IEA Bioenergy

Country Report

Brazil

IEA Bioenergy Task 40

Arnaldo Walter, FEM-NIPE, UNICAMP, Brazil
(awalter@fem.unicamp.br)
Paulo Dolzan

UNICAMP

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Summary

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Arnaldo Walter[1]
Paulo Dolzan
University of Campinas – Unicamp
DE/FEM/Unicamp / PO Box 6122
13083-970
Campinas – Brazil

Abstract

Worldwide, few countries have an energy matrix with such an important share of renewable energy sources as Brazil has: in 2010, almost 46% of its primary domestic energy supply was covered by renewables, being the share of biomass sources estimated as about 28% of the total energy consumption (almost 2,800 PJ). The most remarkable biomass experience is due to fuel ethanol production/consumption in large-scale, reaching the production of 28 billion litres in 2010 (25.7 BL consumed in Brazil and 1.9 BL exported). In 2005, Brazil started a biodiesel program and since 2010 B5 blends (5% of biodiesel in fuel blends, volume basis) are mandatory countrywide; in 2010, biodiesel consumption was 2.4 BL. Concerning ethanol, Brazil has been an important player in the international trade scenario, despite recent drawbacks of its production (since 2009). On the other hand, regarding biodiesel Brazil has reached in few years a position among the top world producers, but barely will be in an exporter. There are also constraints as regard solid biofuels (such pellets) and, despite some plans, the existing potential will be barely developed in very short-term. The lack of adequate logistics is one the main barrier for trading biomass in large scale, even in case of ethanol. In addition, sustainability of biofuels/biomass production is the challenge to be faced in the years to come, despite the fact that a significant share of ethanol production in Brazil – and this is also true regarding forest products – could be already considered sustainable.

[1] Mechanical Engineering Faculty and NIPE. E-mail: awalter@fem.unicamp.br; Tel: ++ 55 19 3521 3283; Fax: ++ 55 19 3289 3722. Also acting as Director of the Sustainability Research Program of the Brazilian Bioethanol Science and Technology Laboratory – CTBE.

Introduction

This is the third edition of Brazil's Country Report, prepared in the context of the IEA Bioenergy Task 40 Sustainable Bio-energy Trade; securing Supply and Demand. The first edition of this report was published in 2005 and the second in 2009.

Since 2005, Brazil experienced consolidated large-scale biodiesel production and is currently the second largest producer country: the production in 2010 reached 2.4 billion litres (BL), and that year only Germany has produced more than Brazil. On the other hand, ethanol domestic consumption has raised continuously since the launch of flex-fuel vehicles in March 2003, and reached almost 26 BL in 2010; Brazil is worldwide the second largest producer and has also the second largest internal consumer market, in both cases just after United States.

Regarding solid biomass, the consumption of firewood and charcoal has been almost constant in recent years. The consumption of pellets is still small, despite the fact that some big projects have been announced in 2010 and 2011.

There is also some optimism regarding electricity production from biomass, mainly from sugarcane residues, that has grown since the 1990s. However, there are still barriers that make difficult taking full advantage of the existing potential.

This report is organized in eight chapters. Chapter 1 presents general information about Brazil (geography, demography and economy), its energy matrix and data available about greenhouse gas emissions. Energy policies regarding biofuels/biomass production and consumption are presented in Chapter 2.

Chapter 3 assess the biomass resources in Brazil, while Chapter 4 presents current figures and expected future energy use of biomass.

Chapter 5 is devoted to assess biomass prices and Chapter 7 to the analysis of barriers and opportunities for biomass (and biofuels) exporting. Finally, Chapter 8 presents the final remarks by the authors of this report.

Complementary information is presented in Annexes.

1. General Information

1.1 Geography, Demography and Economy

Brazil is worldwide the fifth largest country by geographical area, and the fifth most populous country[2] (it surpassed 190 million people in 2010); is the largest Portuguese spoken country. Is located in South America and occupies almost 50% of the region; Brazil has boarders with all South American countries, except Chile and Ecuador.

Figure 1.1 presents a South America maps and details of Brazil's topography. It is worth to note that in 2010, according to the World Bank (Trading Economics, 2011), 61.4% of the country's land area was still covered by forests[3] (almost 5,200 km^2, i.e., the second largest area in the world, just after Russian Federation).

Source: Wikipedia (2009)

Figure 1.1 Brazil in South America and its topography

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[2] The four largest countries are Russia, Canada, China and United States; larger populated countries are China, India, United States and Indonesia.

[3] Defined as land area under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agriculture production systems (Trading Economics, 2011).

According to the last official demographic survey, in 2010 the Brazilian population reached 190.7 million inhabitants[4] (IBGE, 2011). The average population growth between 2000 and 2010 was estimated as 1.17% per year, and has declined[5]. Brazil is divided in five geographic regions, and the population in each one is presented in Table 1.1. The five geographic regions are presented in Figure 1.2.

Table 1.1 Demographic information – Brazil, 2010

Region	Population (1,000)	Area (1,000 km^2)	Density (hab/km^2)
North	15,830.8	3,851.6	4.1
Northeast	53,023.7	1,556.0	34.1
Southeast	80,353.7	927.3	86.7
South	27,465.5	575.3	47.7
Centre-West	14,114.2	1,604.9	8.8
Total	190,732,7	8,514.9	22.4

Source: IBGE (2011)

Notes: Region 1 – Centre-West, with three states and the Federal District (Brasília); Region 2 – Northeast, with nine states; Region 3 – North, with seven states (where most of the Amazon region is located); Region 4 – Southeast, with four states; Region 5 – South, with five states.

Figure 1.2 The five geographic regions in Brazil

In Latin America, Brazil has the largest market and has reached in 2011, according to the International Monetary Fund, the sixth position among the richest countries in the world (see Table 1.2) (IMF, 2011). In 2010 the Brazilian GDP was estimated at 2,090 billion US$. Also according the IMF, the Brazilian GDP based on Purchasing-Power Parity (PPP) was 2,178.5 billion US$, i.e.,

[4] Some publications present different numbers: for instance, 193.7 million according to The Economist (2011).

[5] It has been predicted that keeping the recent tendency of population growing rates, Brazilian population in 2020 will be stable or even start to be reduced (IBGE, 2010).

lower, for instance, than the Indian GDP based on PPP (estimated as 4,057.8 billion US$). In 2010 the GDP per capita was estimated at 11,272.9 US$/habitant[6,7].

Table 1.2 Gross Domestic Product of the main countries in 2010 and 2011 (estimates), in US$ billion (current prices)

Country	GDP 2010	Position 2010	GDP 2011	Position 2011
US	14,527	1	15,065	1
China	5,878	2	6,988	2
Japan	5,459	3	5,855	3
Germany	3,286	4	3,629	4
France	2,563	5	2,808	5
UK	2,250	6	2,481	7
Brazil	2,090	7	2,518	6

Source: IMF (2011)

A big issue in Brazil is income inequality (Gini Index 0.539 in 2009[8]) that has slowly declined due to income support programs (e.g., 0.606 in 1990 and 0.592 in 1995). The Human Development Index in 2011 was estimated at 0.718, with a continuous trend of improvement since 1980 (e.g., 0.549 in 1980, 0.6 in 1990 and 0.665 in 2000) (UNDP, 2011).

By 2009, 69% of the total GDP was due to the Services Sector, being the contribution of industries estimated as about 25% (16% due to manufacturing branch) and of agriculture about 6%. In 2009, total exports represented about 11% of the GDP, while total imports were slightly lower (The Economist, 2011).

The main industrial branches in Brazil are: automobile, petrochemicals, machinery, electronics, cement, textiles, food and beverages, mining, aircraft, etc. The main products of Brazil's agriculture are soybeans, coffee, beef, citrus, sugarcane, rice, corn, cocoa, etc. Table 1.3 presents the main figures regarding foreign trade in 2010; exports reached 201.9 billion US$ and imports were 181.6 billion US$.

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[6] It is worth noting that Brazil in 2009 was not ranked among the 60 countries with the highest GDP per head (both in absolute terms and based on power purchase power) (The Economist, 2011).

[7] About 50% higher than China, and more than 3 times higher than India. However, the Brazilian GDP per capita in 2010 was 3 times lower than Japan and more than 4 times lower than US (IMF, 2011).

[8] The lower its value, the more equally household income is distributed. In 2009, Brazil has worldwide the tenth highest Gini coefficient. The worst figure in 2009 was for Namibia – 0.743 – while the best figures were for Denmark, Japan and Sweden (0.247, 0.249 and 0.25, respectively).

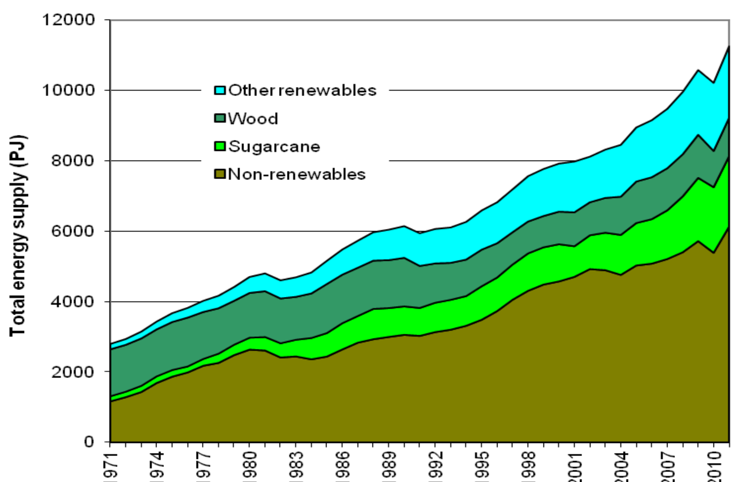
Table 1.3 Foreign trade figures (% of total for the leading markets and leading suppliers)

Main exported products and its share	Main imported products and its share
Ores – 15.3%	Oil and fuels – 16.5%
Oil and fuels – 11.3%	Mechanic equipment – 15.7%
Transport materials – 10.8%	Electric and electronic equipment – 12.2%
Soybeans and products – 8.5%	Vehicles and parts – 9.5%
Sugar and ethanol – 6.8%	Chemicals – 5.6%
Chemicals – 6.7%	Iron, steel and its products – 4.3%
Meats – 6.6%	Plastics – 3.6%
Metallurgic products – 6.4%	Optical and precision equipment – 3.4%
Machines and equipment – 4.1%	Pharmaceuticals – 3.4%
Pulp and paper – 3.4%	Fertilizers – 2.7%
Major countries for the exports and its shares	**Main supplier countries and its shares**
China – 15.3%	United States – 15.0%
United States – 9.6%	China – 14.1%
Argentina – 9.2%	Argentina – 7.9%
The Netherlands – 5.1%	Germany – 6.9%
Germany – 4.0%	South Korea – 4.6%

Source: MDIC (2011)

1.2 Energy

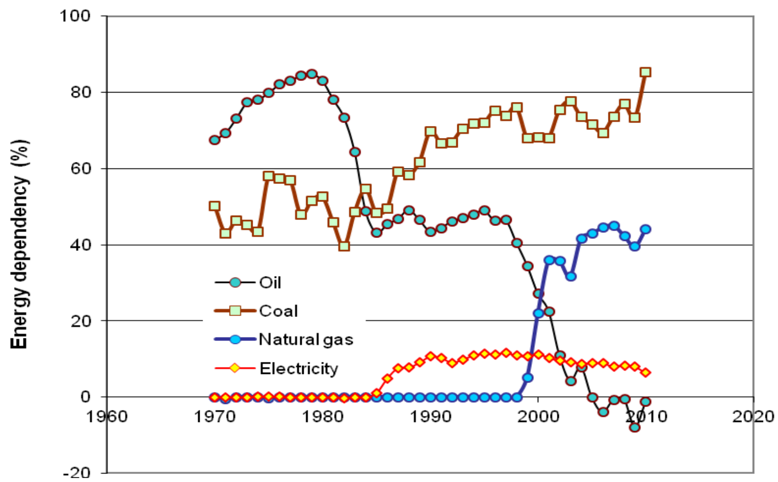
Few countries with reasonable to good level of industrialization, like Brazil, have an energy matrix with such an important share of renewable energy sources. In 2010, almost 46% of its primary domestic energy supply was covered by renewables. The share of hydraulic energy that year was 14.0% of the total supply. In the same year, the set of biomass sources covered 27.5% of the domestic energy supply, with a share of almost 18% due to sugarcane products (ethanol and bagasse). Figure 1.3 shows the evolution of the total energy supply in Brazil in the period 1970-2010, and highlights the share of renewables.



Source: EPE/MME (2011)

Figure 1.3 Evolution of total energy supply in Brazil – 1970-2010

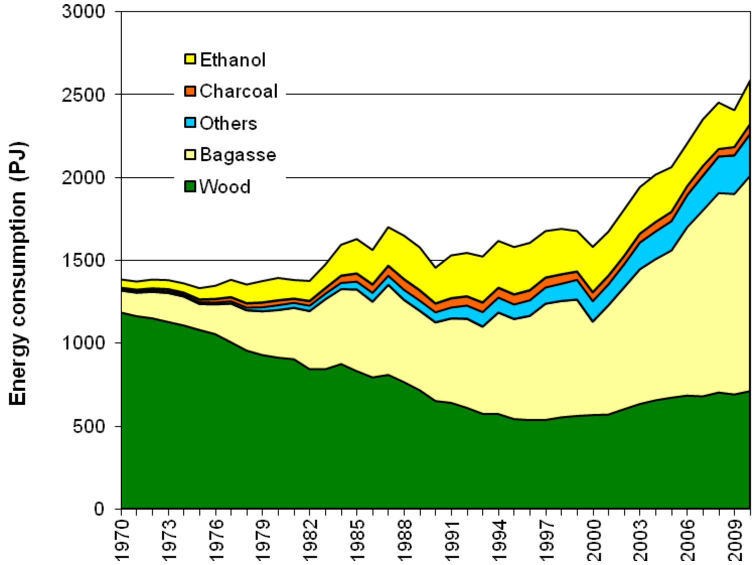
Along the last three decades or so, Brazil has remarkably reduced its dependency on oil supply and is currently (on average) self-sufficient. On contrary, Brazil is highly dependent on high-quality coal (and coal coke), used for iron and steel production; this dependency was reduced in the early 1980s, when Brazilian government implemented policies aiming at substituting coal coke for charcoal, but imports raised again when coal's (coke's) prices declined. The dependency on natural gas is a new event, and started with the imports from Bolivia; Brazilian government (through PETROBRAS, the stated-controlled oil company) has worked on enlarging domestic production and diversifying suppliers. Finally, the dependency on electricity is mostly due to the imports from Paraguay, as it owns half of Itaipu's capacity (the largest hydro power plant, with almost 14 GW installed). Figure 1.4 shows the evolution of external dependency on oil, coal, natural gas and electricity.



Source: EPE/MME (2011)

Figure 1.4 Evolution of energy dependence in Brazil – 1970-2010

Details about the contribution of biomass over the final energy consumption in Brazil are presented in Figure 1.5. It can be seen a continuous reduction of wood consumption until mid-1990s that was strongly influenced by the reduction of non-commercial wood consumption by households. It should be noticed that the data regarding wood consumption, mainly in households, are based on estimations. Bagasse consumption corresponds to the use of sugarcane bagasse as fuel in mills that produce ethanol and sugar; in this case, bagasse is used with low efficiency for raising steam in boilers and this is the main reason for its high share – the availability is high and the opportunities for other uses are limited so far. In Figure 1.5, "Others" correspond to different agricultural and industrial residues, such as black liquor.

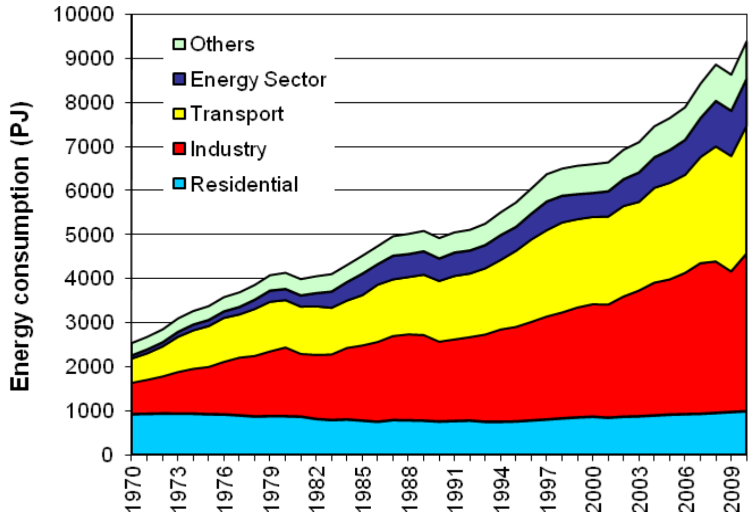


Source: EPE/MME (2011)

Figure 1.5 Final energy consumption of biomass sources – 1970-2010

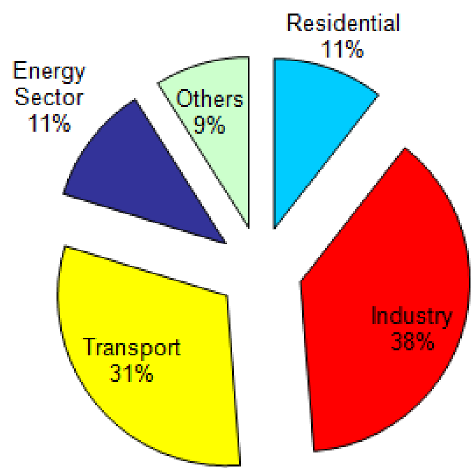
Wood consumption as such is equally relevant in the residential (43%) and in the industrial sectors (42%). The energy consumption of charcoal is mostly due to the industrial sector (82%), and more specifically in the metallurgic industry.

Considering socio-economic sectors, the industrial is the one with highest consumption (3.6 EJ by 2010; 38% of the total), followed by the transport sector (2.9 EJ and 31% of the total by 2010). In Brazil, the energy consumption in the residential, commercial and in the energy sectors reflect some specific aspects: first, due to the weather conditions, space heating is not required in most of the regions; second, due to the importance of hydroelectricity, the total consumption in the energy sector is not too high. Figure 1.6 shows the growth of final energy consumption by sectors from 1970 to 2010. Figure 1.7 shows the distribution of final energy consumption within socio-economic sectors by 2010.



Source: EPE/MME (2011)

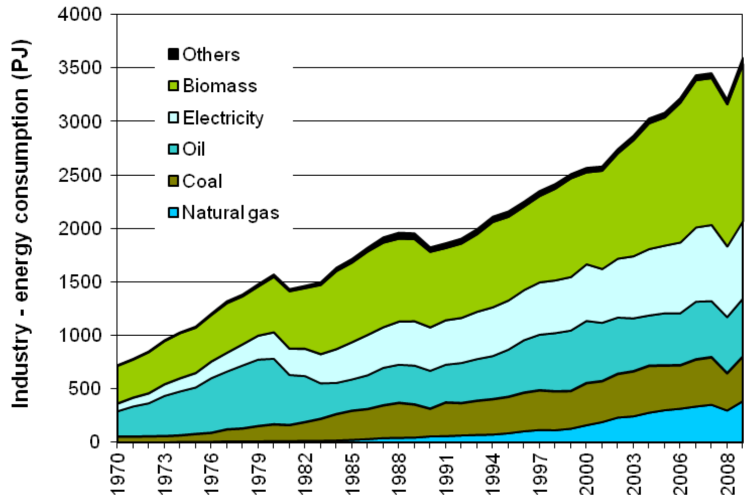
Figure 1.6 Energy consumption by sectors – 1970-2010



Source: EPE/MME (2011)

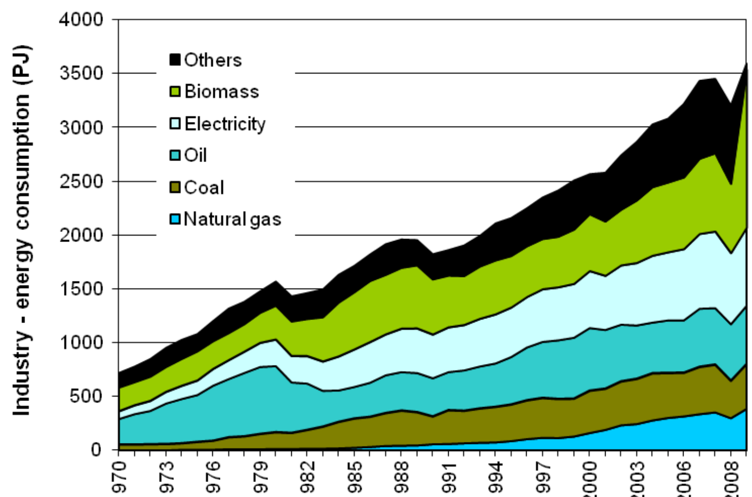
Figure 1.7 Energy consumption by sectors in 2010

The evolution of the final energy consumption within the industrial sector is shown in Figure 1.8 and in Figure 1.9. The difference between these two figures is the inclusion (or not) of the sugar industry in the industrial sector. Most of the sugarcane mills in Brazil produce both sugar and ethanol but, from the point of view of energy statistics, the consumption for sugar production is classified as industrial sector while the consumption for ethanol production is allocated in the energy sector. The difference was almost 750 PJ in 2010.



Source: EPE/MME (2011)

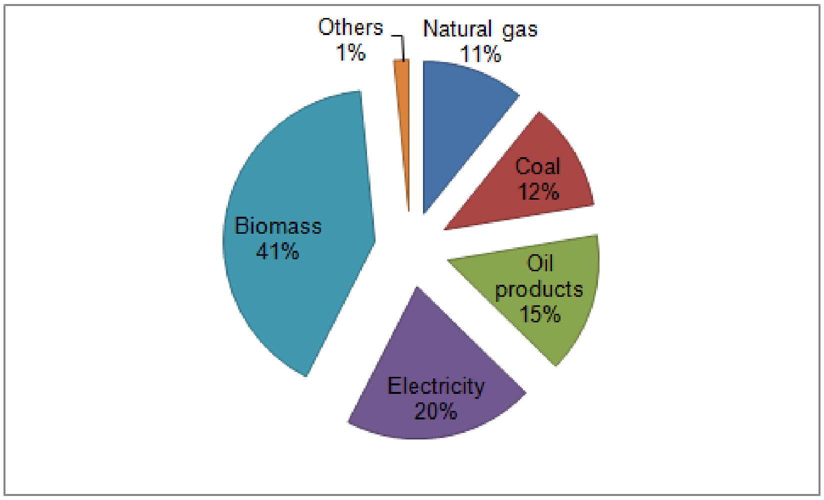
Figure 1.8 Energy consumption in the industrial sector, including bagasse consumed for sugar production



Source: EPE/MME (2011)

Figure 1.9 Energy consumption in the industrial sector, excluding bagasse consumed for sugar production

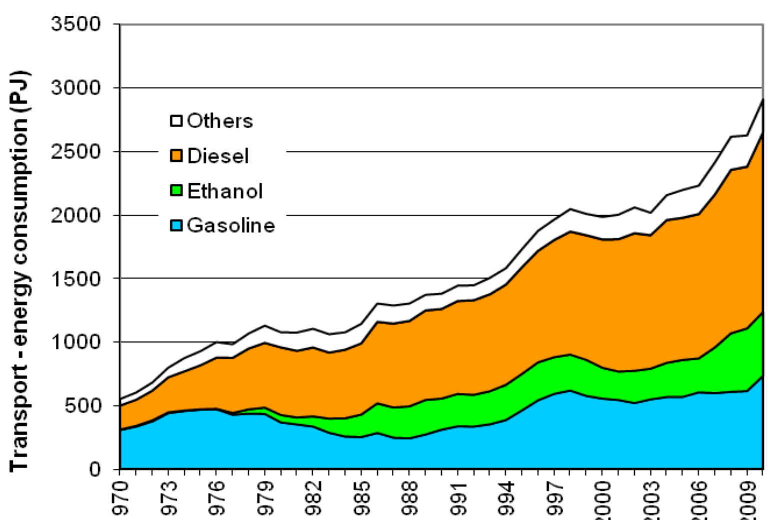
Figure 1.10 shows the structure of final energy consumption in the industrial sector by 2010. The share of biomass would be reduced to 20% in case bagasse consumption is not considered. Details of the energy consumption in the industrial sector from 2000 to 2010 are presented in Annex A.



Source: EPE/MME (2010)

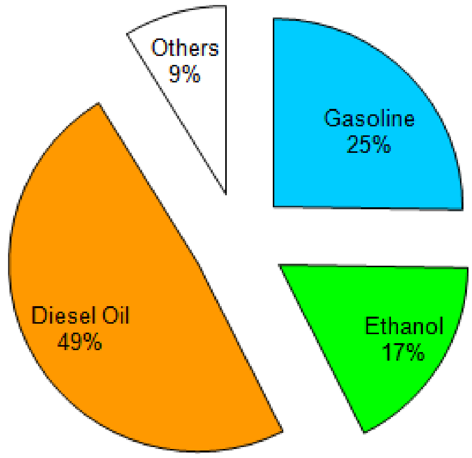
Figure 1.10 Final energy consumption in the industrial sector by 2010

For the transport sector, the evolution of the final energy consumption is shown in Figure 1.11. The growth of ethanol consumption (hydrated ethanol and anhydrous ethanol, that is blended with gasoline) is remarkable since 1976. By 2010, ethanol consumption represented 17% of the energy consumption in road transportation and 38% of the energy consumption of spark-ignition vehicles (69% of the gasoline consumption in energy basis). In Figure 1.11, "Others" correspond mostly to kerosene (consumed in jet engines) and natural gas (consumed in spark-ignition engines). Figure 1.12 shows the distribution of the energy consumption in the transport sector by 2010.



Source: EPE/MME (2011)

Figure 1.11 Energy consumption in the transport sector – Brazil, 1970-2010



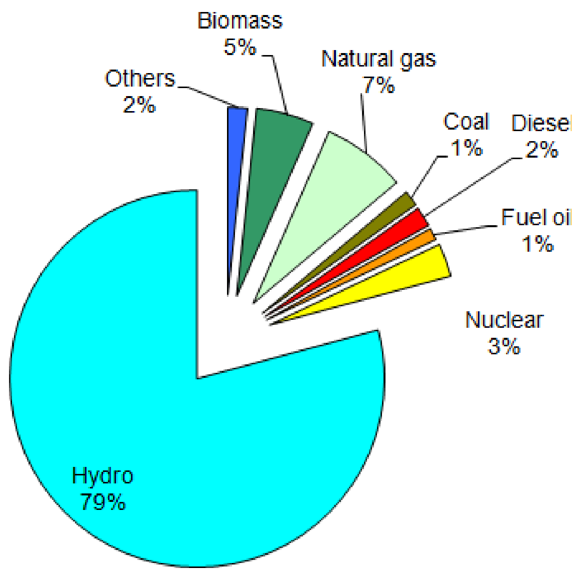
Source: EPE/MME (2011)

Figure 1.12 Final energy consumption in road transport sector by 2010

In Brazil, for more than five decades electricity production has been mostly based on hydro power plants. The bulk of the hydroelectric potential is still untapped (about 70%), but most of it is located in the North region (more than 110 GW over 260 GW). It will be difficult to take full advantage of the remaining potential in the North region as, firstly, there is growing resistance to new large hydro power plants due to the potential environmental and social impacts in the Amazon area and, secondly, because the distance from the largest consumer markets (in Southeast and South regions).

Figure 1.13 shows the profile of electricity generation in 2010, when almost 80% of the generation was based on hydro power plants. Results presented in the figure corresponds to the production in Brazil; as previously mentioned, Itaipu belongs 50% to Brazil (50% belongs to Paraguay), and only the Brazilian share is included in this figure. Electricity generation in Brazil summed-up 509.2 TWh in 2010, while imports (mostly from Itaipu) summed-up 35.9 TWh in the same year.

Regarding the installed capacity of electricity production, by the end of 2011 hydro power plants corresponded to almost 70% of the total (also excluding 50% of the Itaipu's capacity). About 7.5% of the installed capacity is based on thermal power units that burn biomass. Table 1.4 shows the current profile of the installed capacity of electricity production and Table 1.5 shows the profile of electricity production based on biomass; it can be seen that most of biomass power capacity corresponds to cogeneration from sugarcane residues (bagasse) and black-liquor.



Source: EPE/MME (2011)

Figure 1.13 Profile of electricity generation by 2010

Table 1.4 Profile of the installed capacity of electricity generation by December 2011

	Capacity (MW)	Share (%)	Number of plants
Hydro – large-scale	78,706	66.9	180
Hydro – small-scale	3,874	3.3	418
Thermal- conventional	32,857	26.7	1,513
Nuclear	2,007	1.7	2
Wind	1,561	1.2	72
Solar	0	0.0	6
Total	119,227		2,561

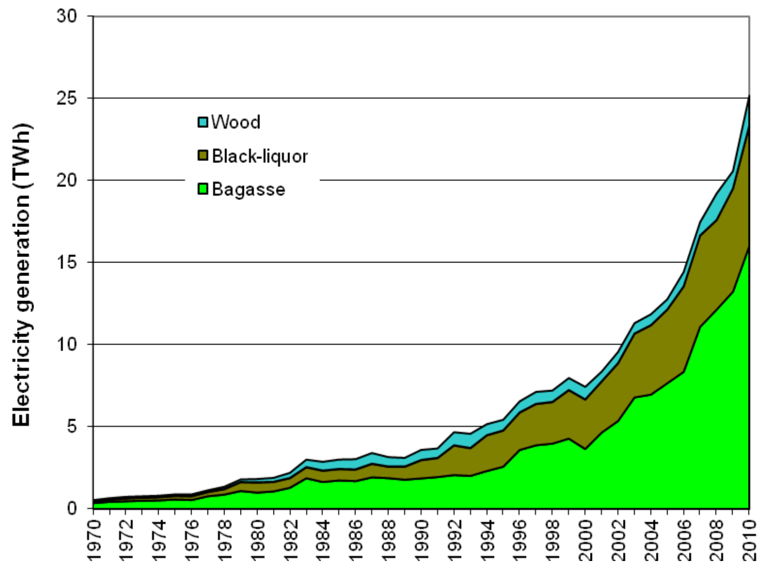
Source: ANEEL (2012)

Table 1.5 Profile of thermal power plants based on biomass by December 2011

	Capacity (MW)	Share (%)	Number of power plants
Sugarcane residues	7,264	80.8	347
Black liquor	1,245	13.9	14
Wood residues	320	3.6	38
Biogas	71	0.8	16
Rice residues	33	0.4	8
Charcoal	25	0.3	3
Vegetable oil	4	0.1	2
Total	8,993		430

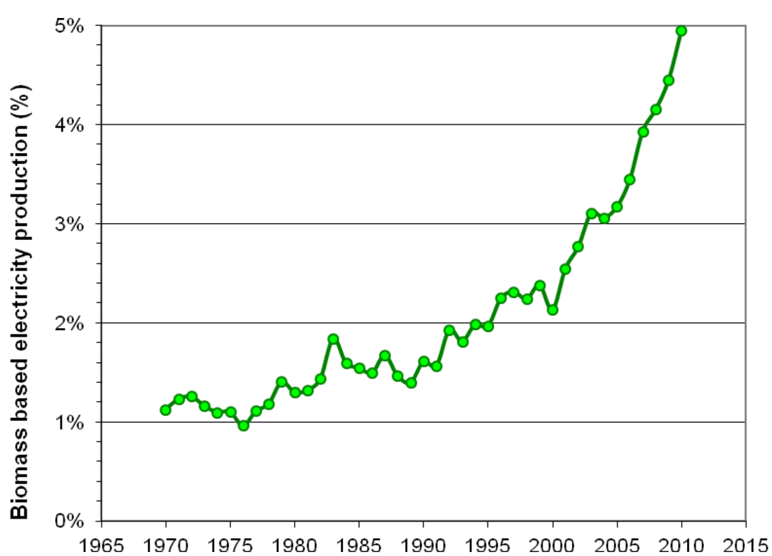
Source: ANEEL (2012)

Figure 1.14 shows the growth of electricity production (since 1970) from the most important biomass sources. In recent years, 40-45% of the electricity produced from bagasse has been commercialised with the grid; the bulk of electricity production from biomass is consumed in the industrial processes where the cogeneration units are located. Figure 1.15 shows the growth of the contribution of electricity production from biomass since 1970.



Source: EPE/MME (2011)

Figure 1.14 Electricity production from biomass – 1970-2010



Source: EPE/MME (2011)

Figure 1.15 Electricity production from biomass over the total (only 50% of Itaipu is included)

1.3 Greenhouse gas emissions

Within the Kyoto Protocol Brazil is not an Annex I country and, thus, does not have commitments regarding emission reductions for the period 2008-2012. Just considering greenhouse gas (GHG) emissions due to energy use, in 2006 Brazil was worldwide in the 18^{th} position among the largest emitters of carbon dioxide (UNDP, 2009). However, taking into account LULUCF emissions[9], Brazil is the 5^{th} largest emitter, being responsible for 5.3% of the total GHG emissions in 2000 (after United States, China, EU25 and Indonesia), with 2,322 $MtCO_{2eq}$ (WRI/CAIT, 2008).

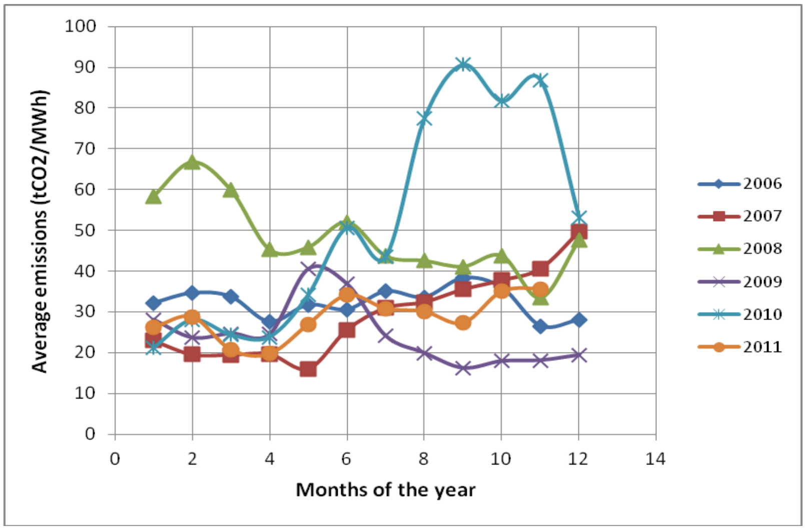
Worldwide, it is estimated that Brazil has the largest stock of carbon in forests (49,335 MtC), 1.5 times larger than Russian Federation (the second largest stock holder) and 2.6 times larger than United States (the fourth largest stock holder) (UNDP, 2009).

Brazil has released two official inventories of its GHG emissions, based on data of the periods 1990-1994 and 2000-2005. According to these studies, the emissions due to land use change and deforestation in Brazil covered 55% and 61% of the total emissions in 1994 and 2005, respectively (1,329 $MtCO_2$ in 2005). In 2005, emissions due to the agriculture were 18.9%, while emissions due to energy production and use contribute with 15%. The balance was due to the emissions in industry (3.6%) and due to waste disposal (1.9%) (Brasil, 2010).

Emissions of CO_2 per capita due to energy consumption were 1.74 tonnes/habitant in 2009 (1.4 t/habitant in 1990), while the figure for carbon intensity of economic growth was 0.20 $ktCO_2$/million US$ PPP (2000) in 2009 (0.22 $ktCO_2$/million US$ PPP (2000) in 1990) (IEA, 2011 and UNDP, 2009). These figures are very low compared to other countries (developed and developing countries).

The average CO_2 emission factors due to electricity generation in Brazil (considering the national electric interconnected system) from January 2006 to November 2011 are presented in Figure 1.16. The results are based only on fuel consumption and on the hypothesis that hydro power plants do not cause GHG emissions. The variations along the year are due to seasonal behaviour of electricity production by hydro power plants, as thermal power plants are mostly complementary in Brazil. Due to the profile of electricity generation in Brazil, the estimated CO_2 emissions are quite low, but it is clear a tendency of growing emissions, as long as hydro power plants have operated with constrains in recent years.

[9] GHG emissions due to land use, land use change and forestry.



Source: MCT (2011)

Figure 1.16 CO_2 emission factors in the Brazilian electric interconnected system

2. Energy Policies

2.1 Ethanol[10]

The so-called chicken and egg problem is classic for alternative fuel vehicles: who will buy these vehicles if a fuelling infrastructure is not in place, and who will build the infrastructure if there is no vehicles in the market? (Romm, 2006). There is high-risk perception both for producers and consumers, and this is one of the main challenges for deploying a new energy source.

During the first 15 years of the Brazilian ethanol program, supply and demand were both stimulated and adjusted through central coordination. Producers accept the Program since the very beginning as it was also created in order to minimize the difficulties frequently faced by sugarcane sector due to the excess of sugar production and fluctuations of its international prices. In addition, the required investment was assured by credits given at low interest rates and risks were extremely reduced as sales were guaranteed (due to mandates – see below – and strict regulation by the government) and prices were controlled – both to sugarcane and to ethanol. In fact, the fixed prices for producers and consumers played an essential role in the general trust of the program (van den Wall Bake et al., 2008).

Also aiming at assuring the supply, during the 1970s and 1980s the government has obliged the state-controlled oil company (PETROBRAS) to provide and operate the required infrastructure for transport, storage, blending and distribution. Eventual losses during ethanol commercialisation were also assumed by PETROBRAS.

In parallel, in order to induce the consumption, the government negotiated with the automobile industry[11] to introduce the required modifications in engines and parts. As large is the share of ethanol in the fuel blend, more modifications are required[12] (Coelho et al., 2006). Already in early 1980s, the automobile industry has accepted to give full warranties to the consumers. The R&D efforts regarding engines able to run with blends and straight ethanol started at a federal research centre (Aeronautics Research Centre) where the development of engines and tests were performed. The first neat ethanol engine was commercially available in 1979 and technology was quickly transferred to the automobile industry.

On the other hand, the ethanol market was induced by mandates. In 1975, a mandate for 20% anhydrous ethanol (E20 – volume basis) on fuel blend was established. However, just by early 1980s the share of ethanol into all gasoline commercialised reached 20%. Along the years the share of ethanol in fuel blend has changed, as can be seen in Figure 2.1. The ethanol share was reduced to 13% between 1989 and 1993 as consequence of a (domestic) supply ethanol crisis, while in 1993 it was defined by law that the share of ethanol in fuel blend should be in the 15–25% range (now the range is defined as 18-25%), depending on the conditions of ethanol market. Since then 20% was the lowest level reached. In practice, this relative wide range allows the production shift to more sugar (when it is convenient), allowing the producer to maximize its earnings. Currently, the share of anhydrous ethanol in the fuel blend is 20%.

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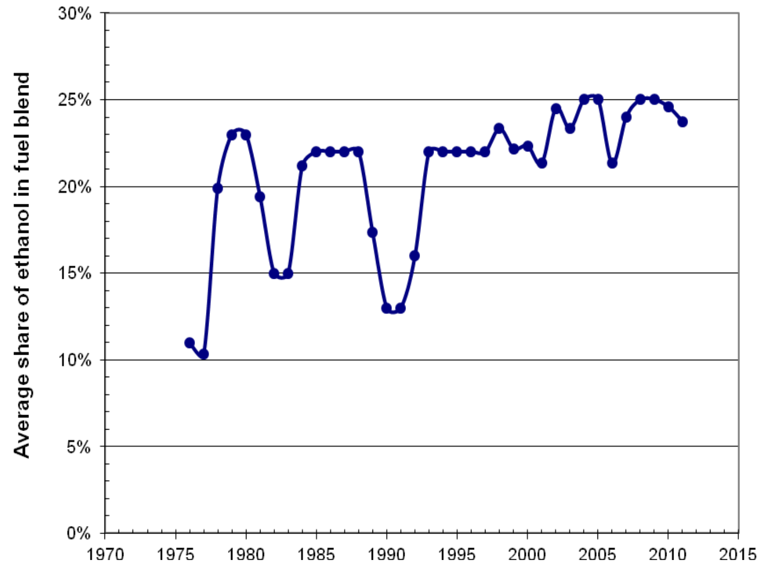
[10] Text based on Walter (2008): Bio-ethanol Development(s) in Brazil; in: Soetaert W. and Vandamme E. (Editors). Biofuels.

[11] At that time, only four main car manufacturers were based in Brazil.

[12] For instance, for 25–100% ethanol in the fuel blend, modifications include materials substitution (e.g. of the fuel tank, fuel pump, electronic fuel injection system) and new calibration of devices (e.g. of ignition and electronic fuel injection systems).



Source: ALOPAR (2011)

Figure 2.1 Average share of ethanol (anhydrous) in the blend with gasoline, according to mandates

Moreover, along the years consumers were stimulated to buy neat-ethanol cars through lower taxes regarding those applied over gasoline vehicles. In addition, fuel prices were controlled until mid 1990s and ethanol prices to consumers were kept close to 65% of the gasoline's price (volume basis).

In Brazil, taxes have a strong impact over the consumer's fuel price. Currently, six different taxes and contributions have been applied over automotive fuels, being just one equivalent to the value-added tax (VAT). As an example, in 2005 the average taxation over gasoline C (gasoline blended with ethanol) in Brazil was estimated as 47%, while the average taxation over hydrated ethanol was evaluated as 34%. In state of São Paulo (the largest producer and consumer of ethanol in Brazil), the local taxation over hydrated ethanol was close to 20% in the same year (Cavalcanti, 2006). In addition, in the state of São Paulo an extra advantage for ethanol consumers is the lower value of the annual license paid by owners of neat-ethanol vehicles (including FFVs).

Direct subsidies were completely eliminated with the deregulation process that finished in early 2000s. However, a tax exemption policy is in place and part of the benefits received by ethanol consumers is due to lower taxes applied to ethanol regarding those paid by gasoline consumers. Anyhow, it should be noticed that in Brazil the taxation applied to diesel oil is even lower than the correspondent applied to ethanol (about 27% in 2005, on average) (Cavalcanti, 2006).

2.2 Biodiesel

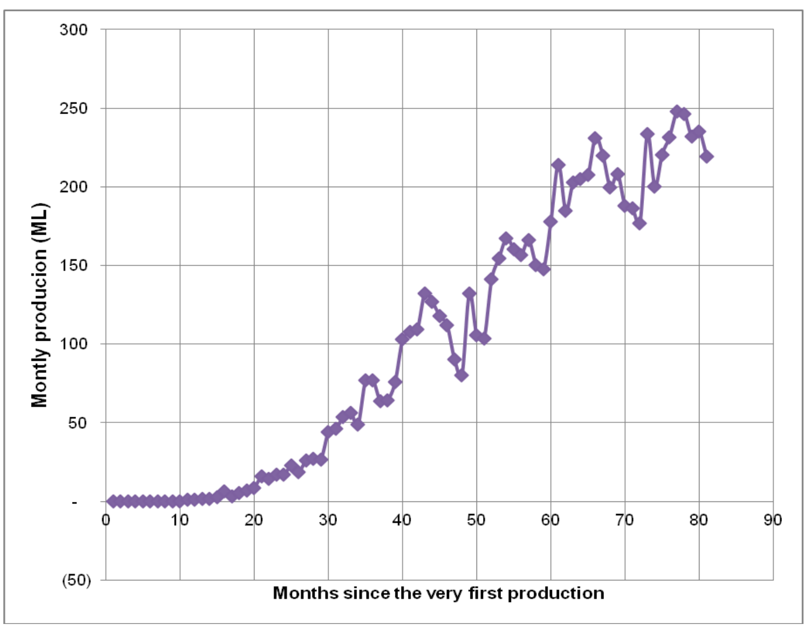
By the end of 2004, Brazilian government decided to implement the so-called National Program of Biodiesel Production and Use (PNPB). The declared targets of the program are generating jobs and income in rural areas and reducing regional inequalities. According to the government, two additional targets are the potential contribution to foreign-exchange savings and environment improvements.

In 2004 it was defined by law that B2 blends would be mandatory countrywide from January 2008, but this target was changed to B3 blends in July 2008 and enlarged to B4 blends in July 2009. It was initially predicted that only in January 2013 the mandatory mix would reach to 5% of biodiesel (B5), but the target was anticipated to 2010. Higher biodiesel blends or even B100 can be used, but only if authorized by the Petroleum, Natural Gas and Biofuels National Agency (ANP). From 2005 to 2007, the use of B2 blends was not mandatory.

The program was conceived in order to foster the production of biodiesel from different raw materials, such as palm oil and babassu in the North region, castor oil and cottonseed in Northeast region, sunflower and peanuts in the South and soybeans, residual oil and fats in the Southeast and Centre regions. However, the bulk of biodiesel production has been based on soy oil (about 82% in 2010; being approximately 12% produced from animal fats and 5% from other feedstocks).

The three main pillars of the PNPB are: (a) the so-called “Social Label”, as specific policies were designed to support subsistence farming systems; (b) reduction of some federal taxes; and (c) biodiesel purchasing auction schemes (Amaral et al., 2008).

The production of biodiesel has been encouraged through purchase auctions organized by ANP. Twenty three auctions took place since 2007 while the total amount of biodiesel sold surpassed 8 BL. Only producers that hold the Social Label (see below) can participate on these auctions; PETROBRAS assures the purchase (Pousa et al., 2007). Figure 2.2 shows the monthly biodiesel production from early 2005 to December 2011. In 2011 the production surpassed 2.5 BL and is predicted to grow about 10% per year in the following years.



Source: ANP (2011)

Figure 2.2 Monthly biodiesel production from 2005 to 2011

The engagement of small farmers and producers of the poorest regions in the biodiesel value chain has been fostered by means of tax incentives granted to firms that purchase oil-producing crops from small farmers. Total or partial taxes exemptions are granted to biodiesel producers that support family farming.

In order to qualify for these tax benefits, biodiesel producers have to hold a certificate, called Social Label. The Ministry of Agrarian Development (MDA) issues the Social Label to biodiesel producers provided that they meet the following requirements:

a) Purchase of minimum percentages of raw materials from family farmers (10% in North and Mid-West regions, 30% in South and Southeast regions and 50% in Northeast and Semi-Arid Regions); and

b) Contracts with family farmers establishing deadlines and conditions for raw material deliverance (including prices) and provision of technical assistance to the family farmers.

2.3. Wood resources

During the 1960s, the existence of just 0.5 Mha of plantations and a growing pace in deforestation led to a revision in the ongoing forestry legislation updating the Forestry Code. In 1967, the IBDF – Brazilian Institute for Forestry Development – was created, together with a national program to foster forestation (the Brazilian Tax Incentive Law). It ruled during 20 years but failed on the target of planting additional 6.5 Mha.

In the 1990s the increment on forested area was reduced from about 300,000 ha/year to about 170,000 ha/year. Two industrial branches (pulp and steel industries) were responsible for most of those plantings, with improvement on wood yields through development and use of new technologies.During the first half of the 2000s, forested areas held about 250,000 ha/year, an amount still lower than the harvested area. At that time, some timber consumers that faced the supply problems imported wood from MERCOSUR countries.

Along the years, several forestry programs have been implemented[13] and they led to increasing annual planted forests through funding at low rates, and incorporating native sustainable forests through certification process (e.g., FSC – Forest Stewardship Council). Targets for planted forests from 2004 to the end of 2007 were additional 0.8 Mha through small and medium farmers and 1.2 Mha through medium and large companies. In the same period the targets for native forests included certification and sustainable management of 15 Mha, being 5 Mha planted and managed by communities or families.

Regarding programs aiming at foster the demand of solid biomass in industries, it should be mentioned a government action in the 1980s that induce the use of charcoal as substitute of imported coal and coke. The peak of charcoal output was in 1989 (about 240 PJ), when almost 40 per cent of the pig-iron production was based on this biomass source. During the 1990s large-scale integrated steel mills shifted again their energy matrix, returning to coke due to its reducing costs. Currently, charcoal use in pig-iron production is concentrated in small independent factories.

Also in the first half of the 1980s, federal government induced the use of firewood targeting the substitution of fuel oil in industries. Previously, the peak of firewood consumption was in 1986

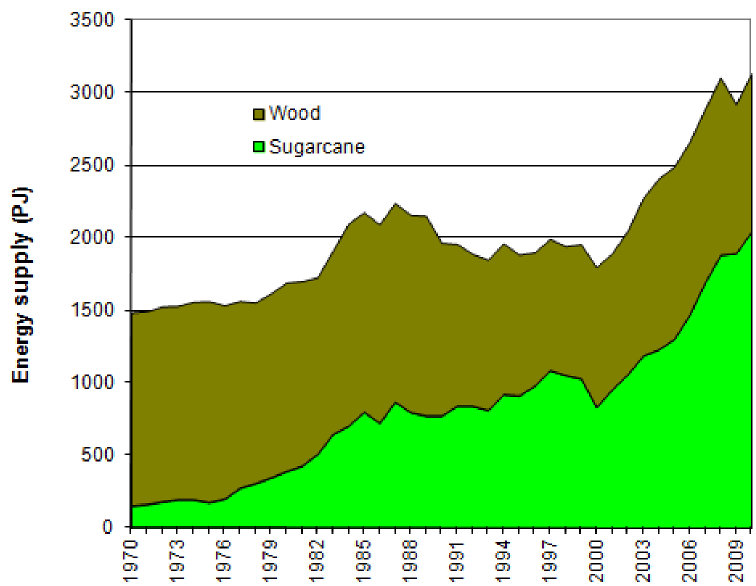
[13] Such as Pronaf Florestal (Forestry Program for Familiar Agriculture Support), Propflora, Profloresta, and Proambiente.

when it reached 280 PJ, and after that it continuously declined down to about 200 PJ in 1992; since 2002 firewood consumption in industries has grown again, and reached 300 PJ in 2010 (more than 8% of the energy consumption in industries).

3. Biomass Resources

The main biomass resources in Brazil are wood, sugarcane and the oil seeds used for biodiesel production; the most important oil seed so far is soybeans. In 2007, the contribution of wood and sugarcane to the total energy supply was 3,137 PJ, or almost 30% of the total (being about 10% from wood and close to 20% from current sugarcane products – ethanol and bagasse)[14]. As shown in Figure 1.5, the contribution of biomass sources to the final energy consumption in 2010 reached 2,590 PJ, or 25.6% of the energy consumption; sugarcane bagasse (1,230 PJ), firewood (714 PJ) and ethanol (262 PJ) are the main biomass energy sources.

Sugarcane has consolidated its position as the main biomass source in Brazil in recent years. Its importance is due to the production of ethanol (hydrated and anhydrous) with the use of sugarcane bagasse as fuel in cogeneration systems at the mills. Sugarcane is also important due to the production of sugar (that also uses sugarcane bagasse as fuel). In fact, most of the sugarcane mills in Brazil produce both ethanol and sugar (see section 4.2), but the statistics of ethanol production are included in the transformation sector while sugar production in within the food and beverage sector. Figure 3.1 shows the evolution of sugarcane and wood supply from 1979 to 2010.



Source: EPE/MME (2011)

Figure 3.1 Supply of sugarcane and wood from 1970 to 2010

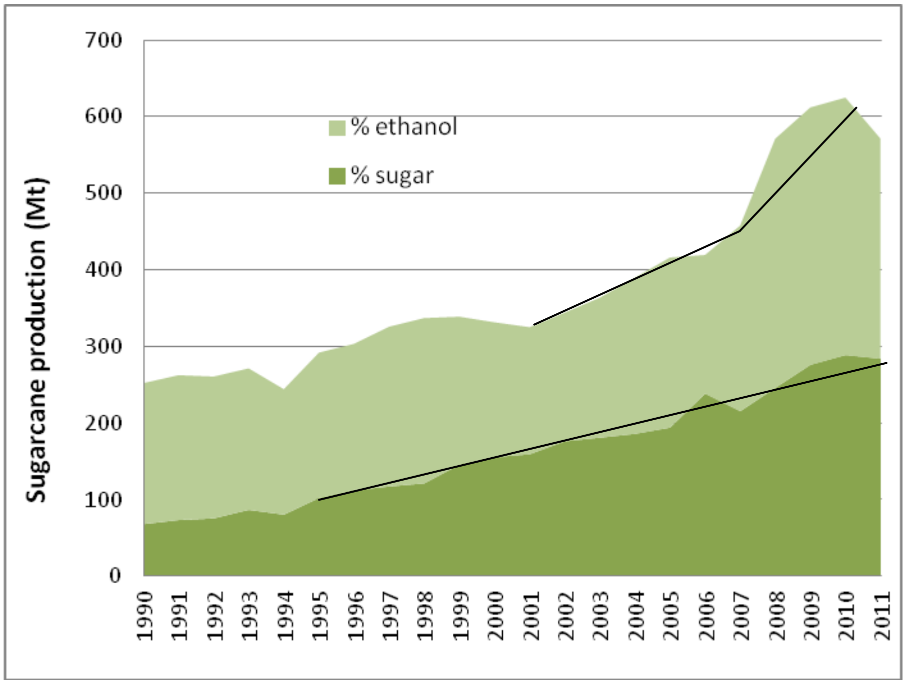
3.1 Sugarcane

Sugarcane is a traditional crop in Brazil. Its use for fuel ethanol production in large-scale started in 1975 (see section 4.2); previously to that, sugarcane was mainly used for sugar and ethanol production for other uses (e.g., industrial).

Figure 3.2 shows the growth of sugarcane production for sugar and ethanol from the harvest season 1990-1991 to 2010-2011. Up to early 2000s the growth of sugarcane production was for sugar

[14] The Brazilian Energy Balance still does not present data about biodiesel production.

production, but this has changed afterwards. On average, during the five last harvest seasons more than half of sugarcane was used for ethanol production.



Source: CONAB (2011)

Figure 3.2 Sugarcane used for sugar and ethanol production from 1990 to 2011

The bulk of sugarcane production is in state of São Paulo, with about 54% of the total production, while in the Centre-South region the production represents almost 90%. A small share of sugarcane production is in the North-Northeast region (13%, being about 10% in the Northeast region). The mills in North and Northeast regions produce more sugar than ethanol and, thus, ethanol production is even more concentrated in the Centre-South region (MAPA, 2011).

Sugarcane bagasse is derived from the fibres of the sugarcane plant. On average, sugarcane has 13-14% of fibres that implies the availability of 260-280 kg of bagasse per tonne of sugarcane crushed, with 50% moisture (absolute). Currently, most of the sugarcane bagasse is burned for steam generation at the mill site; bagasse use as fuel in other industrial branches is constrained by its low density, the low price of fuel oil and the distance between industrial plants. As market opportunities are constrained, bagasse is inefficiently used at fuel; at least 50% of the bagasse could be saved in an efficient industrial unit.

At the field, the availability of sugarcane trash (leaves and points of the sugarcane plant) is almost equal than bagasse, but so far almost no trash has been used as fuel. Traditionally, sugarcane fields are burned before harvesting in order to make manual practice easier and, hence, trash is completely eliminated. Due to environmental reasons the tendency is the phase-out of sugarcane burning, and trash could be available for used as fuel; currently, about 40% of sugarcane has been harvested without previous burning. In Brazil, the average availability is 140 kg_{dry} of trash per tonne of sugarcane; it is estimated that up to 50% of the trash could be recovered and transported to be used as fuel at the mill site, while the balance should be left in the field for soil and plant protection.

In the future, sugarcane bagasse should be used as raw material for biofuels production from hydrolysis (or gasification), or even for the production of chemicals. Research and development efforts have been more effective on ethanol production through hydrolysis.

3.2 Oil seeds[15]

Despite its favourable conditions and large agricultural tradition, Brazil is not among the major producers of vegetable oils, except soy oil (and cottonseed to a lower extent). Table 3.1 shows production data of different vegetable oils from 2002 to 2010 and their share regarding Brazilian and world production. As can be seen, soybean oil represents almost 90% of the total domestic production of vegetable oils.

Table 3.1 Production of vegetable oils in Brazil and their share – 2002-2010

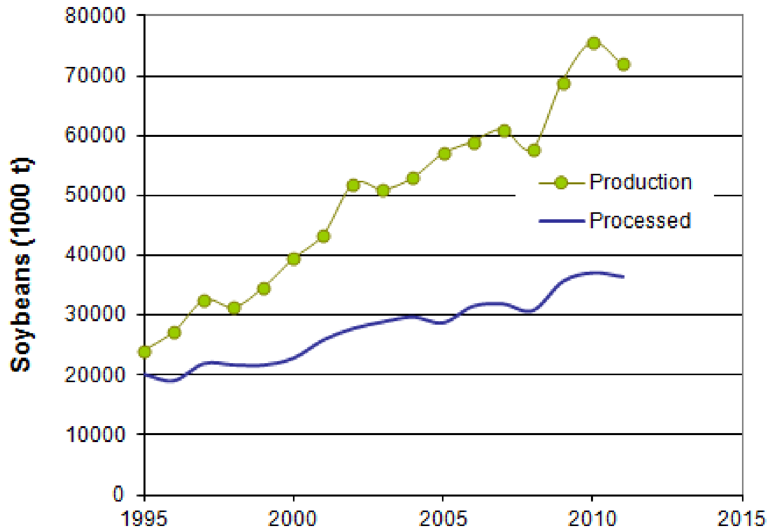
Vegetable oils/data	2002	2004	2006	2008	2009	2010
Soybeans (1,000 tonnes)[1]	5,105	5,630	5,970	6,120	6,470	6,910
(% of world production)[2]	16.8	17.3	16.4	17.0	16.7	16.8
(% of Brazilian production of VO)[3]	77.8	90.1	89.9	90.3	90.6	89.3
Cottonseed (1,000 tonnes)[4]	196	264	242	330	290	326
(% of world production)	5.6	5.5	5.0	6.9	6.3	6.5
(% of Brazilian production of VO)	3.0	4.2	3.6	4.9	4.1	4.2
Palm-oil (1,000 tonnes)[4]	118	142	170	145	165	220
(% of world production)	0.4	0.4	0.5	0.3	0.4	0.5
(% of Brazilian production of VO)	1.8	2.3	2.6	2.1	2.3	2.8

Sources: [1] production data from USDA – Foreign Agricultural Service (FAS-USDA, 2008) and USDA - Office of Global Analysis (OGA-USDA, 2012)
[2] calculated regarding world production taken from USDA – Foreign Agricultural Service
[3] calculated regarding data Oil World, apud ABIOVE (2008), considering soy oil production from USDA and USDA - Office of Global Analysis (OGA-USDA, 2012)
[4] Oil World, apud ABIOVE (2008), USDA-GAIN (2012), Agroenergy Yearbook 2010 (MAPA, 2012)
Notes: na = data not available.
VO = vegetable oils.

Brazil has a long tradition with soybeans production and is currently the second largest producer (after US). Regarding soy oil, Brazil is among the top producers, together with US, China and Argentina. Figure 3.3 shows the evolution of soybean production in Brazil in the period 1995-2010 and also shows the amount of the seeds production locally crushed; as can be seen, the production grew almost continuously but the share locally processed didn't grow as fast. In fact, the production locally crushed declined from 90% in 1995 to about 50% in 2010-2011. This explains Brazil’s lower importance as soy oil producer.

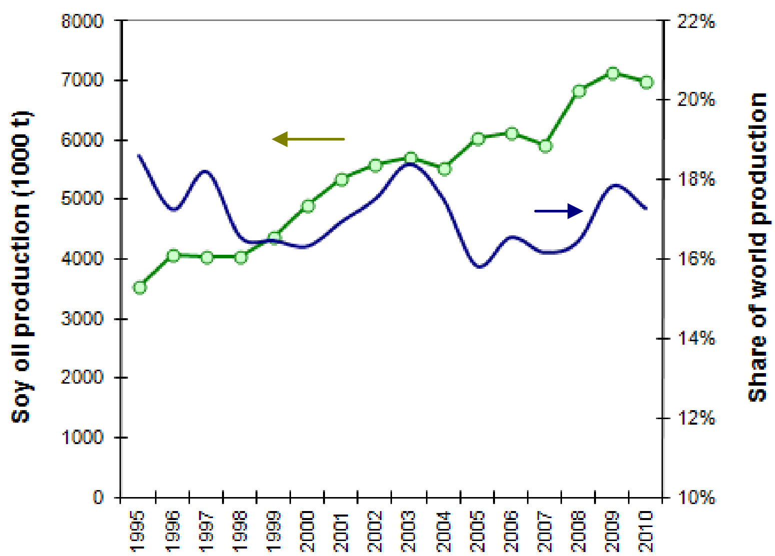
As an illustration, Figure 3.4 shows the evolution of soy oil production and its share regarding the world production.

[15] This section is based on Rosillo-Calle et al. (2009). The information was updated in this report.



Source: FAS-USDA (2012)

Figure 3.3 Soybean production and production locally crushed from 1995 to 2011



Source: FAS-USDA (2012)

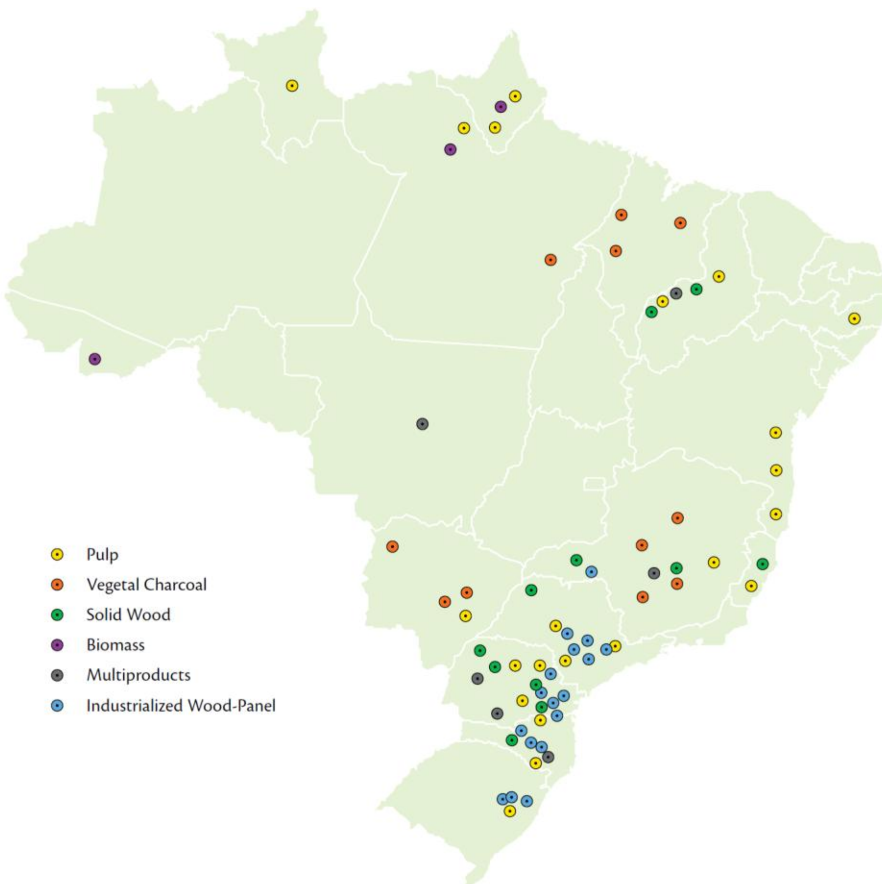
Figure 3.4 Soy oil production in Brazil and its share regarding the world production

The production of soybeans in Brazil has been blamed for deforestation, due to the recent expansion of this crop in the Cerrado region, in the central part of Brazil. It is believed that soybeans expansion has caused deforestation in that area and has indirectly contributed to the deforestation in the south of Amazon region (i.e., causing ILUC). Soybean occupies about 25 Mha in Brazil and is the largest crop in the country, covering about 30% of the land occupied with agriculture.

3.3 Forestry resources

Wood production is a well-established activity in Brazil. Forest activities are concentrated both in the North and in the South regions. In the North region the production is mainly based on extrativism, while in the South planted forests are dominant, based on short-rotation coppices. The production of dedicated forests aims at the pulp and paper industry, timber and logs production, and in a small extent charcoal production[16]. Dedicated forests are mainly of pines and eucalyptus; being estimate as 4.75 Mha planted with eucalypt and 1.76 Mha with pines (ABRAF, 2011).

It is estimated that, in 2010, 37.5% of all the wood produced was used in the production of pulp. The production of sawn wood, panels and plywood consumes 15.8%, 7.8% and 3.5% respectively. The remaining amount (35.4%) is destined to the production of logs, charcoal and other forest products (ABRAF, 2011). The location of the different wood industries based on eucalyptus in Brazil is shown in Figure 3.5

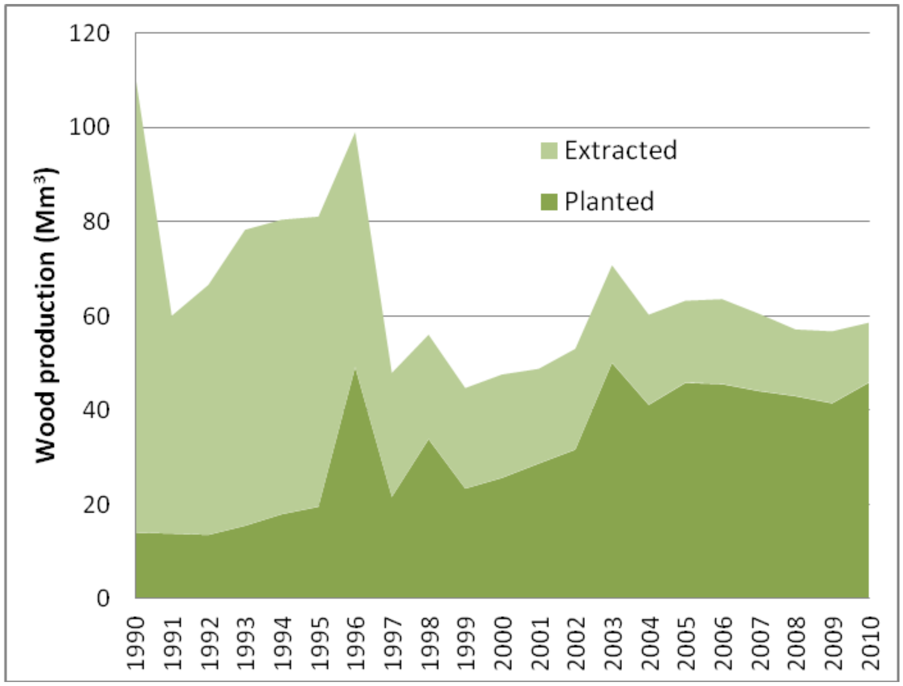


Source: ABRAF (2011)

Figure 3.5 Location of wood (eucalyptus) industries in Brazil, 2010

[16] According to the IBGE data (IBGE, 2009), 38% of the wood production based on dedicated forests is used in pulp and paper industry, 28% for timber and logs, 24% as firewood, and 10% for charcoal production.

Figure 3.6 shows the evolution of wood production mostly for timber and logs, based on extrativism and on dedicated forests, in the period 1990-2010; the information is based on surveys by IBGE, and is an estimate, mainly regarding the extrativist activity[17]. Data are presented in Annex.

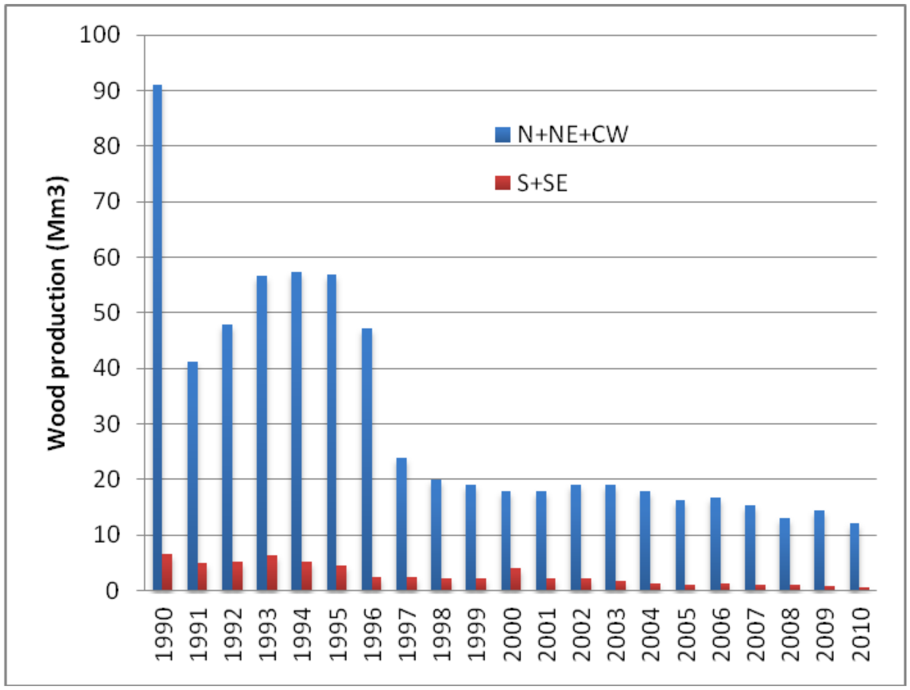


Source: IBGE (2012)

Figure 3.6 Estimates of wood production in Brazil – 1990-2010

Figures 3.7 and 3.8 shows the evolution of wood production mostly for timber and logs, based on extrativism and on dedicated forests, respectively, in regions South + Southeast (S+SE) and other regions of Brazil. Production based on extrativism mostly occurs in the North region (68% in 2010; and mostly in Amazon region), and has declined in recent years (based on estimates by IBGE, reduction was about 14% per year, on average, in the period 1990-2000, and about 5% per year in the period 2000-2010).

[17] Besides the intrinsic imprecision of such surveys, there is also illegal activity based on deforestation, mainly in the North region.

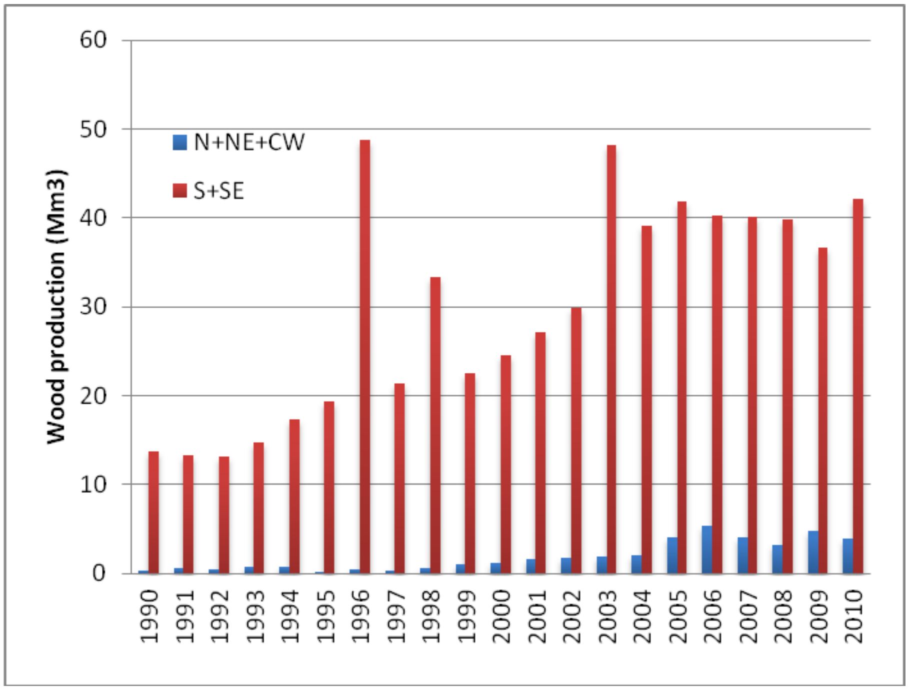


Source: IBGE (2012)
Note: S+SE = South + Southeast regions

Figure 3.7 Estimates of wood production based on extrativism – 1990-2010

As can be seen in Figure 3.8, wood production based on planted forests mostly occur in the southern part of Brazil, and more specifically in the states of Paraná and Rio Grande do Sul (South region) and in state of São Paulo (Southeast region).

Particularly in case of dedicated forests of eucalyptus, it is believed that Brazil has worldwide the best technology for implementing them. Eucalyptus plantations have been condemned for years, but some of the constraints of the past are no longer a matter of concern (e.g., soil drainage, soil degradation, nutrient leaching and reduction of water storage capacity can be almost completely avoided if adequate techniques are applied). Regarding biodiversity preservation, the usual solution is both to form and maintain wildlife corridors connecting areas under conservation (native vegetation) (Couto *et al*., 2002).



Source: IBGE (2012)
Note: S+SE = South + Southeast regions

Figure 3.8 Estimates of wood production based on planted forests – 1990-2010

In Brazil, the forestry sector tends to expand occupying land currently used for several other activities, mainly pasturelands. Among them are the so-called second-class lands, notably those with poor chemical (fertility, cationic exchange capacity) and physical characteristics (texture, depth, drainage), and with high slopes; some of these lands are under a degradation stage. Shifting on land use towards to forest is also happening on orange and coffee fields where both soil and topography use to have better quality.

The location of planted forests of eucalyptus and pines along the country is shown in the Figure 3.9.

Source: ABRAF (2011)

Figure 3.9 Location of eucalyptus (top) and pines (bottom) plantations in Brazil

Field residues have been rarely used for energy production, remaining as an important alternative for both internal and external markets. Saw mill residues have been used more frequently than field residues (wood slashes), although their uses are still low and mostly inefficient.

4. Current and Expected Future Energy Use of Biomass

4.1 Ethanol – current production and perspectives

Worldwide, fuel ethanol consumption in 2010 was estimated at 86 billion litres (REN21, 2009). Brazil is the second largest ethanol producer[18]; in 2010 its production reached 28 billion litres, while the domestic consumption as fuel surpassed 23 billion litres (MAPA, 2011). All motor gasoline sold in Brazil contains 20-25% ethanol on volume basis (E20–E25). Neat ethanol vehicles use hydrated ethanol, while anhydrous ethanol is blended with gasoline.

Large-scale production of fuel ethanol in Brazil started in 1976 but only since 1999, after the complete deregulation of the industry, the consumption has raised steadily. Flex-fuel vehicles (FFVs)[19] have been the main driving force of the domestic consumption of ethanol. In Brazil, FFVs can run with any fuel mix between gasohol (E18–E25) and pure hydrated ethanol (E100). The relative low price of ethanol regarding gasoline and the good technology are the main reasons why currently more than 90% of the new cars sold in Brazil are FFVs.

Since early 1980s, all ethanol production in Brazil is based on sugarcane. In addition to the favourable conditions for biofuels production, such as climate, rainfall, land availability and working force availability, Brazil has taken advantage of the long-term experience with sugarcane production. It is also worth to mention that during about 15-20 years (i.e., from 1975 to early 1990s) the Brazilian federal government offered very favourable conditions for fuel ethanol production (see section 2.1).

Brazilian experience with ethanol blended to gasoline comes back from the 1930s, but it was in 1975 that the Brazilian Alcohol Program (PROALCOOL) was created aiming at partially displacing gasoline in road transport. At that time, the country was strongly dependent on imported oil and gasoline was the main oil derivative consumed. In 1979, with the second oil chock, Brazilian Government decided to enlarge the Program, supporting large-scale production of hydrated ethanol to be used as neat fuel in modified engines.

During the first period of the Program (1975-1979) ethanol production was accomplished by new distilleries annexed to the existing sugar mills, while in the period 1979-1985 many autonomous distilleries were built. It is estimated that at that time about US$ 11-12 billion were invested to create a structure able to produce about 15 billion litres of ethanol per year.

Less support from the government and the lack of a positive attitude by the producers laid the ethanol market to difficulties during the 1990s, starting with a shortage of ethanol supply in 1989-1990 that lead to a strong drop in sales of neat ethanol cars. For instance, sales of neat ethanol vehicles that have reached 92-96% during the 1980s were continuously reduced until summing up just about 1,000 new vehicles per year in 1997-1998. The reduction of the neat ethanol fleet deeply impacted the consumption of hydrated ethanol during the 1990s and early 2000s. Figure 4.1 shows total sales of new vehicles in the period 1975-2010, according to the fuel option; with the success of FFVs, sales of straight-ethanol vehicles vanished in 2006.

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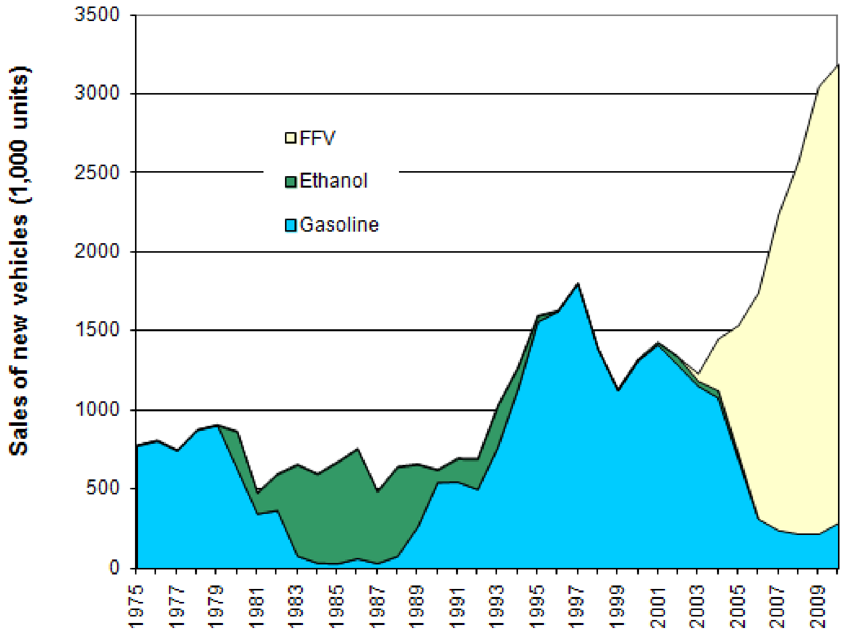
[18] Since 2006 US is the main world producer country.

[19] The first model was launched in March 2003.



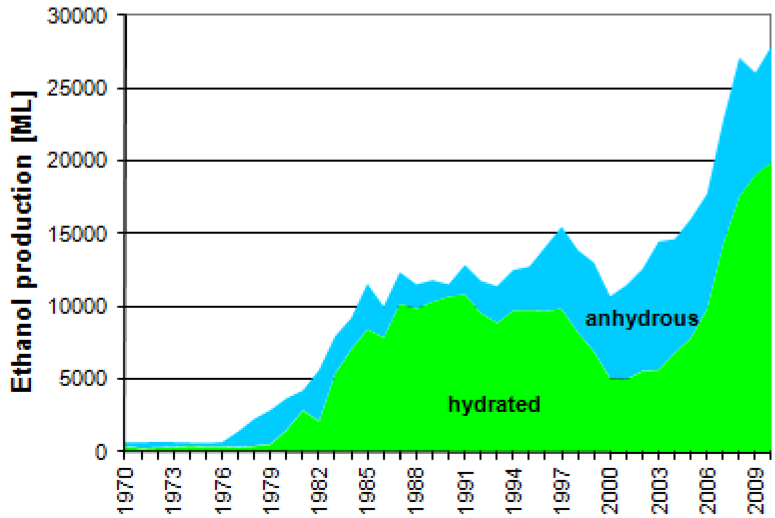
Source: ANFAVEA (2011)

Figure 4.1 Annual sales of new vehicles from 1975 to 2010, according to the fuel option

The PROALCOOL, as initially conceived, finished during the 1990s as long as the government support ceased. In fact, main changes started in early 1990s, first with liberalization of fuel prices to consumers and, second, in late 1990s, with full deregulation of sugarcane industry. The positive results started to be noticed in 2001, when sales of neat ethanol cars increased due to a larger price difference between ethanol and gasoline. However, the main results are due to the boom on sales of vehicles able to run powered by ethanol (FFVs).

Due to the success of FFVs, it is predicted that the domestic market of ethanol shall surpass 40 billion litres by 2015 and reach 52.4 billion litres by 2019. Currently ethanol (hydrated and anhydrous) covers more than 38% of the energy consumption of light-duty vehicles in Brazil. The tendency is that this share will grow in the years to come surpassing 50% (energy basis) in about 10 years.

Figure 4.2 shows ethanol production in Brazil from 1970 to 2010. The production in 2010 was 28 billion litres, while the domestic consumption reached 23.3 billion litres in the same year. It is clear from Figure 4.2 that since 2003 (i.e., after FFVs) the production of hydrated ethanol has increased continuously while the production of anhydrous ethanol (exported and domestically used in fuel blends) has been almost constant.

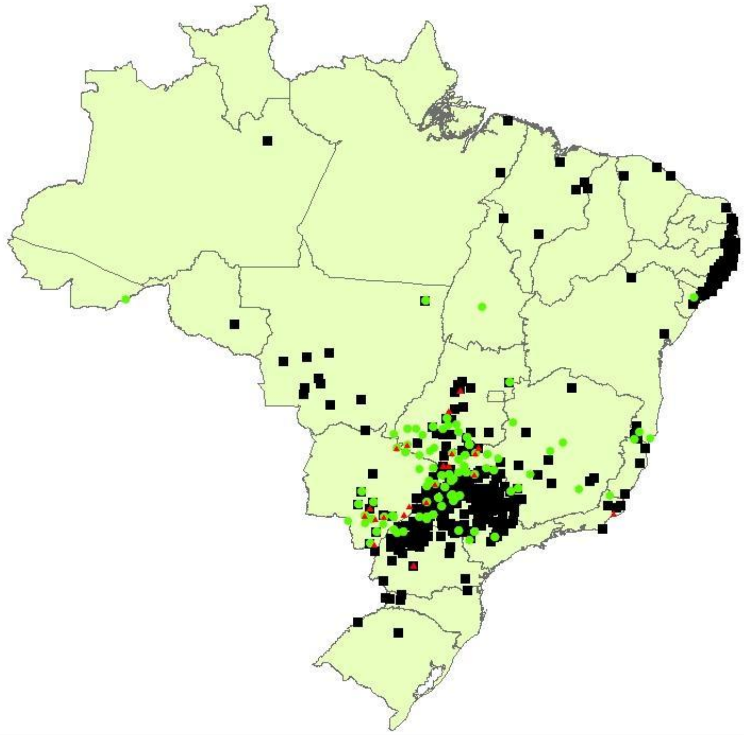


Source: EPE-MME (2011)

Figure 4.2 Ethanol production in Brazil from 1970 to 2010

There are about 440 industrial units under operation and some mills under construction[20]. Figure 4.3 shows the location of sugarcane mills in Brazil by the end of 2008 (existing mills – black squares – and those planned to be built – green circles). It is estimated that 70-80% of the total production is in state of São Paulo and the regions around it. A small share of sugarcane production is in the North-Northeast region (13%, about 10% in the Northeast region).

[20] In 2011 it was estimated that 35 mills were under construction; there is uncertainty regarding this number due to the different stages of the construction.



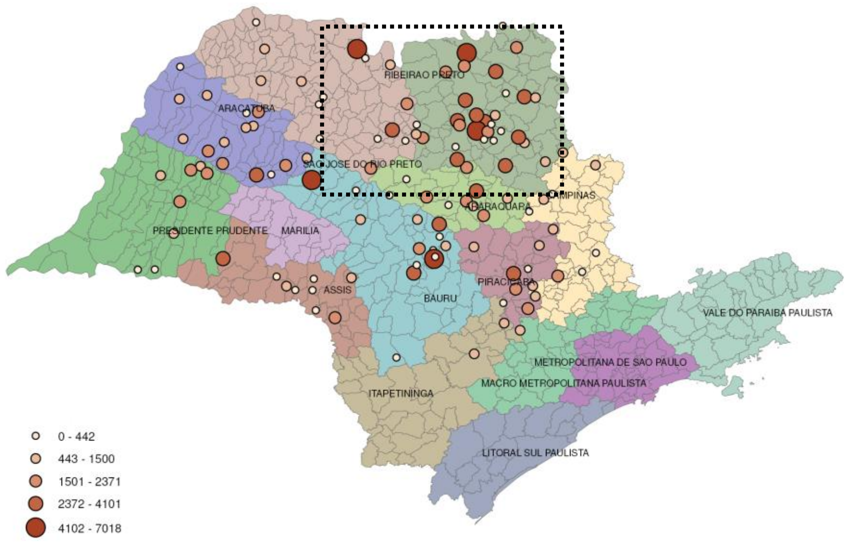
Source: EPE (2009)

Figure 4.3 Existing sugarcane mills and those predicted to be built

In 2007, 273 mills were able to produce both ethanol and sugar, with some degree of flexibility between the two products (general sense, the production varies from 40% to 60% ethanol, and consequently, 60% to 40% sugar), 77 mills were only able to produce ethanol (autonomous distilleries) and 16 mills were able to produce only sugar.[21] "Brazilian model of ethanol production" refers to the combined production of sugar and ethanol, option that brings some advantages to producers, at least regarding risk reduction.

In the state of São Paulo, the region with highest concentration of sugarcane mills – Ribeirão Preto, indicated by dotted lines in Figure 4.4 – has the best conditions for this crop, considering soil quality, weather adequacy, rainfall and topography. This region has high concentration of sugarcane areas and land is relatively expensive there. In state of São Paulo the tendency is the installation of new producing units in the west side of the state, displacing pasture and, in a smaller extent, other traditional crops (e.g., orange). Besides the factors mentioned above, the concentration of sugarcane production in São Paulo and neighbourhoods is also due to the best infrastructure available (including storage facilities, roads, pipelines, harbours, etc.), and the size of the consumer market.

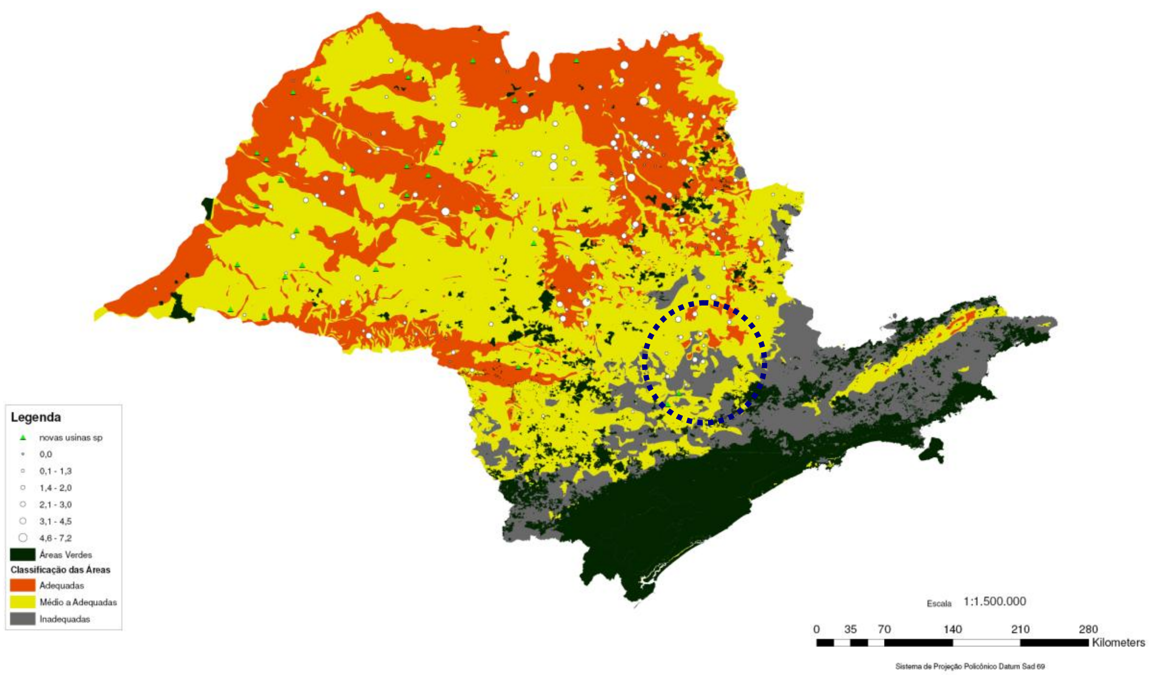
[21] By the end of September 2008, there were 414 sugarcane mills officially registered at the Ministry of Agriculture, being 248 mills with annexed distilleries, 151 mills with autonomous distilleries and 15 mills that can only produce sugar (MAPA, 2008).



Source: Franco (2008)

Figure 4.4 Regions with sugarcane mills in state of São Paulo, in 2006 (circles represent the amount of sugarcane crushed per year in each mill – thousand tonnes)

Figure 4.5 is an illustration of the areas in state of São Paulo with adequate conditions for sugarcane production. Adequacy was defined as function of weather conditions, rainfall, soil quality, risk of erosion and topography. Not surprising, it can be seen that most of the mills already installed (white points in the figure) are located in most favourable areas.



Source: Franco (2008)

Note: Most adequate areas are marked orange, medium-adequate areas are marked yellow, while inadequate areas area marked grey. Areas in dark green are area with environmental constraints.

Figure 4.5. Adequacy of areas for sugarcane plantation in state of São Paulo.

Considering topography constraints the traditional region of sugarcane production around Piracicaba can be classified as inadequate (identified by the dotted circle in Figure 4.5). Topography imposes important constraints for mechanical harvesting, that is a tendency in state of São Paulo as previous burning of the sugarcane field should be completely phased-out by 2017. Previous burning is still a common practice in Brazil in order to make feasible manual harvesting. Currently, mechanical harvesting is already cheaper than manual harvesting, but the required investments and topography are constraints in this process. In the state of São Paulo about 50% of the sugarcane has been harvested without previous burning. There are regions is the state (e.g., in Ribeirão Preto) where more than 90% of the sugarcane is harvested without burning (Jank and Rodrigues, 2008).

It is estimated that there are about 72,000 suppliers in Brazil (UNICA, 2009), being about 14 thousand in the state of São Paulo. Table 4.1 shows the profile of sugarcane suppliers in São Paulo, during the harvest 2006-2007.

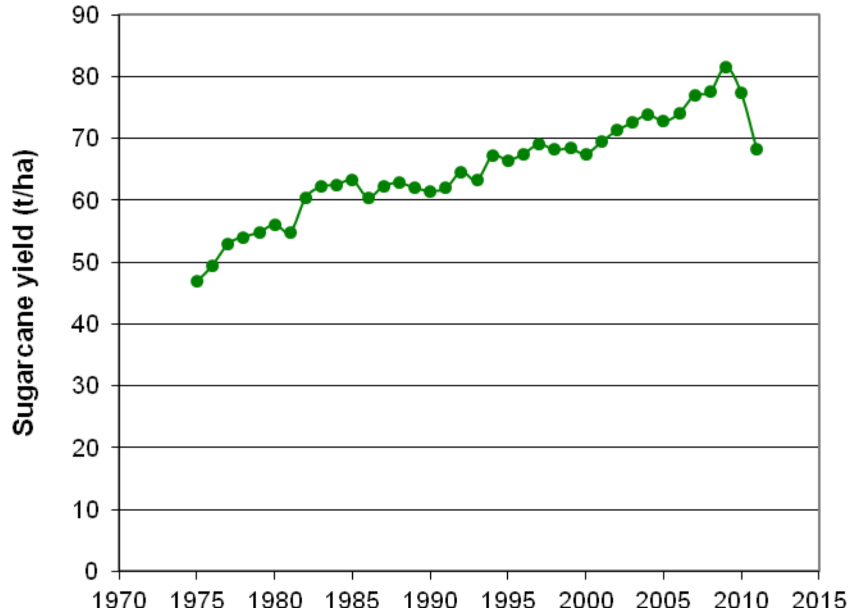
Table 4.1 Profile of sugarcane suppliers in the state of São Paulo – 2006-2007

Range of production (t)	Number of producers	% of producers	Average area (ha)	Production (1000 t)	% of production	Average yield (t/ha)
< 200	1,582	11.3	up to1	190.1	0.3	51.2
201 to 800	3,758	26.9	6	1,754.7	2.6	77.8
801 to 4,000	5,455	39.0	22	10,324.4	15.0	86.0
4,000 to 10,000	1,788	12.8	74	11,257.9	16.4	85.1
> 10,000	1,397	10.0	381	45,121.9	65.7	84.8
Total	13,980	100.0	58	68,649.0	100.0	84.7

Source: Orplana (2008)

Due to the technological developments achieved both in the agriculture and in industry sides, average production yields have grown from 3,000 litres/ha/year (67 GJ/ha/yr) in early 1980s to 6,500 litres/ha/year (145 GJ/ha/yr) in 2005 (UNICA, 2006). Considering these results, for the production of 15.9 billion litres of ethanol in 2005 it was possible to save almost 2.9 million hectares. Production yields based on conventional process can reach 8,000 litres/ha/year (178 GJ/ha/yr) in about 8 years or even 9,000 litres/(ha/yr) (about 200 GJ/ha/yr), in case ethanol production from hydrolysis of sugarcane bagasse would reach a commercial stage.

Figure 4.6 shows the evolution of sugarcane yields in Brazil, from 1975 to 2011. Due to the best conditions, yields are higher in Centre-South region and are particularly higher in state of São Paulo (e.g., at least 82 t/ha in São Paulo, in 2006, vis-à-vis 74 t/ha for the national average). On average, yields grew more than 3% per year from 1975 to 1985 and 1.3% per year from 1986 to 2009. Adverse weather conditions and the lack of investments are the reasons of the drastic reduction of sugarcane yields in the period 2009-2011 (-14%). Since 1975 (and up 2009) yields have grown almost 75% due to the development of new varieties and to the improvement of agricultural practices.



Source: MAPA (2011)

Figure 4.6 Average agricultural yields of sugarcane production in Brazil from 1975 o 2011

4.2 Biodiesel

In 2010 the production of biodiesel worldwide was estimated at about 19 BL. Brazil has covered about 12% of the total world production, and is currently second largest producer, just behind Germany (2.9 BL) (REN21, 2011). In Brazil, the biodiesel production in 2010 was close to 2.1 BL. It is estimated that 82% of the biodiesel production has been from soy oil, approximately 12% produced from animal fats and only 5% from other feedstocks, such as sunflower, castor, palm and babassu (ANP, 2012). Brazil is worldwide one the largest soybeans producers and its production comes from plantations, mostly located in the Central and in the South regions (47% and 36% of the total production, respectively). The two states with higher production are Mato Grosso (29%), in the Central region, and Paraná (21%), in the South (CONAB, 2008).

PETROBRAS, the stated-controlled oil company, is the main agent acting on biodiesel blends. The company has also been engaged in programs aiming at induce the production of raw materials in poorest regions, development of technology and also the enlargement of the production capacity. Currently, PETROBRAS has three industrial plants and produced about 210 ML in 2011.

The authorized capacity of biodiesel production is about 19,400 m^3/day (more than 6 BL), in 65 industrial units. Table 4.2 shows the production and its distribution in 2011. The five top largest biodiesel plants produced about 34% of the total biodiesel in 2011. The three largest units have production capacity varying from 1,030 to 1,350 m^3/day; 15 industrial units have production capacity larger than 500 m^3/day and 28 units have production capacity lower than 100 m^3/day. The large production in South and Central regions is explained by the concentration of soybean production in that part of the country; the production in Southeast the most important feedstock is animal fat (40% of the total production in early 2012)

Table 4.2 Biodiesel production during 2011 and share of the total production

Region	Production (1000 m^3)	Share of total production (%)
North	87	3.6
Northeast	157	6.5
Central	934	38.4
Southeast	347	14.3
South	905	37.2
Total	2,430	

Source: ANP (2012)

The high number of biodiesel plants in the Central region is explained by the concentration of soybean production in that part of the country. For example, Mato Grosso, the main producer region of soybeans (about 25% of the total production in the harvest 2010/2011), has almost 25% of the authorized capacity. This is followed by the states of Rio Grande do Sul and Sao Paulo. A new large producer is the state of Goiás, which has increased production rapidly in recent years stimulated by good infrastructure and closeness to the market (see Table 4.3).

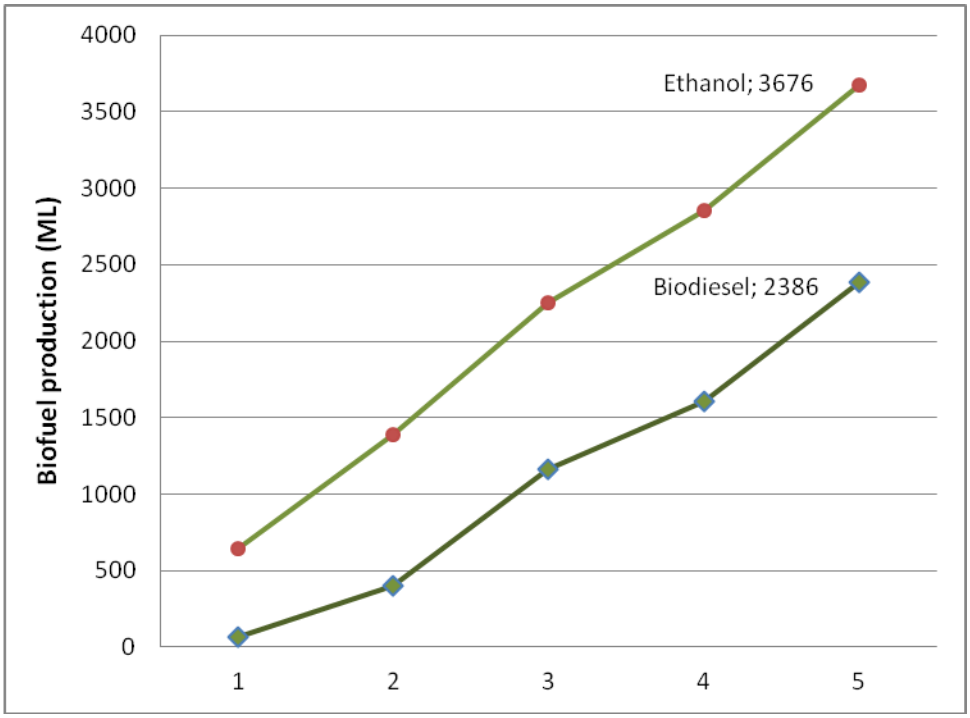
Table 4.3 Accumulated biodiesel production (since March 2005) and production in 2011 (ML)

State	Production in 2011	Accumulated production	Share of accumulated (%)
Rio Grande Sul	801.2	2,210.1	27.4
Mato Grosso	457.6	1,692.9	21.0
Goiás	449.2	1,522.3	18.9
São Paulo	269.3	1,076.8	13.4
Bahia	115.1	428.2	5.3
Brazil	2,429.8	8,065.1	100.0

Sources: ANP (2012)

According to the 10-year (National) Energy Plan (EPE, 2007), the diesel consumption in 2019 in a business-as-usual scenario (not considering deep changes in the transport sector) is estimated as 4.2 billion litres. This result is based on the total diesel oil demand and on the hypothesis of keeping the B5 mandate. It's predicted that about 80% of the production will be based on soy oil, and about 15% based on animal fat.

Figure 4.7 shows a comparison between ethanol and biodiesel production during the first five years of large-scale production of each program (ethanol, fifth year in 1980, and biodiesel in 2010, with a production close to 2.4 BL). As long as B5 mandate has been kept, the tendency is a vegetative growth of biodiesel consumption in Brazil.



Source: MAPA (2009) for ethanol, and ANP (2011) for biodiesel

Figure 4.7 Production of ethanol (1976-1980) and biodiesel (2005-2009) along the first five years of large-scale production

4.3 Solid biomass

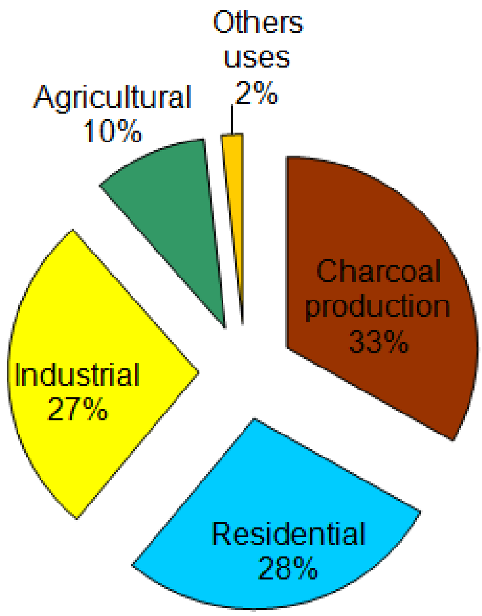
Forestry/wood and sugarcane (residues) are the main sources of solid biofuels in Brazil. Firewood includes wood used for charcoal production and also field and timber residues. Solid biomass from sugarcane includes bagasse and the so-called trash (top and leaves of the sugarcane plant).

4.3.1 Firewood and residues

The statistics of the National Energy Balance do not allow the identification of the energy consumption due to firewood and forestry/timber residues in different sectors. In 2007, the total energy consumption of wood products was evaluated as 1,092 PJ, with the bulk of it (33%) as charcoal. Residential and industrial sectors are also very important consumer sectors (covering 28% and 27%, respectively, of the total wood energy consumption) (EPE-MME, 2011). Figure 4.8 shows the main consumers of wood by 2010.

The consumption of residues is more relevant in industries, mainly in the pulp and paper sector. Firewood is mainly consumed in the food and beverage and in the ceramic branches.

The main use of charcoal has been in the iron and steel industry, where charcoal has displaced coal coke as chemical reducer. Generally, planted forests for charcoal production are located as close as possible to the steel and iron plants, which provides to this fuel a competitive advantage. Eucalyptus plantations in the state of Minas Gerais are an example of this regional supply. Other industrial branches that consume charcoal are other metallurgic and cement industries. The consumption in the residential sector, for cooking, is also relevant (10% of the production in 2010), but with a tendency for stabilizing/declining in recent years due to income growth.



Source: EPE/MME (2011)

Figure 4.8 Wood energy consumption in 2010

4.3.2 Sugarcane residues

Bagasse is by far the main sugarcane residue used as energy source; bagasse derives from the fibres of the sugarcane plant and results from the crushing process for juice extraction. Bagasse is available at the mills site and is used as fuel for raising steam in cogeneration systems. As previously mentioned, from a statistical point of view, despite the fact that most of the sugarcane mills in Brazil produce both sugar and ethanol, the consumption for sugar production is allocated in the industrial sector and the consumption for ethanol production in the energy sector. Despite the growth of ethanol production in recent year, the bulk of bagasse consumption is still due to sugar production. Among the non-energy uses of bagasse, the main destination is as forage for animal livestock. Part of the bagasse not used during the harvest period is also discarded after losing quality when the rain season establishes.

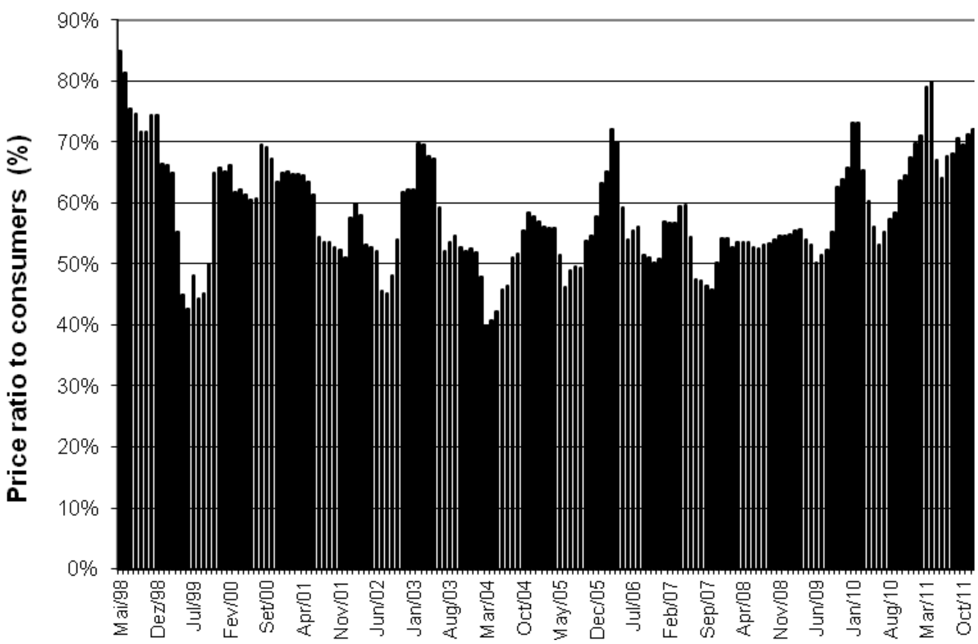
The availability of sugarcane residues at the mills site is expected to grow in the years to come due to the phasing out of cane burning before its harvesting; there is an agreement between sugarcane producers and state governments (e.g., in São Paulo, Minas and Goiás) that define 2017 as the dead-line for the burning practice. As consequence, all sugarcane will be mechanically harvested and tops and leaves will be at least partially available to be used as fuel at the mills. It is estimated that at least 50% of the so-called sugarcane trash (leaves + tops) should be left at the field, to protect the plant and the soil.

5. Biomass Prices

5.1 Ethanol

Figure 5.1 shows the evolution of the price ratio to consumers (ethanol/gasoline) in the city of São Paulo, from May 1998 to December 2011. It can be seen that since the full deregulation of fuels (by the end of 1990s) only in few occasions the price ratio has been close to 70% (prices per litre). It is important to notice that for most of the flex-fuels models currently available in Brazil, 70% is understood, on average, as the break-even ratio between ethanol and gasoline prices.

Recently (since 2010), there is a tendency of rising prices of fuel ethanol, reducing its competitiveness vis-à-vis gasoline. The price ratio is especially high during the off-harvest season in Southeast region, where it's the bulk of the production. The reasons of rising prices of ethanol are related to adverse weather conditions in 2009 and 2010, the high prices of sugar in the international market, and to the lack of investments for enlarging sugarcane production. The last point can be explained by the financial crisis in 2009, the slow response of public financial organizations to the crisis and to the entrance of new investors in the sector, who postponed investments in the field. The price ratio has been also impacted by the decision of the Brazilian government of not adjusting gasoline prices (since 2009-2010) according to the international oil prices.



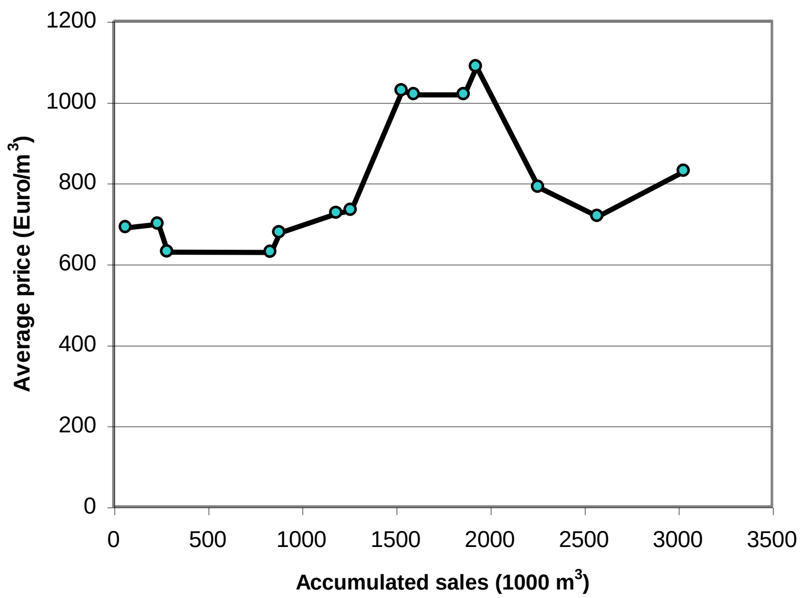
Source: Jornal da Tarde (up to 2001) and ANP (2012) (after 2001)

Figure 5.1 Price ratio to consumers (ethanol/gasoline) in the city of São Paulo – March 1998 to December 2011 – based on current prices per litre

5.2 Biodiesel

As an illustration, Figure 5.2 shows the evolution of the average prices paid in 14 auctions of biodiesel carried out in Brazil up to 2009[22]. The total volume sold in these auctions was more than 3.0 BL. Average prices reached the top in auctions 7 to 10, from April to August 2008, and since then have dropped due to the reduction of vegetable oil prices in the international market.

The average price paid in an auction early 2009 (May 2009) was 828 Euro/m^3 of biodiesel; at the same time the average price paid to producers of mineral diesel was 519 Euro/m^3, that means an over price of about 60%[23].



Source: ANP (2009)

Figure 5.2 Average prices paid to biodiesel producers in Brazil (using the exchange rate at the time of the auction)

5.3 Solid biomass

Average prices to consumers of some solid biomass are presented in this section[24]. Except for metallurgic coal, all prices presented in Table 5.1 are based on EPE-MME (2008); they reflect market conditions and include taxes and transportation costs. Therefore, they may embrace large and small consumers according to the usual market of each energy source. For metallurgic coal prices were from MDIC (2009), adding on them inland transport costs plus internalisation taxes.

Original prices are published in Brazilian currency and were converted to US dollars according to the exchange rate by the end of each year. The results were converted to 2007 constant dollar using

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[22] The auctions are organized by the ANP.

[23] Supposing the same heating value and that the substitution ratio is 1 litre of biodiesel = 1 litre of mineral diesel.

[24] The information was not updated regarding the previous version of the country report. For updated information, be in touch with the author, by awalter@fem.unicamp.br.

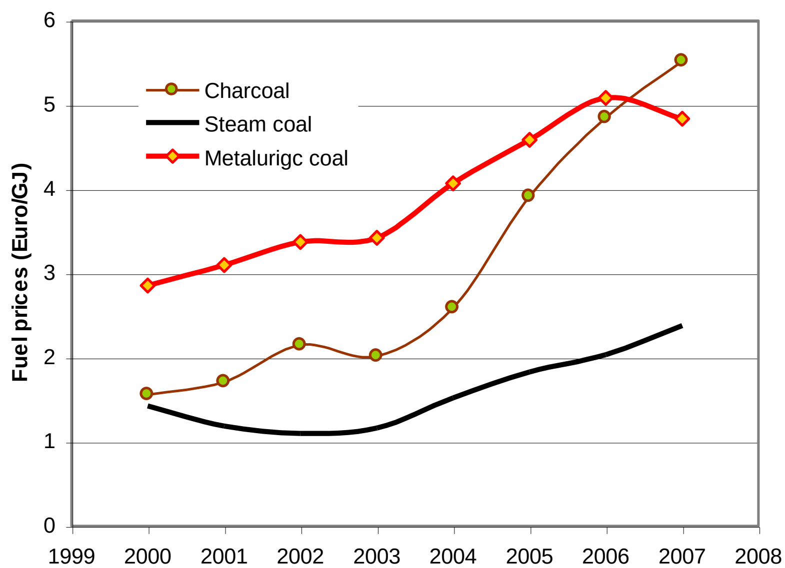
CPI-U index from US. Finally, values in US dollars were converted to Euro using the average exchange rate (parity) found for 2007 (1 Euro = 1.376 US$).

Table 5.1 Fuel prices in Brazil from 2000 to 2007 (Euro/GJ)

	2000	2001	2002	2003	2004	2005	2006	2007
Charcoal	1.6	1.7	2.1	2.0	2.6	3.9	4.8	5.5
Firewood	1.4	1.3	0.9	1.1	1.3	0.8	1.1	1.1
Steam coal	1.4	1.2	1.1	1.2	1.5	1.8	2.0	2.4
Natural gas	3.8	3.3	3.2	3.2	3.8	5.1	6.6	8.0
Fuel oil	4.7	4.1	3.8	4.8	5.1	6.8	7.8	8.1
LPG	14.9	10.8	11.3	12.9	13.4	15.6	18.2	20.1
Metallurgic coal - imported (a)	2.9	3.1	3.4	3.4	4.1	4.6	5.1	4.8

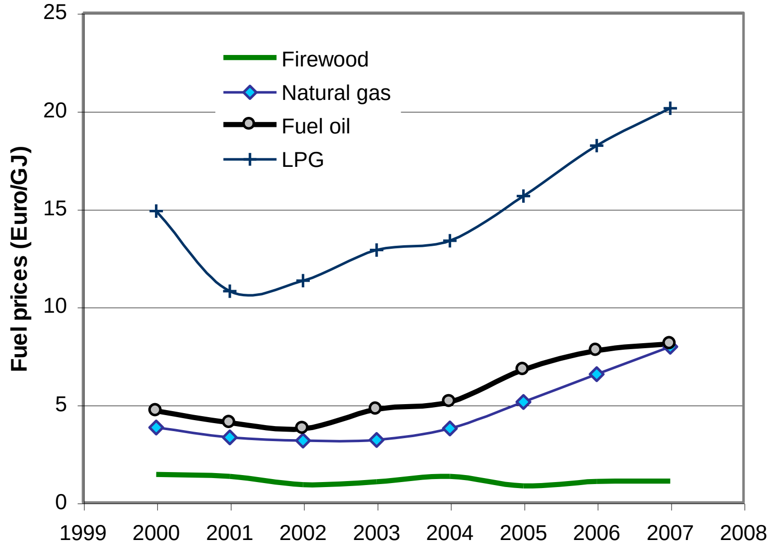
Notes: (a) values from MDIC (2009); FOB prices, adding on them taxes and local transport. Remaining figures are from BEN (2008).

Figure 5.3 and 5.4 shows the evolution of these prices. Figure 5.3 allows the comparison of charcoal prices to steam coal and to metallurgic coal. As previously mentioned, the main market for charcoal in Brazil is in the iron and steel industry. On the other hand, Figure 5.4 allows the comparison of firewood prices to LPG (households use, for cooking) and natural gas and fuel oil (industrial use).



Source: EPE-MME (2008) and MDIC (2009) for metallurgic coal

Figure 5.3 Average fuel prices in Brazil (Euro 2007)



Source: EPE-MME (2008) and MDIC (2009) for metallurgic coal

Figure 5.4 Average fuel prices in Brazil (Euro 2007)

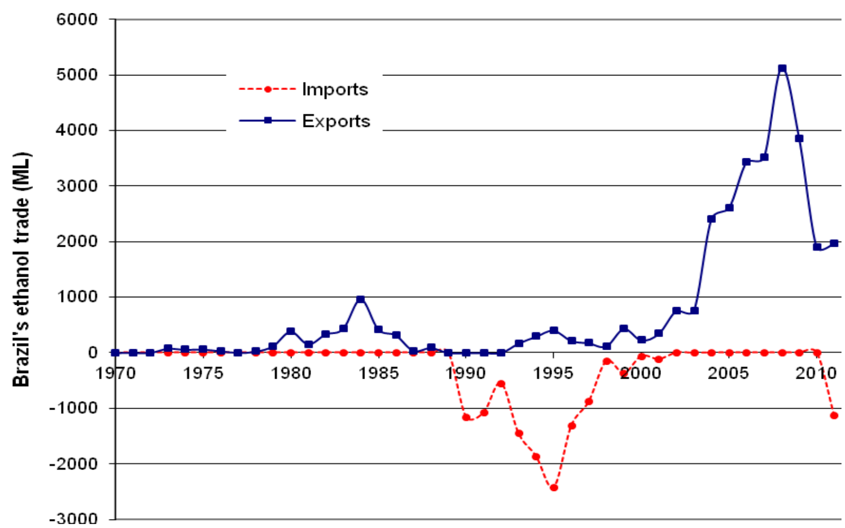
6. Biomass Import and Export

Due to its adequate conditions for biomass production, Brazil is a big potential exporter of biomass. However, what have been remarkable so far were the exports of ethanol, mainly since late 1990s and up to 2008. The exports of fuel export were drastically reduced, recently. The production of biodiesel has been just for the domestic market and just recently the producers have started to do statements about its interest on exporting. In what concern solid biomass, there is no significant information of exports of pellets, briquettes or charcoal.

6.1 Ethanol

Large-scale exports of ethanol from Brazil is a relative new event, as can be seen in Figure 6.1. An expressive amount of alcohol was imported during the 1990s, first during the supply shortage of ethanol (1990-1991) and, after, when international sugar markets were favourable for exports (1993-1997). Traditionally, Brazilian exports of ethanol have been oriented for beverage production and industrial purposes but since 2004 exports of fuel ethanol have been much higher than 1 billion litres. There was a drastic reduction of ethanol exports since 2009, with a tendency of stabilization around 2 BL.

The reduction of exports is mostly due to the drop of direct imports to US, explained by the lower consumption of automotive fuels, the larger production in US and the lower price of gasoline. On the other hand, and certainly mostly important, Brazil has lost competitiveness due to the higher production costs, the lower supply and the evaluation of the Brazilian currency.

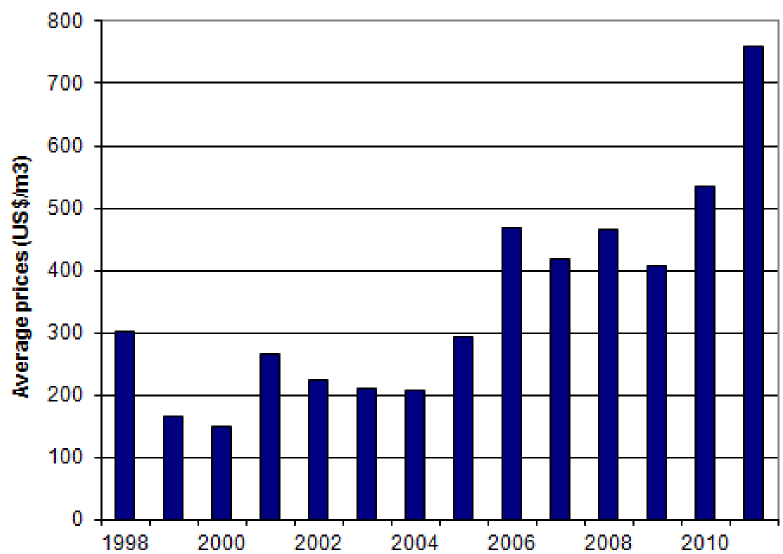


Sources: EPE-MME (2008) and MDIC (2012)

Figure 6.1 Exports of ethanol from 1970 to 2011

Brazil has even imported ethanol in 2011 (about 1.1 BL), mostly from US, due to the lower domestic production. It is interesting to note that even though the trade balance with US was positive and the average prices of ethanol sold were higher than the average prices of ethanol bought. Brazil has imported ethanol at the moments the production was low and the prices of the domestic production were high (basically, during off-harvest season in Southeast) and exported ethanol, mostly to US, because the ethanol suppliers in US need ethanol qualified as advanced by the regulation[25].

Figure 6.2 shows the average prices (FOB) received by exporters of ethanol from 1998 to 2011. It can be seen a rise on prices since 2009, partially because of lower supply and partially because of the higher sugar international prices. Data regarding exports and prices are presented in Annex A.



Sources: MAPA (2009) and MDIC (2012)

Figure 6.2 Average FOB prices of ethanol exported

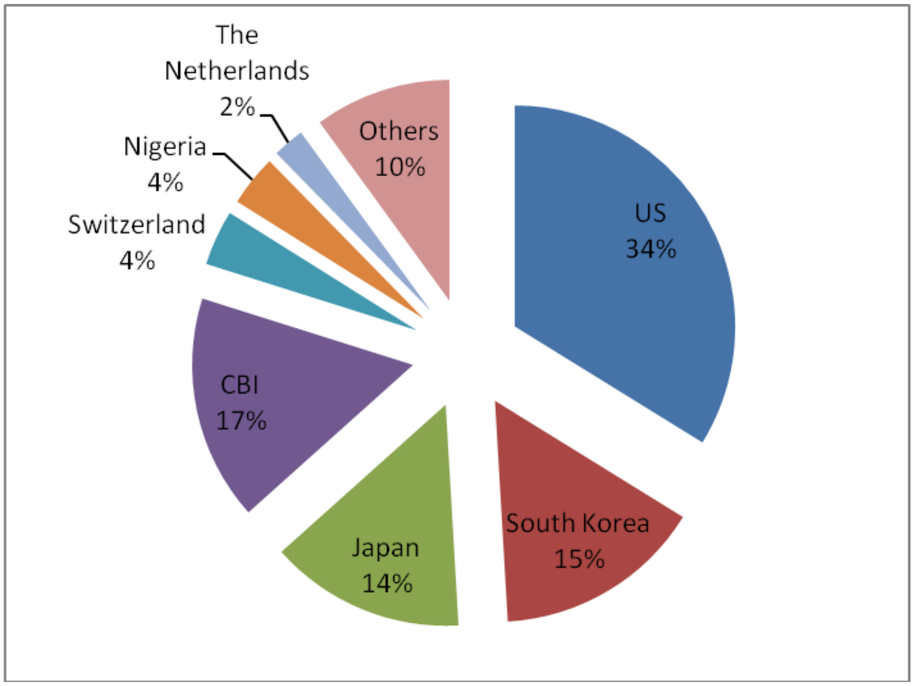
Historically, the bulk of ethanol exporters are to United States, straight to there or through Central America and Caribbean Countries, in order to take advantage of an agreement known as CBI – Caribbean Basin Initiative[26]. As US decided to suspend taxes on imported ethanol since January 2012, the volume traded through Caribbean countries shall be reduced significantly.

Figure 6.3 shows the main importers of Brazilian ethanol in 2011. More than 660 ML were directly imported by United States (34% of the total volume accounted), while more than 320 ML (17%) should have reached US through Jamaica, Trinidad and Puerto Rico. In 2011, The Japan and South Korea were also important markets for the Brazilian ethanol. Brazil lost competitiveness to US for supplying fuel ethanol to Europe in 2010 and 2011.

The bulk of the ethanol exported has been shipped in the port of Santos, in state of São Paulo; the figures for recent years vary from 70 to 80% of the total volume exported.

[25] Ethanol that allow the reduction of at least 50% of GHG emissions regarding the gasoline life cycle, according to the resolution of RFS2.

[26] Up to 7% of the US ethanol demand may be imported duty-free under the Caribbean Basin Initiative (CBI), even if the production itself occurs in another country (UNCTAD, 2006).



Sources: MDIC (2012)

Figure 6.3 Main importers of ethanol in 2011

6.2 Solid biomass[27]

According to EPE-MME (2008), Brazil exported few tonnes of charcoal (irregular flows) along the period 1993-2007 (e.g., 5,000 t in 1997 and 28,000 t in 2004). In fact, since 1993 Brazil has mostly imported (probably high quality) than exported charcoal (almost 3 times more; accumulated imports of 445 thousand tonnes vis-à-vis accumulated imports of 156 thousand tonnes from 1993 to 2007); however, exports have represented very few regarding final energy consumption (about 0.4% along the period).

Regarding briquettes and pellets, it has been impossible to precisely estimate the amount of their exports due to the accuracy of trade statistics from the forestry sector: the NCM – Marcos Harmonic System – Code number 44.01.3000 embraces sawdust, wood chips, wood waste and scrap, and there is no specific information for briquettes and pellets. The great majority of these exports is as wood chips for pulp and paper production abroad. Therefore, all these wood by-products, hide the biomass exported and imported for energy purpose unless charcoal (NCM 44.02) and firewood (NCM 44.01.1000) because they receive individual codes (Braziltradenet, 2009).

[27] The information was not updated regarding the previous version of the country report. For updated information, be in touch with the author, by awalter@fem.unicamp.br.

7. Barriers and Opportunities for International Trade

7.1 Ethanol

Despite the current drawbacks, Brazil is still an important player in the international trade of ethanol: is worldwide the second largest producer, has been for many years the largest exporter, has the lowest cost of production, and is, in mid-term, the only country that can significantly enlarge its production aiming at supply the international market.

On the other hand, the production of biodiesel in Brazil is still a new event and all efforts are currently concentrated on assuring the supply of the growing domestic market. Thus, in short to mid-term there is no real perspective that Brazil could be an exporter of biodiesel. The hypothesis of being an importer is also not effective, as in case of drawbacks with the domestic production the easiest alternative would be slowing down biodiesel introduction in the market.

In this sense, this section exclusively is devoted for the barriers and opportunities for enlarging Brazilian share in ethanol international trade.

7.1.1 Perspectives

The exports of ethanol in 2008 reached 5.1 BL, representing about 18% of the total national production, and covering almost 8% of the world consumption (estimated as 67 BL, according to REN21 (2009)). The reduction of exports since 2009 was due to a set of factors, as listed below:

- Larger production of ethanol in US, and further lower demand due to the financial crisis; the surplus of ethanol in US, combined with the subsidies, implied lower competitiveness for the Brazilian ethanol in Europe.
- Lower production of ethanol in Brazil, mostly because of lower production of sugarcane (already mentioned).
- Higher prices of fuel ethanol in Brazil, due to the lower production, higher prices of sugar in the international market and evaluation of the Brazilian currency.

It is estimated that the amounted of ethanol exported should reach 10 BL in 2019 (the domestic consumption would be 52 BL in the same year) (EPE, 2011). Both figures seem to be optimistic for the time being due to current drawbacks of ethanol production in Brazil; a large effort would be necessary to change the tendencies.

7.1.2 Duty-tax barriers[28]

For many years Brazil has blamed against duty-tax barriers imposed by United States and European Union. US imposed till end of 2011 most-favoured nations (MFNs) import duties of 142.7US$/m^3 plus a 2.5% ad valorem (according to value) tariff on ethanol. MFN basically means normal trade rules, with no special advantage and no special constraint. In many cases, this tariff offsets lower production costs and imposes a significant barrier to imports. An argument seldom presented in US

[28] This section is based on Walter et al. (2008).

was that these tariffs ensure that the benefits of the domestic US ethanol tax credit do not accrue to foreign producers (United States International Trade Commission, 2004).

During years, US gave special treatment under the CBI agreement but the amount traded under this regime has been far below the 7% cap (e.g., about 3% in 2005).

Also under MFN regime, European Union imposes a duty of 192 Euro/m^3 on undenatured alcohol (102 Euro/m^3 in case of denatured alcohol); e.g., all imports from Brazil are under MFN rules. Reduced duty and duty-free regimes operate under preferential trade arrangements between EU and developing countries. Many countries of Africa, South and Central America and Asia are included in these preferential trade arrangements that aim at drug diversion, sustainable development and good governance (Zarilli, 2006).

Part of the difficulties of biofuels trade liberalization has roots in agricultural policies and the need to protect farmers. Ethanol is internationally classified as an agricultural product, but biodiesel is classified as industrial (Zarilli, 2006).

7.1.3 Logistics

Most of ethanol exported has been shipped in the port of Santos, located in the state of São Paulo (relatively close to many ethanol distilleries), but with serious constraints regarding shipment capacity. In fact, only two terminals in Brazil can operate with vessels like Suezmax and VLCC[29], both terminals operated by PETROBRAS (Ilha D'Água, in state of Rio de Janeiro, and São Sebastião, in state of São Paulo). So far, this has not been a serious constraint, but certainly could be in the future.

Other logistic constrain is the distance between mills/distilleries and the ports. Transportation of ethanol by trucks at large distances doesn't make sense from economic, energetic and environmental points of view. Ethanol producers and TRANSPETRO – the logistic subsidiary of PETROBRAS – are investing in pipelines. TRANSPETRO estimates that logistics costs could represent 20% of the total cost of exporting ethanol, and that this cost could be reduced at least 50% with an optimised infrastructure (Lepsch, 2007).

In addition, TRANSPETRO plans to expand by 2015 its capacity of ethanol exports up to 13 billion litres, from 2 billion litres in early 2009. This includes diversifying transport modals (e.g., by pipelines, by railways and boats), enlarging ducts' and terminals' capacity and having more high-capacity vessels available (Agencia Brasil, 2009).

7.1.4. Environmental issues[30]

The current drawbacks of ethanol production are circumstantial and Brazil will continue to be a key producer in the global ethanol market over the coming years, as local conditions for ethanol production are comparatively favourable taking into account factors such as land availability and climate, long-term experience, existing commercial technology (the so-called "first generation"),

[29] Respectively, with transportation capacities of 150 thousand m^3 and 280 thousand m^3.

[30] This section is based on Walter et al. (2008b). For more information, see also Smeets et al. (2008).

and the size of the domestic market. Nevertheless, if the sustainability of Brazilian ethanol production was more widely recognised, these comparative advantages could be reinforced.

It is recognised that Brazilian ethanol is produced at the lowest cost and its feasibility does not depend on subsidies. However, some environmental and social aspects still need to be properly addressed, as there are knowledge constraints and controversy about many crucial issues.

Most of the ethanol production in Brazil can be considered sustainable, taking into account the current standards defined by the Directives of European Union (RED-EU). Does not taken into account greenhouse (GHG) emissions due to land used change (LUC) (both considering direct and indirect impacts), reduction of greenhouse gas emissions vis-à-vis the life cycle of gasoline would be at least 70%. Energy and GHG balances could be improved in the years to come and, in this sense, process diversification, phasing-out of sugarcane burning, trash recovery and its use as fuel or raw material, and trash deposition in the field, will be essential.

Regarding direct impacts of land use change, the growth of croplands, and more specifically the growth of sugarcane areas, has mainly occurred in lands previously occupied with pastures. Other conclusion is that the growth of sugarcane areas did not induce the displacement of cattle herds to other regions of Brazil. Along the period 1996-2006, almost 90% of the enlargement of sugarcane areas was concentrated in four states (São Paulo, Minas, Paraná e Goiás) and in all those states there was significant phasing-out of pasturelands, besides growth of forested areas.

It is difficult to evaluate indirect impacts on land use change, in particular regarding the recent growth of sugarcane. However, there are clear evidences that deforested areas in Amazon and in Cerrado have been used mostly for pasturelands and in a lower extent to soybean production. On the other hand, there is no evidence that the growth of sugarcane is São Paulo has caused deforestation in Centre-West and in North of Brazil.

Regarding socio-economic aspects of sugarcane production, in a recent report by Walter et al. (2008) a regional and more detailed approach was adopted based on welfare indicators (e.g. health and education) and on indicators of wealth and wealth distribution. The analysis was carried out comparing municipalities of the same size, with and without sugarcane activity (sugarcane cropping and industrial conversion to ethanol). The results indicate that in most cases the municipalities in which sugarcane production is present have better parameters than those where it is absent.

Other environmental impacts of the sugarcane sector, such as water consumption, contamination of soils and water shields (due to the use of fertilizers and chemicals) and the impacts on biodiversity, are lower in comparison to other crops. This can be explained by the following: in Brazil sugarcane production mostly occurs without irrigation; the development of sugarcane varieties has occurred over decades (with resulting higher yields and resistance to diseases and plagues); the use of biological control techniques; the use of biological fixers of nitrogen and of residues of production allowing a partial or total reduction of conventional fertilization; and the use of best agricultural practices (e.g. the reduction of erosion). However, due to the concentration of sugarcane production in some regions and the size of many factories, monitoring all the above-mentioned aspects is essential, besides dissemination and wide adoption of best practices (as has already occurred in some producer regions).

7.2 Solid biofuels

Regularly, only wood chips have been exported for Japan and US, in general for pulp and paper production; trade normally occurs among branches of the same holdings. Some constraints for exporting of solid biomass are listed below.

Local demand for biomass residues – In the Brazilian south there is already a market for biomass residues from wood industries, reducing the feasibility of pellets production for exporting.

Exchange ratio – The devaluation of US currency vis-à-vis Brazilian Real (that has started in 2004) reduced the earning of local exporters.

Non-certified wood production – As presented on Chapter 3, there is significant production in the North region of Brazil, but it is mostly based on extrativism. As this wood production is not certified, it would be not possible to produce and export briquettes and pellets with residues of this production.

Logistics – Currently, this is the main barrier for exporting solid biomass. Most of planted forests are located at places where freight is quite expensive up to maritime ports, mainly because of the high cost of transporting biomass by trucks. Values may increase about 150% on the biomass FOB price in some cases. It is known some attempts of pellets production for exporting that failed due to the high transportation costs. Considering the high availability of wood residues in state of Paraná (but rather dispersed in some cities), Serrano (2009) showed that it is not feasible to transport residues for more than 200 km to the pelletization units located at the Paranaguá port.

Fluvial transport may be a solution for the Northern and Centre-Western regions due the existence of several rivers appropriated for this purpose. For the North-Eastern and South-Eastern regions, fluvial transport should be mixed with railway as the main alternatives. For all those regions, crops transport has already started through a multi-modal way in which connections are made by trucks.

Demystifying biomass through pellet and briquettes production may be an alternative to reduce transportation costs for some cases, but it depends on an appropriate cost-benefit analysis. However many sites do not show competitiveness even with such transformations (Dolzan & Walter, 2006).

Considering different sites with biomass availability, Dolzan and Walter (2006) found overall logistic costs ranging from 65% to 90% vis-à-vis the wood chips production costs. Looking at differences between the existing transportation costs and those ones from the ideal logistic composition scenario, the authors found values from 1.69 Euro/GJ to 3.27 Euro/GJ added inappropriate logistic confirming the importance of removing such barriers.

Regarding ports, despite the highly privileged Brazilian conditions in terms of places for structuring them, most of the existing ones are public and their services are both expensive (outstanding tariffs) and inefficient (despite some exceptions). In addition, the ports are not equipped for fast carrying of bulk biomass such as charcoal, bagasse, wood pellets or chips which both have low aggregated value. In order to solve this problem, private ports located at strategic places and conveniently equipped with belt-carriers have been used for wood chips exports. At least three big companies for both energy and pulp purposes have well structured and specialized ports such as Amcel, in Santana – state of Amapá, in the North, and Bianchini (Tanac), in state of Rio Grande, in the South. These companies have presented highly competitive prices at outstanding levels.

8. Concluding Remarks

Brazil has long tradition in biomass production and consumption and has either potential to enlarge the share of biomass in its energy matrix and to be a big player in the bioenergy international trade arena.

For more than 35 years ethanol has been used in large scale, displacing gasoline. Since the launch of flex-fuel vehicles, and due to its large market success, ethanol has a consolidated position in the transportation sector, and the tendency is to enlarge its participation in the years to come. However, since 2009 Brazil ethanol production has faced difficulties. Regarding exports, the perspectives are also positive, but the extent of the international trade, and of Brazil's participation in it, will depend on a set of factors.

The Brazilian experience with biodiesel is new, but even though the results achieved so far are remarkable. However, the rationale of the biodiesel program tends to be contested in mid-term, as the production has been mostly based on soy oil and financial support has been given to large companies that dominate the soy supply chain. More important, the expansion of soy cropping has been blamed for deforestation in some parts of the country. Anyhow, B5 blends have been used and in a conservative scenario the growth on production will be consequence of enlarging diesel demand. There is no perspective for exporting biodiesel in short-term.

Regarding solid biomass, there is either potential for enlarging the consumption in the domestic market and for exporting. The best perspectives in the domestic market are on charcoal use, enlarging its use in steel and iron industries. However, it is necessary to set priority on sustainability of charcoal production. There is also potential for pellets production, both for the domestic and for the external markets, but as there is no tradition on pellets production and consumption, this is the very first barrier to be overcome.

Specifically regarding trading, there are two challenges for Brazil. The first drawback to be addressed is regarding logistics constrains, which impact the feasibility of solid biomass (e.g., pellets) and ethanol exporting. Logistic constrains have been addressed by producers and traders in case of ethanol, e.g., with investments on pipelines and on maritime terminals.

The second challenge for exporting is improving sustainability of biomass (and biofuels) production. Along the years there is a growing perception that rather being a barrier for trading, sustainability can be a comparative advantage. There are initiatives both concerned to forest products and to ethanol, and at least a significant share of the production fulfils the existing criteria in more constrained markets. However, there is still a lot to do in this regard, despite the results so far achieved.

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Annex

Table A.1 Total energy supply (final consumption: energetic and non-energetic uses) – Brazil, 2000-2010 (PJ)

Energy sources	2000	2002	2004	2006	2007	2008	2009	2010
Natural gas	298	421	510	602	647	697	638	723
Coal	119	126	150	146	156	161	124	152
Wood	571	606	660	683	683	706	694	714
Sugarcane bagasse	560	733	849	1020	1120	1201	1207	1298
Other primary renewables	126	140	168	210	208	221	233	253
Other gases	52	49	56	58	58	45	50	59
Coke	272	279	285	281	281	281	222	262
Electricity	1194	1168	1296	1484	1484	1542	1523	1641
Charcoal	202	193	266	262	262	260	166	195
Ethanol	270	275	291	375	375	494	525	557
Other secondary	9	8	9	9	9	8	8	10
Oil products	3527	3461	3464	3870	3740	3935	3896	4248
Diesel	1235	1320	1367	1459	1459	1568	1545	1722
Fuel oil	398	345	273	270	272	263	251	207
Gasoline	558	522	570	601	601	611	616	736
Liquefied petroleum gas	328	310	301	311	311	318	316	322
Naphtha	339	276	300	326	326	288	309	307
Kerosene	136	136	102	110	110	119	119	134
Other secondary from oil	343	364	377	454	454	445	466	499

Source: EPE/MME (2011)

Table A.2 Final energy consumption by sectors – Brazil, 2000-2010 (PJ)

Sectors	2000	2002	2004	2006	2007	2008	2009	2010
Residential	866	866	894	925	933	952	973	991
Industry	2563	2737	3024	3214	3427	3447	3199	3587
Transport	1984	2058	2155	2230	2413	2615	2625	2907
Energy sector	538	603	688	788	881	1028	1022	1061
Others	650	667	701	738	777	823	816	843
Total	6601	6931	7462	7896	8430	8865	8635	9389

Source: EPE/MME (2011)

Table A.3 Energy consumption in industry – Brazil, 2000-2010 (PJ)

	2000	2002	2004	2006	2007	2008	2009	2010
Natural gas	162	234	279	317	337	354	300	387
Coal + coke	391	406	436	403	437	441	346	414
Oil products	579	524	468	484	537	538	522	538
Electricity	528	549	620	660	694	710	659	725
Biomass	860	984	1176	1307	1377	1373	1328	1468
Others	42	40	46	43	46	46	44	56

Source: EPE/MME (2011)

Table A.4. Energy consumption in transport – Brazil, 2000-2007 (PJ)

	2000	2002	2004	2006	2007	2008	2009	2010
Gasoline	555	520	568	605	598	609	614	734
Ethanol	244	255	270	268	361	461	494	504
Diesel Oil	1009	1082	1123	1135	1203	1285	1272	1413
Others	176	202	195	223	251	259	245	256

Source: EPE/MME (2011)

Table A.5. Firewood supply and consumption – Brazil, 2000-2010 (PJ)

	2000	2002	2004	2006	2007	2008	2009	2010
Production	966	986	1,180	1,193	1,198	1,225	1,030	1,092
Charcoal	389	378	515	497	508	520	336	378
Residential	275	321	338	347	327	323	315	305
Agriculture	69	67	89	94	99	106	101	106
Industrial	224	212	229	243	254	274	275	300

Table A.6. Charcoal production and consumption – Brazil, 2000-2010 (PJ)

	2000	2002	2004	2006	2007	2008	2009	2010
Production	212	202	277	263	274	272	175	203
Imports	0	0	1	4	0	0	0	0
Exports	0	0	1	0	0	0	0	0
Iron + Steel	174	166	232	222	230	226	137	168
Residential	17	19	21	21	22	27	25	22

Table A.7. Wood production (except for charcoal and firewood) based on planted forests and extrativism (Mm^3)

	Planted forests		
	Timber and logs	Pulp and paper	Extrativism
1990	14.1	33.0	97.5
1991	13.9	35.8	46.2
1992	13.6	38.6	53.1
1993	15.5	41.7	62.8
1994	18.0	51.4	62.5
1995	19.6	48.6	61.6
1996	49.3	33.8	49.9
1997	21.7	35.4	26.3
1998	33.9	38.6	22.1
1999	23.4	41.1	21.3
2000	25.7	46.0	21.9
2001	28.8	41.0	20.1
2002	31.7	43.4	21.4
2003	50.2	49.5	20.7
2004	41.2	46.3	19.1
2005	45.9	54.7	17.4
2006	45.7	55.1	18.0
2007	44.2	61.0	16.4

Table A.8 Exports of ethanol from 1998 to 2011 and average FOB prices paid

	Volume exported (1,000 m^3)	Average FOB prices (US$/m^3)
1998	118	301
1999	432	166
2000	227	149
2001	346	267
2002	759	223
2003	762	209
2004	2,408	207
2005	2,601	294
2006	3,429	468
2007	3,512	418
2008	5,124	466
2009	3,296	406
2010	1,900	534
2011	1,964	760