source (biomass), including electrical power generation, increased by 9.2% (EPE – Empresa de Pesquisa Energetica (Brazil), 2012).

Table 1 shows the products of sugar cane in relation to production, net imports, consumption, and production yields between 2010 and 2011 (EPE – Empresa de Pesquisa Energetica (Brazil), 2012).

When analyzing the electrical power generation in Brazil, with respect to domestic supply, generation, net imports, consumption, and capacity, for the period 2010–2011 (Table 2), the autonomous production is noteworthy, given the intense participation of the agricultural sector. In the same period, electrical power domestic supply had an increase of 3.2% as compared to an increase of 3.0% in power generation, including power plants and public service self-generators. In particular, self-generators power plants grew by 5.2% in the same period (EPE – Empresa de Pesquisa Energetica (Brazil), 2012).

The main application of wood in Brazil is to produce charcoal, at the charcoal mills. However, especially in rural areas, it is also used in homes for cooking and heating. In 2011 approximately 21 million tons of firewood were consumed, a decrease of 11.9% over the previous year. Table 3 shows the performance of firewood and charcoal in terms of production, processing, and consumption

Table 1
Sugar cane products.

	Unit	2010	2011	% 11/10
Ethanol production	10^3 m^3	27,924	22,916	17.9
Ethanol imports and exports[a]	10^3 m^3	−1,825	−827	54.7
Stock variations, losses and adjustments	10^3 m^3	−1,685	−360	78.6
Ethanol final consumption	10^3 m^3	24,414	21,729	11.0
Anhydrous ethanol consumption-transports sector	10^3 m^3	7,097	8,435	−18.9
Hydrated ethanol consumption-transports sector	10^3 m^3	16,163	12,216	24.4
Other purposes ethanol consumption	10^3 m^3	1,139	1,060	6.9
Sugar cane ethanol performance	10^3 t	185,080	143,310	22.6
Molasses ethanol performance	10^3 t	17,465	19,557	−12.0
Bagasse thermal consumption[b]	10^3 t	141,173	128,247	9.2

[a] Minus sign for exports and no sign for imports.
[b] It includes self-producers consumption for electrical power generation.

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