Bioenergy Thematic Study

Bioenergy, rural development and poverty alleviation in Brazil and Colombia

Prepared for

Global Network on Energy for Sustainable Development (GNESD)

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EXECUTIVE SUMMARY

This text is part of a larger study under development by GNESD – the Global Network on Sustainable Development created as a Type 2 Initiative in the World Summit of Johannesburg, on December 2002.

This GNESD network (www.gnesd.org) includes excellence centres mainly from developing countries and since 2002 has been responsible by the production of several documents on energy access, renewable energy and energy efficiency on developing countries (DC´s), aiming to poverty alleviation.

This study, "Bioenergy Thematic Study - Bioenergy, rural development and poverty alleviation" is the first one addressing one specific type of renewable energy, the so-called *bioenergy*. The present study discusses situation in Brazil and Colombia, and it was performed jointly by CENBIO/USP and CentroClima/UFRJ.

It is well known that in most DC´s only "traditional biomass" is available (from deforestation and charcoal mainly for inefficient cooking and heating), and that modern bioenergy (both liquid biofuels and solid biomass, as well as biogas for electricity production), is foreseen by most local governments as a possible perspective for energy supply and poverty alleviation (not only to reduce oil import expenditures but also through the generation of jobs in rural areas).

In this context, the present study intends to show not only the current situation on bioenergy production and use in Brazil and Colombia but also the perspectives for modern bioenergy in both countries.

Then, in this chapter, the current situation and perspectives for bioenergy on Brazil and Colombia are presented.

Later on, the overall Synthesis Report for all countries will be prepared by Cenbio/CentroClima, based on the information of each DC.

Brazil has a huge experience on biofuels and bioenergy in general, since its Alcohol Program is more than 30 years old. The lessons learned can be shared with other DC´s, aiming to collaborate for local development of biofuels programs. In this report the Brazilian experience is presented not only for sugarcane ethanol but also for biodiesel, as well as perspectives for other DC´s.

Also, Colombia is starting its biofuel program and local perspectives are presented here.

Brazil produced 27,5 billion litters of sugarcane ethanol in 2008/2009, being the second largest producer in the world, using an area of 6.8 Mha, corresponding to 1.5% of total arable land in the country (from this area around 50% is for alcohol production and the other 50% for sugar production) and 1.6 billion litters of biodiesel in 2009 (www.anp.gov.br).

For the 2012/2013 season, a potential of 38 billion litters is forecasted, using an area of 10.3 Mha. It must be remarked that, as discussed here, this expansion (as well as the one for biodiesel) can be done in a sustainable way (session 2.4). Existing zoning from Brazilian Federal Government and from some states (like Sao Paulo) defines which areas are adequate for sugarcane crop without pressure against fragile biomes. Also a recent study from ICONE (NASSAR et al, 2010) show that LUC (Land Use Change) and ILUC (Indirect Land Use Change) are not a problem in Brazil.

Colombia started in 2004 its National Program of Biofuels, with a mandatory blend of sugarcane ethanol in gasoline in 2005 and, in 2007, its Biodiesel Program, aiming to produce and use biodiesel from palm oil (with a mandatory blend of biodiesel in diesel oil in 2008).

Considering the production of biofuels in Colombia, 327.2 million litters of ethanol were produced in 2009, 26% more than in 2008 and 350,000 m3 of biodiesel in 2008, mainly from palm oil, in an area of 337,000 hectares for palm oil plantation (FEDEPALMA, 2008).

New legislation is being introduced to incentivate biofuels as well as to guarantee their sustainable production.

In a similar way of sugarcane crops in Brazil, in Colombia, palm plantations are set up without having to cut down native forest areas and are built in regions which were once used for farming. Colombian palm growers are committed to caring for the environment and have adopted a range of good practices which allow them to maintain a competitive edge and promote sustainability, while complying with international standards.

However, for the biofuel industry to be consolidated as an energy commodity in the international market and, therefore, have their production and marketing increased, some barriers must be overcome (PIACENTE, 2006):

- It´s necessary to have many countries as suppliers and consumers. However, currently the high costs of raw materials hinder the production diversification, because only the production from sugarcane is considered economically viable without subsidies, and it is unlikely that this situation be changed in the 5 or 10 years, unless in the ethanol from cellulose will be obtained in large scale and competitive prices.

- End of subsidies and protectionism (ie, the shares imports) that distort international trade, preventing the free products flow and limiting the market to occasional transactions, when there are deficiencies in supply.

• The ethanol must have specifications (standardization) and possibly also be required for production certification.

• It is also necessary that the ethanol has quoted prices in a transparent world market. Therefore, it is important to develop a futures market, and that "hedgings" are applied (a good start was the launching of ethanol contracts on the New York Board of Trade in 2004 and contracts of corn ethanol on the Chicago Board of Trade in 2005).

Bioethanol is sometimes considered impractical because of low demand and the large-scale investment needed to produce it, the costs involved in converting filling stations and vehicles. However, gasoline engines can be adjusted to ethanol and its blends. Besides, flex-fuel vehicle technology has become available with no extra costs to consumers.

The strategic nature of bioethanol implies the existence of some degree of protectionism in almost any producing country. Protectionism is especially acute where energy security is equated with self-suficiency or where biofuels are promoted to help domestic farmers in high-cost producing countries (DUFEY et al., 2007).

Subsidies are a key concern. In industrialised countries, government support for the domestic production of energy crops, the processing or commercialisation of biofuels seems to be the rule (DUFEY, 2006). Amounts involved are enormous. In the United States, Koplow (2006) estimated that subsidies to the biofuels industry to be between US$ 5.5 billion and US$ 7.3 billion a year.

The use of tariffs to protect domestic biofuel industries is a common practice and, as the impacts these policies have on the developing countries competitiveness and on their potential for poverty reduction needs to be understood as domestic support in these countries is likely to be very limited. Moreover, subsidies impacts on environmental sustainability are also questionable as they promote bioethanol industries based on the less efficient energy crops and with the least greenhouse gases reductions such as maize and wheat (DUFEY, 2006).

In particular, the extra US$ 0.14 to each litre (US$ 0.54 per gallon) of imported bioethanol on top of the 2.5 percent tariff applied by the United States, it is said to be targeting Brazilian imports as it brings the cost of Brazilian bioethanol in line with that produced domestically (SEVERINGHAUS, 2005). Tariff escalation, which discriminates against the final product, can also be an issue, for example, where there are differentiated tariffs on bioethanol and feedstock such as raw molasses (DUFEY, 2006).

Although the main barriers consider markets aspect, there are still issues that need to be better elucidated to the biofuel development in the world, and especially considering countries in this study: Brazil and Colombia.

In addition to tariff barriers, can exist Non-tariff barriers, that considering: Technical and sanitary requirements; Quality standards; Public Health policies; Labor regulation; Rules on competion; Consumer's protection; Corporative politicies; Social and environmental policies.

Certification issues, despite the fact that are important to guarantee the sustainability of biofuels production and use, can be a non-tariff barrier. For Least Developing Countries (LDC), where the lack of funding and adequate capacity building is a matter of fact, can be a huge barrier for biofuels exports for industrialized countries (UNCTAD, 2008). In these cases a waiver related to certification schemes could be a significant collaboration for the economic development of such countries, not only considering the local supply but also the export of biofuels. Considering that in many cases local demand is quite low due to economic conditions, export of biofuels could allow a higher production, in a scale which allows economic competitiveness of biofuels with fossil fuels.

Such waiver could include more time for capacity building in these developing countries to allow adequate adaptation, as well as for the introduction of modern technologies such as mechanical harvesting of green cane.

Considering all these issues, further discussion are needed about the environmental and social concerns, with a wider dissemination of the current results obtained with the use of biofuels, making a consistency of reporting and not considering uncertain issues, that make a barrier for the market of producer countries.

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1. INTRODUCTION

The demand for bioenergy – which includes firewood and charcoal, energy crops such as sugarcane, sweet sorghum and rapeseed, as well as agricultural and forestry residues, to produce heat, ethanol, biodiesel, bioelectricity or biogas – is increasing all over the world. Drivers for bioenergy are the uncertainty of future domestic energy supply, the increasing demand for energy worldwide with sharply increased energy and instability of oil prices as well as the need for reducing greenhouse gases emissions in order to the targets defined in the global climate change policies (mainly those correlated with the Kyoto's Protocol).

In fact, bioenergy is not an alternative able to fully solve the energy problem, but it has the potential to partially replace fossil fuels in the means of transport, reducing GHG[3] emissions, mainly in transportation sector, where no other renewable energy is commercially available nowadays.

It is important to note that biomass can be produced in a sustainable way (the so called modern biomass) or from deforestation (wood and producing charcoal), which correspond to the traditional biomass. In several developing countries the only biomass available is the traditional biomass, mainly in African and Asian countries. In this text when the term biomass or bioenergy is mentioned, it means modern biomass (or modern bioenergy), which is produced in a sustainable way and not from deforestation. Further discussions will be presented ahead.

Bioenergy can be categorized according to feed stock´s origin– from agriculture, forestry or from waste sources. From a global energy perspective, the use of woody based (lignocellulosic) bioenergy currently by far exceeds that from both agricultural and waste based sources. In the future, the potential probably will come from lignocellulosic materials, including by-products like sugarcane bagasse and straw from the agricultural system. In countries where bioenergy plays a substantial role in the energy system, production is usually based on forestry feed stocks, with energy supply from these sources well integrated with the production of other forestry products. Compared to forestry, agriculture demands more labour and intensive investment. Therefore, high-value products such as food or fodder are generally required to cover the production costs associated with the relatively high-intensity system.

[3] GHG – Green House Gases

Among the various renewable energy sources, bioenergy provides the most diverse group of technologies, offering a range of options in different conditions (solid biomass, liquid biofuels, biogas).

Most renewable energy sources generate one or two specific type of energy. Hydro, wind, and solar PV[4] can generate electricity, while solar thermal can provide either electricity or heating and cooling. The situation for bioenergy is more complex. Bioenergy concerns not just one energy technology, but a matrix of processes converting a multitude of biological raw materials for heating and/or cooling, or for the production of electricity or fuels for the transportation sector. Bioenergy systems also use the same types of biomass traditionally used for food, fodder, and raw material for industrial processes, but in an efficient way.

The expansion in the use of biomass for energy could also lead to improved economic development and poverty alleviation, especially in rural areas, since it attracts investment in new business opportunities for small- and medium-sized enterprises in the fields of biofuel production, preparation, transportation, trade and use, and generates incomes (and jobs) for the people living in and around these areas.

Bioenergy, nowadays, is seen as an opportunity for enhanced market and smallholder oriented rural development in many developing countries, where comparative advantages of bioenergy production exist.

It can also contribute a lot to diversify and expand the forestry and agricultural production (maintaining, at the same time, the watersheds, the soil fertility and the biodiversity). In such context, bioenergy can indeed improve the food security.

It should be noted that bioenergy is the largest and most rapidly growing renewable energy source. Bioenergy covers the whole spectrum of applications, including economically competitive and mature technologies (such as heat production from industrial by-products in forest industries). Several systems operate under very different conditions and interact with completely different sectors. Not only feedstock, but conversion technologies and end-uses differ from one to the other, but also the policy drivers and the incentives can create the conditions under which they can be developed and commercialized.

[4] PV - Photovoltaic

In developed countries, the conventional agricultural crops are usually too expensive to produce biofuels able to be profitable for the energy market. Production of bioenergy from these sources has been supported by various policy incentives. The rationale for providing this support is often purported to be to ensure security of supply and to provide environmental benefits. However, often the main reason is to support agricultural and rural development policy objectives. The situation is completely different in countries like Brazil where climatic and socio-economic conditions allow a profitable bioenergy industry.

Even holding great promise for developing countries, the potential of bioenergy is still too often neglected by policymakers and needs to be urgently integrated into agricultural and forestry programs. In fact, there is an evident inertia associated with planning and implementation of bioenergy-based systems.

So, the present report analyzes all forms of bioenergy in the two countries selected – Brazil and Colombia - to specifically examine the roles they can play in rural development and poverty alleviation.

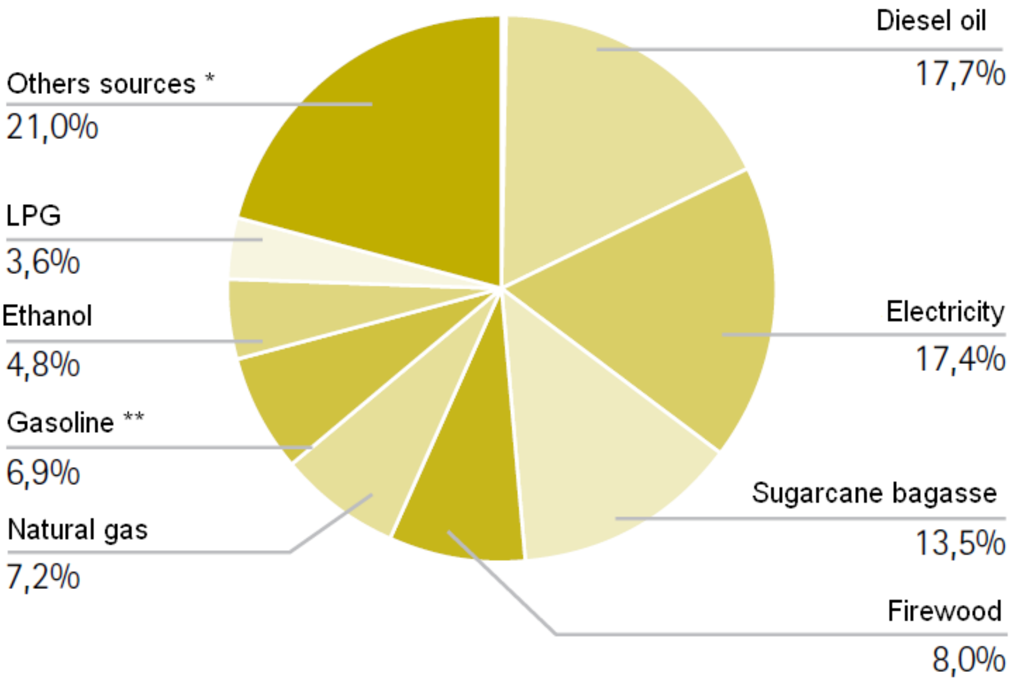
Brazil is the largest ethanol producer, consumer and exporter in the region, and is also introducing biodiesel in its transportation matrix. Colombia is the first producer and exporter of palm oil in the region.

In this context, this report includes information about current situation of bioenergy in the two countries, as well as perspectives for the future, always with the aim of contributing for poverty alleviation in a sustainable way.

2. Bioenergy in Brazil

Brazil is a country with 8,500,000 square kilometres and a population of 188.298.099 inhabitants.

In this country, cconsidering the total energy consumption, sources from oil represents more than 45% in the country (see the following figure)(EPE, 2009).



* fuel oil, refinery gas, coal coke, charcoal, others
** only gasoline A (cars)
Figure 1: Total energy consumption in Brazil, by type of sources (%) 2008
Source: BEN, 2009

Collaborating to guarantee the share of 17.4% of electricity consumption in Brazil, Table 1 shows that electric power generation in Brazil from renewable sources are prevailing, due to the large-scale hydroelectric power plants. Comparing this data with Figure 1 data it can be noticed that the Brazilian energy matrix is typically “clean” with large share of renewable energy. Besides hydro power it must be noticed the significant share of biomass in this electric matrix (27.4 TWh in the total of 461.8 TWh of renewable energy).

Table 1: Electricity production in Brazil (2009)

Resources	**TWh**
Non-renewable energy	**47.8**
Natural Gas	13.3
Oil and derivatives	14.7
Nuclear	13.0
Coal and derivatives	6.8
Renewable energy	**461.8**
Hydro	391.0

Imports	42.1
Biomass	27.4
Wind	1.24
Total	**509.5**

Source: EPE, 2010 – National Energy Balance 2010, base year 2009

In fact, this Brazilian energy matrix, currently, is a result of the 1970's strategy to replace imported fossil energy (mainly petroleum) by renewable sources such as hydropower and biomass.

It is important to stress that national coal has low quality being approximately 17% of such imported from other countries and it is difficult to be use in thermoelectric power plants.

Nuclear power currently accounts for approximately 2% of the Brazilian installed capacity for electricity generation. So far, it is a secondary source of energy due the country large hydropower availability.

The national petroleum reserves, in general, are characterized by medium (and even low) API degree[5], in other words, oil process in the refinery does not produces large amounts of medium oil derivates, like diesel oil, necessary to supply the Brazilian transportation energy matrix. Recently a large reservoir of oil and gas was discovered that can change this scenario (Pre-salt reserves). However these reserves are located over six kilometers below sea level. On average, the deposits lie under two thousand meters of depth water, plus two thousand meters of rock, and another two thousand meters of pre-salt. Not to mention that some fields are more than 300 km from the coast (LUCAS, 2009).

The pre-salt could turn Brazil into a major producer and exporter of oil and oil products; however, oil exploitation at this depth combined with the geological composition of salt, and the challenges of transportation and refining lead in technological challenges to be defeated. Even though, in 2006, Brazil achieved self-sufficiency in its oil energy balance, but diesel import is still necessary. Furthermore, according to Ferreira 2003, the Brazilian petroleum self-sufficiency is proportional not only to its production increase, but to the country capability of demand intervention including competition with the petroleum substitutes, like natural gas and ethanol.

[5] Represents a standard measurement of viscosity developed by American Petroleum Institute.

Brazil has a sophisticated and efficient structure of power generation. Due to the territorial extension of the country, and consequently to transmission restrictions, the electricity sector is segmented into two principal sub-systems: South/Southeast/ Center-West and North/Northeast. These two integrated sub-systems form the National Interlinked System (*Sistema Interligado Nacional -SIN*) and are responsible for 98% of the electricity market of the five regions corresponding to a consumption of 390 TWh.

The power generation capacity is characterized by large reservoirs of pluri-annual regularization. The power plants are located in different hydrological basins and interconnected by extensive transmission lines. Conventional and nuclear thermal power plants complement the remaining power supply, as well as renewable energy sources such as biomass and wind.

Regarding the electricity sector, the Brazilian final electricity consumption is distributed as following: residential sector 22%, commercial sector 14%, services 8%, agriculture and cattle raising 4%, energy sector 4%, transport sector 0%, industry 48% (ELETROBRÁS, 2009).

The South/Southeast/Center-West sub-system concentrates the major part of the installed capacity, summing up 43 GW. The production structure is comprised of hydroelectricity, natural gas, diesel, fuel oil and two nuclear power plants, plus 50% of the installed capacity of the bi-national hydro power plant, which capacity is 12.6 GW (Eletrobrás, 2009). However the isolated system (mainly Amazonian region) still presents difficulties on energy supply, mainly when considering the isolated systems, which are mainly based in diesel oil engines, despite several efforts to introduce electricity from local biomass in some pilot plants (COELHO et al. 2005a; 2005b; 2005c).

Besides this electric system, biomass also plays an important role in the Brazilian matrix, mainly sugarcane products (for bioethanol) in transportation sector, with a share of 13.5%/. These bioenergy products are the ones to be presented ahead in this document, showing the lessons learned by Brazil in its Alcohol Program, as well as the Biodiesel Program nowadays being introduced.

2.1. USE OF BIOENERGY IN BRAZIL

Bioenergy sources in use in Brazil are: biofuels (ethanol and biodiesel), agricultural residues (sugarcane bagasse, rice husks, etc), wood residues, charcoal and firewood.

However the most important ones are sugarcane ethanol and biodiesel, as well as sugarcane bagasse cogeneration. Therefore these are the biofuels to be presented here.

Biofuels represent 20.5% of the national transportation matrix (MME, 2010), mainly ethanol from sugarcane and biodiesel.

Brazil is the largest world cane and sugar producer, the second in ethanol and also the leading sugar and ethanol exporter. About 40% of the sugar and 85% of the ethanol production are now directed to the domestic market. Ethanol is used in the country blended to gasoline (anhydrous ethanol, in a proportion of 20%-25%) in dedicated blended gasohol (gasoline blended with ethanol) and flexible engines and (hydrated ethanol), in dedicated ethanol or flexible engines. In 2008, the total ethanol volume used as fuel in the Brazilian light vehicle fleet exceeded the gasoline volume.

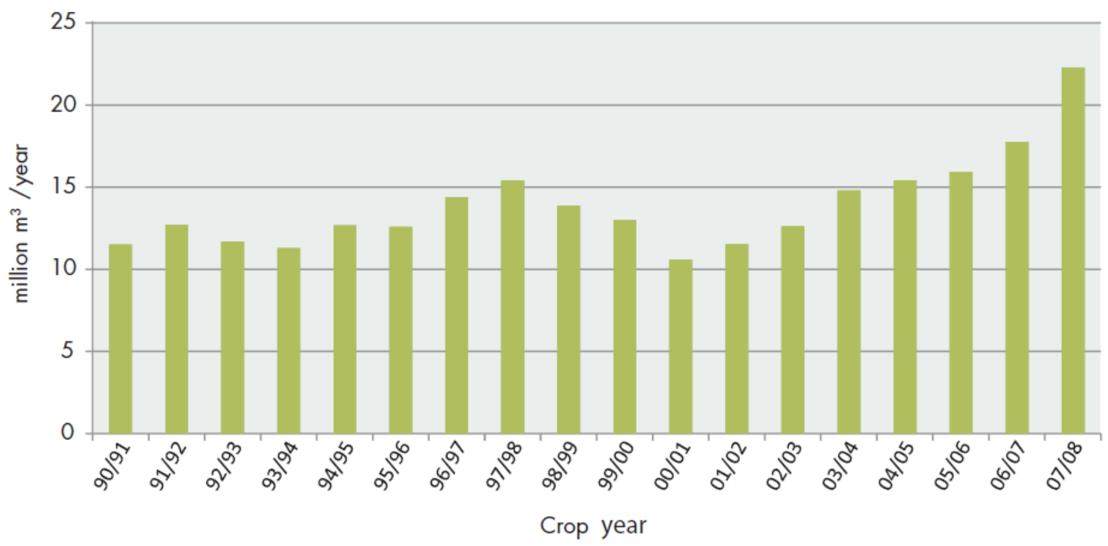


Figure 2: Ethanol production in Brazil.
Source: UNICA , 2007

During 2008-2009, 569 million tons[6] of sugarcane were produced, resulting in 27.5 billion litters of ethanol. The estimate for 2012-2013 harvesting season is that approximately 728 million tons of sugarcane will be crushed, producing 38 billion litters of ethanol (UNICA, 2010).

Ethanol was not used in significant amounts until the mid-1970's, when the increase in the cost of imported oil at the time of the first world oil crisis imposed severe foreign

[6] Metric tones.

exchange burdens on countries dependent upon oil imports, including Brazil. As a leading sugar producer from sugarcane, Brazil was able to explore the option of ethanol as an alternative to gasoline. The Alcohol Program was then launched to fulfil these requirements.

As discussed in Goldemberg, 2010, under these conditions the Government decided to accelerate ethanol production thorough Decree 76,593 of November 14, 1975 which is really the birth certificate of the Brazilian “Alcohol Program”. The idea was to reduce gasoline consumption and therefore decrease oil imports. Production goals were set at of 3 billion liters of ethanol in 1980 and 10.7 billion litres in 1985.

This decree determined that very generous financing terms were to be offered to entrepreneurs through Government banks[7] and that the price of ethanol should be on parity with sugar 35% higher than the price of 1 kg of sugar[8].

The decree made the production of ethanol and the production of sugar equally attractive to the entrepreneurs. This opened the way for the increase in the production of ethanol which happened indeed

Therefore the problem of increasing ethanol production was solved. The remaining problem was to make sure that the ethanol produced was consumed. The Government solved the problem using two instruments:

- Adopting mandates for mixing ethanol to gasoline. Up to 1979, the mixture of ethanol in the gasoline increased gradually to approximately 10% which required small changes in the existing motors. In 1981, ethanol consumption reached 2.5 billion liters.

- Setting the price of ethanol paid to producers at 59% of the selling price of gasoline (which was more than twice the cost of imported gasoline). The high price of gasoline has been used for a long time by the Government as a method of collecting resources to subsidize diesel oil. Parts of such resources were then used to subsidize ethanol.

Subsidies of approximately 1 billion dollars per year on the average over the 30 years were needed to sustain the program. These subsidies were removed gradually and in

[7] The interest to be paid on these loans was lower than the rate of inflation which resulted in a negative real interest rate.

[8] Theoretically one can produce 0.684 liters of ethanol with 1 kg of sugar which is fairly close to the value established by the decree 76,593.

2004 the price paid to ethanol producers was similar to the cost of gasoline in the international market as seen in Figure 3.

The so-called “*Brazilian Ethanol Learning Curve*” shows, implicitly, that the remarkable fall in ethanol prices from 1980 to 2005 are a series of results from: policy, research and development, mainly gains in (agricultural and industrial) productivity, as mentioned before, together with the use of sugarcane bagasse to supply all energy needs of the mill, as discussed ahead in details.

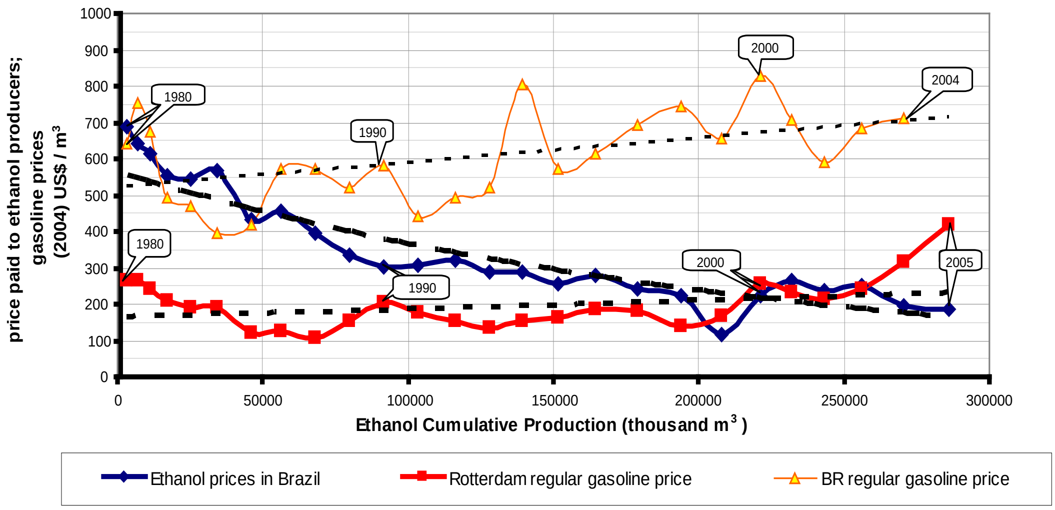


Figure 3: Competitiveness of sugarcane ethanol to gasoline
Source: GOLDEMBERG et al (updated), 2003

But in the early 1990’s, due the high prices of sugar in the external market, a shortage in ethanol production for internal market led to a gradual abandonment of the use of neat-ethanol driven cars, since consumers decided to change for gasoline cars since they were afraid of a long period of shortage of ethanol. At that time many considered that the ethanol program was finishing.

However, the introduction of flex-fuel motors in Brazil in 2003 solved this problem. Flex-fuel vehicles are capable of running with blends from E0 to E100, which means that they can use pure gasoline, or pure ethanol, as well as any blend of both. The introduction of these cars in the market was a hit, popular because they allowed the consumer to make a cost-driven choice on fuel. Today more than 95% of all new cars sold in Brazil are flex-fuel. It is important to note that flex vehicles were introduced by the automotive industry, with no participation of government, since this sector was already mature enough to launch such vehicles. The only advantage required by flex fuel vehicles manufacturers was related to federal taxes: flex fuel vehicles have the same IPI (federal tax for industrialized products) tax of ethanol vehicles, being lower than gasoline ones.

The dominance of agricultural technology in tropical environment allowed the natural abundance of soil, luminosity, temperature and water to be used to increase productivity in agriculture. In sum, technological development allowed Brazil to make use of its comparative advantages in agriculture, besides increases also in industrial phase.

Brazil counts on an expressive volume of potentially tillable area. There are different studies concerning land availability which generally tend to converge to an area potentially larger than 100 million hectares in the cerrado region but it must be considered that *cerrado* (the *Brazilian Savannah*) presents a significant amount of biodiversity. On the other hand there is still a huge grazing area characterized by the low productivity of fodder and which is now starting to be integrated to the grain system, configuring an innovator rotation system. This nowadays is used for cattle raise in a very inefficient way (less than one head per hectare, in an area of more than 200 million hectares). If this cattle density could increase up to 1.5 as happened in the State of Sao Paulo we could have 60 million hectares available not only for biofuels but also for food production (GOLDEMBERG et al., 2008).

Besides the Alcohol Program Brazil has also a National Biodiesel Program, which nowadays mandates the blend of 5% of biodiesel to the mineral diesel all over the country.

Despite government programs that aimed to foster farming oil seeds[9], currently 86% of the biodiesel production is based on soybean oil, 11% on tallow, 1.5% on cotton oil and 1.5% on other sources. Nowadays some industries are starting to produce biodiesel from animal fat, which present positive economic results such as the case of soy based biodiesel. The advantage of using animal fat, besides the economic competitiveness, is that there is no environmental impact as happening in the case of soy, which presents a significant pressure on Amazon deforestation.[10]

[9] Mainly castor oil production in a type of familiar agriculture which did not present positive results (MENDES and COSTA, 2009)

[10] Biodiesel is produced traditionally through the reaction of transesterification using vegetable oil or animal fat and an alcohol, either methanol or ethanol.

The country consumed, in the year 2009, 1.56 billion litres of biodiesel, an increase of 39% in comparison to 2008. Due the mandatory blend of B5 that started in January 2010, the expectation for this year is a consumption of 2.4 billion litres. The installed capacity in the country is 4.2 billion litres per year, what means that we still have space to increase the biodiesel production.

Brazil has a significant potential to become a leading country in biodiesel production as well. New biodiesel capacities are being installed, encouraged mainly by the incipient growth of domestic consumption and external demand.

However there is still the problem of using methanol to produce biodiesel instead of ethanol in most biodiesel plants in Brazil. Methanol is used because the technology in use is same used in Europe, where methanol is used. Also there are some technological bottlenecks to be solved when using ethanol and only one industry in the State of Sao Paulo informs that they are using ethanol (FERTIBOM – www.fertibom.com.br).

2.1. Bioethanol in Brazil

2.1.1. Current Policies

This session resumes main legislation related to ethanol in the country, still in use.

Previous legislation creating subsidies and incentivising the ethanol production are no more in use and not mentioned here. MOREIRA and GOLDEMBERG (1999) discusses such legislation.

It must be noticed that in Brazil there is a free market for fuels in general; only the blend of anhydrous ethanol in gasoline – gasohol- (E-80-E-85) and the blend for biodiesel in diesel oil (B5) are mandatory.

Fuel prices are now defined by the free market and the ethanol producers know they must keep ethanol prices at pump station up to 70% of gasohol price otherwise consumers go for gasohol instead of ethanol, since most vehicles nowadays are flex fuel ones. This percentage was calculated taking into account the lower heating value of ethanol compared to gasoline, as well as the higher consumption of alcohol when compared to gasoline.

Therefore the existing legislation in the country is as follow:

- **Law N°8.723/1993**

Establishes the anhydrous ethanol to be blended in the gasoline ranging between 20 and 25%, to be defined by Inter Ministerial Council (Conselho Inter Ministerial do Alcool - CIMA). . The Council consists of four ministries: the Ministry of Agriculture, Livestock and Supply – MAPA; Ministry of Development, Industry and Foreign Trade – MDIC; Ministry of Finance - MF and Ministry of Mines and Energy - MME.

- **Decree N°3546 / 2000**

CIMA (Article 1 of DEC N°3546/2000) defines the policies related to the activities of sugar-alcohol sector, considering, among others:

I. Adequate participation of sugarcane products in the National Energy Matrix;

II. Economic mechanisms necessary for self-sustainable industry;

III. Scientific and technological development.

CIMA approves the programs of production and use of alcohol fuel, establishing their financial figures and expenditure ceilings.

ANP activities on sugarcane sector are set in the agreement ANP 07/2005, signed between the MAPA and ANP. The agreement defines the standards for technical cooperation and operational monitoring and supervision of activities related to the production of ethyl alcohol and the national supply of ethanol fuel, and deployment of systems of information exchange.

- **RESOLUTION ANP number 36, December 06, 2005 – Technical Regulation ANP number 07/2005**

This Technical Regulation applies to Anhydrous Ethyl Alcohol Fuel (AEAF) and Hydrated Ethyl Alcohol Fuel (HEAF), for use as standards in the tests of consumption and emissions for the approval of vehicles.

The determination of the characteristics of ethyl alcohol fuel is achieved through the use of Brazilian standards (NBR) of the “Brazilian Association of Technical Standards” – ABNT (*Associação Brasileira de Normas Técnicas*).

The data for accuracy, repeatability and reproducibility provided in the reported methods in this Regulation must be used as a guide for acceptance of the determinations in duplicate of the test and must not be regarded as tolerance applied to the limits specified in this Regulation.

The analysis of the product must be held on a representative sample obtained by methods ABNT NBR 14883 - Petroleum and petroleum products - Sampling Manual or ASTM D 4057 - Practice for Sampling of Petroleum and Petroleum Products (*Prática para Amostragem de Petróleo e Produtos Líquidos de Petróleo*).

Therefore ANP controls the quality of every fuel commercialized in the country, including ethanol and biodiesel, among other traditional fuels.

2.1.2. TECHNOLOGY FOR SUGARCANE ETHANOL PRODUCTION

Brazilian sugar and bio-ethanol production process is based on the same feedstock: sugarcane. Sugarcane contains high amounts of sucrose or reducible sugars, which are expressed in the amount of total reducible sugars (TRS) per tone of cane (tc) [kg TRS/tc]. Sucrose is the most important feedstock in the fermentation industrial process. The production process thus has two complete different aspects, sugar production by cultivating cane and industrial ethanol processing. Both processes will be described separately in the next section, to begin with the production of cane. The sections are mainly based on (MACEDO & CORTEZ, 1999; DAMEN, 2000; BRAUNBECK et al., 1999).

Sugarcane cultivation in Brazil is based on a ratoon-system, which means that, after the first cut, the same plant is cut several times on a yearly basis. Harvesting season in the state of Centre West and Southeast (including São Paulo, the main producer state) is from May until November. Nowadays before planting in the first year, the soil is intensively prepared by most mechanical operations, such as sub soiling, harrowing and application of mineral fertilizers. After this the soil is furrowed and phosphate-rich fertilizers are applied, seeds are distributed and the furrows are closed and fertilizers and herbicides are applied once again. The plant is furrowed and treated with artificial fertilizers or ´filter cake´4 once or twice again during cultivation in the first year. After 12-18 months the cane is ready for the first cut (SMEETS et al., 2006).

Sugarcane harvest periods vary according to rainfall to allow cutting and transportation operations while reaching the best maturation point and maximizing sugar accumulation. The traditional harvest system — which is involves the previous burning of the sugarcane crop and the manual cut of the whole sugarcane stalk — is being progressively replaced by the mechanized harvest of green chopped sugarcane (without burning, the so called greencane), due to environmental restrictions on burning practices. Recent agreements between the government and producers made for an estimate of all sugarcane to be mechanically harvested by 2020, without previously burning the sugarcane crop (BNDES, 2008). Sao Paulo was the first one to introduce the mandatory harvesting of greencane[11]. Later on, other states started to introduce the same legislation, including it in the licensing system of new mills; Minas Gerais, Goias, Mato Grosso do Sul are examples of such procedures.

After cutting and sometimes chopping cane stalks by a chopped cane harvester, the cane stalks are loaded in trucks and transported by trucks to the industrial plant. Burning and delays before processing such as loading and transport lead to significant losses of the amount of sucrose per ton. Losses of 6-10 kg TRS within the first 72 hours is normal, which stresses the importance of quick harvesting, loading and transportation (CTC, 1988).

Then the process starts all over again excluding intensive soil treatments and planting. Depending on the rate of the declining yields, the same stock can be used. Yields decline with approximately 15 percent after the first harvest and 6-8 percent in the years that follow. Declining yields depend on treatment of the stock during maintenance and harvesting but are mainly determined by the combination of applied variety and type of soil (BRAUNBECK, 2005). During preparation for the next season, the soil is treated less intensively but fertilizers and herbicides are heavily used. A simplified overview of the production process of sugarcane is shown in Figure 4 Processes between brackets are only necessary at the beginning of the ratoon-system.

[11] State Law N. 11 241, 19 September, 2002

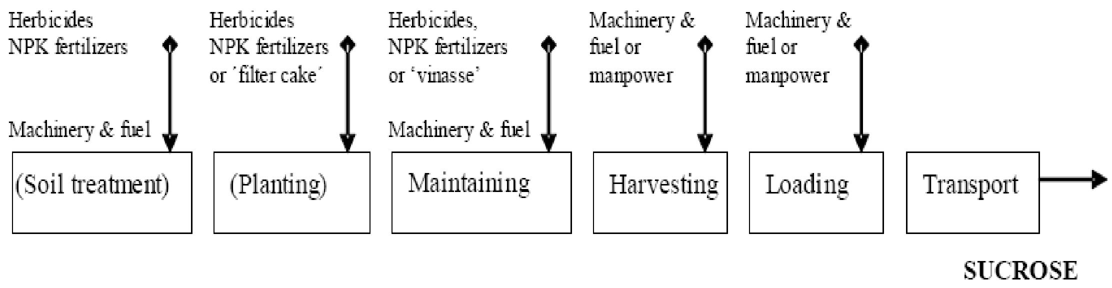


Figure 4: Simplified overview of sugarcane production and transportation
Source: SMEETS et al., 2006

In the sugarcane-based bioethanol agroindustry, all energy consumed in the process can be supplied by a heat-and-power production system (cogeneration system) installed in the mill, using only bagasse as an energy source[12]. Actually, many sugarcane mills all over the world produce a significant part of the energy they consume. Particularly in Brazil, mills are energy self-sustained and they often manage to export increasing amounts of electric power surpluses to the public grid, thanks to the growing use of energy-efficient equipment, as discussed in Box 1 (BNDES, 2008). From the juice obtained from the crushed process both sugar and ethanol can be produced depending on the market.

The figure 5 ahead shows the whole process of production of sugar and alcohol from sugarcane, illustrating the possibilities for the mill to choose which product is the best one to be produced considering market situation.

[12] Bagasse is the by product of sugarcane crushing process, 50% wet. For each ton of sugarcane crushed, around 300 kg of bagasse are produced. This huge amount of bagasse produced was the main factor which influenced the mills in burning it in boilers.

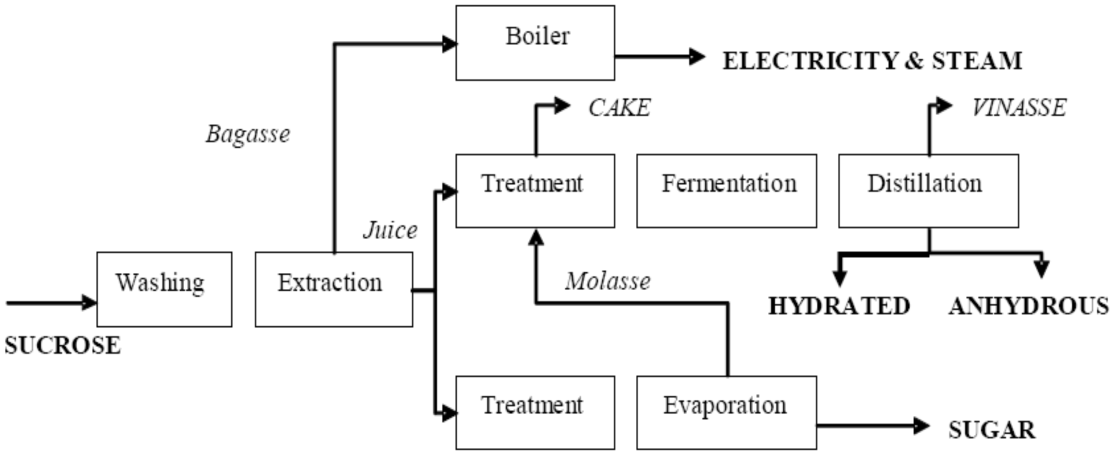


Fig 5 - Simplified overview of the industrial ethanol production process.
Source: SMEETS et al., 2006

Box 1: Electricity production from residual sugarcane biomass

Considering sugarcane production in 2006 (425 million tons), about 3.5 TWh of surplus electricity could be produced and commercialized. However, for the same amount of sugarcane produced, but using both sugarcane bagasse and trash (e.g., leaves of the sugarcane plant) as fuels, the potential would be 5-7 times higher than what has been produced (BNDES, 2008).

UNICA (2008) estimates that in 2007 the electricity production from sugarcane bagasse contributed with 3% of the total electricity production in Brazil. The installed capacity of electricity production at the sugarcane mills is estimated as about 3,400 MW (ANEEL, 2008), being about 1,800 MW the capacity of surplus electricity production. The potential of surplus electricity production is evaluated by UNICA (2008) as 11,500 MW and 14,400 MW in 2015 and 2020, respectively, what could contribute with 15% of total electricity production. The same organization estimates that in the current breakdown of revenues of sugarcane industry the selling of surplus electricity contributes with only 1%, but this figure could reach 16% in 2015.

2.1.3. POTENTIAL FOR BRAZILIAN SUGARCANE BIOETHANOL

The perspectives of the Brazilian bioethanol market are different from other countries because of the maturity of its biofuel program and the large expansion observed in bioethanol consumption and production capacity.

The estimates of future scenarios are not an easy task because of the intense dynamics observed in the bioethanol agroindustry, in which new projects are frequently implemented to meet the growing internal demand. However, some conservative production and consumption estimates are obtained for the period of interest.

The bioethanol production estimate is based on the production for 2008/2009 (27.5 billion litters) and considers an annual growth rate of 8%, which is consistent with the evolution observed in recent harvests and the number of projects currently under implementation and expected to become operative (35 new plants in the 2008/2009 sugarcane crop season and 43 units in the next season) (NASTARI, 2008). That yields a bioethanol production estimate of 30.5 billion litters in 2010. During the next years the foreign market should become more important allowing bioethanol production capacity to reach about 47 billion litters by 2015, which is equivalent to a 9% annual growth rate (MILANEZ et al., 2008).

Traditionally, sugar producing units were family-owned enterprises such as Costa Pinho, São Martinho, and Santa Elisa, but new ones are owned by Brazilian companies including Votorantim, Vale and Odebrecht. Also there are foreign companies entering the sugarcane business, including French (Tereos, Louis Dreyfus), Spanish (Abengoa), British (BP) and Japanese (Mitsui, Marubeni) groups.

The financial sector is also quite visible, including Merrill Lynch, Soros, and Goldman Sachs. The presence of foreign investors has given the sector a new dynamism and new concepts of management, but as of 2007, investments by foreigners were only 12 % of the total (GOLDEMBERG and GUARDABASSI, 2010)

Regarding bioethanol demand, it is important to point out that previous estimates for the Brazilian market underestimated real consumption, because of the market expansion caused by the introduction of flex-fuel vehicles.

This new technology is a source of uncertainty for demand estimates because [as already mentioned - drivers can choose using pure bioethanol, gasohol blended with bioethanol in any proportions, or the straight gasohol, also available in the market. In addition, the government can change the bioethanol blend between 20% and 25%. Finally, the margin of error of consumption estimates increases because of the uncertain petroleum price scenario. Based on the evolution of the small-size vehicle fleet and fuel consumption patterns, internal bioethanol demand for Brazil is estimated to be in the range of 28 - 34.3 billion litters by 2015 (BNDES, 2008).

The estimate considers that 50% and 70% of consumption by flex-fuel vehicles, respectively, is met by hydrated bioethanol (MILANEZ et al., 2008). The study presents several estimates of the Brazilian bioethanol market, which show reasonable dispersion. Also following a conservative approach, it was assumed that bioethanol production will be used to meet the needs of the domestic market; exports are estimated at 5 billion litters by 2010 (which is equivalent to exports in 2008) and 10 billion litters in 2015, when the international bioethanol market should be better structured. It is important to stress that the domestic bioethanol demand estimates correspond to vehicular uses and industrial applications, segments that have shown significant expansion in Brazil during the course of the last few years (BNDES, 2008).

Perspectives for ethanol from sugarcane in Brazil seem quite positive considering economic aspects. At present, ethanol from sugarcane in Brazil is the cheapest biofuel in the world, and the price is competitive with fossil fuels (taking into account the recent increase in oil prices).

Presently, there are no subsidies for anhydrous or hydrated ethanol production. Hydrated ethanol is sold for 60–70% of the price of gasohol at the pump station, due to significant reductions in production costs. These results show the economic competitiveness of ethanol when compared to gasoline (GOLDEMBERG et al., 2003).

Since the creation of PROALCOOL, prices received by ethanol producers were determined by the federal government, as were the prices of fuels in general. In May 1997, the price of anhydrous ethanol was liberalized, and the same occurred with the price of hydrated ethanol in February 1999.

In 2003, the flexible fuels were launched in Brazilian market, and reversed the decline in ethanol production, even in the absence of any subsidy. The new flexible-fuel cars, that can use any mixture of gasohol and hydrated ethanol, gave the consumers assurance about fuel availability, and the capacity to choose the cheapest of both fuels available at any moment and place. This proved to be a powerful argument in years of rising gasoline prices. By 2008, 89% of all new cars sold were flex-fuel type, and ethanol Brazilian market was again buoyant. Besides, a new and strong demand appeared since 2004, in the form of ethanol exports to Japan, USA, and Europe.

As shown in Table 2 the ethanol production, domestic consumption and exports of Brazil have been steadily growing in the last 5 years. Average increase of ethanol output has been 1.9 between 2002 and 2006; of which 1.2 million m^3 per year for the domestic market and 0.7 million m^3 per year for the export markets (RIEGELHAUPT et al, 2009).

Table 2: Development of domestic and external ethanol markets, Brazil

Season	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009
Sales, domestic market, Mm^3	11.8	13.8	12.9	13.3	14	18.9	27.5
Production, Mm^3	12.62	14.8	15.4	15.9	17.7	22.5	22.8
Exports, Mm^3	0.82	0.96	2.48	2.62	3.69	3.62	4.7
Final use	E25/E100						
Market substitution	n.a.	3.5% of light cars sold	21.5% of light cars sold	53.2% of light cars sold	83.1% of light cars sold	89% of light cars sold	95% of light cars sold
Number of commercial plants	321	n.a.	n.a.	n.a.	375	421	434

Source: UNICA 2010

Most sugar mills/ethanol distilleries in Brazil can alternatively produce sugar or alcohol in a variable ratio; between 40 to 60% of sugarcane can be processed into ethanol. Brazil is the first global exporter of sugar, but sugar prices are quite volatile, having oscillated from 0.18 to 0.09 US$ per pound (453.6 grams) in the last 3 years. Oil prices have been far more volatile, and ethanol price reflects the combination of these two independently varying factors. Brazilian government, as the owner of PETROBRAS, finally covers the difference between international and domestic gasoline price, which can be positive or negative.

2.2. BIODIESEL IN BRAZIL

2.2.1. CURRENT POLICIES FOR BIODIESEL IN BRAZIL

The Brazilian Biodiesel Program is much more recent than the Alcohol Program and so corresponding legislation is also more recent. In a similar way to the Alcohol Program, the Biodiesel Program established the mandatory blend of biodiesel in mineral diesel aiming to create a market for the product.

In 2003, Brazil created the National Biodiesel Production and Utilization Program (PNPB), which, by means of the Federal Government, aims to sustainably implement, both technically and economically, the biodiesel production and utilization, with focus on social inclusion and regional development, by generating jobs and income.

The Law N. 11097, below, published in January 2005, introduced biodiesel in the Brazilian energy matrix. A minimum blend of 5% biodiesel in diesel fuel sold in the country was set; but this percentage should be achieved in a period of eight years.

From July 1st, 2008 on, all the diesel fuel sold in Brazil must contain 3% of biodiesel. This rule was established by Resolution N.2 of the Brazilian Energy Council (CNPE), published in March 2008, which increased from 2% to 3% the mandatory blend of biodiesel in diesel. However, due to the high production of biodiesel the government anticipated the timetable and established the B5 blend to January 2010. In order to meet the B5 goal, studies show that around 2.3 billion litters of vegetable oil will be necessary. Therefore, it is not possible to consider a single species of oleaginous plant as raw material supplier to fulfil such goals (CAMARA, 2006).

- **Law No. 11.097**

The Law Number 11.097, published on January 2005, introduced biodiesel in the Brazilian energy matrix. The minimum percentage required for the addition of biodiesel to diesel fuel sold in the country was set at 5%, this percentage being achieved in the period of eight years. It must be noted that the manufacturers of diesel engines were against higher blends and so the program started with a blend of only 2% of biodiesel.

- **Resolution CNPE 6/2009**

From 1 January 2010, all the diesel fuel sold in Brazil must have, necessarily, 5% of biodiesel. This rule was established by Resolution 6 of the Brazilian Energy Council

(CNPE), published in September 2009, which increased from 4% to 5% the percentage of mandatory blending of biodiesel to diesel oil.

- **RESOLUTION ANP number 07, DE 19.3.2008 – Technical Regulation ANP number 01/2008**

This Technical Regulation applies to biodiesel, national origin or imported, to be commercialized in national territory added, according to the relevant laws applicable to diesel oil, in accordance to the specification in force, and in specific blends authorized by the ANP.

The determination of biodiesel characteristics will be made using the standards of the Brazilian Association of Standardization (ABNT), international standards "American Society for Testing and Materials (ASTM), the International Organization for Standardization (ISO) and European Committee for Standardization (CEN).

The analysis of the product must be performed on a representative sample obtained by methods ABNT NBR 14883 - Petroleum and petroleum products - Sampling manual or ASTM D 4057 - Practice for Manual Sampling of Petroleum and Petroleum Products (*Prática para Amostragem de Petróleo e Produtos Líquidos de Petróleo*) or ISO 5555 (Animal and vegetable fats and oils - Sampling).

2.2.2. Technology for Biodiesel Production in Brazil

The biodiesel production can be made from new or residual vegetable oils and from animal fat, and a series of technological processes can be used, the most common ones being the alcoholic transestherification by acid, basic or enzymatic catalytical route, the direct estherification and the catalytical or thermal cracking.

In Brazil, the production process of best relation between economics and efficiency is by the alkaline alcoholysis route. Considering the obtainment of ethylical/methyical esters, the most adequate process is transestherification (Figure 6) using sodium hydroxide as catalyzer and being able to obtain, besides the ester as main product, also glycerol and other liquid fatty acids as byproduct (MAPA, 2003).

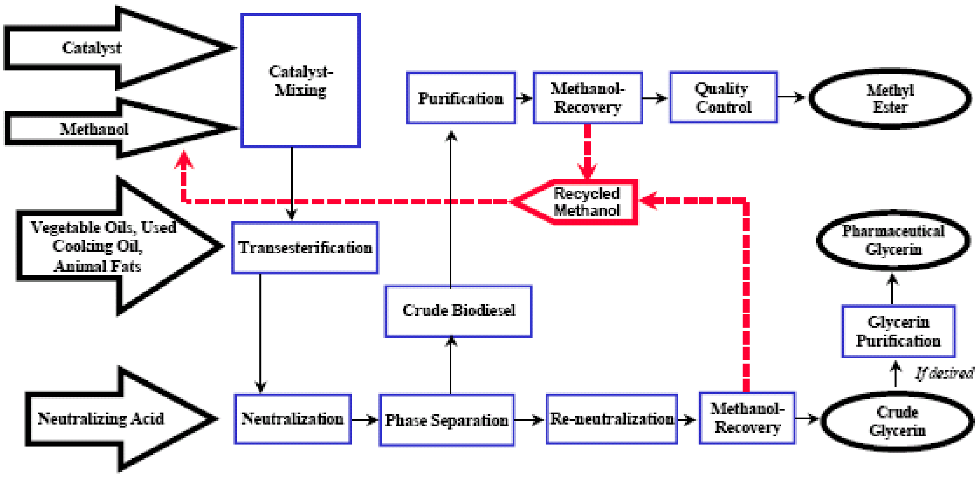


Figure 6: Simple flow chart of biodiesel production
Source: National Biodiesel Board, 2007

Biodiesel refers to a non-petroleum-based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters of several fatty acids, which can be used (alone, or blended with conventional diesel) in unmodified diesel engine vehicles.

Reacting one part of vegetable oil with three parts of methanol, which is the most common used alcohol, one can get three parts of methyl esters and one part glycerol. In practical terms, the volume of biodiesel will be equal to the input volume of vegetable oil. Transestherification is basically a sequential reaction. Triglycerides are first reduced to diglycerides and then to monoglycerides. The monoglycerides are finally reduced to fatty acid esters (BALLESTEROS E MANZANARES, 2009).

For each 1% of caustic soda used as catalyzer, 7% of liquid fatty acids will be originated, from which it will be possible to recover about 6% in weight of the initial total of fatty matter. However, the glycerin and fatty acids recovering facilities are still much more expensive than the semi-continuous or descontinuous transestherification instalment itself (MAPA, 2003).

Related to the utilization of co-products, in the case of Brazil, biodiesel industry produces 105,000 tons of glycerine per year. Brazil consumes 30,000 to 40,000 tons annually of glycerine, also as by-product of the soap industry. As more and more crude glycerine is continuously generated from the biodiesel industry, it is very important that economical ways for glycerine utilization be explored to further defray the cost of biodiesel production in the growing global market (BALLESTEROS E MANZANARES, 2009).

It must be noticed, again, that in Brazil biodiesel is produced through the transestherification reaction using methanol (as in Europe) and not ethanol, as one could expect, considering the huge amount of ethanol produced in the country. However, as already mentioned above, the use of ethanol seems pose technological problems and most industries do not consider this possibility, excepted Fertibom[13], in Sao Paulo State, which informs that they can produce biodiesel both from methanol and ethanol.

The large amount of glycerine produced in the reaction and the difficulties to separate it from the biodiesel obtained are the main reason presented for not being used ethanol. However some universities like UFPR (Federal University of Parana) and State University of Pernambuco are among those already working to solve these problems at least in laboratory scale. However pilot plants are necessary to allow the solution of such difficulties and in this case, the experience of Fertibom industry could collaborate to it.

Owner of a big territorial extension, Brazil presents a wide diversity of raw materials for biodiesel production. However, the viability of each raw material will depend on its respective technical, economic and socio-environmental competitiveness, considering even important agro-economic aspects, such as (RAMOS, 1999 and 2003):

a) content in vegetable oils;

b) agricultural productivity (production per unit of area);

c) agro-economic balance;

d) attention to different production systems;

e) cultural cycle (seasonality);

f) regional adaptation, which must be wide to attend to different edaphoclimatic conditions; and

[13] www.fertibom.com.br

Figure 7 below illustrates the different possibilities for oleaginous plants in Brazil.

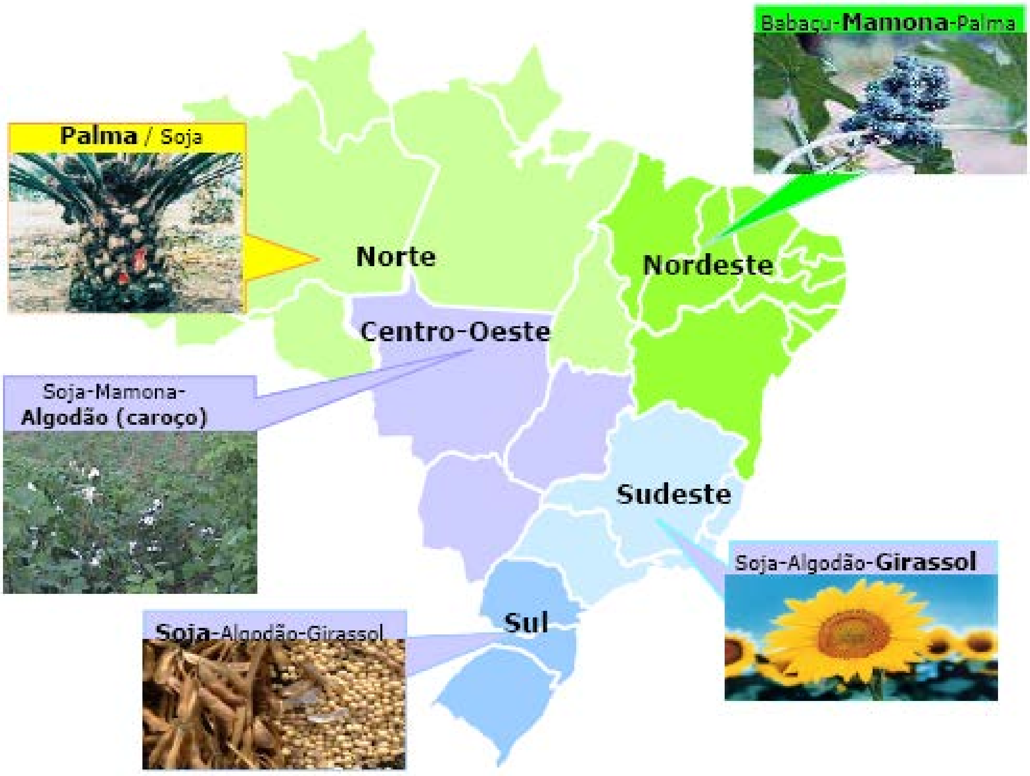


Figure 7: Different oleaginous plants in Brazil for each region.

Source: MEIRELLES, 2003

Table 3 shows yields of oleaginous crops. The oleaginous crops from sunflower (38-48%), castor (43-45%), babassu (66%) and from palm oil (20%) are significantly richer in oil when compared to the soybean grain (17%).

Table 3. Oleaginous characteristics

Oleaginous plants	Oil content (%)	Cycles (years)	Months of harvest	Productivity (ton oil/ha)
Palm oil	20	8	12	3.0-6.0
Babassu	66	7	12	0.1-0.3
Sunflower	38-48	annual	3	0.5-1.9
Rapeseed	40-48	annual	3	0.5-0.9
Castor	43-45	annual	3	0.5-0.9
Soy bean	17	annual	3	0.2-0.4
Cotton	15	annual	3	0.1-0.2

Source: COSTA and SANTOS, 2008

Castor oil was considered at the beginning of the program as a potential possibility for semiarid, collaborating to reduce poverty in this region. However, as discussed in the next section, results were not positive for several reasons. Therefore, despite the fact that soybean presents the lowest yield when producing biodiesel, it has been the most used crop since it has been completely attending the Brazilian biodiesel production, due to its inherent scale production. More recently biodiesel from animal fat is also increasing its participation in the biodiesel production due to the low prices of the raw material. However since animal fat started to be used for biodiesel production, its prices showed a significant increase in the market.

In Brazil, after the production, any fuel must attend specifications determined by the National Petroleum Agency (ANP). The first Brazilian specification for biodiesel was released on September 15th, 2003, after months of public consultation.

In 2008, a Technical Regulation was applied to national and imported biodiesel to be sold on the domestic market, according to the relevant laws applicable to diesel, in accordance to the specification in force, and in specific blends authorized by the ANP.

The determination of biodiesel characteristics will be made using the standards of the Brazilian Association of Standardization (ABNT), and international standards "American Society for Testing and Materials (ASTM), the International Organization for Standardization (ISO) and European Committee for Standardization (CEN).

The analysis of the product must be performed on a representative sample obtained by methods ABNT NBR 14883 – Petroleum and petroleum products – Sampling manual or ASTM D 4057 – Practice for Manual Sampling of Petroleum and Petroleum Products (*Prática para Amostragem de Petróleo e Produtos Líquidos de Petróleo*) or ISO 5555 (Animal and vegetable fats and oils – Sampling).

2.2.3. POTENTIAL FOR BIODIESEL IN BRAZIL

Studies show that the area cultivated only with soybean to meet the B5 goal would be of about 3,750,000 hectares, that is, 18% (B5) of the area currently cultivated (21,000,000 ha) with soybean in Brazil (CAMARA, 2006).

By applying the same study for the castor oil plant culture, there would be the need to cultivate 7,000,000 hectares for B5. To show what it represents, it must be registered that the current national cultivated area with castor is of approximately 180,000 hectares, considering that among the cultures of oleaginous plants of annual cycle (peanut, canola, sunflower and castor), “the castor culture occupies the second rank in cultivated area” (CAMARA, 2006). In the case of castor oil, there is an additional problem. This oil has other end uses which are much more economically competitive and subsidies would be needed to make it competitive with diesel oil (MENDES and COSTA, 2009).

Therefore, greater researches and technological development will be needed with agricultural cultures such as castor, peanut and sunflower to improve agricultural productivity, besides the incentive for biodiesel production from residual raw materials or animal fat.

2.4 Sustainability aspects of biofuels in Brazil

This issue has been raised all over the world since several studies have showed concerns related to the sustainability of biofuels production, including crop expansion, use of water, contamination of underground waters, atmospheric emissions, competition with food and so on (FARGIONE *et al.*, 2008, SEARCHINGER *et al.*, 2008),

However it s already well known that these studies consider only the worst case, corresponding to the production of biofuels from deforestation of native forest. In fact, several other studies, more recent (GOLDEMBERG, 2008; GOLDEMBERG et al, 2008; GOLDEMBERG and GUARDABASSI, 2010; NASSAR et al., 2010) have shown that the production of biofuels can be done in a sustainable way, as it is happening in Brazil and is possible to be replicated in other countries.

This session intend to discuss these issues deeply. Sustainability of biofuels includes not only environmental but also social aspects, as discussed ahead, and it is considered nowadays as a fundamental issue for the international market.

2.4.1. Environmental and Social Aspects on Sugarcane Ethanol in Brazil

Despite the fact that the main reason for the introduction of the Alcohol Program in Brazil was to reduce expenditures with oil imports, soon the environmental aspects related to ethanol production became more and more important allowing several studies in Brazil, and then major policies have been implemented to allow sustainability criteria. The main topics related to the ethanol environmental sustainability are:

- **Water**

In general there is enough water to supply all foreseeable long-term water requirements in the Centre-South region of Brazil as whole, but local water shortages can occur as a result of the occurrence of various water uses and water polluting sectors (agriculture, industry) and/or cities and the uncontrolled use of water and uncontrolled dumping of wastewater.

No detailed information is readily available about in which areas water shortages may occur in the Centre-South and what the contribution is of sugarcane and ethanol production to these problems.

Sugarcane production is mainly rain fed, which is generally not perceived as a problem, but the use of irrigation is increasing mainly in North eastern region. The use of water use for the production of ethanol from cane is a significant problem (SMEETS et al., 2006), but it is being solved nowadays in Brazil.

As discussed in Coelho et al, 2010, one of the most important issues related to water pollution in sugarcane industry is the adequate disposal of vinasse. Vinasse is a black liquid derived from alcohol distillation and fermentation, as already mentioned; this by-product is rich in organic matter with an acid pH (4 to 5). It is potentially pollutant to water because of its composition and high temperature. Therefore, it cannot be discharged directly on rivers, what is forbidden all over the country.

In the beginning of the program there was any control on vinasse disposal from the mills and in most cases it was disposed in rivers, being responsible for high pollutant impacts. Then solution to dispose this by-product was found and it started to be recycled and used it in fertirrigation. For some time it was used for this fertirrigation but without any control; so impacts related to the contamination of underground waters became important.

Then, in 2006, in Sao Paulo State, the Environmental Agency – CETESB – started to control the amount of vinasse disposed on soils, aiming to avoid this contamination of underground water[14]. Nowadays, other states are also introducing the same control for the licensing of the mills.

Also there are now some initiatives aiming to reduce the amount of vinasse produced using systems for concentrating it[15]. Through the introduction of such systems, the amount of vinasse produced decrease to 5 liters per liter of ethanol produced.

Besides that, local environmental agencies all over the country are controlling the maintenance of riparian forests nearby sugarcane crops and requiring the reforestation of such areas with native forests, according the Federal Forest Code, aiming to guarantee the quality of water in rivers. In fact it must be noted that this Code only states that it is forbidden to jeopardize the growing (or re-growing) of riparian forests, but environmental agencies are requiring more than that: they consider mandatory the conservation (and/or reforestation) of these riparian forest of the plantations. This is an important issue since it protects the quality of water in rivers.

Water is used in two ways in producing sugarcane and ethanol. First, large quantities of water are needed to grow the cane. The cane requires significant rainfall, in the range of 1,500 to 2,500 mm a year, ideally spread uniformly across the growing cycle. Most of the sugarcane production in Brazil relies on rain fall, rather than irrigation, including nearly the entire São Paulo State sugarcane-producing region. Large amounts of water are also used to convert sugarcane to ethanol. In 1997, this amount was calculated as cubic meters per tone of cane, from which 87% was used in four processes inside the plant.

In general there is sufficient water to supply all foreseeable long-term water requirements in the Centre-South region of Brazil as whole, but local water shortages can occur as a result of the occurrence of various water using and water polluting sectors (agriculture, industry) and/or cities and the uncontrolled use of water and uncontrolled dumping of wastewater. No detailed information is readily available about in which areas water shortages occur in the Centre-South and what the contribution is of sugarcane and ethanol production to these problems. Sugarcane production is mainly rain fed, which is generally not perceived as a problem, but the use of irrigation is increasing. The use of water use for the production of ethanol from cane is an important problem (SMEETS et al., 2006), but it is being solved nowadays in Brazil.

[14] Cetesb Technical Rule P4.231 *(*2005); www.cetesb.sp.gov.br
[15] Luiz Antonio Magazoni, magazoni@cerradinho.com.br

In general lines, there is one process for sugarcane washing and three other industrial processes for ethanol production. Water consumption has substantially decreased in recent years. Nowadays, most of the water used is recycled and a dry washing process is replacing the standard wet-washing process.

In addition, sugarcane is 70% water, which should provide enough for all the steps needed in ethanol production. There are distilleries being developed to be self-sufficient regarding water consumption[21]. Also, nowadays the dry cleaning if sugarcane is being introduced in several mills, reducing the water consumption in the process[16].

To ensure an efficient use of fresh water resources, legislation is being implemented in some regions. This legislation includes the billing of water, for both the agriculture and the industry. In SP, a State Plan on Water Resources (*Plano Estadual de Recursos Hidricos* or *PERH*) was made that includes data on and projections of the water demand in SP.

The following environmental aspects are based in Coelho at al, 2010.

- **Soil Quality**

Sugarcane culture has become more sustainable over the years as some practices have been introduced insuring the appropriate use of fertilizers and soil protection against erere teosion, soil compaction and moisture loss. In Brazil, some soils have been producing sugarcane for more than 200 years, with no yield reduction. Sugarcane culture in Brazil is well known for its relatively small loss of soil to erosion, especially when compared to soybeans and corn.[18]

Nowadays, with the introduction of the green harvesting of sugarcane, a significant discussion is on the way, related to the amount of residues that should be left in the field to protect the soil. Studies from EMBRAPA[17] show the importance of the sugarcane residues left in the soil, since they protect the soil and allow the infiltration of water in the soil and reduce erosion, among other benefits.

- **Agrochemicals**

Many inorganic compounds are introduced during the production of ethanol, including chemicals that kill weeds, insects, mites, and fungi, along with defoliants and other

[16] Luiz Antonio Magazoni, magazoni@cerradinho.com.br
[17] EMBRAPA – Brazilian Enterprise for Agricultural Research - Ministry of Agriculture. "A importancia de nao queimar a palha na industria da cana de açúcar". Technical paper, March, 1991. http://www.cnpab.embrapa.br/publicacoes/download/cot005.pdf

chemicals that help the cane to mature more quickly. In one hand, fewer agrochemicals are used in sugarcane production than for some other crops. Pesticide consumption per hectare for sugarcane is lower than for citrus, corn, coffee, and soybeans. On the other hand, sugarcane requires more herbicides per hectare than coffee, but still less than do citrus, corn, and soybeans. Furthermore, comparing Brazil's major crops (those grown on areas larger than one million hectares), sugarcane uses smaller amounts of fertilizer than cotton, coffee, and oranges, and about the same amount as soybeans. Sugarcane also uses less fertilizer than sugarcane crops in other countries, for instance, compared to Australian sugarcane growers use 48 % more fertilizer than Brazilians.[22]

One practice that helps here is using industrial waste as fertilizer, especially vinasse. This has led to a significant increase in productivity and in the potassium content of the soil.[23] Genetic research, especially the selection of resistant varieties, has made possible to reduce the diseases affecting sugarcane, such as the mosaic virus, sugarcane smut and rust, and the sugarcane yellow leaf virus. With genetic modifications, some are now being field tested, plants are more resistant to herbicides, fungus, and the sugarcane beetle. At present, there are more than 500 commercial varieties of sugarcane.

- **Air pollution**

Besides the advantages of sugarcane ethanol replacing gasoline in engines, with most of pollutant emissions being reduced, also atmospheric emissions in sugarcane ethanol production must be addressed. In this area there are two issues to be considered. Atmospheric emissions from sugarcane burning before harvesting and those from bagasse burned in boilers for cogeneration.

The sugarcane burning before harvesting practice was introduced in Brazilian sugarcane fields after the fifties, aiming at higher productivity of the sugar cutter workers[18]. This practice eliminates the leaves of the sugar cane cleaning the way to proceed with the manual or mechanic harvesting. Ripoli et al. (2005)[19] also affirms that up to 90% of undesirable vegetal matter can be removed from the harvesting feedstock. Another reason for the burning is to avoid accidents with poisonous snakes and spiders.

[18] RIPOLI et al., 2005.
[19] RIPOLI et al., 2005.

There are serious drawbacks such as damaging the tissue of sugarcane, disturb the soil structure enhancing the possibility soil erosion[20]. Besides, there is an increase of pollutants such as particulate matter, carbon monoxide and methane; locally it can increase the troposphere ozone concentration. Yet, according to Ripoli et al. (2005) there are several implications to the industrial phase like difficulties in the purification, need for faster utilization of the feedstock due to the shorter period for exteriorization. It is important to emphasize that elimination of the burning practice raises the energy balance of the sugarcane, which means more energy is produced. Even though the burning is a controlled fire in a delimitated area with maximum duration of ten minutes[21] it might represent risks to the grid cables, roads and highway. Harvesting manually the green cane is possible, but the celluloid leaves can hurt if none protection equipment is used. Sugarcane burning enhances the level of organic compounds, particulate matter and methane.

Recently, environmental legislation establishing the phase out of sugarcane burning in the State of Sao Paulo was introduced (State Law 11.241, 19 September, 2002), as showed in Figure 11 ahead, and, further on, it was signed the so called Green Protocol. This protocol, is to a voluntarily one (4 June, 2007), signed between the Government of Sao Paulo State, thorugh its Environmental Secretariat and its Secretariat for the Agriculture, together with the Sugarcane Agroindustrial Sector of Sao Paulo State, reducing the timetable for the elimination of the burning process[22]. Also in many other states the local environmental agencies are requiring the harvesting of green cane as one of the exigences for the environmental licensing.

Therefore, in the State of São Paulo, in 2008/2009, 49% of the cane was harvested mechanically (SMA, 2010) (Figure 8). It is important to remind that 80% of the sugarcane produced in Brazil is from the Centre-South producing region where the State of São Paulo is located. Therefore, the legislations aforementioned are driving forces stimulating the mechanization of the sugarcane harvesting.

[20] CENBIO, 2006.
[21] UNICA, 2007.
[22] To anticipate from 2021 to 2014 de elimination of sugarcane burning in the state, as well as increasing the percentual of green cane harvesting from 50%to 70% in 2010, for soils with slope until 12%; for slopes higher than 12%, to anticipate from 2031 to 2017 and to increase the harvesting of greencane from 10 to 30% in 2010.

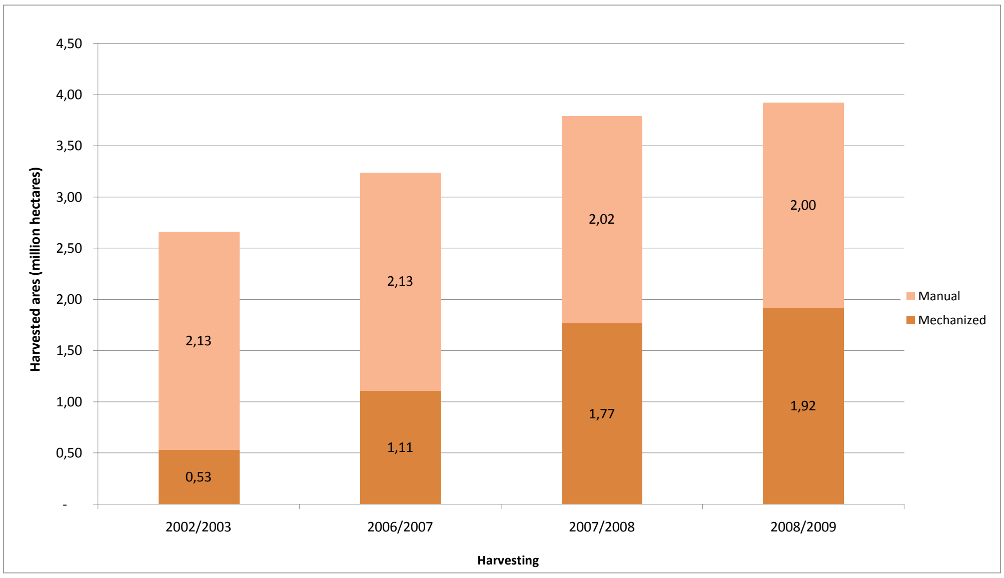


Figure 8: Evolution of Mechanical Harvesting in the State of São Paulo (Law 11,241/2002)
Source: SMA, 2010

These legislations aim at environment issues whereas sugarcane burning practice can realize emissions of carbon monoxide, methane and particulate matter causing air pollution and diseases. Besides, cane burning may affect the plant itself having an outcome in the industrial phase it also represent risks to forest and biodiversity[23].

Regarding the burning of bagasse in boilers for cogeneration, despite the advantages of this process for the industrial productivity of sugarcane ethanol, there are pollutant emissions to be controlled. Even considering that there is no sulphur emissions in biomass, there are particulate matter and NO_x emissions to be controlled. Both are emissions easily controlled and there are adequate environmental legislation in the country do so (CONAMA – Federal Council for Environment). Therefore there are now limits for emissions (particulate matter and NO_x) from such equipment established by CONAMA[24].

Besides that there is a special legislation in Sao Paulo State (Decree N. 48.523, March 02, 2004[25]), which establishes additional requirements in regions where the so called Suport Capacity is near its limits. This Decree allows the Environmental Agency

[23] RIPOLI, 2005.
[24] CONAMA – Federal Council for the Environment – Ministry of Environment – Resolution N.382, 26 Dec, 2006.. http://www.ima.al.gov.br/legislacao/resolucoes-conama/Resolucaon20382.06.pdf
25 WWW.cetesb.sp.gov.br

CETESB to impose more strict rules (or even to refuse) for the installation of a new plant in an area where atmospheric pollutants concentration is near the adequate lmits.

- **Land use, forest protection and biodiversity**

The trade-off for the facility created by the burning practice might also represent the biodiversity loss, since sugar cane fields are the habitat of many species. Biodiversity encompasses a number of services provided by a chain organisms and reactions capturing energy and producing food, fuel, fiber and medicines[26]. In developing countries 80% of the people depend on medicine that originated from flora or fauna[27]. Biodiversity stability relies on the resilience of the system, being critical to find out the effects of species addition or loss[28]. Ripoli et al. (2005) comments that despite none specific scientific study about the worsening of the fauna has been found, one can deduce that it is affected by the fire. The introduction of the harvesting of sugarcane allowed the increase in biodiversity in such regions.

The impact of the sugarcane production on biodiversity can be summarized as follows: the direct impact of cane production on biodiversity is limited, because cane production replaces mainly pastures and/or food crop and sugarcane production takes place far from the major biomes in Brazil (Amazon Rain Forest, *Cerrado*[29], Atlantic Forest, *Caatinga*, *Campos Sulinos* and *Pantanal*[30]).

Concerns related to the conservation of native forests and other important biomes are always presented and some studies even consider that any bioenergy crop comes from deforestation (FARGIONE *et al.*, 2008, SEARCHINGER *et al.*, 2008, WORLD BANK, 2008). However these studies only consider the worst case, which is not currently occurring, since biofuel production is not expanding into pristine tropical forests. If that did happen, of course, it would release a large amount of CO_2, but extensive studies have been conducted on the CO_2 releases resulting from other agricultural practices that do not involve deforestation, and the results are much less alarming (CERRI *et al.*, 2007). Nevertheless, other studies such as Goldemberg (2008), among others (referenced ahead) show that this is not adequate and bioenergy crops are being expanded in pasture lands without deforestation.

[26] TILMAN, 2000.
[27] FUNBIO, 2003.
[28] McCANN, 2000.
[29] The Brazilian Savannah
[30] Wetlands

In 2007, the land availability for agriculture in Brazil was 355 million hectares, from which 21% had already been used for agricultural purposes and the area occupied by sugarcane ethanol accounted only for 1.5% (UNICA 2009).

Moreover, there were 30% available land and 49% was occupied by pasture land. In this land there is the possibility of expansion of agricultural crops, like has already occurred in the state of São Paulo through the replacement of pastures, which have become more intensive (LORA, 2006).

In 2001, in the state of São Paulo, the average number of heads of cattle per hectare was 1.28. As of 2008, it had increased to 1.56 because of the expanding sugarcane plantations pressuring cattle grazing. In the country as a whole, the density is even lower, at closer to one head per hectare. In fact, if the 200 million of hectare currently occupied by the low density cattle breeding would be used more intensively, 60 million hectares would be free for food and energy crops (GOLDEMBERG *et al.*, 2008).

The Brazilian sugarcane crops expansion is concentrated in the Center-South production region that does not encompass important biomes like Amazon Rain Forest, the Atlantic Forest and the Pantanal (SMEETS *et al*., 2006). The deforestation in the Amazon basin is linked closely with the raising of cattle for meat, for both domestic consumption and export; it is not linked with ethanol production. Today, Brazil has approximately 200 million heads of cattle on 237 million hectares (IBGE, 2009b). If this cattle could grow in a more intensive way, reaching 1.5 heads for hectare (which is not yet an intensive growth), we could have around 60 million hectares available.

Furthermore, as already been mentioned, recent studies from Nassar *et al*, 2009 and Nassar et al, 2010 have analyzed Indirect Land Use Changes (ILUC), showing that there is no concrete evidence that sugarcane expansion crops is producing deforestation. These studies allowed that the Environmental Protection Agency (EPA) from United States recognized that sugarcane ethanol indeed reduces carbon emissions.

- **Greenhouse gas emission and energy balance**

Without examining in detail impact of land-use changes[31], several studies were already carried out to assess energy and environmental impacts of biofuels. In the case of

[31] This is a subject matter that deserves attention; further research is then necessary to consistently estimate the actual share of such emissions in the biofuels lifecycle

sugarcane bioethanol production in Brazil several environmental advantages are already known, especially considering the replacement of gasoline and GHG emissions reductions, since the disclosure of first detailed studies on the subject (MACEDO and HORTA NOGUEIRA (1985) and MACEDO (1992)). Since then, updating studies have been published (MACEDO (1998) and MACEDO et al. (2004)), following up the development of agroindustrial practices and the improvement of knowledge on environmental aspects of the sugarcane industry in general.

The last assessment study published analyzes the energy and GHG emission balances for the current situation and for a 2020 scenario, considering an approach "from sugarcane crops to the mill gate" (MACEDO et al., 2008). The study concludes that nowadays — based on the average rates of key agricultural and industrial parameters of 44 mills in the Center-South Region of Brazil — for each fossil energy unit used to produce sugarcane bioethanol, more than nine renewable energy units are produced, in the form of bioethanol and surpluses of electric power and bagasse. Moreover, the ratio of energy production to energy consumption is expected to increase above 11 by 2020, even in a scenario of higher mechanization and use of agricultural technologies that increase the energy demand by 12%, mainly because of the increase in bioethanol production per unit of processed sugarcane and the significant increase of electric power production.

Regarding GHG, current production of sugarcane anhydrous bioethanol involves emissions of almost 440 kg CO_2eq/m^3 of bioethanol, with prospective reduction in the years to come. In addition, bioethanol use in 25% gasoline blends — as adopted in Brazil — results in a net GHG emission reduction of around 1,900 kg CO_2eq/m^3 of bioethanol, in current conditions, and it will possibly reach levels above 2,260 kg CO_2eq/m^3 of bioethanol by 2020. The net increase in emissions reduction will be associated to the use of bagasse and electricity surpluses and net emissions avoided (resulting from the difference between emissions in production and emissions avoided).

- **The Brazilian environmental legal framework regulating ethanol production**

The Brazilian environmental legal framework is complex and one of the most stringent and advanced in the world. As an agribusiness activity, the ethanol/sugar industry has several environmental restrictions that require appropriate legislation or general policies for its operation. Some of them are pioneers in the area which define principles in order to maintain the welfare of living beings and to provide resources for future generations: the first version of the Brazilian forest code dated from 1931, already addressed the need to combine forest cover with quality of life and livelihoods (ZUURBIER and VOOREN, 2008).

They also involve frameworks such as the Environmental Impact Assessment and Environmental Licensing, among others, especially for the implementation of new project: i.e. greenfield projects in Brazil are being stringently assessed using these frameworks.

Volunteer adherence to Environmental Protocols represents also a major breakthrough for the sugar business. For example: *'Protocolo Agroambiental do Setor Sucroalcooleiro'* (Agriculture and Environmental Protocol for the Ethanol/Sugar Industry) signed by UNICA and the Government of the State of São Paulo in June 2007 deals with issues such as: reducing timetable for green havesting of sugarcane, conservation of soil and water resources, protection of forests, recovery of riparian corridors and watersheds, reduction of greenhouse emissions and improve the use of agrochemicals and fertilizers. But its main focus is anticipating the legal deadlines for ending sugarcane burning by 2014 from previous deadline of 2021.

- **Social aspects**

According to the Brazilian Institute of Statistics (IBGE, 2009a) in the year 2008 the sugarcane sector was responsible for the 1.2 million jobs. These jobs are widely distributed throughout a large part of the Brazilian territory and include a range of competencies and training; however, most of them are low qualification jobs.

With the evolution of the technologies employed, less growth can be observed in labour demand, along with higher required qualifications and an increase in quality of the work performed. This dynamic has been the driving force for many studies in the realm of rural economics and sociology, which provide a comprehensive view of the processes in progress and their implications. In the next paragraphs, issues related to the generation of jobs and income within the scope of bioethanol production will be covered. First, information about the levels of employment and their recent evolution will be reviewed and then their perspectives discussed, especially those associated with the expansion of mechanization in sugarcane harvesting.

From the total number of direct and formal jobs in the sugar-alcohol agroindustry 63% are in the Center-South, where more than 85% of Brazilian sugarcane is produced. This is evidence of higher labour productivity in this region (BNDES, 2008)[32].

Related to jobs quality, Balsadi (2007) shows improvements in various socioeconomic indicators in Brazilian agriculture between 2001 and 2004, as:

- an increase in job formality, with a high percentage of workers with labour ID cards, which makes sugarcane production one of the activities with the highest level of job formality in the rural environment;

- real gains in salary between 1992 and 2005, 34.5% for permanent employees with urban residence, 17.6% for permanent rural employees and 47.6% for temporary rural employees;

- increase and diversification of benefits received by workers, such as transportation and meal vouchers in all categories as well as housing benefits for rural residents and health benefits for permanent employees with urban residence.

2.4.2. Environmental and social aspects of biodiesel

In contrast to Brazil's ethanol development, the biodiesel market in Brazil is very young and still quite small.

The same legislation framework existing for sugarcane crops and sugar/ethanol mills are used for vegetable oil crops and biodiesel industries.

A "social fuel label" was established in the same law that established biodiesel blends, giving small farmers involved in the cultivation of castor and oil palm access to technical assistance and credit lines in concessionary terms. Social enterprises such as cooperatives and farmers associations involved in oil extraction and biodiesel processing have also access to preferential credit lines in the Brazilian Development Bank (BNDES, 2008).

However, the participation of small farmers in feedstock production has not reached the proposed goals. By 2008, only 10% of biodiesel output was derived from castor oil, and

[32] It must be noticed that the Ribeirão Preto region in the São Paulo State is nowadays known as Brazilian Califórnia, dur to high level of life quality achieved mainly through the sugarcane crop in the region.

the foreseen expansion of castor cultivation areas has not occurred, in spite of official support. Low productivity and small or negative benefit margins are two main causes appointed to explain this fact, which has led to the massive use of soybean oil and animal fats in the Brazilian production of biodiesel (RIEGELHAUPT et al, 2009).

Table 4: Biodiesel production 2005 – 2009, Brazil.

Year	2005	2006	2007	2008	2009
Sales, domestic market, Mm^3	0.0007	0.0069	0.404	1.167	1.608
Production, Mm^3	0.0007	0.0069	0.404	1.167	1.608
Exports/imports, Mm^3	No exports				
Final use	B2	B2	B2	B3	B3 and B4
Feed stocks	Soy, tallow, cottonseed. waste oil, sunflower				
Number of commercial plants	4	13	n.a.	62	64

Source: ANP, 2010

Despite soybean being the main input for biodiesel production in Brazil, this is not the most attractive option, regarding its oil production cost when compared to other oleaginous plants. As mentioned before, animal fat is increasing its participation on biodiesel production. However, the production scale, the options of convertibility of the product and the way how its complex is structured place the soybean biodiesel as an alternative to be strongly considered.

An important and complex question is the composition of biodiesel cost. The introduction of biodiesel in the national energy matrix is usually seen as an opportunity to fix men to the rural area with family agriculture valorisation. The values of the social and environmental components must, necessarily, enter in the calculation of the final value of the product. In the case of soybean in Brazil, since it is a structured sector and, considering that biodiesel will keep being a by-product, the social component of the cost practically does not exist.

Therefore, the cost calculation is simplified to consider solely the economic value. According to Abiove (*apud* HOLANDA, 2004), the soybean biodiesel final cost can be estimated in approximately US$ 0.35 per litter, in average for production in the Southeast and South regions, considering the glycerine commercialization value. In 2003, refined soybean oil had an average quotation of US$ 0.49 per litter in the market. The diesel production cost is approximately US$ 0.20 per litter[33] and the sale cost to

[33] EBB – European Biodiesel Board – www.ebb-eu.org.

the consumer is about US$ 0.46 per litter. The final cost of the fuel is only affected by the difference between the production costs.

Considering environmental aspects, biodiesel combustion is relatively cleaner than the one from mineral diesel oil, due to its molecular structure and to chemical components; biodiesel does not have some components, such as sulphur, which presence, in relatively small quantities, is tolerated in diesel oil due to its lubricant properties. Even if the sulphur quantities are relatively small, their emission to the atmosphere causes great impacts on human health and on the environment. Because of this, the sulphur emission exemption in biodiesel combustion is an environmentally very important datum. These advantages are directly proportional to the blend percentage.

Biodiesel production from soybean can have a utilization strategy of part of the nominal crushing capacity installed in the country that has over 40% idleness. To complete the biodiesel productive process, it would be necessary to incorporate the transesterification units to the crushing plants. That means that the current distribution of the control of the agroindustrial segment, where 50% are controlled by four economic groups, would not be altered. Pasquis (2004) observes that the restrictions to the entry of new companies are leading to a concentration of the crushing sector control in power of great international economic groups. In the case of biodiesel production, this tendency is unlikely to change since it is coming from the oil production segment, where are the best opportunities for *soybean complex* to be competitive.

As it can be seen, soybean biodiesel has great potential and it can have economic sustainability in the future, once it can open new markets for traditional agriculture. However, this potential does not liven up the effects on the environment that the soybean production in large scale represents, especially if it comes along an increase in cultivated area. Even if the culture area is maintained, the soybean biodiesel production does not sustain itself environmentally, once it will not reduce much the engines emissions levels and it will not change the carbon balance.

Regarding social sustainability, soybean biodiesel does not present itself as sustainable either, since in short time it will change the labour occupation profile of the *soybean complex*. It is important to remember here that the soybean production is an income concentrator and socially excluding activity.

Regarding employment generation, the option for soybean biodiesel may not be the most appropriate one, mainly when compared with other oleaginous plants, such as castor. A soybean processing plant, with crushing capacity of 2.5 tons/day, can employ 40 people and the increase of 2,500,000 tons/year would generate about 11,000 jobs; while castor biodiesel production has as a goal established by the Federal Government for 2010 to settle 153 thousand families and to generate 1,350,000 jobs in all the biodiesel productive chain. This goal results from a projection of the production capacity of 1,500,000 tons/year of castor biodiesel which will allow a blend of up to 5% to diesel. This way, taking castor as a reference, soybean biodiesel does not have social sustainability. One can infer that soybean biodiesel has a doubtful strategic sustainability, since its production leans to stay with big economic groups, mostly international ones (WEHRMANN et al., 2006).

The soybean biodiesel presents competitive advantages regarding production cost, regionalization and international market, however environmental and social dimensions should be considered.

In the context of the *Programa Biodiesel* (Biodiesel Program), a special attention has been dedicated by the Federal Government to the projects of biodiesel production from oleaginous plants traditionally cultivated in each region: palm in Pará; castor in Piauí, Ceará and Rio Grande do Norte; babassu in Maranhão and soybean in the South and Southeast regions (WEHRMANN et al., 2006).

About these feed stocks, there were not many success cases; for example, the biodiesel produced from castor show high viscosity. Therefore, castor oil should be mixed with other oils to obtain a biodiesel better and not compromise the proper performance and durability of engines. In addition there are initiatives to develop and use jatropha to produce biodiesel, which in principle would present higher productivity than other crops, except for palm oil, but there is no much knowledge about this crop; it´s resistance to diseases and pests and the areas most suitable for planting. That means there is high need for capital in early agricultural activity (MENDES and COSTA, 2009).

Anyway, Brazil over time should find a feed stock (vegetal traditional culture or algae) more efficient than soybean, rather than used for food, avoiding or minimizing any possibility of producing biodiesel and affecting, in somehow, the prices of vegetable oils (or beans) used as food (MENDES and COSTA, 2009).

3. COLOMBIA

Colombia is a country with 1,138,913 square kilometres and a population of 45,586,233 inhabitants. The country has about 2.6 billion barrels of proven oil reserves, although potential reserves are much larger. Estimates indicate that, without new discoveries, Colombia could become a net oil importer in the medium term.

Proven gas reserves stand at an estimated 6.9 trillion cubic feet (Tcf), and production (and consumption) in 1999 totalled 183 billion cubic feet (Bcf). Production is centred along the Northern Coast and Barranca regions; other areas of production are in the south and in basins to the east of Bogotá.

Colombia is the largest coal producer in Latin America, and its reserves consist of high-quality bituminous coal and a small amount of metallurgical coal. Its coal is relatively clean-burning, with a sulfur content of less than 1%. Coal is Colombia's third largest export in terms of revenue, after oil and coffee, and the country is one of the largest coal exporters in the world.

The country’s electricity generation capacity is 12.8 gigawatts, and typically almost 70% of generation is hydroelectric. Colombia's power sector endured a difficult year in 1992, as a severe drought left hydroelectric plants unable to meet electricity demand and forced power rationing. In the wake of that drought, plans to reform the sector began to form.

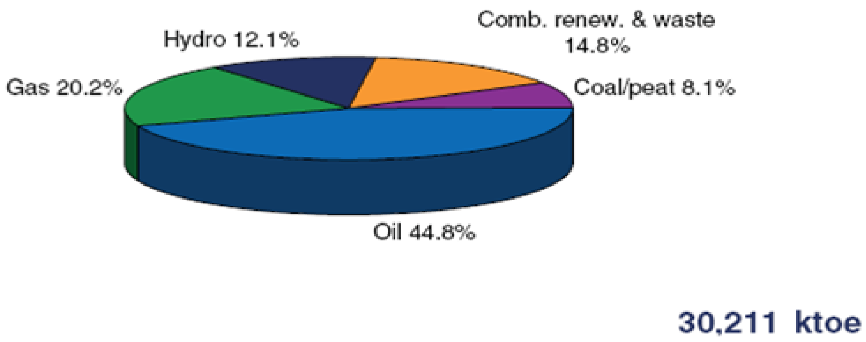


Figure 9: Share of total primary energy supply* in Colombia, in 2006 (IEA, 2009). *Share of TPES excludes electricity trade. Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%.

It is possible to observe that renewable energy, in Colombia, basically, still means traditional hydro power generation.

In transportation sector a strong dependence on gasoline and diesel canbe observed, as shown in Figure 10.

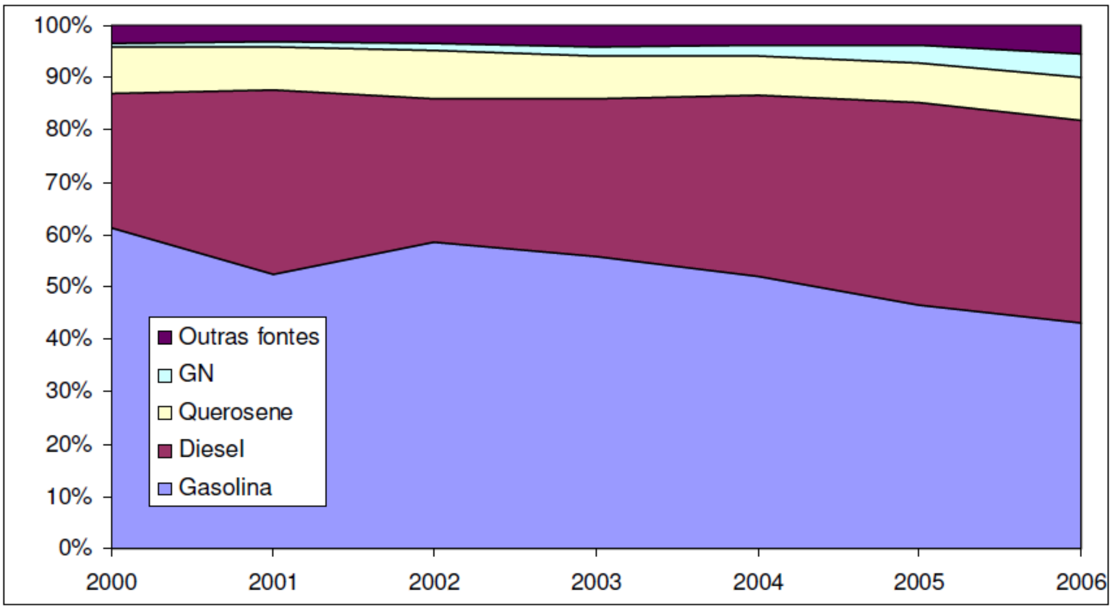


Figure 10: Share of each energy source in transportation sector in Colômbia from 2000 to 2008

Source: AMAYA AVILA, 2009

Besides that a huge increase on such prices happened from 1999 to 2009, as shown in Figure 11.

Considering this situation the Government of Colombia decided to improve its Biofuels Program.

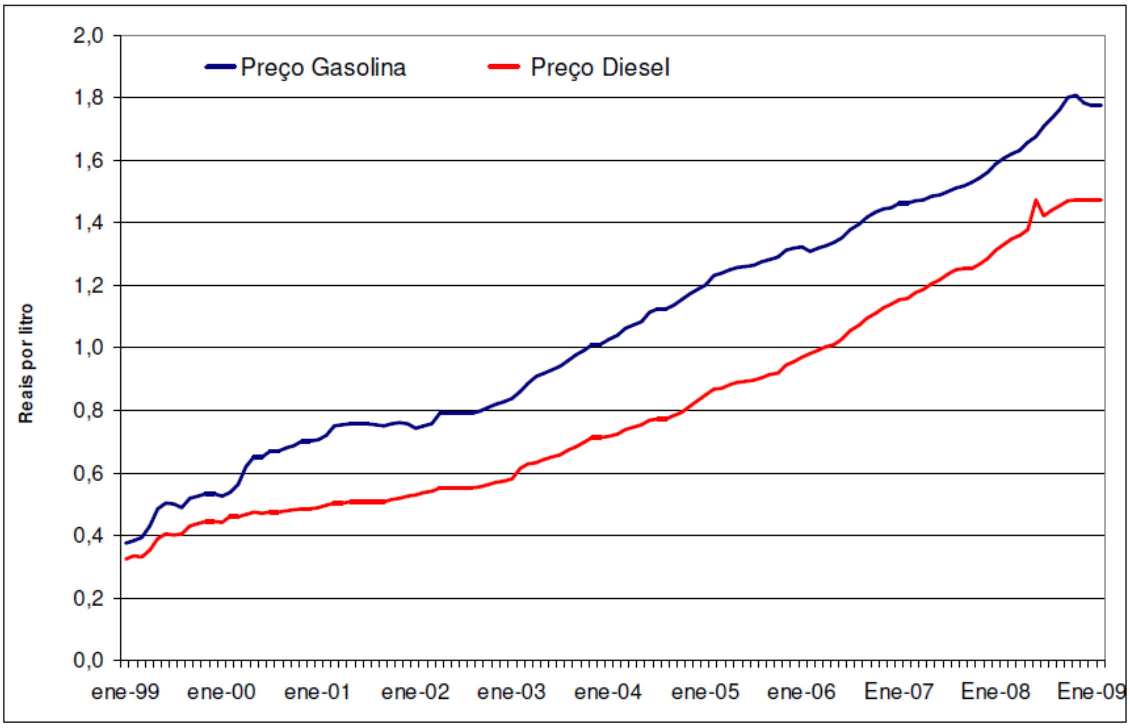


Figure 11: Prices of gasoline and diesel oil in Colombia from 1999 to 2009
Source: AMAYA AVILA, 2009

3.1. Bioenergy in Colombia

Considering the production of biofuels in Colombia, 327.2 million litters of ethanol were produced in 2009, 26% more than in 2008. Through the legislation above, nowadays in Colombia most gasoline is blended with 10% of ethanol (83% of Colombian territory). There are excellent conditions to grow sugarcane in Colombia and since 2001 there is legislation regarding the production and blending of bioethanol (CIEMAT, 2008, and ASOCAÑA, 2009).

Colombia started in 2004 its National Program of Biofuels, with a mandatory blend of sugarcane ethanol in gasoline in 2005 and, in 2007, its Biodiesel Program, aiming to produce and use biodiesel from palm oil (with a mandatory blend of 5 % biodiesel in diesel oil in 2008).

After launching the ethanol program with the goal of achieving 10% blend of bioethanol in gasoline, Colombian ethanol output grew steadily, as shown in Table 5. All five plants dedicated to anhydrous ethanol concentrate 90% of the national output, fully dedicated to the domestic market (RIEGELHAUPT et al, 2009).

Table 5: Colombia, ethanol market

YEARS	2005	2006	2007	2008	2009
Sales, domestic market, $Mm^3 yr^{-1}$	0.027	0.21	0.27	0.258	0.315
Production, $Mm^3 yr^{-1}$	0.027	0.21	0.27	0.258	0.315
Exports / imports, $Mm^3 yr^{-1}$r	n.d.	n.d.	n.d.	n.d.	n.d.
Final use	E10	E10	E10	E10	E10
% of market substitution	0.70%	5.70%	7%	n.d	n.d
Feedstocks	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane
Number of commercial plants	2	5	16	n.d.	5

Source: CIEMAT, 2008, and ASOCAÑA, 2009

The Decree 2629 of July 2007 established that since year 2012 all new light vehicles must be equipped with Flex Fuel motors, opening the way for a fast expansion of ethanol consumption – provided that hydrated ethanol is available and its price is competitive with gasoline (RIEGELHAUPT et al, 2009).

In Colombia, bioethanol producers'price is deermined by a formula combining the international prices of gasoline and sugar. Thus, ethanol price in Colombia reflects the price variation of both components in the global markets.

There are excellent conditions to grow sugarcane in Colombia and since 2001 there is legislation regarding the production and blending of bioethanol.

On the other hand, concerning biodiesel, the figures show a production of 350,000 m3 of biodiesel in 2008, and the most important perspectives for biodiesel production are for palm oil, with a potential of 6.5 billion litters of biodiesel in an area of 3 million hectares for palm oil plantation (AMAYA AVILA, 2009).

.Several studies are under development aiming to implement a palm oil biodiesel program. As discussed ahead, oil palm is a promising feedstock for biodiesel production because of its low cost and high productivity per unit of planted area.

The Colombian Biofuels Policy[34] has the following overall goal: "to increase biofuel production in a competitive and sustainable way". And, to reach this goal, the Colombian Biofuels Policy is based in five main targets:

- Promotion of productive system/alternative leading to legal land use;
- Contribution to formal rural employment;
- Diversification of energy mix in Colombia;
- Ensuring environmental sustainability of the production chain;
- Promotion of biofuel export.

Biofuel target in the case of bioethanol is 10% of mixture in gasoline, and, in the case of biodiesel, the target is 5% mixture in diesel until 2009; and 10% from 2010.

In such context, the following table 6 resumes, for each one the primary matters, the main characteristics for biofuel targets and the respective land requirements in Colombia.

Table 6: Biofuel targets and land requirements in Colombia

	Land required – 10% target (1000 ha)	Current harvest area (1000 ha)	Biofuel land requirement (% current harvest area)	Current export (% production)
Sugarcane	63	200	32%	50%
Palm oil	147	170	86%	33%

Source: ECOFYS 2008

Observing the previous table and the data showed in the following figures 12 and 13, it is possible to conclude that lack of land will not be a problem for Colombia to reach the biofuels targets.

[34] Policy on biofuels in Colombia was officially published on March 2008, in the Document "Conpes 3510".

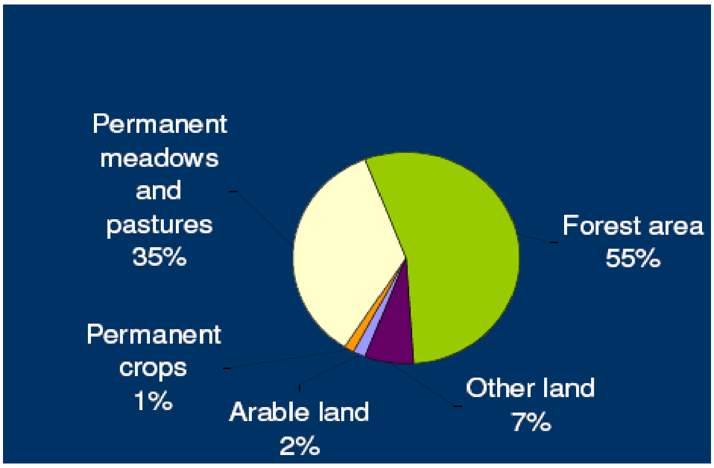


Figure 12: Colombia – Total land area = 1.131.910 km^2

Source: DIAZ, 2007

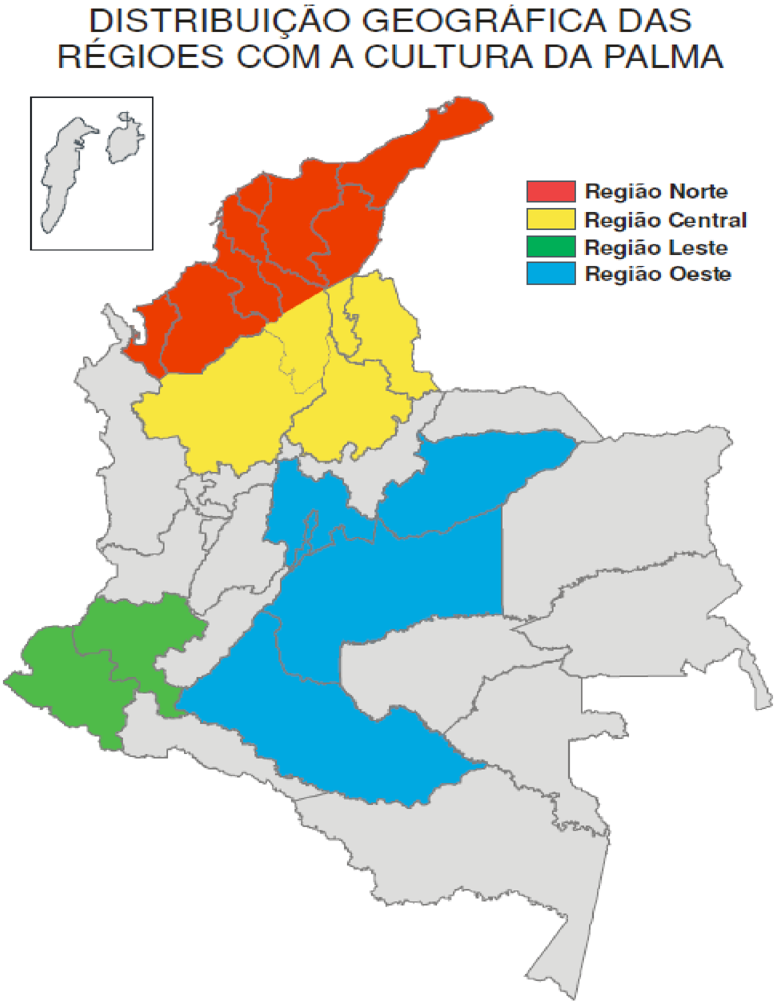


Figure 13: Geographic distribution of oil palm in Colombia

Source: AMAYA AVILA, 2009

3.2. Biofuels Legislation in Colombia

In Colombia the main legislation related to biofuels is as follow:

- Law N°693-2001 - Regulation of ethanol use in gasoline blends.
- Law N°939-2004 - Promotion of production and commercialization of biodiesel to be used in diesel vehicles.

Tax incentives

- Law N°788-2002 – VAT exemption to fuel-ethanol for blending with gasoline.
- Law N°939-2004 – i) Sales tax exemption and diesel-fuel tax exemption to biodiesel for blending with diesel fuel. ii) Tax exemption to incomes from cultivation of crops for biodiesel production.
- Decree N°383-2007 of tax-free areas – Incentives to implement tax-free areas for the development of biofuels projects.
- Tax Reform establishing incentives to investment in biofuel projects: credit facilities.

Biofuel quality requirements

- Resolution N°447-2003 (modified by resolution N°135-2005) – Technical and environmental requirements of fuel-ethanol and oxygenated additives used in the country since 2005.
- Resolution N°1289-2005 (modified by resolution N°182087-2007) – Technical and environmental requirements of biodiesel and biodiesel/diesel blends used in the country since 2007.

Prices

- Resolution N°18 1780-2005 – Prices structure for diesel fuel blended with biodiesel to be used in diesel engines.
- Resolution N°12 1232-2008 – Regulation of fuel ethanol producers' income distributing in the country.

Technical regulation

- Resolution N°18 1069-2005 – Technical regulation on the production, storage, distribution and blending facilities of fuel-ethanol and its use in national and imported fuels.
- Resolution N°18 2142-2007 (modified by 18 0243-2008) – Rules for the register of producers/importers of biofuels to be used in diesel engines and other regulations in relation to the blending with diesel fuel.
- Decree N°2629-2007 – Obligation from 1st January 2012 for new vehicles to be flexi-fuel, capable to use 20% or higher blends of ethanol

Technical rules on biofuels

- The "*Instituto Colombiano de Normas Técnicas, ICONTEC*" (Colombian Institute of Technical Rules), under the responsibility of the Technical Committee 186 "Liquid Biofuels, Fuel-alcohols and Biodiesel" has issued the following in force rules (Corredor, G., 2009).

3.3. Ethanol in Colombia

3.3.1. Technologies for the production of ethanol in Colombia

Ethanol in Colombia is produced from sugarcane like in Brazil. However, a distinctive characteristic of Colombian ethanol, associated with the technology, is the use of Indian technology rather than Brazilian technology. According to engineers at Colombian ethanol plants, Indian technology enables the plants to comply with tight environmental regulations set by the Colombian government.

The main advantage of Indian technology is that it produces lower volumes of vinasse, the by-product generated after the distillation of fermented molasses, and allows for the vinasse to be further processed. Most ethanol plants in Brazil do not process vinasse.

On average, Colombian ethanol production generates 1 to 2 litters of vinasse per litter of ethanol, whereas in Brazil, a litter of ethanol generates 10 litters of vinasse and even with more recent technologies mentioned above the amount is around 5 litters of vinasse per littler of ethanol. If not properly disposed of or further processed, vinasse can pose a threat to water or soil conditions (TOASA, 2009).

The decision to use Indian technology appears to be paying off. Colombian processed vinasse contains high volumes of potassium, phosphor, and magnesium, which allows it to be sold as fertilizer (Figure 14). Annual vinasse sales return about $40 million to the industry.

Lastly, ethanol plants in Colombia use about one-third of the water of Brazilian plants, and about one-half of the energy (ASOCAÑA, 2008). However, most sugarcane plantations in Colombia need irrigation, whereas most Brazilian plantations do not.

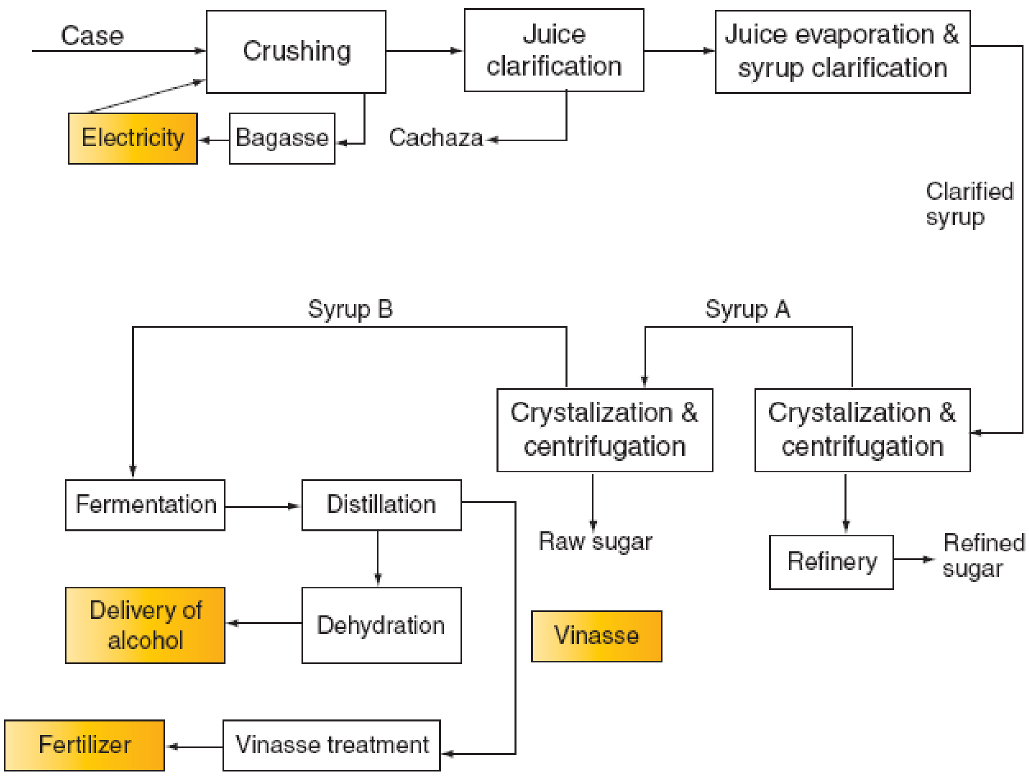


Figure 14: Sugar and ethanol production process in Colombia
Source: USDA, ERS using information from Manuelita sugar mill

Considering energy consumption for ethanol production, it must be noted that, as it happens in Brazil, every Colombian mills which produce ethanol are energy self-sufficient.

Also like Brazil, they use the sugarcane bagasse to generate all the energy needed for processing. They also sell surplus bagasse-based power to the national electric grid. According to ASOCAÑA (2008), even though the cost of production of bagasse-based electricity is higher than the coal-based or hydroelectric-based electricity, the final price (after tax, commercialization, and transportation costs) that the mills would have to pay for conventional electricity would be higher than that of bagasse-based electricity.

3.3.2. POTENTIAL FOR ETHANOL IN COLOMBIA

The first Colombian sugarcane bioethanol plant started operation in 2005, with a production of 300 thousand litters/day. In 2006 other five sugarcane bioethanol plants began operation in the Cauca River Valley with a combined production capacity of 357 million litters/year. Sugarcane production in the Cauca Valley is well established and production can be carried out during the entire year, which allows the operation of an elevated number of distilleries.

The Colombian government expects that in 2010 the country reaches an annual production of 1.7 million litters of bioethanol; such volume would be needed for a blend of 10% of bioethanol in gasoline and generate an exportable surplus equivalent to 50% of total production (HORTA NOGUEIRA, 2007).

According to USDA’s Foreign Agricultural Service, the decrease stems from the diversion of cane to ethanol production. As it plans for further expansion, the industry is looking beyond the Cauca Valley, which has only 29,947 ha remaining that could be used for sugarcane. CENICAÑA, for example, has identified the North-western and eastern parts of the country as potential sugarcane-growing areas (TOASA, 2009).

Colombia has plans to increase both domestic and foreign demand for ethanol. Within 2 years, at least 99,957 ha of new sugarcane area located in the North-western part of the country could be available to use in ethanol production. As North-western cane yields are expected to be lower than those in the Cauca Valley, the 247,000 new acres could result in production of about 2,297,745 litters of ethanol per day (ASOCAÑA, 2008). This amount, plus trend-based production elsewhere in the country, could boost production in Colombia to about 3,747,558 liter per day. Colombia’s production could grow even more if sugarcane is grown on the identified land in the eastern region and on the remaining 99,957 ha in the North-western region

Colombian entrepreneurs are not just focused on identifying land for sugarcane within Colombia; they have plans to grow sugarcane and produce ethanol abroad. For instance, the business group that owns the Manuelita mill is building an ethanol plant in Northern Peru. This plant, located in the State of Trujillo, is expected to start producing by 2010, and its managers intend to ship its output to the United States to take advantage of the 2005 U.S.-Peru Trade Promotion Agreement, which is pending implementation (U.S. Trade Representative). This same business group holds a 25-percent share in the Brazilian Vale do Parana sugar refinery, which was scheduled to start producing in July 2008. Moreover, in early 2008 a Colombian delegation visited Cuba and declared that the Colombian government will install a small pilot ethanol plant on the island. This plant will produce 4,921 liters per day and will serve as a trial to help determine the feasibility of future investments (TOASA, 2009).

Related to energy production the country has the potential to increase in cogeneration power of 631 MW, of which more 200 MW can be provided by the sugarcane sector (ASOCAÑA, 2008).

3.4. Biodiesel production in Colombia

3.4.1. Technologies for biodiesel production in Colombia

Biodiesel production in Colombia is also based primarily on transestherification technology. The main raw material used is palm oil. As already mentioned, in 2008 the production was 350,000 m3 of biodiesel from palm oil. Colombia is the fourth largest palm oil producer in the world and the largest in Latin America. Palm oil is a promising feedstock for biodiesel production because of its low cost and high productivity per unit of planted area (CIEMAT, 2008).

Domestic production of oils and fats is around 535 thousand tons[35], and within this total crude palm oil is 440 thousand tons. Between 1975 and 1997 domestic production of crude palm oil increased from 51.000 to 440.796 tons. This growth is explained by increased area and by improving crop productivity and the efficiency of extracting oil from fresh fruit (CORPODIB, 2003).

[35] Metric tons

The oil palm is a perennial crop with long-lasting yields, because its productive life can last longer than 50 years; however after 25 years harvesting becomes difficult due to the height of the stalk (YUSOFF, 2004).

The processing of the oil palm's fruits is developed at the oil mill or extraction plant. That is where the process of extracting crude oil from the palm and from the palm kernel is carried out. The process consists of sterilizing the fruit, separating the palm kernels, crushing them, extracting the palm oil from the pulp, clarifying it and recovering the palm kernels from the resulting husks. Two products are obtained from the kernels: palm kernel oil and palm kernel cake, which serves as animal feed (YUSOFF, 2004).

By fractionating the palm oil, two products result: palm olein and palm stearin. The first is liquid in hot climates and can be mixed with any type of vegetable oil. The second is the most solid fraction and is used to make fats, mainly margarines and soaps. The properties of each part of the palm oil explain their versatility as well as their numerous applications (YUSOFF, 2004).

Related to the utilization of co-products, the production and use of glycerine from biodiesel in Colombia depend on the size of the industry. According to Fedepalma, if the plant is small, there is no separation of glycerine and methanol. They are both considered a liquid effluent stream that requires a treatment before disposal. If the industry has a greater size, glycerine is purified up to 80% and, depending on the market and investment; it can be further treated until reaching 99% purity. Purified glycerine is used in internal oils and fats processing industry as raw material for chemicals, plastics, cosmetics, pharmaceuticals and feed (BALLESTEROS AND MANZANARES, 2009).

The main by-product and wastes produced from the processing of palm oil are the empty fruit bunches (EFB), palm oil mill effluent (POME), sterilizer condensate, palm fibre and palm kernel shell. EFB and POME have been used extensively as mulch and organic fertilizer in oil palm areas while palm fibre and shell are used as fuel, making the palm oil mill self-sufficient in energy. The excess shells have been used for road surfacing on estates (YUSOFF, 2004).

3.4.2. Potential for Biodiesel in Colombia

Biodiesel production increased in 2008, although at a slower pace than initially expected due to delays in building refineries. The Figure 15 shows the demand projection of biodiesel until 2025 (UPME, 2009).

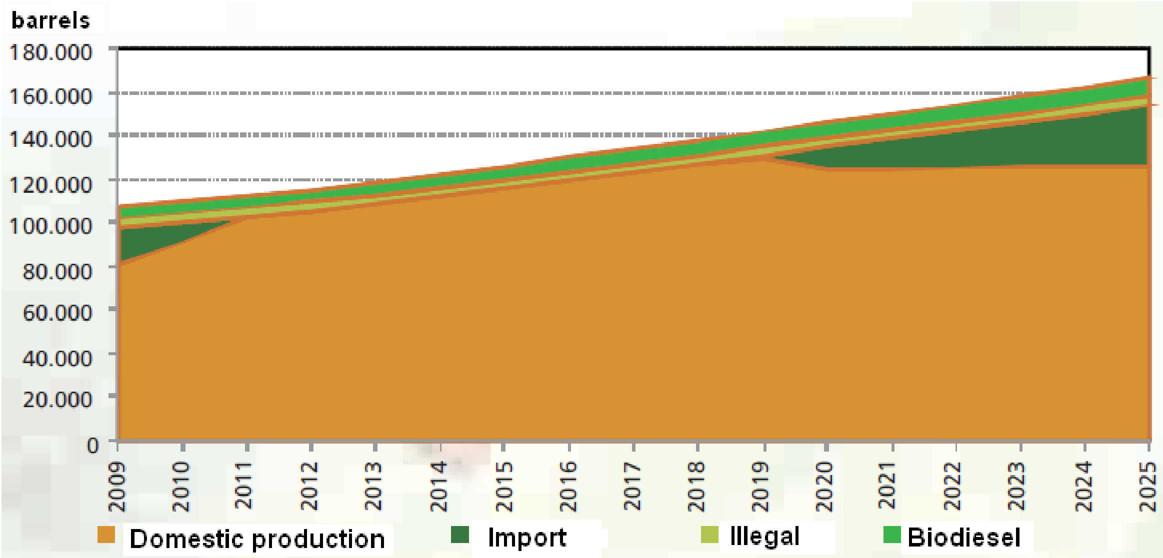


Figure 15: Demand projection of biodiesel until 2025

Source: UPME, 2009

The requirements for biodiesel consumption are increasing at an average annual rate of 2.8% during the projection horizon with a mixture of 5%.Thus during 2009 will require 5,411 barrels per day in and in 2025 will require 8,400 barrels per day, an increase of 55.1% (UPME, 2009).

Adding to the plant capacity of 86,000 tons per year reached in 2008, five new plants are expected to enter into operation during 2009 to total 230,000 tons production capacity per year by the end of 2009, a calculated production capacity of 791,000 liters per day. The Colombian Ministry of Energy estimates that domestic biodiesel demand at 839,000 litters per day will be met by 2010.

Projections (CORPODIB, 2003), using a 10% biodiesel in all fuel domestic demand, correspond to produce 6 thousand barrels per day of biodiesel, which will require 100 hectares of palm that produce 300 thousand tons per year of oil. This corresponds to 75% of production in 2003 of palm oil.

Figure 16 shows the prospects for production, traditional domestic consumption, and supply for other uses and markets of the palm oil in Colombia (FEDEPALMA, 2008).

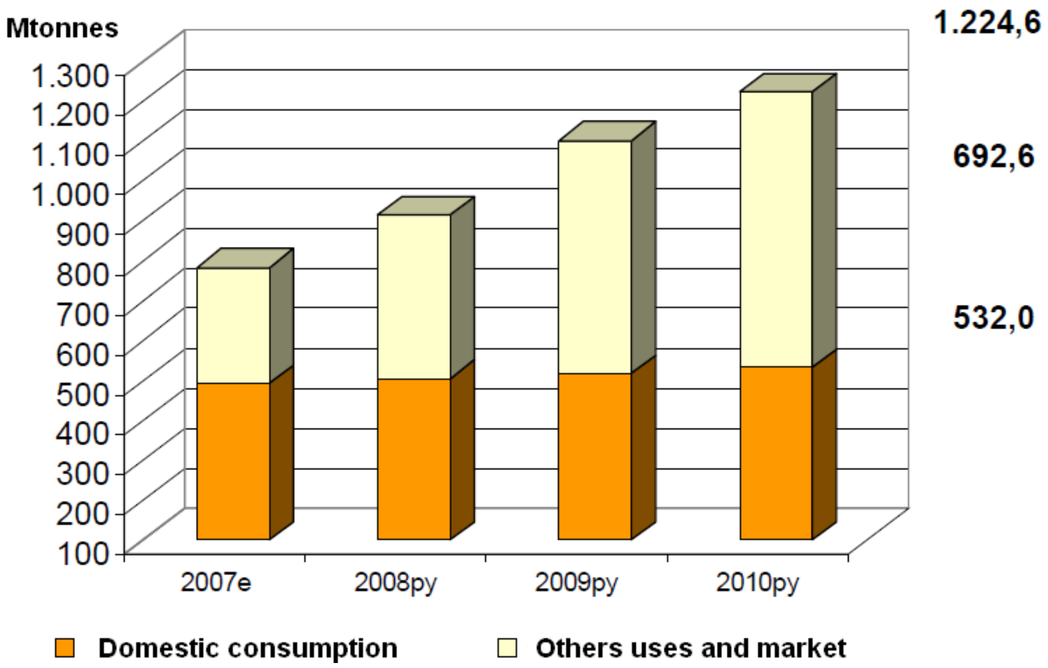


Figure 16: Prospects of palm oil production in Colombia (2007-2010)
Source: FEDEPALMA, 2008

According to a study conducted by Fedepalma (2008) the potential area for production of palm oil in Colombia is 3,500,000. For that 1,934,000 are in the East of the country; 580,000 in the North; 693,100 in Central zone; 66,800 in West; and 226,100 in others.

According to Law 939/2004, a 5% blend rate of biodiesel in national diesel consumption is mandatory since 2008. Tax incentives have spurred expansion of palm oil in Colombia. Production data (Table 7) reflect the initial phase of development of this market in Colombia. However, no data are available on the substitution rate so far achieved. Installed capacity was 0.321 Mt yr-1 in 2007, with a projected growth to 0.721 Mt yr-1 for 2008. Colombia is also exporting biodiesel (RIEGELHAUPT et al, 2009).

Table 7: Colombian biodiesel production and consumption

YEARS	2005	2006	2007	2008
Sales, domestic market, $Mm^3\ yr^{-1}$	n.d	n.d	n.d.	0.27
Production, $Mm^3\ yr^{-1}$	n.d	n.d	n.d.	0.35
Exports / imports, $Mm^3\ yr^{-1}$	n.d	n.d	n.d.	0.08
Final use	n.d	n.d	n.d.	B5
% of market substitution	n.d	n.d	n.d.	5% in "costa atlántica"
Feedstocks	Oil palm	Oil palm	Oil palm	Oil palm
Number of commercial plants	n.d	n.d	n.d.	9

Source: .CIEMAT, 2008

3.5. Sustainability aspects of Biofuels in Colombia

3.5.1. Environmental and social aspects on sugarcane ethanol

The environmental aspects discussed in Colombia for ethanol production are similar to those occurring in Brazil, but in a smaller scale of production. Some regional initiatives for sustainable production of sugar and ethanol are under development in Colombia.

According to ASOCAÑA (2008), the sugar mills in 1970 discharged 98 ton/day of organic load and 110 ton/day of TSS (Total Suspended Solids.). This means that the sugar mill in those years contributed about 44 kg of organic load per ton of sugar. Today, in 2007, the sugar mill contributes 1.3 kg of organic load per ton of sugar. In the case of suspended solids discharged into the Cauca River it was about 49 kg of TSS per ton of sugar. In 2007, the sugar mill contributes 0.4 kg of TSS per ton. These actions for pollution reduction made the sugar mills responsible for 2% of the total contribution of waste discharged into the river Cauca.

There is a concern related to the management of waste and co-products of the sugarcane mills, like vinasse. In Colombia, particularly in the industry located in the Valle del Cauca, from 0.8 to 3 litters of vinasse/litters of ethanol are produced, while in other ethanol production countries up to 14 litters/litter of ethanol can be obtained. In general, vinasse originated from distillery has a solid concentration from 22-60%; due to it is recirculated in the fermentation process and then concentrated.

The dose of vinasse/ha is defined depending on its solid concentration. If vinasse is directly applied to the crop, the dose vary from 2 to 7 m^3/ha, providing from 150 to 200 kg of K_2O/ha. This is an average potassium requirement of sugarcane cultivation, although this requirement always depends on the agroclimatic conditions of the area (ASOCAÑA, 2008).

Other option to the direct use of vinasse as fertilizer is its application as a compost produced in composting plants using vinasse and other co-products as bagasse, ashes and “cachaza”. These co-products are all composted through biological processes based on decomposition of organic matter under controlled conditions. The composting process takes about 56 days. Compost is a product rich in organic matter, minor elements, potassium and phosphorus very attractive not only for sugarcane farmers but for other crops in the area, which can substitute chemical fertilizers. An average dose of compost would be from 7 to 10 tons/ha, which provides from 150 - 200 kg/ha of K_2O (ASOCAÑA, 2008). The adequate dose must be always calculated taking into account specific characteristics of the area as potassium requirements of crop, irrigation systems or ground-water vulnerability. According to Cenicaña (2008), sugar industry in Colombia can replace about 14,000 tons of potassium oxide, which is currently imported, with the use of compost from vinasse.

Regarding social aspects, the sugarcane sector employs many people in the chain, both directly and indirectly. With the current level of ethanol production, according to market estimates there are 40,600 jobs. This value is increasing to 56,900 with a blend of 10% and 138,300 for a blend of 25% (ASOCAÑA, 2008), as shown in table 8 below.

Table 8: Colombian employment indicators – Ethanol.

Numbers of jobs - Ethanol Production		
	Blend 10%	**Blend 25%**
Indicator		
Ethanol (l/day)	1,400,000	3,400,000
Area (ha)	47,500	115,500
Direct jobs	8,100	19,800
Indirect jobs	48,800	118,500
Total jobs	56,900	138,300

Source: ASOCAÑA, 2008

3.5.2. Environmental and Social Aspects on Palm Oil-Origin Biodiesel

As it happens with the use of ethanol replacing gasoline, also the main environmental feature for the use of biodiesel is the reduction of GHG emissions compared to fossil fuels.

On the other hand, as the Colombian production is primarily from palm oil, the negative aspects of this crop are mainly due to concerns related to water use in crop and when its cultivation is in areas of native forests. This cultivation practice in areas of native forests had higher proportions in Asian countries, what mobilized a number of initiatives to control this deforestation.

Sources show that Colombia has a large territory for the cultivation of palm oil, but currently these areas are focused on raising cattle extensively. In a similar way to what is happening in Brazil, through an adequate organization of the region, making cattle raising more intensive, it is possible the sustainable production of palm oil in Colombia.

Colombia is the second most biodiverse country in the world. The country's rich biodiversity is found in its national parks and protected state forest reserves. In addition, a large number of oil palm plantations and estates are found in Colombia's natural ecosystems. According to FEDEPALMA (2008), palm oil is planted in a triangular, with a distance of around 9 meters separating each other. Trees are planted in straight lines and can cover tens, hundreds and even thousands of hectares. As palm trees grow and mature, the area becomes like a forest where a variety of flora and fauna live.

As a result of photosynthesis, palm trees can fix large amounts of carbon gas and in such a way help to lessen the effects of global warming. Micro-climates form around palm plantations which contribute to the sustainability of other crops and benefit communities living nearby (FEDEPALMA, 2008).

In Colombia, palm plantations are set up without having to cut down native forest areas and are built in regions which were once used for farming. Colombian palm growers are committed to caring for the environment and have adopted a range of good practices which allow them to maintain a competitive edge and promote sustainability, while complying with international standards (FEDEPALMA, 2008).

Within the last few years, environmental issues are increasingly becoming more important in Malaysia and the world over. The palm oil industry is aware of the environmental pollution and is striving towards quality and environmental conservation through ‘sustainable development and cleaner technology’ approach. Thus, to remain competitive, the oil palm industry must be prepared for the new challenges ahead (YUSOFF, 2004).

Rapid development in the palm oil industries over the years should be in tandem with the development of its environmental technical know-how. There are still many environmental pollution issues that need to be addressed on a dynamic basis. Must be considering the effects of crude palm oil mill effluent discharge, more studies should be conducted in areas like boiler design technology, solid fuel treatment and combustion, fly ash control system, and energy conservation concept in relation to complete combustion. More stringent water quality standards might also be stipulated in the future .Thus, new and improved treatment technology would be required in order to meet the new requirements (YUSOFF, 2004).

Considering social aspects, the oil palm community is made up of small, medium and large-scale oil palm growers, agricultural workers, administrative staff, technicians and professionals with different areas of expertise and numerous companies with diverging interests in agriculture and industry. A whole range of people make up the oil palm community, who bring different experiences and levels of expertise to the sector. Though people working in the oil palm sector have different roles, they are united by their undettering work ethic and commitment (FEDEPALMA, 2008).

For the palm oil crop the harvesting have a lot of jobs in this sector. Some calculations were made based on the blend of 5% biodiesel to diesel. The numbers indicate that links with production is in 13,125 direct and indirect jobs. According to table 9 is possible to observe the quantity of jobs considering blend of 20% biodiesel to diesel and also pure biodiesel (FEDEPALMA, 2008).

Table 9: Colombian employment indicators – Biodiesel

Numbers of jobs - Biodiesel Production			
	Blend 5%	**Blend 20%**	**Biodiesel 100%**
Indicator			
Biodiesel (ton)	210,00	840,00	4,200,000
Crude palm oil	210,00	840,00	4,200,000
Area (ha)	52,50	210,00	1,050,000
Direct and indirect jobs	13,125	52,500	262,500

Source: FEDEPALMA, 2008

4. Existing Barriers against Biofuels

Under the Kyoto Protocol, industrialized countries must reduce their carbon emissions. Many of these countries have already passed specific legislation establishing voluntary or mandatory replacement of fossil fuels by biofuels. Importing biofuels from other, mainly developing countries, could help them reach their targets, however, many biofuel exporting countries still face technical trade barriers. To prevent asymmetry between trade liberalization objectives and Kyoto Protocol reduction targets, new approaches and policy space are warranted in order to ensure that trade liberalization efforts and policies in implementing Kyoto Protocol become truly and mutually supportive.

Biofuels are: (1) a form of energy that is easily transported and stored, thus tradable; (2) environmentally preferable products; and (3) obtained from agricultural feed sotcks, which in many cases compete internationally with subsidized products. Therefore, they are affected by protective legislation and are subjected to the rules currently under discussion in the WTO's Doha Work Programme. This includes negotiation on certain trade and environment issues, starting with the aimed liberalization of trade in environmental goods and services (EGS).

Biofuels have become a high priority issue in the US, the EU and in a number of other countries around the world, due to concerns about oil dependence, reduction in CO_2 emissions or restrictions on other octane enhancement additives and oxygenation.

One further advantage is that ethanol has much lower (or even zero) emissions of particulate matter (PM), lead, sulfur, benzene and 1-3 butadiene.

Bioethanol is sometimes considered impractical because of low demand and the large-scale investment needed to produce it, the costs involved in converting filling stations and vehicles. However, gasoline engines can be adjusted to ethanol and its blends. Besides, flex-fuel vehicle technology has become available with no extra costs to consumers.

The strategic nature of bioethanol implies the existence of some degree of protectionism in almost any producing country. Protectionism is especially acute where energy security is equated with self-suficiency or where biofuels are promoted to help domestic farmers in high-cost producing countries (DUFEY et al., 2007).

Subsidies are a key concern. In industrialised countries, government support for the domestic production of energy crops, the processing or commercialisation of biofuels seems to be the rule (DUFEY, 2006). Amounts involved are enormous. In the United States, Koplow (2006) estimated that subsidies to the biofuels industry to be between US$ 5.5 billion and US$ 7.3 billion a year.

The use of tariffs to protect domestic biofuel industries is a common practice and, as Table 10 shows, these can be very high (ZUURBIER and VOOREN, 2008).

Table 10: Import tariffs on bioethanol[1]

Country	**Import tariff**
US	2.5% + extra US$ 14 cents/litre (46% *ad valorem*)
EU	€ 19.2/hl (63% *ad valorem*)
Canada	4.92 US$ cent/litre
Brazil[2]	20%
Argentina	20%
China	30%
Thailand	30%
India	186% on undenatureated alcohol

Source: Dufey et al. 2007

Notes: [1] Undenaturated alcohol. [2] Temporarily lifted in February 2006.

The impacts these policies have on the developing countries competitiveness and on their potential for poverty reduction needs to be understood as domestic support in these countries is likely to be very limited. Moreover, subsidies impacts on environmental sustainability are also questionable as they promote bioethanol industries based on the less efficient energy crops and with the least greenhouse gases reductions such as maize and wheat (DUFEY, 2006).

In particular, the extra US$ 0.14 to each litre (US$ 0.54 per gallon) of imported bioethanol on top of the 2.5 percent tariff applied by the United States, it is said to be targeting Brazilian imports as it brings the cost of Brazilian bioethanol in line with that produced domestically (SEVERINGHAUS, 2005). Tariff escalation, which discriminates against the final product, can also be an issue, for example, where there are differentiated tariffs on bioethanol and feedstock such as raw molasses (DUFEY, 2006).

Although the main barriers consider markets aspect, there are still issues that need to be better elucidated to the biofuel development in the world, and especially considering countries in this study: Brazil and Colombia.

In addition to tariff barriers, can exist Non-tariff barriers, that considering: Technical and sanitary requirements; Quality standards; Public Health policies; Labor regulation; Rules on competion; Consumer's protection; Corporative politicies; Social and environmental policies.

Certification issues, despite the fact that are important to guarantee the sustainability of biofuels production and use, can be a non-tariff barrier. For Least developing countries (LDC), where the lack of funding and adequate capacity building is a matter of fact, can be a huge barrier for biofuels exports for industrialized countries (UNCTAD, 2008). In these cases a waiver related to certification schemes could be a significant collaboration for the economic development of such countries, not only considering the local supply but also the export of biofuels. Considering that in many cases local demand is quite low due to economic conditions, export of biofuels could allow a higher production, in a scale which allows economic competitiveness of biofuels with fossil fuels.

Such waiver could include more time for capacity building in these developing countries to allow adequate adaptation, as well as for the introduction of modern technologies such as mechanical harvesting of green cane.

Considering all these issues, further discussion are needed about the environmental and social concerns, with a wider dissemination of the current results obtained with the use of biofuels, making a consistency of reporting and not considering uncertain issues, that make a barrier for the market of producer countries.

5. Policy Recommendations and Conclusions

As mentioned above, the Alcohol Program was created only with the aiming of reduce oil imports of the country due to the huge rise of oil prices in that time (the first two oil crisis in the world); later on environmental and social issues were gradually introduced. Initially the mandatory blend of anhydrous alcohol in gasoline was introduced. With the further increase on oil prices in the beginning of the 80's the dedicated ethanol vehicles started to be produced with significant subsidies paid to sugarcane and ethanol producers, as well as incentives for car manufacturers.

In the short to medium term ethanol was appointed as a cheaper alternative and effective way to replace MTBE and gasoline, which would allow the continued use of existing infrastructure and similar vehicles.

Later on environmental and social advantages of sugarcane ethanol were discovered and adequate legislation started to be improved.

Nowadays Brazil has a strong legislation in both the social and environmental sectors. In the social sector it is important to note recent initiatives from Sao Paulo Government to avoid unemployment due to the introduction of the mechanical harvesting of green sugarcane. Several initiatives were implemented, including special capacity building not only to operate the very sophisticated machines (computerized ones) but also to create opportunities for jobs in other sectors such as building and industrial ones.

Considering environmental issues, significant improvements were made in several government levels (Federal, State and Municipal ones) with the introduction, in September 2009, of the Federal zoning of sugarcane in the country aiming to protect fragile ecosystems (*Amazonia*, *Pantanal*, *Brazilian savannah – cerrado*, *Rain Forest*) and biodiversity [36]. Before that state initiatives have happened, the most important one being from Sao Paulo State [37].

Also more strict limits for vehicles emissions were introduced, not only for gasoline and diesel engines, but also for alcohol and flex fuel ones [38].

In the case of stationary sources special legislation for environmental impacts were implemented by Cetesb in São Paulo State but also at CONAMA[39], in federal level.

Among different programs for renewables in Brazil, together with Proalcool, the most important one has been the National Program for Production and Use of Biodiesel (Programa Nacional de Produção e Uso do Biodiesel). The goal of this program was to introduce a new fuel in the Brazilian energy mix from self sustained projects that combine good price, quality, supply guarantee and social inclusion policies. The addition of biofuels to diesel, together with the ethanol program, is the main sustainable program for the transport sector.

In fact, the Federal Government is making all the efforts to stimulate more renewable sources of energy. Regarding electricity generation, Brazil has invested in projects of renewable alternative energy, distributed by the Program of Incentive to Alternative Sources of Electric Energy (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica - Proinfa*) in 63 small hydroelectric power plants, 54 wind parks and 20 thermal units (for investments in energy through biomass).

The main reason for Colombia invest on biofuels (and, in an ample vision, for other Latin American countries) is that programs like the Brazilian one has (Proálcool in the 1970s for bioethanol and the 'National Program for the Production and Use of Biodiesel') require an official commitment of the government together with an integral system of obligations, subsidies, and incentives, and big investments in infrastructure and development. If similar programs were intended to be launched in Colombia, many challenges would have to be faced. Primarily, political stability to guarantee long-term governmental support is necessary.

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[36] EMBRAPA - Brazilian Agricultural Research Corporation (www.embrapa.br)

[37] São Paulo State Environment Secretariat (www.ambiente.sp.gov.br)

[38]CETESB - **Environmental** Agency of São Paulo State
http://www.cetesb.sp.gov.br/Ar/emissoes/proconve2.asp

[39] CONAMA – CONSELHO FEDERAL DE MEIO AMBIENTE – Federal Council for Environment.

In fact, in countries with petroleum most established fuel producers tend to consider biofuels a competitor that could negatively impact their market share and hence lobby against it. Moreover, end users are still reluctant to use an alternative or different type of fuel in their cars' engines, which is basically due to the lack of proper information. These are some of the main challenges the region needs to get through. However, increasing investments from Europe, the United States and Japan prove that the market expects Colombia to overcome these challenges gracefully. Still, the question mark is put on timing and the answer relies heavily on political commitment to the cause and as usual in Colombia (and in Latin America, as a whole): economic stability.

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