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Liquid Biofuels for Transportation in Brazil

Potential and Implications for Sustainable Agriculture and Energy in the 21st Century

Study commissioned by the German Technical Cooperation (GTZ)
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The views and opinions of the authors expressed in this study do not necessarily reflect those of the BMELV

Partnership

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BIOFUELS FOR TRANSPORTATION:

BRAZILIAN POTENTIAL AND IMPLICATIONS FOR SUSTAINABLE AGRICULTURE AND ENERGY IN THE 21ST CENTURY

FOREWORD

There is an increasing dynamic in the use of bio fuels supplementing or replacing fossil fuels. Supported by the international conference for renewable energy in Bonn (renewables 2004) there is evidence for a rising interest in the use of alternative fuels. While the production in the US and in Europe is accelerating quickly several other industrialised and developing countries are already planning the promotion of bio-fuels.

Currently, a number of single initiatives with different motivations have been started. Some of the countries expect growing export opportunities to Europe, Japan and the US markets whereas others have been driven by ecological aspects, the reduction of the oil import dependency or by internal economic problems. At the same time sound information of costs, potentials, chances and risks are only rarely available in a few cases. The current patterns (of the bio-fuel markets) are diverse and unclear.

The GTZ has therefore been commissioned by the German Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) to comprehensively survey the issue of “fluid bio-fuels for transportation” in a global environment guided by the principle of sustainable agriculture, energy and transport and to bring the results of the analysis in the international debate. The global survey is being carried out by the Worldwatch Institute, Washington.

As a basis for the formulation of an international policy approach also country-specific considerations have to be analysed and to be taken into account. Therefore, regional studies are being undertaken in Brazil, China, India and Tanzania and experiences and knowledge from Germany, Europe and the US are also under consolidation. These regional studies act as a basis for the global survey.

The present document is the result of the work done in Brazil. The study was conducted by The Brazilian Foundation for the Sustainable Development – FBDS on behalf of GTZ.

For the preparation of this study report an extensive list of references were used, including published reports, articles, proceedings of technical meetings, government agencies and private data banks, internet websites, press-releases. When found it necessary, references were indicated in the text body as well as in all figures and tables not generated by the authors themselves. Because of the ambitious time schedule, no own research work could be done for this study.

EXECUTIVE SUMMARY

Fuels from renewable energy sources are considered a basic ingredient for the sustainable development. Brazil is one of the countries with highest potential for fuels production from biomass and has already given a good example to the world as how to implement a program for the production and use of biofuel based on renewable source. The Brazilian bio-ethanol program has already 30 years of experience and has produced a mature industry. During that time the economies of scale obtained and the technological advances introduced led to increased competitiveness of the renewable alternative with respect to conventional fossil resources. Using sugarcane as raw material the bio-ethanol produced has a very high energy balance of the order of 8.3 units of energy delivered per each unit of fossil fuel spent for its production.

Government control of prices and subsidy concession to production and logistics were eliminated for sugar and ethanol in a transition regime initiated by the middle of the 90's and finalized in 2002. Now, the government is only present in the regulation of ethanol specifications and in the definition of its content of ethanol in gasoline – about 25%, at present. In 2003 the first flex-fuel vehicles were introduced to the Brazilian market. Since that time, the new transport technology is spreading throughout the Brazilian automobile industry. Flex-fuel vehicle is the dual fuel engine, powered with gasoline and/or alcohol, giving the consumer total liberty in choosing one of the fuels, or mixing them in any proportion. Prices of ethanol are competitive with gasoline at the filling station. The fast growing of flex-fuel car sales is a proof of acceptance of this technology by the Brazilian consumers.

For the years to come, Brazil has to make efforts to keep the competitiveness of its ethanol industry, expanding its production and export market with environmental sustainability. New plant varieties to keep path of the future crop expansion and the full development of hydrolysis of sugarcane bagasse technology will be important allies to this aim. According to projections (to be used as reference numbers and not as definite scenario) of the sugar/alcohol sector in Brazil, to meet the internal and export market demands for sugar and ethanol, the industry should be able to produce, by the year 2015, the following amounts: 33.7 M t of sugar – 12.8 for the internal and 20.9 M t for export markets, and 26.4 M m^3 of ethanol – 22.0 internal and 4.4 M m^3 for exportation. This will mean to expand the planted area of sugarcane to more 3 to 4 million hectares and investing about US$ 10 billion.

The use of sugarcane bagasse to generate electricity is today one important outcome from sugar / alcohol mills. All mills installed in Brazil became self-sufficient and some of them are even supplying the excess electricity to the public grid. Due to difficulties in expanding the generating capacity of the Brazilian interconnected network, as a result mainly of environmental license restrictions to new hydro-power plants, the Government is trying to motivate the sugar / alcohol producers to increase their share in the electricity market. Recent studies (Nov 2005) made by Tolmasquim, M.T. et coll. showed that, in Brazil, it is presently less expensive to generate electricity from sugarcane bagasse – US$ 719 per installed kW, resulting in generation costs of US$ 33.77 per MWh – than from hydroelectric power plants – US$ 820 per installed kW resulting in generation costs of US$ 35.76/MWh. A simplified evaluation indicates that with 350 million of sugarcane per year it is possible to have an installed surplus electric power capacity from 4,000 to 5,000 MW.

The Brazilian government is aware of the need to develop instruments that promote the deconcentration of the production, when considering sugarcane plantations expansion to new areas. The State of São Paulo solely concentrates 60% of the production and 70% of sugarcane plantations are owned by the mills themselves. Regional concentration is therefore a fact that has to be faced.

Countries with potential for producing sugarcane can profit from the lessons learned during the implementation of the Brazilian bio-ethanol program. There were questionable policy decisions at the start of the program, market supply difficulties, severe social and environmental problems to be solved and technological challenges to overcome. But today it is recognized that the majority of the problems were solved or satisfactorily mitigated.

Biodiesel, in turn, is just in the initial phase, with a chain of production being structured and looking for the best solutions from the economic, social and environmental standpoint. The Brazilian government when designed its policy for this sector created the social seal for biodiesel production. It is a valid policy at this time, mainly for a country with severe social unbalance. The program has a strong focus on small farmer production with special exemption in most of the taxes.

The Federal Law Nº 11.097, passed in January 2005, established the roadmap for the commercial use of this new biofuel in the country. It will be mandatory to use 2% biodiesel mixture (B2) to the conventional diesel from 01 of January, 2006 onwards. The obligation is restricted to the biodiesel volume produced by companies which have obtained the Social Seal. This means a potential market of about 800 Million liters of biodiesel (B100) per year. From 2013 onwards, a further mandatory step of 5% biodiesel mixture (B5) will be considered, meaning a firm market of 2.4 Billion liters per year.

Aiming at reaching the production goal for B2, a first electronic auction has been just realized (23 of November, 2005), under responsibility of the National Petroleum Agency (ANP), for purchasing biodiesel produced by industrial plants awarded with the “Social Fuel” seal. Price of the biodiesel produced is still much higher than the price of the conventional diesel. The Federal Government goal of purchasing 70 Million liters, to be delivered from January to December of 2006, has been reached. In this first round, 65,500 families were benefited.

However, it is considered an immense challenge to reach those volumes of production with the requested quality to the end-consumer, as the present production capacity is not sufficient and the control of fuel at filling station is much more complex than in the case of ethanol. And investments should be considered carefully by new entrepreneurs as regulatory marks are in process of consideration.

Biodiesel can be esterified using as reagent either methanol or ethanol. Methyl route is less expensive. Since the Brazilian Program recommends the Biodiesel production through the ethyl route but does not make it mandatory, the market will have to define the technology to be used, especially for the first phase of the industrial and technological development. Despite the environmental advantage of ethanol, the biodiesel production technology through ethyl route currently presents a series of challenges that will have to be solved in order to allow large-scale utilization.

Vegetable oil is responsible for about 80% of the total cost of production of biodiesel. Therefore, it is of utmost importance to identify the best oleaginous species and to obtain increasing productivity in its production. This includes accurate studies on the species from which it is possible to obtain the better energy balance in the biodiesel production.

Soybean oil can have an important role in the first years of implementation of the Brazilian biodiesel program, as the country is already one of its major world producers. One of the problems with this route is that soybean has low oil content. The soybean crop could be combined, in a second harvest in the same rainy season, with the culture of sunflower using about 20% of the soy area, thus obtaining more oil per hectare. Additional disadvantages of soybean for biodiesel, which has to be taken into account, are the poor energy balance in its production and the low employment generation.

Ecologically sensitive regions having high biodiversity may suffer negative impacts both due to the soybean production rate and to methods employed in its expansion.The impact on the gallery forests of the Cerrado, for instance, which is the habitat of half of the Brazilian endemic species and of a quarter of the threatened species, is among the most harmful ones. The expansion of the agricultural production in these areas of ecologically complex ecosystems may result in irreversible damages and should be object of concerns.

The castor oil and palm oil plant cultures are the main crops identified with potential for family agriculture production. It is however necessary to organize those producers through production cooperatives, to train and qualify them for production and supply compatible credit for their activity, among other measures.

African palm is the most promising specie for biodiesel production with productivity of 4,500 liters of vegetable oil per hectare. It can be produced by family producers and by enterprise producers in degraded areas of the Amazon. Presently, there is a legal limitation for reforestation of altered areas of the Amazon with palm trees, which poses an economic difficulty. However, the Federal Senate Commission on the Environment recently approved a project that will permit forest replanting with palm tree species in degraded areas.

It is necessary to strengthen the programs of genetic and phyto-technique of castor oil developed by the Brazilian Enterprise for Agricultural Research – EMBRAPA, in order to increase the offer of genetic material – higher number of varieties and commercial hybrids – with improvements in productivity and of the production systems used in the country. EMBRAPA should also work in the development of new varieties of African palm, increasing its germo-plasm bank and improving the resistance of these plants to plagues and diseases.

There are more than one hundred of native plants species identified with potential for the production of biodiesel, in Brazil, most of them palm trees. However, their information are only obtained from wild groves. Intensive research and development studies are necessary to permit commercial production. Normally, native specimens grow wild in protected areas, so the exploitation is more difficult and environmentally dangerous.

The government agencies should help with financing funds, technological support, provision of the necessary infrastructure and policies related to social and economical development, in addition to providing means for better education and environmental skills. It should guarantee the buying and selling of production according to pre-fixed rules related to quality and economic return. It is fundamental that the Government provides technical assistance and innovation development to the small producers in order to assure quality and productivity with environmental commitment.

Brazil is a potential exporter of biodiesel, which is already in commercial use in the United States and the European Union. Due to limitations for production growth in Europe, Brazilian biodiesel looks for the opportunity to build market share in the European continent. However, for this to become a reality it is necessary that technical specification for biodiesel adopted in Europe will be modified. European biodiesel specification is an excludent factor for the Brazilian exportation, because the only oleaginous that atttend 100% the specification is the colza. Biofuels in general are affected by protective legislation and are subjected to the rules currently under discussion in WTO – World Trade Organization.

Most of the developed countries are looking at hydrogen as the promising substitute for petroleum in the economy. In this scenario, hybrid vehicles (combined electric and fossil fuel derivatives) are looked as the transition option for transports until the full implementation of a hydrogen-based economy, estimated to occur after about 30 years. Brazil does not need that option. For Brazil, this transition to hydrogen might be made by ethanol. The country has a great potential for hydrogen production from renewable source such as solar energy, biomass in opposition of fossil fuel and hydro-electricity.

To succeed in its effort to go further with its ethanol program and to fully and safely implement its biodiesel program, Brazil will need support both in terms of capital investment and leading-edge technology. Germany is one of the countries which have a great tradition of investments in Brazil. Especially in the industrial sector, such as vehicle manufacture, metallurgy of iron and steel, electrical and medical equipments, telecommunications, etc. Therefore, Germany has the necessary means to establish a good partnership with Brazil.

The present Report deals with the Brazilian experience and broad possibility for production of biofuels for transport, the most relevant of which are ethanol and biodiesel, showing the potential for Brazil as an intensive user and possibly as a world supplier of bio-fuels in the years to come.

The Report is divided in 5 Parts:

i) Part 1 – Bioethanol, which gives a general view of the implementation of the production program started three decades ago, distribution and end-use of bio-ethanol; describes its present production structure and gives elements for the evaluation for the years to come of the potential for ethanol production and the internal and external markets.

ii) Part 2 – Biodiesel, gives a view on the vegetal oil industry presently installed in the country; describes the most promising plant species for biofuel production; shows the incipient structure for biodiesel production in Brazil, including governmental regulations and offer elements for evaluation of the potential for future biodiesel production for internal and external markets.

iii) Part 3 – Sustainability Targets, discuss the dilemma on food security and energy supply and the environmental and socioeconomic impacts of bioenergy production.

iv) Part 4 – Energy Scenarios, which gives a view of the present and future World and Brazilian demand for fuels, showing how it is possible to cope with that demand and to what extent this will impact the international trade.

v) Part 5 – Recommendations, indicates the pathways for improvements in the national and international policies to ease the biofuel market in Brazil and Abroad, and indicate possible fields of Germany-Brazil cooperation.

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INTRODUCTION

A large territory, excellent agricultural areas associated with geographical location and climate give Brazil a privileged position as a world biofuel producer. One important aspect for such comparative advantage is the fact that Brazil is a country plenty with sun.

Sun radiations, incident over the earth, result in other different forms of energy sources, either to be used directly in thermo-solar collectors and in photovoltaic cells, or to be used indirectly through intervention over other natural phenomena induced by solar energy, such as, wind, water cycle and photosynthesis. All these are sources of renewable energy.

Photosynthesis is the synthesis of carbohydrate and other organic compounds of high energy content from substances of low energetic potential existent in the atmosphere, like carbon dioxide and water. In the process of photosynthesis, by means of chlorophyll, solar energy is stored in vegetal tissues (cellulose, glucyde, lipidium, protein, lignin, etc.), which after all comprises potential chemical energy. [1, 2] *

The main factors which affect photosynthesis are solar radiation, temperature and water availability, besides nutrients. Gross biomass productivity varies considerably with the geographical latitude due to the associated solar energy availability and temperature. Those conditions for highest productivity are met by large portion of the Brazilian territory.

Photosynthesis produces organic matter as vegetables, such as: sugarcane, sorghum, soybean, castor oil plant, manioc, babaçu palm, oil palm tree, eucalyptus, pinus, water hyacinth, water lily and others. From these plants it is possible to produce bio-fuels such as: ethanol, biodiesel, methanol from wood, charcoal, biogas and hydrogen.

Different vegetal species can be converted into solid, liquid and gaseous fuels by means of different processes of conversion, economically adequate to each application, as exemplified in Table 1. [1]

Table 1 – Processes of Conversion of Biomass to Biofuels

Biomass or its derivative	Process	Biofuel
Sugar cane	Mechanical	Bagasse
Fermented of sugar cane, sorghum, etc.	Distillation	Ethanol
Eucaliptus and other forest species	Mechanical	Wood, chips, etc.
Vegetal oils	Transestherification	Biodiesel
Crop residues, urban residues, etc.	Anaerobic digestion	Methane
Water hyacinth, water lily, etc.	Anaerobic digestion	Methane
Crop residues and from wood industry	Pyrolysis and reform	Hydrogen
Ethanol	Direct reform	Hydrogen
Green algas	Bioconvertion	Hydrogen

* *Indication inside brackets [ ] shows position of technical literature and information used and listed under "References" at the end of this Report*

The production of biofuels is, however, essentially a question of agricultural production and it is from this point of view that a study of alternative programs of energy production and use should mostly be conducted.

In modern agriculture one has five relevant factors to consider in feasibility evaluation:

(i) to have land with soil and climate suitable for the crop to be planted;

(ii) to have enough capital, even if subsidized in a first phase, for it survive the market competition;

(iii) to have technology – technology is increasingly refined and restricted, in the sense it selects producers that know how to use and removes exploiters who only take advantage of land, pasture and forests;

(iv) to have management knowledge – such knowledge permits turning productive resources (land, capital, labor force) into economically sustainable activities;

(v) to be included in a productive chain of agro-business, meaning to be part of a productive chain with origin in the wishes of the consumer, going through distribution, agro-industry, processors and agro-cattle breeding production and ending in the industries of modern machineries and inputs. [15]

It is important to mention that Brazil still has numerous structural problems which impair the development of its economy or, saying in other words, which affect it to attain a better productivity in general – the productivity of the Brazilian economy is, for instance, equivalent to 18% of the American productivity.

The sugar / alcohol and the biodiesel sectors are also affected to a certain extent by those problems. According to a recent study made by the consulting firm McKinsey (*Veja*, Issue Nr. 1934) there are several barriers that prevent Brazil to get a better economic productivity. The five most relevant barriers with respective relative weights are the followings:

- Macroeconomic deficiencies (weight in set of barriers: 13%): distortions, mainly high interest rates, due to unbalance on government accounts.
- Regulatory problems (weight: 11%): excess of bureaucracy, taxes, prices control, commercial barriers, and rigid labor legislation.
- Infra-structure (weight: 5%): precarious system of transports, reduced limits for agriculture silage and uncertainties of the electricity supply.
- Quality of public services (weight: 8%): inefficiency of the State to provide to the whole society basic services such as education, justice, health and security.
- Informality (weight: 28%): evasion, piracy, disregard of the environment rules and violation of the rights of consumers.

The good news the above mentioned study indicates is that 65% of the barriers to the increase of the Brazilian economy, represented by those five ones, can be removed by means of punctual actions executed by the government. But the uncertainty of when those barriers will be overcome makes any projection for future expansion of biofuels production a high risk exercise.

PART 1

BIOETHANOL

1 Introduction

Sugarcane arrived in America by the time of the discovery of Brazil, in 1500. The first seedlings were disseminated in fertile ground in the hot and humid tropical climate. The spread of Brazilian sugar all over Europe enriched Portugal, the conqueror of the new colony.

Protectionism and subsidies – long-term impediments for the expansion of markets for Brazilian products – and the sprouting of the sugar-beet in Europe brought about the end of the “sugar cycle” in Brazil that entered a declining phase, initiated in the 18th century and ended up towards the end of the 19th century. [3]

Ethanol, as fuel, was the basis for the studies of the German inventor Nicolaus August Otto at the end of the 19th century. Liquid energy was effectively used in vehicles only in the 20th century. After several centuries of the sugar cane agro-industry existing in Brazil, it was discovered in the 20th century that alcohol could be an attractive alternative source of energy. Between 1905 and the middle of the twenties, several experiments were carried out by the sugar cane agro-industry to promote the alcohol as fuel.

The international prices were depressed and harmed the performance of sugar exportation during the 1929 economy crisis, opening space for State intervention in the sugar economy. On 20th of February of 1931, the Brazilian government forced, through decree no.19717, the mixture of 5% of alcohol in the gasoline imported.

The Institute of Sugar and Alcohol (IAA) was created in 1933 with the objective of ensuring the market equilibrium with the formation of stocks, the creation of sugar production quotas and a wide control on the commercialization. *IAA* established the basis to increase the national alcohol production by financing distilleries located near the sugar refineries.

The production growth of ethanol expanded the sugar cane culture to the Southeast, especially in São Paulo, where the product gained more space into the carbureting mixture due to importation difficulties of petroleum during the Second World War. On 23rd of September of 1938, decree-law no. 737 extended the mixture of 5% of alcohol to the gasoline produced internally with the implementation of the first national refinery of petroleum.

With the difficulties of petroleum and derivative supplies caused by the Second World War, the mixture of carbureting alcohol with gasoline reached up to 42% in the decades of 50 and 60. However, the alcohol as carburant became less interesting for the Government as well as for the business community. The ratio was significantly reduced in the beginning of the seventies, reaching 2.9 % all over country, except the city of São Paulo where the ratio was 7%.

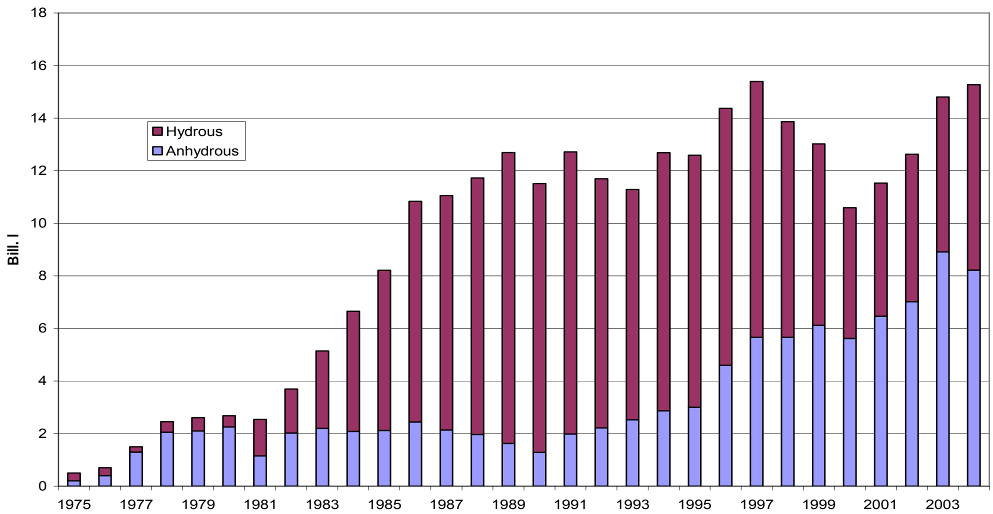
In the mid 1970´s a new swap of the international economy occurred with the drop of the sugar external price as well as the raise of oil prices, creating favorable conditions for the return of fuel alcohol to the national energy matrix, including the introduction of the use of ethanol exclusively as carburant.

The National Program of Alcohol – PROALCOOL - was created in November 14, 1975 through decree no. 76.593. This was the first and most successful large scale biofuel program in the world. The Program was adopted by the Brazilian government as a response to the international oil crisis. The objective of the program was to introduce a blend of gasoline with ethanol (gasohol), produced from sugarcane, to the Brazilian market and to incentive the development of pure ethanol fueled vehicles. Government measures of incentive included: a guarantee for ethanol fuel prices (maximum 65% of gasoline price); a 5% tax reduction for alcohol fueled vehicles; subsidized loans for ethanol producers to improve capacity; compulsory sales of ethanol at fuel stations and government control of fuel stocks to guarantee the supply and price. With PROALCOOL, Brazil promoted rural development, lower dependence on oil imports, reduction in local pollutants from vehicles and net reductions in greenhouse gas emissions.

In a brief summary, three specific phases are distinguished during the implementation of PROALCOOL (Figure 1).

Initial Phase (1975 to 1979) – the effort was addressed mainly to the production of anhydrous alcohol for mixture with gasoline. The alcohol production grew from 600 million liter/year (1975/76) to 3.4 billion liter/year (1979/80). The first cars moved exclusively by alcohol were introduced in 1978.

Figure 1 – Evolution of the Production of Ethyl Alcohol (1975 to 2004), Bill. liters
(Source: UNICA)



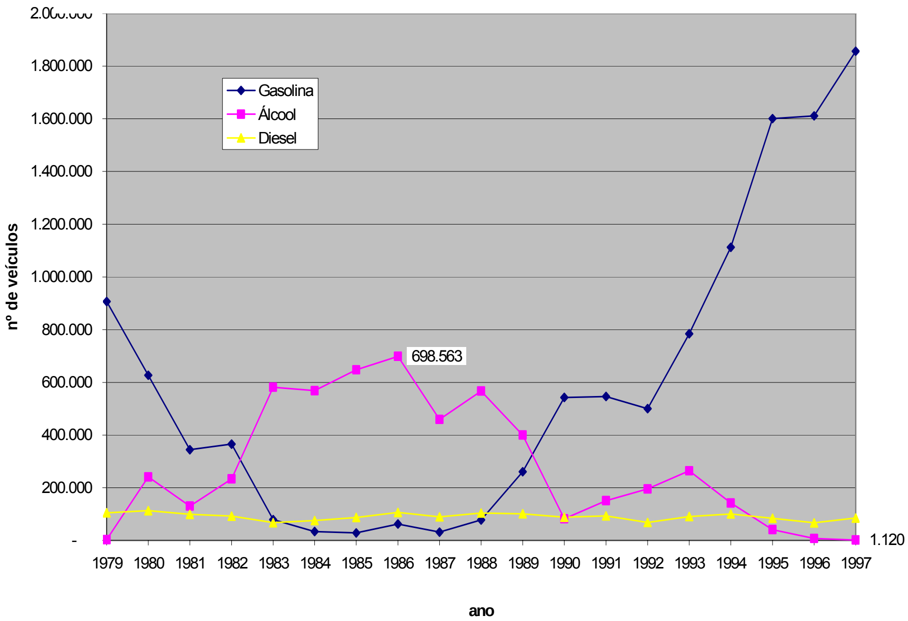
Affirmation Phase (1980 to 1987) – the second shock of petroleum (1979/80) tripled the barrel price and the petroleum imports accounted for 46% of the total Brazilian importations in 1980. The Government then decides to add measures for the PROALCOOL full implementation. New agencies were created such as the National Council of Alcohol (CNAL- *Conselho Nacional do Álcool*) and the National Executive Commission for Alcohol (CENAL- *Comissão Executiva Nacional do Álcool*) in order to speed up the program. The alcohol production reached a peak of 12.3 billion liters in 1986/87, surpassing by 15% the Government forecast 10.7 billion liters/year for the end of period.

The proportion of the alcohol-powered cars produced in Brazil within the total fleet, individual and of mixed use, increased from 0.3% in 1979 to 24.5% in 1980, reaching the peak of 80.6% in 1986 (Figure 2).

Stagnation Phase (1987 to 1997) – the international scenario of the petroleum market has changed. The crude oil barrel prices dropped from US$ 30 to 40 to a level of US$ 12 to 20. The new period called "Petroleum Counter-Shock", put in check the programs for the substitution of hydro-carbon fossils and efficient use of the energy worldwide. For the Brazilian energy policies, the effects were noticed from 1988, coinciding with a period of public resource shortage to subsidize the programs of alternative energy, resulting in a significant decrease in the volume of investments for internal production of energy. Nevertheless, the volume of the alcohol production showed a small increse to 12.7 billion liters in 1995.

The alcohol supply, restrained by market factors and government intervention, could not follow the demand's disorderly growth when alcohol-powered automobile sales reached 80.6% of the vehicles produced in 1986, just before the shortage crisis of 1989-90. The ephemeral shortage in the supply of alcohol at the end of 1980s affected the government's credibility and the confidence of the population in PROALCOOL, generating a significant reduction in the production of alcohol-powered automobiles. (Figures 2 and 3).

Figure 2 – Production of vehicles per fuel type (1979 – 1997) [22]



In addition, other determinant motives also contributed to the reduction of the production of alcohol automobiles. At the end of the 1980s the barrel price was substantially reduced. With this framework where the barrel prices were steady for the following ten years, Brazilian industry showed a strong tendency to produce cars and engines of a global standard, gasoline powered. Furthermore, in the beginning of 1990s, Brazil released some restrictions on the importation of automobiles, all gasoline or diesel-powered, and introduced a government policy to give incentive to the "popular car" – up to 1000cc – designed to be gasoline-powered.

Re-definition Phase. Current Situation – The radical changes in the decade of 1990s had only been completed in 1999, with the total deregulation of the sector: from the privatization of the exportations (1991) to the extinction of the production quotas (sugar and alcohol), and prices freedom (sugar, anhydrous alcohol and hydrate alcohol) with an enormous reduction in production cost that currently, in sustainable conditions is around US$0.18 per liter of ethanol – in the South Center region of Brazil. Such costs are competitive (not considering other external factors) with the gasoline derived from petroleum at US$ 23/barrel – in the international market. From the one million tons of sugar per year exported in 1990, the country reached up to 10 million tons per year, dominating the international market and reducing the price of the products.

In August 21, 1997 the Sugar and Alcohol Inter-Ministerial Council (CIMA - *Conselho Interministerial do Açúcar e do Álcool*) was created by decree in order to deliberate on the policies regarding the sugarcane industry including all aspects: production, energy, environment, economic, scientific and technological.

Finally, it could be said that the production and use of ethanol in Brazil were all based on the competitive culture of ground sugarcane, the main product of which, by the beginning of the 20th century, was sugar. Ethanol was already a balancing factor for the excess of that raw material given the limitation of the Brazilian internal market. This strategy yielded good results for the development of today's modern Brazilian renewable ethanol as a fuel and raised the competitive level for the sugar cane of the agribusiness sector. [3]

2 The Ethanol Fuel

Ethanol or ethyl alcohol (CH_3CH_2OH) is one of the main existing alcohols. It is flammable, colorless, has a characteristic smell and is miscible with water and with other organic components. Its melting point is -114.1°C, the boiling point, 78.5°C. Its density is lower than that of the water: 0.789 g/ml at 20°C.

Ethanol usually comes from biomass—crops rich in sugar, starch or cellulosed material—rather than from natural gas. As a matter of fact, sugarcane is considered the most efficient biomass energy feedstock in the world today. Its manufacture involves the fermentation of sugar, using yeast. Because sugar (glucose) occurs as such in only very few plants, larger carbohydrate molecules have to be cracked by hydrolysis to fermentable sugar, after the raw material has been size-controlled by splintering and milling. Several different hydrolysis techniques reflect the most important differences in production methods required by different feed stocks. Most of the glucose can be extracted directly from sugar-rich plants, which demands only a very mild hydrolysis; the starch-rich crops yield to available technology for enzymatic hydrolysis and cellulosed materials require acid hydrolysis.

Ethanol is a liquid that is produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosed residues from crops or wood. It may be used as a gasoline octane enhancer and oxygenate - it increases octane by 2.5 to 3.0 points at a 10 percent concentration.

Basically, there are three processes applied in the ethanol production: fermentation of carbons, catalytic hydration of ethylene with sulfuric acids, and reduction of acetaldehyde (usually prepared through acetylene hydration).

Alcohol has proven to be a good motor fuel showing a superior level of octane rating, it does not contain sulphur preventing its composite emission and the contamination of catalytic converters, and due to a lower steam pressure, results in lesser evaporative emissions (Table 2).

Table 2 – Properties and characteristics

	GASOLI NE	ETHANOL
Specific heat (kJ/kg)	34,900	26,700
Octane number (RON/MON)*	91/80	109/98
Latent heat of vaporization (kJ/kg)	376 ~ 502	903
Temperature of ignition (ºC)	220	420
Stoichiometric reason Air/Fuel	14.5	9

** RON – research octane number / MON – motor octane number — Source: GilTech*

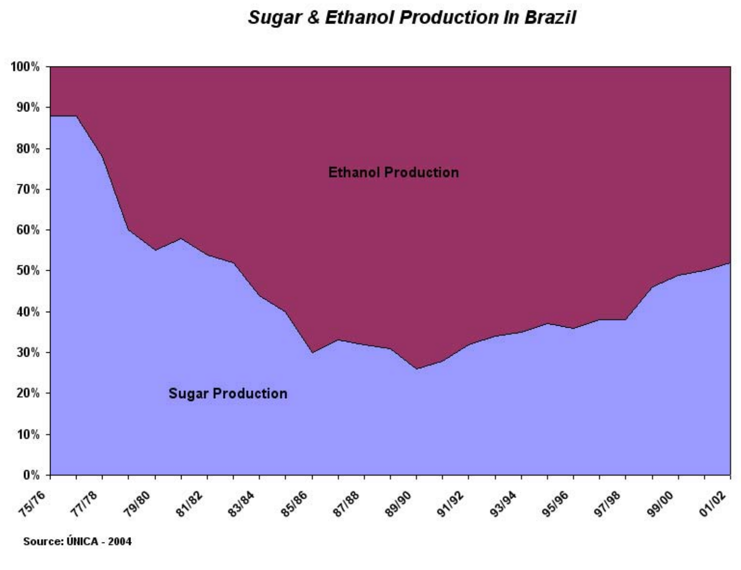
3 Current Situation

3.1 Production and End-use Technology

Brazil is the largest world producer of sugarcane, being responsible for about 25% of world production and followed by India and Australia. The culture of sugarcane in the country is spread in the Central-South and North-Northeast Regions. Crop periods occur from September to March in the North-Northeast Region and from May to November in the Center-South.

Sugarcane crops presently occupy 2.4% of the Brazilian agricultural area, which means, almost 5.5 million of hectares. In the last five crops, an average of 52% of this production was destined for ethanol plants, anhydrous and hydrated, and 48% for sugar production, refined, crystallized and raw [4]. Therefore, ethanol production in Brazil occupies about 2.8 M hectares which is about 1.2% of the surface already used for agriculture or 0.5% of the surface with potential for agriculture use.

Figure 3 – Percent of sugar cane production for sugar and ethanol production in Brazil (1975/76 to 2001/02)



The sugarcane culture in Center-South Region represents around 85% of the Brazilian production and is located between the states of São Paulo, Paraná, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro and Espírito Santo. In the Northeast Region, the states of Alagoas, Pernambuco, Paraíba, Sergipe, Rio Grande do Norte and Bahia are responsible for the remaining 15% of the sugar cane production. (see Table 3)

Table 3 – Production of Sugarcane and Alcohol, per Region, 1999 / 2005

Region	Product	99/00	00/01	01/02	02/03	03/04	04/05*
Center-South	Cane (Mt)	264.14	206.84	244.31	267.52	298.33	327.58
	Alcohol (Mm^3)	11.64	9.06	10.16	11.01	12.99	13.57
North Northeast	Cane (Mt)	43.02	49.72	48.82	50.10	59.45	47.47
	Alcohol (Mm^3)	1.37	1.53	1.36	1.46	1.72	1.34
Brazil Total	Cane (Mt)	307.16	256.56	293.13	317.62	357.78	375.05
	Alcohol (Mm^3)	13.01	10.59	11.52	12.47	14.71	14.91

Source: ALCOPAR: Paraná; ÚNICA: São Paulo; MAPA: Other states
**NOTE: North-Northeast: CROP 04/05 – position on 02/01/05*

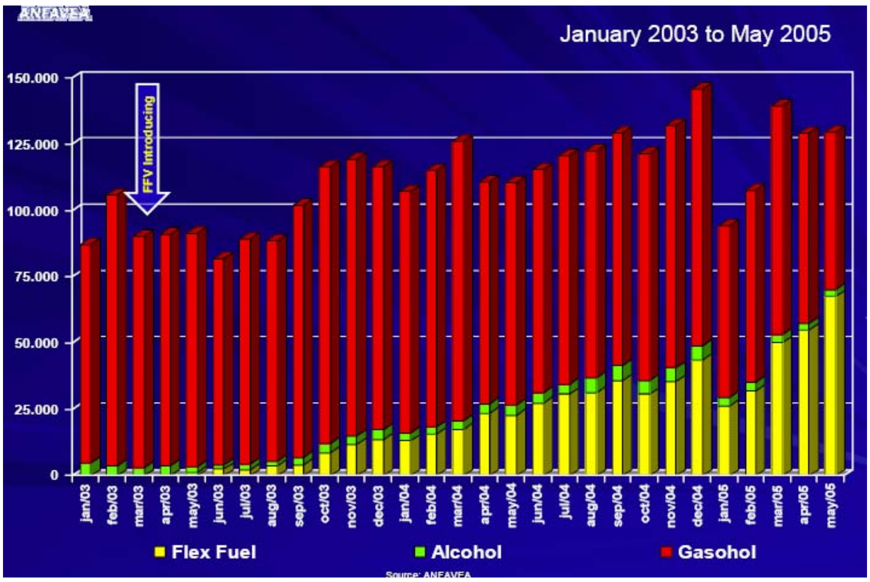
In the period 1990-2005, sugarcane production increased 58.6%, from 260 to 414 M t and the correspondent increase in planted area was 31.6 %, from 4.2 to 5.5 M hectares. The evolution of those two parameters reflects considerable increase in productivity.

Of the 320 sugar cane processing units for the 2003/2004 crop, 226 were based in the Center-South region and divided into mills, mills with distillery plants, and independent distilleries. The first ones only produce sugar, while those with distillery plants produce both sugar and ethanol and the independent distilleries produce ethanol only. [3]

Brazil produces two types of ethyl alcohol or ethanol: hydrated and anhydrous. Since the end of years 90's, the production of anhydrous alcohol has increased in relation to hydrated alcohol (see Table 3.A). Hydrated ethanol (with a 4% water addition) is used to power alcohol and "flex fuel" vehicles. The anhydrous type, absolute and water-free, serves as a gasoline oxygenator in several countries, as an alternative to highly pollutant additives, such as tetraethyl lead and the MTBE (Methyl Tertiary-Butyl Ether), an oil derivative. Presently, there are no subsidies for anhydrous or hydrated ethanol production.

In the Brazilian market of light vehicles the local manufacturers sold, from 1979 to 2002, 5,505,214 units (25.2%) alcohol powered and 16,305,554 units (74.8%) fueled with gasoline (this meaning, gasohol, with 19 to 26% alcohol added to pure gasoline).

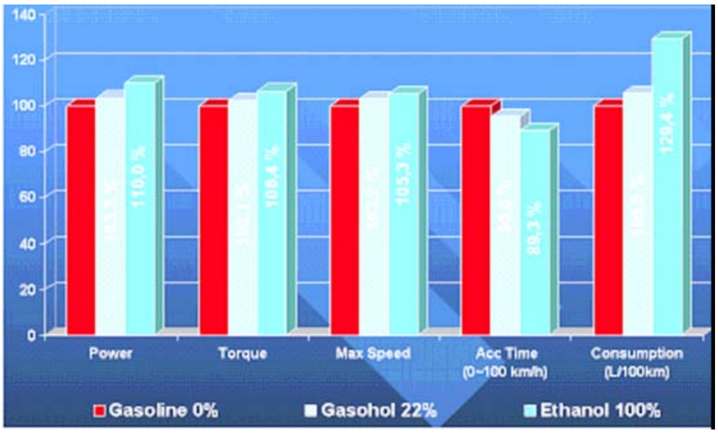
Figure 4 – Vehicle sales in the Brazilian Market (thousand of units) [6]



In 2003, the first Flexfuel Vehicles were introduced to the Brazilian market (Figure 4). Since then, the new transport technology is spreading throughout the Brazilian automobile industry. It is the dual fuel engine, powered with gasoline and/or alcohol, giving the consumer total liberty in choosing one of the fuels, or mixing them in any proportion. By today the manufacturers Volkswagen, Ford, Fiat, GM etc. have introduced 19 car models on the Brazilian market. In 2005, it is expected that around 700,000 or 60% of the car sales will be Flexfuel cars. Is is believed that by the end of 2007 up to 67% of the overall car sales will be equipped with the Flexfuel technology. There is a general believe in the market that the alcohol price is competitive up to 70% of that of gasoline. Today (Sept. 2005), alcohol is sold in gas stations at around 51% of the gasoline price. [6]

The introduction of Flexfuel technology required several modifications of the engine. This is due to the corrosion of metallic materials, the chemical attack on the plastic materials and the low molecular energy content. Furthermore, the different air / fuel ratio for combustion and the low vapor pressure need to be taken care of. Figure 5 shows the relative performance of ethanol engines.

Figure 5 – Relative performance of ethanol engines [6]

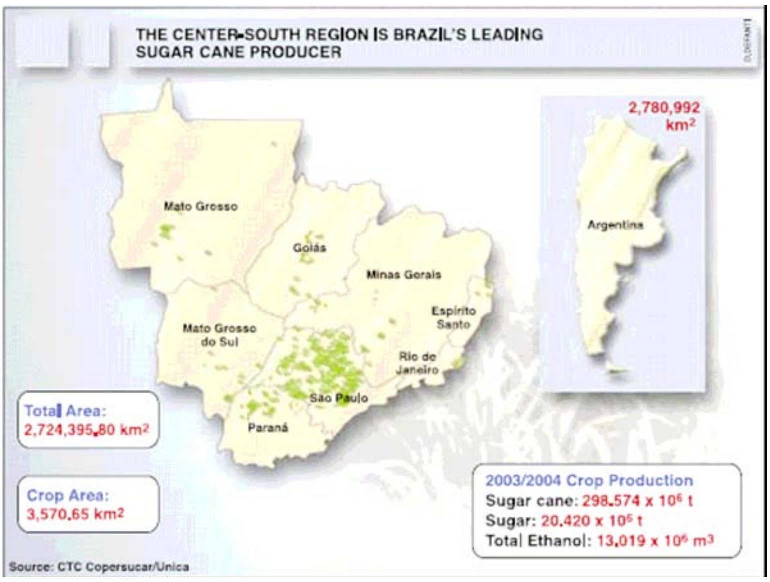


3.2 Structure of Processing Industry

There are presently 320 sugarcane processing units in Brazil, with different capacities, ranging from 0.6 to 6.0 Mt annually. On average, each processing unit owns about 70% of planted area that supplies its needs for sugarcane. The remaining 30% is supplied by around 60,000 producers, most of them small.

According to official information from the Agricultural Ministry, the Brazilian installed capacity for ethanol production is of the order of 15.5 Mm^3, which correspond to the same production of 1997. Each production plant processes 1.5 million tons of sugarcane per year, on average. The ten leading mills crush 3.6 to 6.8 million tons of sugarcane per unit during the crop period, producing 298,000 to 455,000 tons of sugar and 174.2 to 328.8 million liters of ethanol, also in industrial facilities. [4]

Figure 6 – Map Indicating Area of Cane Producers - Center-South Region



Almost all of them operate with equipment manufactured by national capital goods companies whose technology has allowe Brazil to achieve a quite expectional industrial yield. If used in ethanol production only, each ton of ground sugarcane would result in 89 liters of hydrated or 85 liters of anhydrous ethanol today; if used exclusively in sugar production, each ton would yield 118 kg of sugar and 10 liters of ethanol from the molasses. It should be noticed, however, that under normal market operation the national average yield is 71 kg of sugar, 42 liters of alcohol per each ton of crushed sugarcane. [3] Careful consideration should be taken when using those indicators of productivity, taken from different sources, as they vary in accordance with the relation of sugar and ethanol produced, the type of ethanol (if hydrated or anhydrous) among other factors.

3.3 Cost and Prices Competitiveness

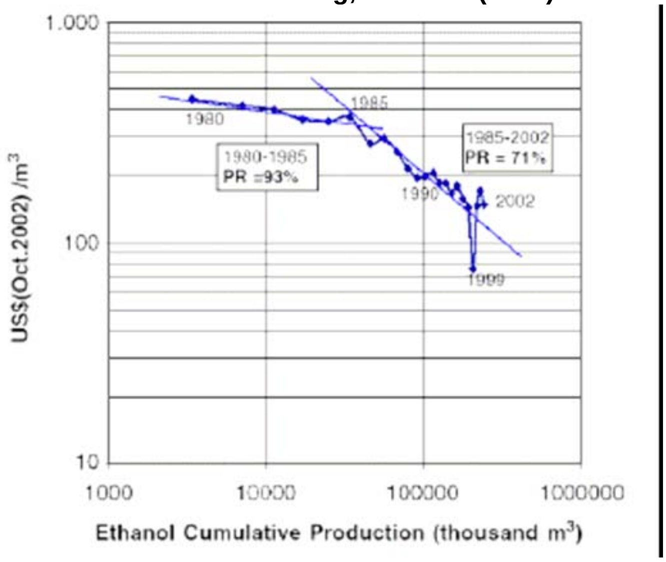
The National Program of Alcohol (PROALCOOL), as mentioned earlier, was adopted in 1975 by the Brazilian government as a response to the international oil crisis. Government measures of incentive, at that time, included several subsidies. Today, there are no more subsidies for ethanol production.

As stated by Goldemberg et al. [7], 30 years after launching the program, it is recognized that the Brazilian experience with bioethanol is a proof that economies of scale and technological advances can lead to increased competitiveness of renewable alternatives compared to conventional fossil resources. It is also clear from such experience that adequate government incentives can lead to positive environmental and economic as well as social development in emerging economies. From 1980 to 2002, the price reduction obtained was to the order of 71%. As the efficiency and cost competitiveness of ethanol production evolved over time, this support was no longer needed and was not applied.

It should be mentioned that, government control, such as quotas for production and exportation, prices control and subsidies concession to production and to logistics, were eliminated for sugar and ethanol in a transition regime, initiated by the middle of the 1990s and finalized in 2002. Nowadays, the government is only present in the regulation of hydrated and anhydrous alcohol specifications and in the definition of the content of ethanol in the gasoline (about 25%, at present). [Lucon, India]

Prices are liberated in all levels of the commercialization chain. 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 filling station (as guaranteed in the initial phase of PROALCOOL and even lower nowadays, as mentioned earlier), due to significant reductions in production costs. Then, there is a general believe in the market among consumers that, the alcohol price is competitive up to 70% of that of gasoline. Today (Sept. 2005), alcohol is sold in gas stations at around 51% of gasoline price. This economic competitiveness is already a reality for several years and will continue for years to come, especially with the current increase of the crude oil prices on the world market.

Figure 7 – Ethanol learning curve. The prices quoted are for alcohol producers in Brazil
Source: Goldemberg, J. et col. (2004)



Such tremendous increase in productivity of the Brazilian production of ethanol has been the result of progressive implementation of new technologies and management advances, which have resulted in a renewable fuel highly competitive with fossil fuels. The best examples of this in the industrial area are the gains in extraction and fermentation efficiency. But, there is no doubt that the introduction of new species of sugarcane plants, developed in Brazil by Planalsucar and Copersucar, were responsible for the highest cost reductions. New technological tools for the agro-industrial production management became of increasingly importance: programs for optimization of the reform of sugarcane plantations, follow-up of harvests, process operational control, mutual control and simulation of mass and energy balances, among many others. [4]

The results of efforts for increasing productivity can be visualized by the improvements of indicators summarized in Table 4. [4]

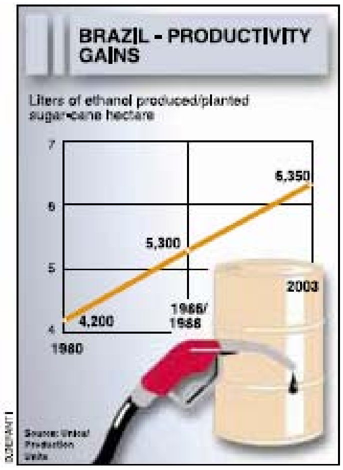
Table 4 – Indicator of productivity in the sugarcane agri-business in Brazil (1975/2000) [4]

Indicator	Change
Agricultural Productivity	+ 33%
Saccharose Average Content in Cane *(1985/2000)*	+ 8%
Efficiency in Saccharose Convertion to Ethanol	+ 14%
Productivity in fermentation (ethanol m³ / reactor-day m³	+ 130%
Agro-Industrial Convertion, Average	+ 172%

Other activities in the chain of ethanol production gave also their contribution to the overall increase in productivity, such as the improvement in transportation of sugarcane from the field to the mill, and the use of processed industrial waste in culture irrigation and fertilization. Other significant technological advances have occurred in the last few years, generating an increase in the average productivity of the sugarcane conversion to ethanol (hydrous and anhydrous) from 75 l/ton in 1985 to about 85 l/ton in 1996, as for instance:

- Broth extraction – reached a level of 97% in the milling of the sugarcane (45% superior if compared with1975);
- Broth treatment and fermentation – first, biological control followed by continuous fermentation (more than 230% of productivity if compared with 1975);
- Distillation – increase in the capacity in accordance with the alcoholic level of mixture, due to equipment improvements.

Figure 8 – Productivity Evolution (1980-2003), in liters per hectare [3]



Ethanol producers in Brazil have a firm market represented by 25% of the fuel volume consumed by the gasoline cars. This is the present percentage of anhydrous alcohol added to gasoline. The Brazilian light vehicle fleet of around 18 million units consumes 27.5 billion liters of fuel per year: 16 billion liters/year of “A” gasoline, and 11.5 billion liters/year of hydrated or anhydrous ethanol. The “A” type, a pure gasoline, is the refining standard. In the retail fuel market, all of the gasoline has a 25 percent addition of anhydrous ethanol. For each liter of pure gasoline, 0.72 liter of fuel ethanol is consumed in Brazil.

Agricultural producers, most of whom being small-to-mid-sized property owners, are paid according to a parametric formula that takes into account the total sugar content of the raw material and the prices for sugar and ethanol in both the domestic and export markets.

The amount paid for sugarcane in Brazil represents 60 percent of the industry's turnover. In the State of São Paulo, producers received an average of US$ 10.35 per ton of sugarcane supplied to the industrial units for the 2003/2004 crop [3]. Recently, small producers have claimed strongly against the way producers are paying for their supply of sugarcane.

As a signal of vitality of the open market of ethanol, the implantation of the market for future contracts for anhydrous alcohol (for physical delivery or negotiation) in the São Paulo Commodities and Futures Exchanges registered, by the middle of 2003, an average monthly movement of more than 4,000 contracts (each one corresponding to 30 m^3) amounting 34 million reais (about US$13.6 million). This market permits certain protection against volatility of the prices or the obtention of economical gain associated to the same fluctuation of the prices. [3]

3.4 Infrastructures

Ethanol stocks are essentially administrated by the producers themselves, since in general the distributors have tanking for only a few days. According to the Petroleum National Agency (ANP), in the 428 fuel distribution bases that there are in the country, there is a storage capacity for ethanol of the order of 668 Mm^3, of which 50% is located in the Southern region and 21% in the Northeast Region.

Presently ethanol is sold (anhydrous blended to gasoline or hydrated for use pure) by means of consolidated distribution logistics using pipes, railways and highways, as well as 29,646 fuel stations with dedicated ethanol supply equipment of a total of 31,979 fuel stations throughout Brazil's continent-sized territory. [3]

3.5 Agricultural Crops for Ethanol Production

3.5.1 Plants

When the PROALCOOL Program was created, in the years 1970s, the average production of ethanol in the country was 3,000 liters per planted hectare and the total planted area was about 1.5 Million hectares. At that time, only 10 varieties of sugarcane were available. Today, the average production of ethanol is 7,000 litres per hectare, more than 550 varieties of sugarcane are cultivated and the crop period has increased from 150 to 220 days.

Sugarcane is presently cultivated in about 5.5 Million hectares, spread over the 27 States of the Brazilian Federation. In the last ten years, 51 new varieties have been released, the main 20 of which occupy 70% of the total planted area. Those varieties were produced mainly by two programs of genetic improvements: the Copersucar program (varieties SP) and of the *Rede Interuniversitária de Desenvolvimento do Setor Sucroalcooleiro* – Ridesa (for instance, Planalsucar, with varieties RB). A third active program is of the *Instituto Agronômico de Campinas* (IAC). [4]

The germoplasm bank of Copersucar has more than 3,000 genetypes, including a large collection of native (wild) species, like *Saccharum officinarum* (423 genetypes), *S. spontaneum* (187 genetypes), *S. robustum* (65 genetypes), *S. barberi* (61 genetypes), which are precursory species of modern varieties of sugarcane and source of the great genetic variability found in this plant. [4]

In 2003, the Brazilian investment group Votorantim (cement mills, cellulose plants, siderurgy, etc.) created the enterprise Canavialis, in São Paulo State. With initial investment of around US$ 1 Million, Canavialis is a huge laboratory for genetic selection and development of sugarcane. Each year, their laboratory releases over 1.5 million seedlings to be planted and tested in three farms, named experimental stations, located in different parts of the country.The Votorantim Group also formed a biotechnology company, Alellys, dedicated to modify the genetic composition of sugarcane varieties produced by Canavialis. New varieties more productive and resistant to diseases are under development.

3.5.2 Production technology, input requirements, resource and climatic requirements

Production technology of sugarcane has been continuously increased, not only in terms of productivity of tones of sugarcane per hectare, but also in terms of the quality of the plant produced, namely the saccharose content.

The sugarcane agro-industry employs about 1 million Brazilians. Over 80% of the cane harvested is cut manually; burning cane trash, which makes the work safe and more productive for cane cutter, precedes cutting. But mechanization is advancing. In the State of São Paulo, 25% of the cultivated area is harvested mechanically. The São Paulo legislation sets deadlines for eliminating the use of fire in crop management. Technological evolution is therefore gradual, requiring development of realistic policies for recycling and redeploying labor and monitoring the environmental impact related to erosion and the spread of pests that follow mechanization.

The evolution in agricultural area, in recent years, indicate an increasing level of mechanization of the harvest, a tendency that in São Paulo is particularly associated to the progressive reduction of the pre-harvest burn.

Improvements in technique of transportation of sugarcane from the field to the mill have also reflected in better productivity. Transportation of sugarcane pieces made with the so-called *“rodotrain”* is about twice as effective as the simple towing truch.

Diseases in sugarcane are avoided by an adequate selection of resistant varieties in programs of genetic improvements. The control of the main sugarcane plagues like “broca” (Diatraea saccharalis) and “cigarrinha” (Mahanarva fimbriolata) are made by biological means (wasp, Cotesia flavipes, in the first case and fungus, Metachizium anizophiae).

In the combat of damaging herb, more herbicides are used in sugarcane culture than in plantations of coffee or corn, less than for citric-culture and about the same as for soybean.

The use of insecticides is relatively low and practically no fungicides are used. Herbicides are of more use, with an average of 4.00 kg of active principle per hectare.

Brazilian agriculture is not intensive in fertilizes use. The average intensity of fertilizers use (N-P_2O_5- K_2O kg/ha) in Brazil, is equivalent to the use in USA and Venezuela, 40% of France or China and 22% of Holland, according to 1998 data. The total consumption in 2002 was 7.68 M t. The most important factor for achieving this better comparative performance is the nutrient recycling with application of industrial residues, such as vinasse and filter pie. Sugarcane plantations in Brazil, compared with other cultures with planted land areas over 1 million hectares, occupy fourth place with a use intensity of 460 kg/ha of fertilizers (N-P_2O_5- K_2O).

For water use, see Part 3, item 2.2.

Large land areas in Brazil have excellent climatic characteristics for cultivation of sugarcane with no need for irrigation. Sugarcane culture demands a rainy period for its vegetative development, followed by a dry period for maturation and harvest. The ideal climatic is: average annual temperature lower than 20°C and water deficit lower than 200 mm per year. Such conditions are found mainly in the States of São Paulo, Paraná, Minas Gerais, Alagoas, Pernanbuco, Mato Grosso, Rio de Janeiro, Bahia, Goiás and some Amazonian regions, especially Acre, Roraima, Amapá and north of Pará.

3.5.3 Size and structure of farms

As mentioned before, at present, in Brazil, the sugarcane planted area totals 5.5 M hectares, 70% of which are owned by the 320 mills in operation in the country. The remaining 30% belongs to 60,000 small and medium size producers. This results that in each mill has an average property of 12,000 ha of planted area and the independent producers, in average, own 27.5 hectares.

If one takes into consideration the average productivity of 75 t / yr this result that each mill produces 0.9 M t per year. The capacity of processing of the existent 320 mills varies from 0.6 to 6.0 tones of sugarcane per year. These numbers also indicate that each independent producer yields 2,062 t / yr.

3.5.4 Farm enterprise gross margins, financial feasibility

The average production cost of ethanol in Brazil is in the order of US$ 0.20 per litre. An industrial plant yields on average about 80 liters per ton of sugarcane. This results in an average cost of production of ethanol of US$ 16.00. According to the Union of sugarcane producers of the State of São Paulo, the price paid per tone of sugarcane is US$ 11.4 (UNICA 2005).

Recent ethanol production cost assessment (ref. CNAE) with the intent of determining what is the cost of production economically sustainable, including return on capital, made use of average values for the most efficient mills, with present technology. Table 5 summarizes the results. [4]

Table 5 – Costs of production of sugarcane and processing for ethanol (April 2001) [4]

Parameters and Costs	Scenarios	
	Efficient Mills	Prospective Mills
Agricultural Productivity t cane / ha	85	90
Cane Quality, %pol / cane	14.5%	15
Industrial Productivity - ethanol l / cane t	85	90
Industrial efficiency in Ethanol Production	88 to 89%	90
Average Cost of Cane(at mill), R$ / cane t	23.50	22.60
Industrial Processing Cost, R$ / cane t	15.10	15.10
Ethanol Cost, R$ / cane t	38.60	37.70

Sugarcane products in Brazil have no mechanisms of prices support by public policies. No subsidies to the production and commercialization are given today.

3.5.5 Availability of area for energy crops

The cultivated area with sugarcane today in Brazil totals about 5.5 Million hectare. Fifty percent (50%) of the yield is directed to the ethanol production. Therefore, 2.75 Million hectares are dedicated to ethanol production, today, which is about 0.5% of the agricultural surface of Brazil. The expansion of areas are been made mainly by use of areas previously occupied by cattle, without displacement of plantations of other species. See also item 4.1.1 of Part 1 and item 1.1 of Part 3.

3.6 By-product markets

3.6.1Relevant by-products [8]

Sugarcane is an extremely versatile raw material. From it, sugar and various types of alcohol can be made; beverages can be manufactured and electricity can be generated from the bagasse. Everything from the cane is used: bagasse, syrups, cake and waste from the harvest.

Using 3 kg of sugar and 17.1 kg of bagasse, for example, 1 kg of cane-derived biodegradable plastic can be obtained, using other byproducts from the sugar mill as solvents.

From the bagasse, hydrolyzed bagasse can be obtained for animal feed, various types of paper, pharmaceutical products and other items such as highly reactive furfurol, for synthesizing organic compounds that have a great number of applications in the chemical and pharmaceutical industries.

From the effluents, the liquors are used as fertilizers.

Sugarcane thus generates, as is the case with petroleum, innumerable products ranging from yeast to herbicides and insecticides, with an important difference: they are biodegradable and inoffensive to environment.

In terms of energy production, it can be said that, the conversion of 1 ton of sugar cane can be summarized as indicated in Table 6.

Table 6 – Energy Products from 1 ton of Sugarcane (Source: CTC – Coopersucar)

Product/Sub product	Quantity	Toe = Equivalent Tons of Oil
Ethanol	80 litres	0.0408
Bagasse	280 kg	0.0570
Straw	280 kg	0.0570
Total (Toe)		**0.162 = 1 barrel oil**

The use of sugarcane bagasse to generate electricity is today one important outcome of sugar / alcohol mills. In fact, by 1980 only 40 to 50% of the electricity consumption of the mills was produced internally using bagasse. By the year 2000, all mills became self-sufficient and some of them are even supplying the excess electricity to the public grid. This activity of independent electricity producer is becoming an additional important source of revenue for sugar / ethanol producers. By the year 2003, there were184 self-producers of electricity in this sector, with a total installed capacity of 1,582 MW or 10% of the Brazilian total thermal capacity.

Due to difficulties in expanding the generating capacity of the Brazilian interconnected network, as a result of environment license restrictions to new hydro-power plants, the Government is trying to motivate the sugar / alcohol producers to increase their share in the electricity market. Recent studies (Nov 2005) made by Tolmasquim, M.T. et coll. showed that presently is less expensive to generate electricity, In Brazil, from sugarcane bagasse – US$ 719 per installed kW, resulting in generation cost of US$ 33.77 per MWh – than from hydroelectric power plants – US$ 820 per installed kW and generation costs of US$ 35.76/MWh.

More advanced and efficient co-generation technologies are progressively being used by the sector to permit more electricity generation. Also, with the mechanization of sugar harvest it will be possible to use sugarcane straws, which is almost totally burned today, to increase the capacity of energy generation. It is possible to increase productivity from 10 kWh/ton of sugarcane, by using counter-pressure steam turbines 22 bar/300°C, to 150 kWh/ton of sugarcane, with condensation extraction 80 bar/480°C. A simplified evaluation indicates that with 350 million of sugarcane per year it is possible to have an installed surplus electric power capacity from 4,000 to 5,000 MW.

However, due to relatively lower prices paid for electricity and the very high interest rates charged to capital investments in Brazil, the expansion of generation based on biomass from sugarcane mills is being slower than expected.

3.6.2 Market and prices

Sugar produced by mills installed in the Center-South Region of Brazil is maintaining already for many years the lowest world sugar production cost. Brazil is one of the most important world producers being responsible for about 40% of the commerce in the “free market”. However, Brazil still has a relatively high transportation and loading costs at shipping ports.

Production cost for the most efficient mills is around US$ 125 / t of sugar (US$ = R$ 2.80). Exportation costs, including transportation costs and harbor taxes, are aspects to be improved for better competitiveness of the Brazilian product.

Prices to be offered for electricity produced from sugarcane biomass (market and government) will be decisive for investments in new generating plants. It is believed that for the next ten years, the tendency is that mills will keep self-sufficiency with small excess; some mills will produce electricity only during harvest period; but, another group of mills will produce during the whole year complementing their biomass with straw. The government decision to promote thermo-electric generation by biomass is considered extremely important for the sector.

3.6.3 Interrelation between by-products and fuels

Sugar and ethanol production in Brazil has reached a balanced situation that allows the export growth due to the new market openings, without compromising the domestic sugar supply. See previous Item 3.1 of this Part 1.

3.7 Relevant Markets and Agreements

3.7.1The relevant fuel markets for fossil and ethanol

The Sugar-Alcohol sector in the world is presently in an important transition for its main products, sugar and ethanol. Brazil, responding for 40% of sugar world exports, has taken a fundamental decision in a short term: to increase domestic sugarcane production in order to attend both markets. From now on, sugar and energy markets are being considered at the same level. The current world oil prices at high levels are driving many other countries to adopt biofuels to complement their domestic market.

In addition, the global concern about environment questions, contributes to a significant increase of new market opportunities for the Brazilian bioethanol.

Export market for Brazilian ethanol fall into two kinds: for blends, in mixtures with gasoline up to 10% and for direct use with a content higher than 70%. This later market is essentially represented by the United States and Sweden. The market for blends includes the following countries: South Africa, Australia, Colombia, United States, India, Paraguay, Sweden, Thailand, Venezuela, Japan and China.

3.7.2 Targets

According to projections of the sugar/alcohol sector in Brazil, to meet the internal and export market demands for sugar and ethanol, the industry should be able to produce, by the year 2015, the following amounts: sugar, 33.7 M t (12.8 for the internal and 20.9 M t for exportation); ethanol, 26.4 M m^3 (22.0 M m^3 internal and 4.4 M m^3 export).

An important target for the sector is to assist the Brazilian diplomacy to successfully conclude negotiations in the World Trade Organization (WTO), in order to remove market barriers.

3.7.3 Current situation of WTO agreements

To develop fuel-ethanol use it is necessary to ensure conditions for a well structured international trade market. The rationale for this logic is quite obvious and is based on real-world Brazilian and USA experiences. Both countries, despite of being the two largest world fuel-ethanol producers, have on various occasions faced the need to import fuel ethanol or have taken commercial advantage of product abundance. In fact, not very long ago, imports from the USA, Europe and South Africa helped Brazil to supplement domestic production and fulfill market needs. In 2004, the USA imported the product from Brazil mainly because of momentary low price. [9]

Therefore, the notion of “supplementary supply sources” needs to become a key element to all countries engaged in the use of the product. In this context, world fuel-ethanol trade is essential because of: i) strategic needs to have alternative sources of supply in case of domestic market problems; ii) possibility to build planned stocks; iii) contribution to domestic price balance when production costs are high; iv) reduction of subsidies; v) feasibility to speed-up implementation and/or expansion of new programs adding extra capacity to domestic production; vi) possibility of fuel-ethanol use in non-producing countries.

Presently about 4 billion litres/year of the ethanol produced worldwide comes into international trade. This represents almost 10% of total world production and is largely of industrial and potable brands. With regard to fuel usage about 700 million liters (4.4 million barrels) were traded in 2004 representing less than 20% of the trading market, and this is still a very low volume considering market potential. Although it is true that this market is in an infant stage and therefore is not well structured, the protectionist barriers that exist in important energy markets such as the European Union, the USA and Japan certainly limit its evolution and inhibit its consolidation.

Although it may be understandable that there is a political need to support domestic fuel ethanol production in many countries it must be clearly understood that this attitude does not contribute to the effort of market expansion, which in due course is of interest to all stakeholders. At this point it is worth reminding that total domestic market protection in any field of economy is negative to technological development, increase in productivity and cost reduction. Therefore, it is our belief that free-trade can live side-by-side with existing domestic ethanol production and actually contribute to its economic sustainability.

Some sort of international harmonization of fuel ethanol policies such as standardization of specifications could be a first, but important fact to enable the product to actually become an energy commodity and be easily traded as is the case of gasoline or diesel. To accomplish this goal three principles need to be adopted in a coordinated effort: i) all fuel-ethanol import prohibition or limitation because of flat quotas should be substituted by agreements which would allow imports under more flexible but clear conditions; ii) high fuel ethanol import tariffs should be substituted by lower tariffs than those adopted for fossil fuels import given the low-pollution and renewability qualities of the product; iii) subsidies should be progressively phased-out in order to promote production efficiency and fair market competitiveness.

In the Background Note "*Strengthening participation of developing countries in dynamic and new sectors of world trade: trends, issues and policies"*, UNCTAD states that development gains can be derived from international trade and trade negotiations. The experience of the Brazilian Alcohol Program is a concrete example of such gains. [10]

The international trade of biofuels, however, still faces high barriers from developed countries. There are several problems that limit the expansion of biofuels in developed countries:

(i) they are almost exclusively dependent on internal producers (even in countries not naturally endowed for the growth of biomass);

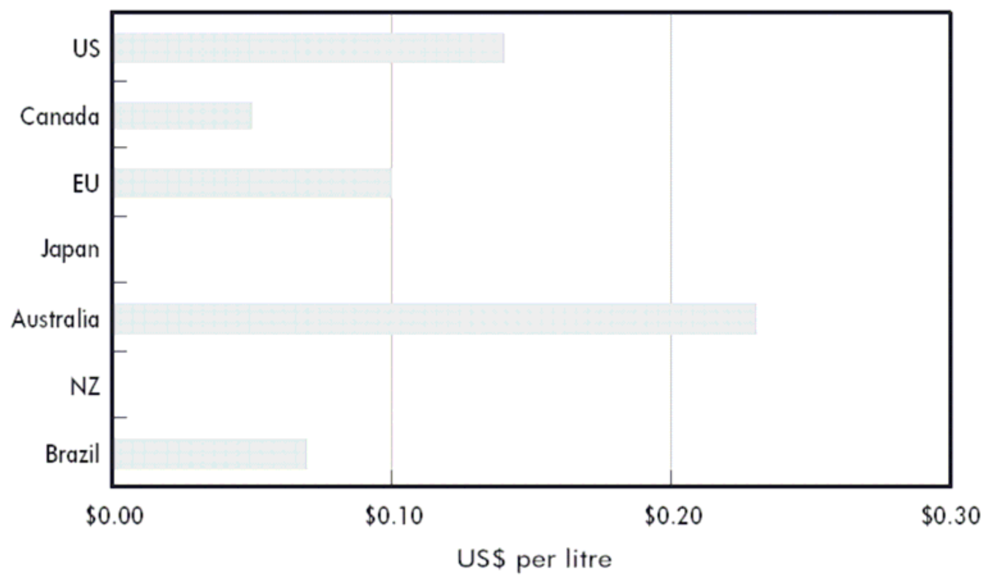
(ii) restrictive regulations (e.g. limits in blends), often based on not entirely justifiable environmental reasons; and

(iii) R&D support directed preferentially to “clean fossil fuels”, which will maintain unsustainable consumption patterns.

Ethanol imports do not usually enjoy the same fiscal benefits as those produced locally. According to the IEA (2004), ethanol import duties are US$ 0.10 per liter in European Union, US$ 0.14/litre in the United States, US$ 0.06/l in Canada, US$ 0.23/l in Australia and zero in Japan and New Zealand. In the EU there is a preferential treatment for ethanol imports from EBA (Everything But Arms) and ACP (Africa, Caribbean and Pacific) countries, which are exempted from duties. Internal production is subsidized through tax reductions of as much as EUR 0.65/l in Germany, Stlg 0.2/l in the UK, EUR 0.38/l in France and EUR 0.525/l in Sweden. See Figure 9.

Biofuels are affected by protective legislation and are subjected to the rules currently under discussion in the World Trade Organization. This includes negotiation on certain trade and environment issues, starting with the targeted liberalization of trade in environmental goods and services (EGS). It is therefore necessary to define the scope and clarify existing WTO provisions, in order to clearly consider biofuels as EGS, and thereby make it possible for them to benefit from progressive world trade liberalization. [10]

Figure 9 – Ethanol Import Duties Around the World



Note: Ethanol import duties in Japan and New Zealand are zero.
Source: Various national tax reports and websites.

With the mandate to work towards global trade liberalization and environmental sustainability, the WTO's Fourth Ministerial Conference adopted in November 2001 the Doha Ministerial Declaration, which agreed to negotiations on the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services (EGS). However, win-win negotiations among developed and developing countries still require clearer scope definitions and more precise classification of environmental goods and services. [10]

3.8 Overview and analysis of existing policy instruments

As it was mentioned before, Government control, such as quotas for production and exportation, prices control and subsidy concessions to production and logistics were eliminated for sugar and ethanol in a transition regime initiated by the middle of the 1990s and finalized in 2002. Nowadays, the government is only present in the regulation of hydrated and anhydrous alcohol specifications and in the definition of the content of ethanol in gasoline (about 25%, at present). [11]

Prices are liberated at all levels of the commercialization chain. Presently, there are no subsidies for anhydrous or hydrated ethanol production.

Flex-fuel and alcohol cars are benefited with reductions in the Federal Tax over Industrialized Products (IPI) incident on vehicles. For instance, the IPI to be payed by flex-fuel and alcohol cars powered with engines up to 2.0 liters is 13% and 15% by gasoline cars. For cars over 2.0 liters, IPI is 20% for flex-fuel and alcohol and 25% for gasoline. It is important to mention that, according to the car manufacturers, each 1% of IPI reprsents 0.98% of the price of the vehicle.

Two legal acts of the government are the foundation of the implementation of an ambient of free commerce of fuels in Brazil (end of state monopoly in the oil industry) and definition of taxation model over fuels: Law n° 9 478 and Constitutional Ammendment n° 33. They were complemented by Law 10 336 which created CIDE (Contribution for Intervention in Economic Domain). From the Brazilian taxes, CIDE is an object of discussion. CIDE is a Federal tax on oil fuels. Natural gas and ethanol do not pay it. As the ratio alcohol to gasoline tends to increase over the years, there is a concern that CIDE may be incident to alcohol in the future in order the Federal government might keep its same level of taxes collection.

For the expansion of ethanol production capacity, the official Brazilian Development Bank BNDES has lines of financing adequate to give full support to entrepreneurs. The volume of loans for both familiar and commercial agriculture, increased from R$ 11.8 Billions in 1999/00 to R$ 48.5 Billions in 2004/05.

4 Potentials

4.1 Production Potential

According to projections of the sugar/alcohol sector in Brazil, to meet the internal and export market demands for sugar and ethanol, the industry should be able to produce, by the year 2015, the following amounts: sugar, 33.7 M t (12.8 M t internal and 20.9 M t for export); ethanol, 26.4 M m^3 (22.0 M m^3 internal and 4.4 M m^3 export).

For this to become a reality, the necessary production of sugarcane should be of the order of 572 M t / cane per year. This will mean an increase of about 230 M t of sugarcane in ten years – a doubling in the ethanol production and an increase of 44% in sugar production.

Such increase will demand an expansion of the planted area of about 3.0 M hectares over the next ten years. Private investments are already giving impulse to the ambitious expansion of the present production. [4]

4.1.1 Availability/restrictions of sugarcane plants and area

Sugarcane was cultivated in 484 micro-regions, by the year 1976, and in 495 micro-regions in 2000 – 453 were the same as in 1976, with the addition of 42 newcomers. In this period, the sugarcane planted area increased from 2.1 to about 5 M ha (more 133%), and the production increased from 105 to 334 M T of sugarcane (more 219%). [3]

According to EMBRAPA, there are in Brazil about 100 Million hectares with conditions for the expansion of agriculture of annual cycle species. In addition, it is estimated that 20 Million hectares can be potentially become available as a result of technological improvements in cattle handling. Therefore, the 3.0 M ha of expansion for the next 10 years would be met by less than 3% of the expansion area. The locations of new areas are function of logistics for the exportation of ethanol and sugar.[11] Doubts have been expressed during a recent FBDS/GTZ workshop that this EMBRAPA 100 Million hectares figure is not based on more detailed studies of edafo-climatic zoning which is considered necessary to get a definite figure for agriculture expansion area.

4.1.2 Improved potential by plant breeding

In the past, Brazil developed highly successful programs of genetic improvements of sugarcane and has today large research facilities. Therefore, Brazilian industry could have the necessary plant varieties to keep on track with the present and future crop expansion in any conditions of soil and climate of the country. The necessary investments in these areas of research should be to the order of US$ 8 Millions per year. [4]

Preliminary results of recent variety developments are promising. They will be more resistant to plagues and diseases and to some important stresses like drought and cold. However, Brazilian legislation for genetic production should be improved, especially to simplify procedures for those enterprises interested to registering a transgenic product for commercial use. [4]

4.1.3 Improved potential via processing

To cope with expansion planning such as indicated in previous sections, it is necessary to see the capacity of equipment suppliers to fullfil the orders for new machinery for the new production levels of sugar, ethanol and also systems for co-generation to produce excess electricity.

In the past, the Brazilian manufacturers supplied about 200 autonomous distillers plant and the 200 corresponding co-generation plants, with an average of 5 new plants per year. [4]

The local capacity to supply turnkey units was evaluated, recently, based on two alternative sizes of processing plant:

Plant 1 → 1 M t cane / harvest → 40 plants / year + 3.2 M m^3 anhydrous

Plant 2 → 2.16 M t cane / harvest → 24 plants / year + 4.3 M m^3 anhydrous

The Brazilian experience shows that existing technology for alcohol production has had an increase of 3% per year on industrial productivity during the national alcohol program. It is expected that, efforts in this direction will bring more competitiveness to ethanol made in Brazil.

But, the most promising advance for the coming years should result from the development effort in producing ethanol from hydrolysis of sugarcane bagasse, as explained in section 3.1.6

4.1.4 Improved potential via future technologies

There is at least one Brazilian high technology enterprise offering biomass-to-liquid (BTL) commercially for different industrial applications, other than transportation. The prospect for its use as a fuel for transportation is far from the present scenario.

4.1.5 Improved options for end-use technologies

It is up to car assemblers to attend the need of the market for more efficient units. A recent publication showed the possibility of having cars 50% more efficient than at present in terms of fuel waste, by simply incorporating already existenting technologies, with modest prices increases.

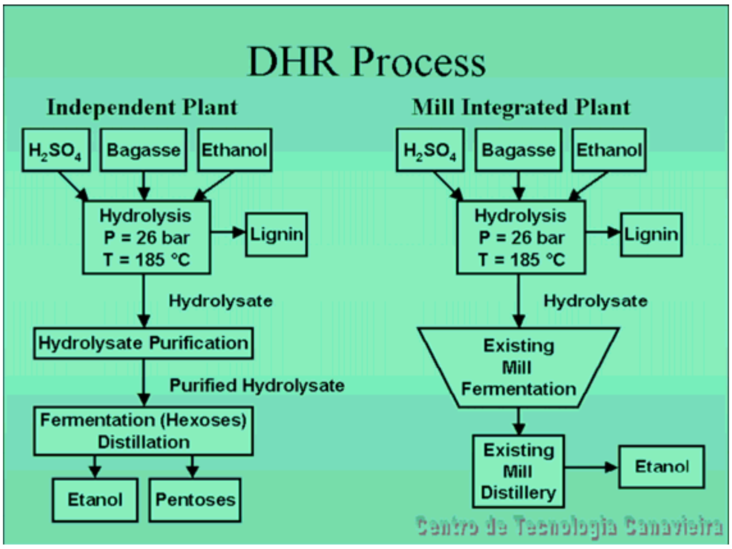
4.1.6 New Technologies

Ethanol Production from Hydrolysis of Sugar Cane Bagasse [12]

Processes for ethanol production from cellulosic residues by means of hydrolysis are in development in several countries. It is not, however, known of any commercial plant in operation. In Brazil, the process in development is the Dedini Rapid Hydrolysis (DHR), a joint development between Dedini S.A. and Copersucar, which is a derivative of processes that use organic solvent.

The DEDINI Rapid Hydrolysis Process (DHR) introduces a solvent in order to dissolve lignin and to change the structure of the cellulose-hemicellulose-lignin complex. The required chemical reactions can then be accomplished at a lower temperature and pressure, while the saccharification reaction is faster and sugar decomposition can be minimized.

Figure 10 – General Flow-chart for DHR Process



In the present stage of development, the DHR system yield 109 liters of hydrated alcohol out of one ton of sugarcane bagasse. At this level of production, the ethanol produced would cost R$ 0.40 per liter, equivalent to the traditional process. In a final stage, this process would yield 180 liters with the same ton of bagasse and per unit price of ethanol production would drop to R$ 0.24/liter.

The process design for a commercial unit based on DHR technology is currently being prepared and evaluated in order to plan the next steps of the project. The benchmark to turn this process feasible is a yield of about 12,000 liters ethanol per hectare of integral cane. This would almost double the current yield of 6,400 liters of the traditional process.

5 Requirements for infrastructure in order to utilize the ethanol potential

The assumption made previously is for an expansion of about 230 Million t of sugarcane in the next 10 years. This will require more about 3 Million hectares of land area. The total duration of harvest is 210 days, which means processing 1.095 Million t of sugarcane per day. With an efficiency of 80 liters of ethanol per t of sugarcane the daily production will be 87.6 Million liters of ethanol. For a standard distillery producing 450,000 liters of alcohol per day, 195 mills will be necessary. The necessary investment is:

a) industrial investment ,195 units x R$ 80x10^6 = R$ 15.6 Billion

b) agricultural investment, 195 units x R$ 40 x10^6 = R$ 7.8 Billion

This totals an investment of about US$ 10 Billion in 10 years.

Further, the production chain of sugar/ethanol has some problems common to other agricultural commodities, especially dependence on the road transportation network.

6 Main actors

6.1 Governmental Institutions/State companies

During the liberalization of the sugar and alcohol sector in the last decade, there also occurred some changes in the institutional arrangement. Since then, decision making has been concentrated in the Federal Ministry of Agriculture (MAPA). As the leading ministry of the Council for Sugar and Alcohol (CIMA), who is completed by the federal Ministries of Finance, Industry and Energy, it plays an important role, as sector legislation is mainly based on recommendations of this council. In addition the ministry can now establish the ethanol content of Brazilian gasoline mixture, as this competence was transferred to it from the Brazilian presidency in 2001.

The Federal Agency for Petroleum (ANP) was established in 1998 and is the regulating agency of the fuels sector and therefore responsible for the enforcement of the specifications, quality standards and free price competition. Due to the different treatment of hydrous and anhydrous taxation, one major concern of ANP is to avoid false declaration of hydrous alcohol as anhydrous and to prevent tax revenue losses.

During the Proálcool program the federal oil company Petrobrás played a major role due to its monopoly as it had to buy and offer ethanol on gasoline stations at prices fixed by the government. As it owns the biggest retailer “BR Distribuidora”, it’s still of importance due to its downstream capacities. Actually, Petrobrás is investing in several countries to introduce ethanol blends and to supply these markets. Petrobrás’ storage and transport facilities thus could play an important role when promoting Brazilian ethanol exports.

6.2 Private sector

The Sugar Cane Agro Industry Union of the State of São Paulo (UNICA) is by far the most important pressure group in the Brazilian sugar and ethanol sector. This association was created in 1997 as a successor of several other sectorial organizations and is now representing more than 100 sugar and alcohol producers that are responsible for 40% of ethanol and 37% of sugar production in Brazil.

Another important sector association is the Union of the Sugar and alcohol producers from Western São Paulo (UDOP) that represents more than 41 companies who are responsible for the crushing of more than 39 Mill. t of sugar cane.

There are some big sugar and alcohol producing companies that own several mills of which total ethanol output exceeds 400 Mill. l. One example is the COSAN group with 23,000 employees and a harvested area of about 400,000 ha that resulted in alcohol production of 825 Mill. l in 2004/05. Due to the acquisition of six other sugar and alcohol mills, its turnover more than doubled since 2001. Another example is the São Martinho group whose units are located in São Paulo state. In 2004 it crushed 10 Mill. t of sugar cane that resulted in an output of 400 Mill. l of ethanol and 800,000 t of sugar. Contrarily to these two groups who are mainly expanding in the state of São Paulo, there are some groups from the Northeast who tend to acquire new sugar and alcohol plants in the Central-West or Southeast region. One of these groups is the group Carlos Lyra, traditionally located in the Northeast, which has constructed new plants in Minas Gerais and is now crushing 9.6 Mill. t of sugar cane.

In the equipment sector DEDINI, located in the state of São Paulo (Piracicaba), is by far the most important company for sugar and ethanol plants. As it played a major role during the Proálcool program, its plants are now responsible for more than 80% of the national alcohol production. It can supply machinery for the whole production chain, from sugar cane crushing to co-generation of energy. The company is doing research on producing ethanol through hydrolysis of sugar cane straw and is constructing the first plant in Mato Grosso where ethanol and biodiesel production as well as electricity generation are integrated.

Important research work is done by the Centre for Sugar Cane Technology (CTC), which was created in 2004 and replaced the former Technology Centre Copersucar that had been founded in 1970 by the Cooperative of the São Paulo sugarcane, sugar and alcohol producers. Its important role consists in developing new varieties of sugar cane that are being planted in over 50% of the Brazilian sugar cane plantations. It is maintained financially through contributions by the associated producers.

PART 2

BIODIESEL

1 Introduction

Biodiesel can be obtained from the following sources: (i) vegetable oils; (ii) animal fats; (iii) residual oils and fats; (iv) fatty acids from public sewer networks.

From these sources, the only one relevant for the present study is vegetable oils. Residual fats, recovered after use, should be studied from another viewpoint as they are not products obtained from agricultural chain.

Animal fats, especially from cattle suet and oil obtained in chicken processing, have great potential for fuel replacement in vehicle fleets of big producers of such raw materials, as is the case of the project in implementation by the company Bertin.

The retail price of suet, which is about US$ 150/ t, turned that raw material rather attractive. However, the availability of such raw material is very restricted and as it is a sub-product, it is not possible to produce it for a biodiesel program.

The productive chain of cattle suet presents some interesting peculiarities, as its main consumer is the soap industry, and the big suet producers are also soap producers. As there are no surpluses in great quantities, the only substitute for cattle suet is vegetable oil. As a result, for each ton of suet used for biodiesel production, it would be necessary to replace it with an equivalent amount of vegetable oil.

Chicken oil is a residue with similar potential of cattle suet, but its availability on a large scale is recent and its use as an energy source still depends on investments in inventory and research.

2 Vegetable Oils

Vegetable oils are liquid substances at environment temperature, with low fusion point, formed by unsaturated fat acids.

Vegetable oils are an important source of energy liquid biomass. They are the main input to biodiesel production, but can also be used “in natura” to move diesel-fueled engines.

The possibility of using pure vegetable oils or their by-products as fuel has been known since the developing phase of the diesel engine. There are records of groundnut oil utilization in experiments performed by Rudolf Diesel, in the year of 1911. Mr. Diesel stated a premonitory affirmation: “the diesel engine can be fueled with vegetable oils and it may be able to help the development in the countries that may use it”. Since then, many studies, projects and programs have been carried out with the sole purpose of verifying the technical viability and the sustainable competitiveness when it comes to the use of this renewable energy source.

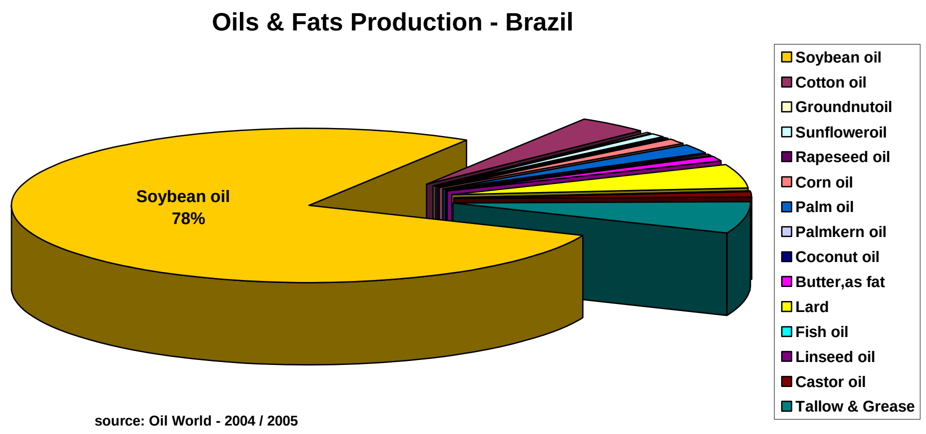
Vegetable oils are present in a huge variety of plants commonly called oil crops. Oil normally presents itself in fruits of these species. It can be concentrated in the pulp, the almond or both.

Brazil is a major producer of vegetable oils and animal fats, being responsible for about 5.5% (7,400,000 tons in the 2004/2005) of the global production. Brazilian current production is equivalent to 20% of diesel oil's national consumption. Figure 11 shows the participation of vegetal oils and fats of different origins in the country's production mix.

The main world producers of agricultural and industrial inputs for vegetable oil production are working in the country and Embrapa – the Brazilian State Enterprise of Farming Research has an active participation in the research and technological development suited to Brazilian conditions. The main productive chain of oil crops, especially soy, is well structured. It means that the production is able to grow substantially in a short-term period.

Brazil has production potential, consumer market, and an expressive agricultural frontier. It also counts on extensive areas available at the Center-West, Northeast, and North regions. These areas make expansion possible with high growth rates. The utilization rate of arable lands at these regions shows that there is an enormous space to enlarge the oil crops cultivation in the country. Table 7 shows the evolution of planted area, production and productivity of the main vegetable oil species in the period 1994-2004.

Figure 11



A description of the main characteristics of the most promising species for biodiesel production, based on the present knowledge, is presented in Part 2, Item 4.1. Figure 11 shows the main possible sources of vegetable oil esters by Region of the Brazilian territory.

Table 7 – Brazil – Planted Area – Production and Productivity

Crops 1994/95 & 2003/04

PRODUCT	Area (ha x 1,000)		Production (ton x 1,000)		Productivity (kg/ha)	
Crops	1994/95	2003/04	1994/95	2003/04	1994/95	2003/04
COTTONSEED	1,228.5	1,100.0	997.6	2,099.2	1,249	3,099
GROUNDNUT TOTAL	93.2	98.2	142.5	217.3	1,529	2,213
CORN TOTAL	14,282.2	12,822.0	37,441.9	42,191.5	2,622	3,291
SUNFLOWER	-	52.8	-	82.0	-	1,553
CASTOR OIL	77.6	164.9	44.2	106.1	570	643
PALM TREE (*)	31.9	59.3	75.7	132.0	2,374[1]	2,226[1]
SOYBEAN	11,678.7	21,275.7	25,934.1	49,770.1	2,221	2,339
BRAZIL	38,538.9	47,352.7	81,064.9	119,152.2	2,103	2,516

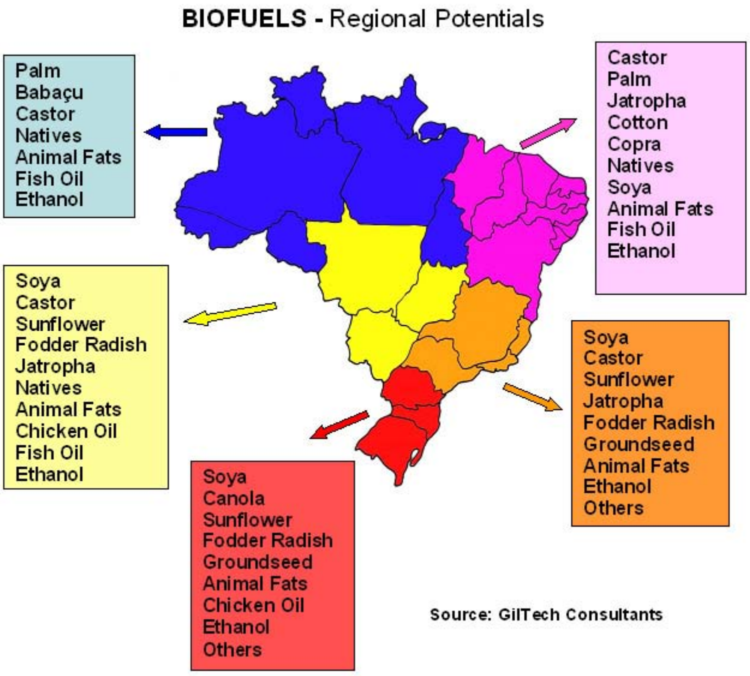
source: CONAB / AGRIANUAL (*)

[1]**: productivity of Palm Oil**

There are records in the Brazilian Amazon of more than one hundred native vegetable species that can potentially be used for commercial oil production. There is a wide field for genetic improvement research and for oil crop thickening.

The outlook concerning the utilization of crude vegetable oils as fuel is essentially important to increase energy availability to the Amazonian isolated communities, either for electricity or transport.

Figure 12 – Biofuels – Regional Potentials



Native Crops – Wild Groves

Celestino Pesce published in 1941 the most important reference report on oleaginous plants in Amazônia. Pesce has identified 116 plants with potential to produce edible oil.

Recently Embrapa researchers Carvalho, J.E.U. and Farias Neto, J.T. have presented the study “Oleaginous Fruits of The Amazon with Potential for Biodiesel Production” (only available in Portuguese), in which they identified the native plants with more potential for use for biodiesel production. Some of these species include: babaçu, buriti, bacaba, tucumã, pupunha, macaúba. See Annex 1.

The potential for the production of biodiesel from these native plants is limited. On the other hand, at this moment, only the information obtained from wild groves are available. Intensive research is necessary with development studies to allow commercial production. Normally, native specimens grow wild in protected areas, so the exploration is more difficult and environmentally dangerous.

A remarkable example is given by the large Babaçu reserves in the NE, which were despoiled with the expansion of cattle farm agri-business and since 1975, no reliable statistics on this extractive activity have been available. The 300,000 women dedicated to benefit Babaçu is a legend. There is no relevant oil production from Babaçu and Brazil imports great quantities of Palm Kernel Oil.

The apparently high yield visualized in wild groves is an illusion. To exploit these reserves continuously, the application of fertilizers would be necessary to minimize plant stress.The simple collection process will result in fast productivity reduction.

Considering a potential yield in wild groves of 0.2 t per hectare, it is necessary to exploit 275 hectares of land to produce 55 tons of oil for feeding diesel generators with a capacity of 1 MWh/h with operating cycle of 6 hours/day. Most of the native specimens have no more than 5% in weight of oil, so it is necessary to transport 1,100 t of fruits. This has a negative energy result. Despite its high demand for application in the market of natural products, there are no records of continuous organized production of oil from native plants.

Production of vegetable oil from native specimens will be possible in selected extractivistic isolated reserve if subsidies are available to guarantee economic viability.

3 Current Situation

3.1 Production and end-use technologies

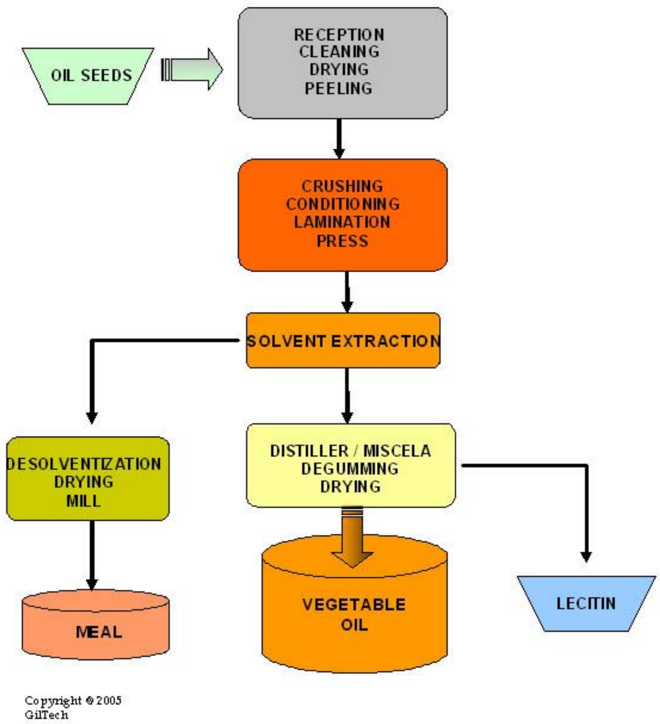
Vegetable oils can be obtained by processing oil crops by means of two different forms:

- Cold extraction: oil is obtained by pressing the oleaginous fruit;
- Solvent extraction: fruit mass is diluted in solvent. Then a distillation of the dissolved oil is performed. Hexane is the most commonly used solvent which is a by-product of fossil fuels.

The flowchart below shows the palm oil production main phases. Palm oil is one of the most interesting oils to be used as liquid fuel.

Figure 13

VEGETABLE OILS - FLUXOGRAM



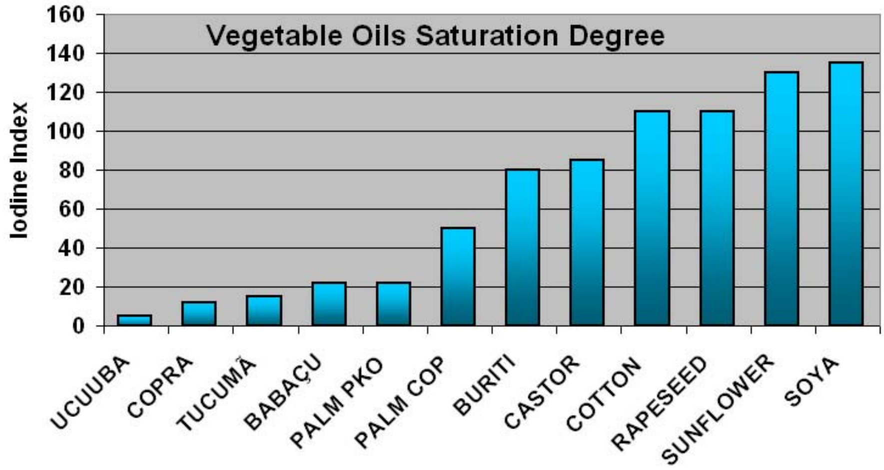
Performance of diesel engines operating with some straight vegetable oils is compatible with those obtained operating with diesel oil. However, long-term use causes a series of operational problems. These problems can be minimized through a few changes in the conventional engines available in the market or by using engines especially designed for this application.

Using straight vegetable oils in Diesel engines is more viable in hot weather areas with tropical oils, such as palm and coconut. The most complex problems, like gum formation and carbonization, are mainly caused by the vegetable oil unsaturation degree. These problems occur due to the existence of unsaturated fatty acids. Polymers are formed when vegetable oils are subjected to the combustion chamber high temperatures. Thus, crude oil with high quantities of unsaturated molecules – such as soy, cotton, colza and sunflower oils – are not recommended for operation as fuel in diesel engines.

The iodine value, the property expressing the oil unsaturation degree, is the most important parameter to define the vegetable oil potential for direct application in diesel engines. Vegetable oils with iodine value less than 40 have excellent performance in diesel engines, even if they have not undergone any adaptation to work with this kind of oil. See Figure 14.

Figure 14

Source: F. Kaltner



The use of straight vegetable oil must be the small farmer's preferred option, since the extra maintenance cost of the diesel engine and injection system is infinitely less than the cost of transforming this oil in Biodiesel at industrial plants, even in a small scale production. Tests performed by Kaltner et al.(unpublished) indicate that mixtures up to 5% of neutralized palm oil with diesel oil display excellent stability and all the physiochemical properties remain strictly within the ANP (The Brazilian National Petroleum Agency) specification for diesel oil. So, it is possible to use the B5 mixture with some oil crops making the straight vegetable oil go only through a simple neutralization process.

This technological route has enormous potential for applications in rural communities located in regions located far from diesel oil production centers. Engine adjustments and modifications are not necessary.

Brazil is not able to produce conversion kits yet for use of vegetable oils at higher mixtures (> B5), but there are financial lines available at the Brazilian National Bank of Economical and Social Development (BNDES) in order to stimulate production and development of this equipment in the country. It's possible to buy engine conversion kits in the European market.

3.2 Structure of the processing industry

Table 8 shows the present installed processing capacity of the vegetable oil industry in Brazil, per state. As can be seen, only the first five States – Paraná, Mato Grosso, Rio Grande do Sul, Goias and São Paulo are responsible for almost 80% of the processing capacity.

VEGETABLE OIL INDUSTRY INSTALLED CAPACITY ACTIVE AND INACTIVE UNITS
TONS/DAY PER BRAZILIAN STATE AND COUNTRY TOTAL

Table 8 – Processing Capacity (source: ABIOVE)

STATE	ABBREVIATION	Processing Capacity				
		2001 (ton/day)	2002 (ton/day)	2003 (ton/day)	2004 (ton/day)	%
Paraná	PR	31,500	28,650	28,950	3,765	24.1
Mato Grosso	MT	10,820	14,500	14,500	20,600	15.6
Rio Grande do Sul	RS	19,000	20,150	20,100	19,700	15.0
Goiás	GO	8,660	9,060	10,320	16,920	12.8
São Paulo	SP	14,700	12,950	14,450	14,950	11.3
Mato Grosso do Sul	MS	7,330	6,630	6,980	7,295	5.5
Minas Gerais	MG	5,750	6,450	6,350	6,400	4.9
Bahia	BA	5,200	5,460	5,460	5,344	4.1
Santa Catarina	SC	4,130	4,050	4,000	4,034	3.1
Piaui	PI	260	260	1,760	2,360	1.8
Amazonas	AM	-	2.000	2,000	2,000	1.5
Pernambuco	PE	400	400	400	400	0.3
Ceará	CE	200	-	-	-	-
TOTAL		107,950	110,560	115,270	131,768	

The relevant information for this study, however, is the refining capacity because soybean oil cannot be used crude in biodiesel production. This is shown in Table 9: the same five States named previously are responsible also for about 80% for the refining capacity of vegetable oil installed in the country.

Table 9 – Refining Capacity (source: ABIOVE)

STATE	ABBREVIATION	Refining Capacity				
		2001 (ton/day)	2002 (ton/day)	2003 (ton/day)	2004 (ton/day)	%
Paraná	PR	2,730	2,490	2,650	2,910	16.2
Mato Grosso	MT	600	650	650	1,250	6.9
Rio Grande do Sul	RS	1,860	1.890	1,720	1,650	9.2
Goiás	GO	1,420	1.570	1,610	2,090	11.6
São Paulo	SP	6,256	5.840	5,880	6,230	34.6
Mato Grosso do Sul	MS	490	540	540	540	3.0
Minas Gerais	MG	1,050	1.270	1,270	1.270	7.1
Bahia	BA	570	970	880	880	4.9
Santa Catarina	SC	530	530	530	530	2.9
Piaui	PI	120	120	120	120	0.7
Amazonas	AM	-	-	-	450	2.5
Pernambuco	PE	500	500	450	80	0.4
Ceará	CE	42	-	-	-	-
TOTAL		16,168	16,370	16,300	18,000	

3.3 Cost and prices, competitiveness

The competitiveness of vegetable oils as substitute of fossil fuels is strongly associated to the production costs of different species of oleaginous plants. Production cost is related to the correspondent productivity given in Kg per hectare per year of each specie (see Table 10).

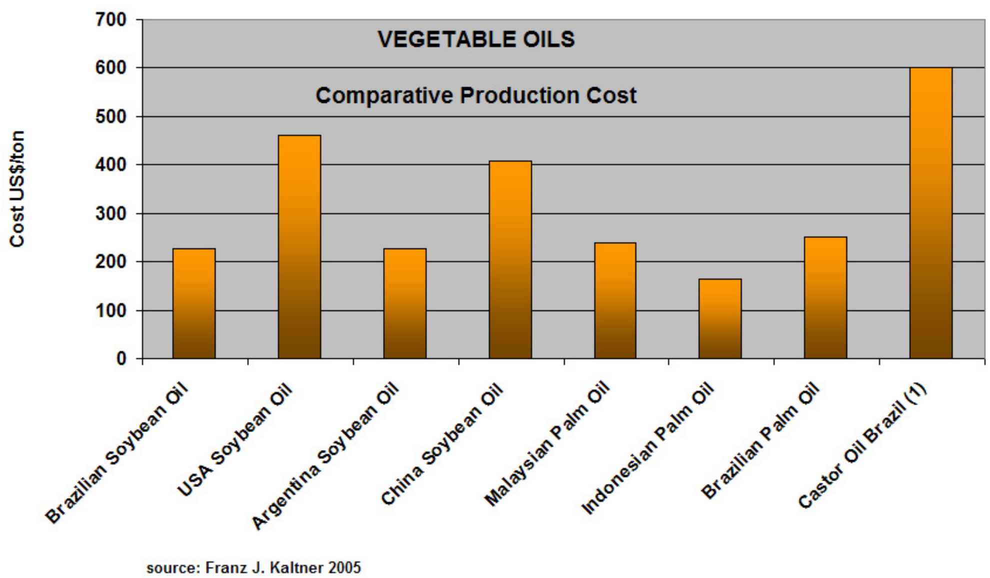
Table 10 – Productivity of Several Oil Crops

Culture	Commercial Name	Crop period months	Oil content %	Oil Productivity kg/ha/year
Palm (Pulp)	Palm Oil ("dendê")	12	26	3,500 to 5,000
Palm (Almond)	Palmkern Oil			200 to 350
Soy	Soy Oil	3	17	400 to 600
Coconut (Copra)	Coconut Oil			2,000 to 3,000
Babaçu	Babaçu Oil	12	66	400 to 800
Rapeseed	Rapeseed Oil	3	40-48	500 to 900
Sunflower	Sunflower Oil	3	38-48	600 to 1,000
Peanut	Groundnut Oil	3		600 to 800
Castor	Castor Oil	3	43-45	600 to 750

Sources: LMC & others

Each country has its own associated cost. Figure 15 presents a comparison of production cost of: i) soybean oil from Brazil, USA, Argentina and China; ii) palm oil from Malasya, Indonesia and Brazil; iii) castor oil from Brazil — which allows us to see how difficult it would be for castor oil to compete with vegetable oils from soybean and African palm in Brazil.

Figure 15 – Production cost comparison, according to species and origin



More detailed study of production cost and competitiveness is presented in part 2, item 5.2.5

3.4 Infrastructures

The production chain of vegetable oils has the same problems of others agricultural commodities, such as: (i) dependency on the road transport chain; (ii) production concentration far from consumers centers; (iii) lack of storage capacity for strategic grains.

The above mentioned factors are responsible for the high cost of transportation of the Brazilian grain harvest as compared with the one of the other producer countries, enforcing the immediate commercialization of the product at the end of each harvest. Table bellow presents the different transport cost practiced in Brazil.

WAY OF TRANSPORT	UNIT CAPACITY - t	Cost – US$/t x 1,000km
Waterway- Ferryboat	1,500	16.03
Railroad- Hooper wagoon	100	26,72
Road -Truck	25	42,30

1 U.S. dollar = 2.24539974 Brazil reais (25.01.06)

Source: Eduardo S. Marques, MAPA 2005

4 Production Potential of Vegetable Oils

Vegetable oils displays a great variation in their physiochemical characteristics, production techniques and productivity, making the energy balance of each oil crop also variable, from 1.3 to 8.5.

Integrating all production chains, from agricultural, industrial and stockpiling phases to commercialization with the purpose of reducing transport and moving cargo operations is fundamental. This is the way to achieve competitiveness for an energy program using vegetable oils. Therefore, in order to assure the sustainability of a large-scale energy program, the simultaneous production of several vegetable oil types is strongly recommended. The oil type choice must be related to the production potential of the area in which it will be consumed. The market perspectives for its by-products must also be considered, adding value to them in the productive chain context.

4.1 Most Promising vegetable Species

In this section is presented relevant information on the most promising vegetable species, in the view of the authors, for biodiesel production in Brazil. That is: soybean, castor plant, palm tree and sunflower. Annex 2 gives complementary information on those species.

4.1.1 Soybean (Glycine max)

This plant has come from Eastern Asia. There are reports of its cultivation during the Shang dynasty (1500-1207 B.C) in the northeast of China. It was taken to Europe in the 15th century as a Botanical Garden curiosity. In Brazil, the first reference dates from 1882, D'Utra (Agriculture Newspaper - Jornal da Agricultura). In the decade of 1960, it was introduced into Rio Grande do Sul, succeeding wheat. The main world producers are the USA, China, Brazil and Argentina.

The soybean grown for seed production is a leguminous annual, normally bushy, erect, usually less than 75 cm in height, with many branches, well-developed roots and producing numbers of small pods containing round usually yellow or black seeds.The grain presents 9% peel, 90% cotyledon and 1% hypocotyls, whose composition can be found in the following table:

Table 11 – Properties and Characteristics

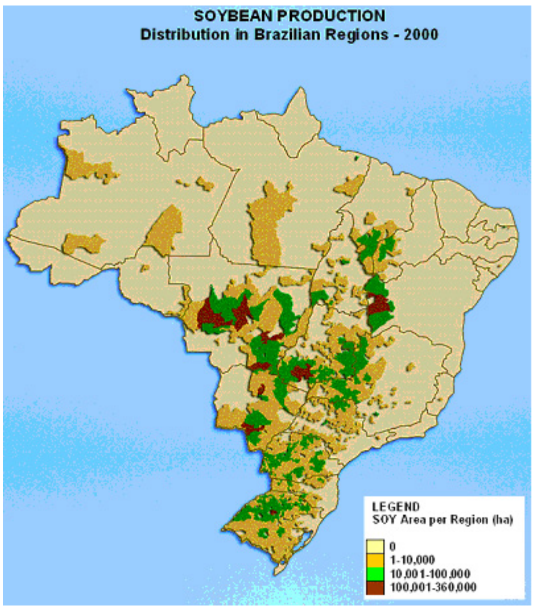
COMPOSITION	PROTEIN	OIL	ASH	CARBOHYDRATE
SEED	40.3	21.0	4.9	33.9
COTYLEDON	24.8	22.8	5.0	29.4
PEEL	8.8	1.0	4.3	85.9
HYPOCOTYL	40.8	11.4	4.4	43.4

The soy seed production potential, per 1,000 kg is:

Meal	780 kg
Soy Oil	190 kg
Others	30 kg

Due to the high volume of soy meal, produced with the present technologies, it drives the international market for proteins. So, the growth of oil production is limited by the consumption of soy meal. Biodiesel may become a new and large market opportunity for its oil, contributing to extend the production throughout the productive chain, and with competent management, may bring gains of quality, scale and competitiveness.

Figure 16 – Áreas of Soybean Production (Brazil, 2000)



In the beginning of the present century, the growth rates of the soybean sector in Brazil exceeded the growth of any other production in the country. Soybean is an essential component of the Brazilian economy and is an important export product. It represents 6% of the gross domestic product (GDP) and employed approximately 5.5 million people in 2002. Brazil is the world's second exporter of soybean grain, only behind the USA, being the second in the exportation of soybean hulls as well, only behind Argentina. The expansion of the soybean sector is related to a number of factors, some internal and others associated to the international trade and the behavior of large exportation markets. In Brazil, the soybean and its derivative consumption has been growing since the decade of 1990s. But most of the production is exported in the form of grains or, on a smaller scale, by-products from the primary processing, especially the hull and the soybean oil. The production expansion to meet this increasing demand is linked to the world's growth consumption of animal protein, among birds, swine and bovine, which in their majority are fed with diets containing a high content of soybean hulls.

On the other hand, the demand from the European markets rose due to the prohibition of the use of meat and bone proteins for feeding animals, as a consequence of the recent cases of Bovine Spongiform Encephalopathy (BSE or mad cow disease). In the meantime, China, due to its adhesion to the World Trade Organization, has become a large importer of the Brazilian soybean. This fact generated even more pressure for the expansion of the sector without taking into consideration the improvement of production practices normally considered as non-sustainable.

The increase in the global demand has been followed in Brazil by the production and exportation growth of soybean grains. A number of policies in Brazil and of its main commercial partners benefit this national specialization in the production and exportation of non-processed grains. First, the processing industry of grains of the Brazilian soybean is not as competitive as its Argentinean competitor, who takes advantage of more favorable taxes, and the industry there uses high technology. Second, the grain destined to the processing industry in Brazil is subject to taxes that reduce the markup of the soybean crushing industry, thus encouraging production for exportation. Last, the policies related to the increase of tariffs for soybean processed products imposed by the importing countries benefit the Brazilian exportation of grains more than hulls and soybean oil.

The combination of those factors determines a negative pressure on investments in the sector of the soybean processing industry in Brazil, keeping its reduced competitiveness. The following Figures 17, 18 and 19 and Table 13 give a view of some indicators which allow us to understand the soybean production in the country, soy oil production and soybean evolution of planted area per region, over the last decade.

Figure 17 – Soybean and soy oil production (Brazil, 2003 – 2006)
(2006 are estimated value) Source: ABIOVE

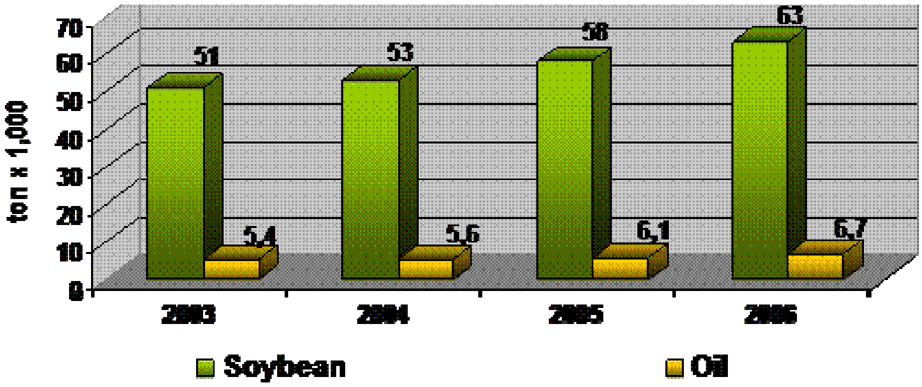
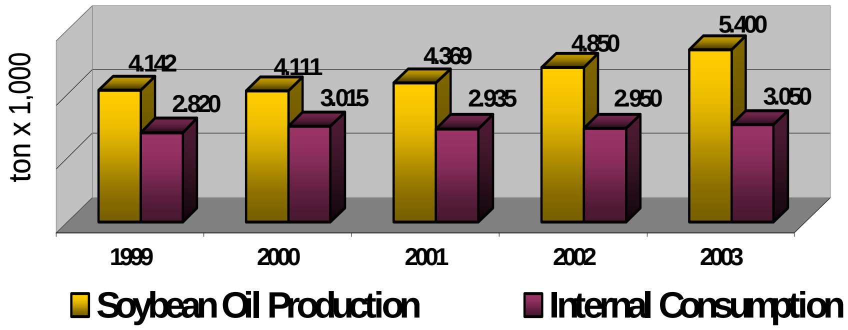


Figure 18 – Soybean oil surplus (Brazil, 1999 – 2003)



Source: ABIOVE

Figure 19 – Soybean production and crushing (Brazil, 1999 – 2003)
(values in ton x 1,000) Source: ABIOVE

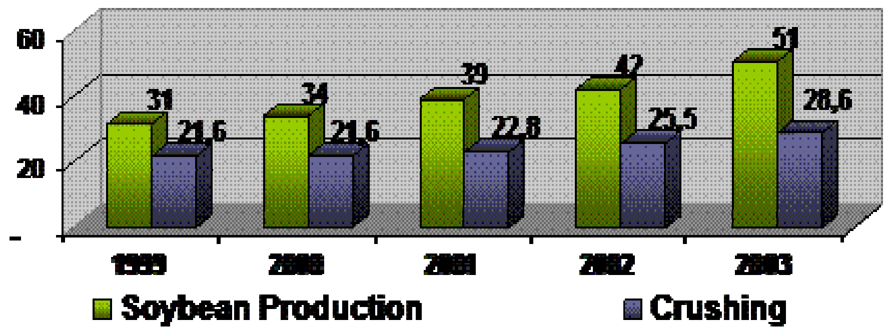


Table 12 – Soybean - Brazil

Area - Crops 1994/95 & 2003/04

1,000 x ha

REGION - UF	1994/95	2003/04	2004/05
NORTH	21,4	344,0	410,9
NORTH EAST	575,9	1.323,3	1.446,9
CENTRAL WEST	4.559,8	9.567,6	10.081,9
SOUTH EAST	1.163,6	1.826,9	1.876,3
SOUTH	5.358,0	8.213,9	8.503,2
NORTH/NORTH EAST	597,3	1.667,3	1.857,8
CENTRAL SOUTH	11.081,4	19.608,4	20.461,4
BRAZIL	11.678,7	21.275,7	22.319,2

source: CONAB

a) Availability/restrictions of bio-energy plants and area. Size and structure of farms

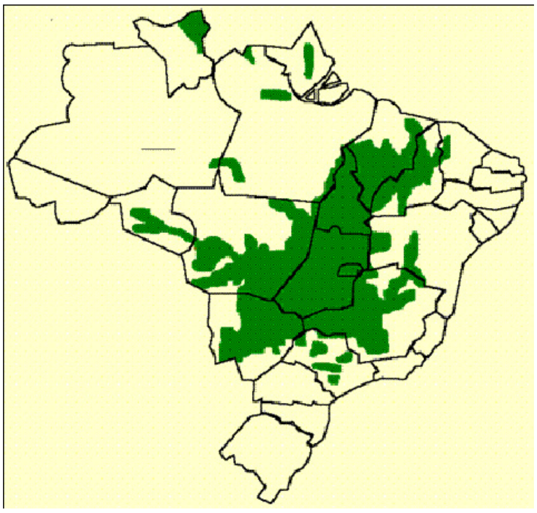
Soybeans are very suitable for capital-intensive, large-scale cultivation. Due to the mechanized character of cultivation, soy is planted almost exclusively on plains offering easy access for farm machinery.

Table 13 – Current and potential Soy Planted Area, Brazil

Soya Planted Area (Million ha)			
Region	State	2002/03 Planted Area	Potential Soy Planted Area
South	Rio Grande do Sul (RS)	3.6	5.0
	Paraná (PR)	3.6	5.0
	Santa Catarina (SC)	0.26	0.5
Subtotal South		7.4	10.5
South East	Minas Gerais (MG)	0.86	1.4
	São Paulo (SP)	0.60	1.1
Subtotal South East		1.47	2.5
Central West	Mato Grosso (MT)	4.5	40.0
	Mato Grosso do Sul (MS)	1.4	13.0
	Goiás (GO)	2.2	12.7
Subtotal Central West		8.2	65.7
North East	Maranhão (MA)	0.28	1.0
	Piauí (PI)	0.12	5.
	Bahia (BA)	0.85	1.5
Subtotal North East		1.24	7.5
North	Tocantins (TO)	0.15	0.8
	Pará (PA)	0.01	1.0
	Roraima (RR)	0.01	1.5
	Rondônia (RO)	0.04	1.0
	Amazonas (AM)	0.003	0.5
Subtotal North		0.21	13.8
TOTAL		*18.5*	*100.0*

The soybean production in Brazil firstly occurred in the states of the south of Brazil. This production has been expanding to other states since the 1990s. Today more than half of Brazilian soybean is produced in the Cerrado of the Middle-West region of the country, which has climate and soil projection adequate for its cultivation (Figure 20). However, the Cerrado is also an ecologically sensitive region having an extremely high biodiversity, which may suffer negative impacts both due to the soybean production rate and the methods employed in its expansion.

Figure 20 – Areas of *Cerrados*



This inmotensification in the cultivation of the soybean is characterized by large production units designed to take advantage of the scale economy. Typically, these large properties are established by the acquisition of several smaller land portions of small owners. However, there is also the expansion process of new areas that need to be deforested and prepared for soybean production. The side effects of this process include forest devastation, the destruction of species and their habitats, the removal of natural vegetation, the loss of functions of ecosystems and the decrease in the offer of environmental services. The natural vegetation does not only protect and supports the biodiversity, but it has an important role in the climate and hydrologic cycle control as well.

Studies of tropical forests show that forest devastation on a wide scale may cause a decrease in precipitation and an increase in temperature. Among the most harmful impacts is the impact on the gallery forests of the Cerrado, which is the habitat of half of the Brazilian endemic species and of a quarter of the threatened species. The expansion of the agricultural production in these areas of ecologically complex ecosystems may result in irreversible damages.

The property concentration in large production units also results in negative social impacts. The expansion of the cultivation is characterized by the encouragement that the small owners sell their lands, which causes the effective loss of their nourishment mean. The soybean production does not require a large manpower and many of these small producers are forced to migrate to urban centers, contributing to the problems associated to the population growth in the cities. Other farmers begin to dedicate themselves to land speculation in regions more to the west of the Cerrado or northward in Amazônia, which they "clean" and resell.

The national production has not grown just as a result of the expansion of the area cultivated.

There was also a significant increase in the Brazilian productivity due to a fast and efficient technology diffusion, including seeds, agro-chemicals, fertilizers and other inputs for cultivation.

While the productivity increase relieves the pressure on the earth, it also produces negative effects on the use of rural manpower. In addition, bad practices of plantation preparation cause the erosion and the degradation of the soil quality. The agrotoxics commonly used to control pests, diseases and invading weed may cause impacts on the environment, contaminating the soil and the water, as well as human health if preventive methods are not used carefully.

Policies addressed to the improvement of the transportation infrastructure in the Middle-West region are another encouraging factor for production expansion. Major projects are being prepared in order to create new exportation corridors, thus improving the production transportation from the Middle-West to ports or processing industries located close to large urban centers. While the transportation infrastructure develops towards the Amazon region, there is the risk that forest conversion for the agricultural expansion reaches this area, which up to this moment has not shown to be economically viable for intensive exploration of grains.

Based on the expectations that the internal and external demand for soybean products will continue to grow, it is essential that the improvement of the infrastructure be followed by policies that mitigate the growth effects on regions that are particularly vulnerable. The sectorial policies must take precautions against uncontrolled expansion towards sensitive areas and must protect key ecosystems in the Cerrado, Pantanal and Amazônia as well. In such a manner, it is expected that the production expansion will be encouraged for areas already degraded by means of the use of appropriate technologies in order to ensure the productivity maintenance and the integrity of natural resources.

b) The soybean commerce and its by-products

The Brazilian government is involved in a number of international negotiations related to trade liberalization, which will cause a strong impact on the soybean sector. The government's negotiators aim at obtaining access to the market and eliminating discriminatory practices, such as internal subsidies and scheduling of tariffs in competitive countries.

If these policies are succeeded, there will be a competitiveness increase for the Brazilian soybean and the exportation of large quantities of processed products will be encouraged. This may also have positive results for the sustainability, adding value to the product and increasing job offer in urban areas.

By expanding the gains accumulated in the sector, the replacement of non-processed soybean production may relieve the pressure in lands located in vulnerable areas of the Cerrado, Pantanal and Amazônia. Good commercial opportunities associated to the continuous refusal in adopting the indiscriminate use of genetically modified organisms (GMO's) may also arise. The "transgenic-free" status of some part of the Brazilian soybean production may result in a competitive advantage for its commercialization in some markets, such as in EU and Asia. This is possible because soybean industries of the major competitors, like the USA and Argentina, are associated to transgenic products.

At the same time, an increase in the liberalization of the soybean sector may encourage producing trends that already exist, which have socio-environmental effects potentially negative. While the opportunities offered by commercial negotiations aiming at eliminating policies that foster a non-sustainable profile must be seized, the Brazilian government should also develop and practice policies to manage the expansion of the soybean production and of other oleaginous products. It must also encourage more sustainable cultivation practices in parallel to efforts to promote the exportation. This will demand strong and effective social and environmental policies, among other things.

Biodiesel Potential

- Soybean production on an extensive scale to attend biodiesel market is not recommended considering the energy balance. Only the vegetable oil can be used as fuel. Detailed studies of energy balance for Brazilian conditions were not found. It can be said that it is necessary in Brazil more studies on this subject. There are some studies mentioned by CNAE [4] and another one from National Renewable Laboratory – NREL for the conditions of United States. Pimentel & Patzek have published in Brazil an energy balance evaluation. Segundo Urquiaga, Bruno José Rodrigues Alves and Roberto Michael Boodey from EMBRAPA also published a study not sufficiently detailed, however.
- However, given the importance of soy agri-business, organization level and installed capacity of processing, the production of soy oil will be of relevant importance to organize biofuel production in Brazil. The soy agribusiness can be used to structure the Brazilian biodiesel program. This subject, however, needs to be studied better because soy has been growing in Brazil and occupied its space in the world market in function of the growth of meal disappearance, and this is the vocation of this culture. The current production of vegetable oils in Brazil concentrated in the soy does not make sense because Brazil has the potential to produce the most varied types of vegetable oils. Considering food safety, Brazil needs to increase production of other vegetable oil species.
- A biofuel program should also be thought as an inducing factor of change in the vegetable oil production matrix, because the energy balances confirm the inaptness of soy for biofuel production.
- The fact that soy is the only organized vegetable oil production chain does not justify its use in a program whose legislation has strong social focus.

4.1.2 Castor plant – “Ricinus communis l.”

The oleaginous castor plant (*Ricinus communis L.),* of relevant economic and social importance, is found in wild conditions in several regions of Brazil, presenting as comparative advantage the countless industrial applications in plastics, metallurgy, toilet soap, perfume, tanneries, paints and varnishes, in addition to being an excellent lubricating oil for engines of high rotation and fuel of diesel engines.

The castor plant belongs to the *Euphorbiaceae* family, which includes a wide number of native plants of the tropical region. Its seeds, after being industrialized, result in pie and castor oil that, among several uses, are used in the industry. Castor oil contains about 90% of ricinoleic acid that represents an almost pure substance of this fatty acid, a rare fact in nature. See Table 14 for its chemical composition.

Basically, two types of production systems can be defined; the first where the culture assumes a social role of great relevance, the family workforce explores small areas always in a joint association with bean and corn; in this system there neither exists mechanization nor the use of modern inputs, such as improved seeds, safeguards, fertilizers etc. In the second system, cultivation assumes a more commercial character, with the participation of the mechanical traction and the use of modern inputs.

This component gives castor oil a wide range of industrial applications, including that of an alternative source of fuel, making the castor plant culture an important economical and strategic potential for the country.

The crop productivity may reach 2,000 kg of seeds per hectare, but the average productivity in Brazil actually is about 700 kg/ha.

Castor plant production always occupied a secondary or even marginal position in the market when compared with the production of large cultures. However, as it is a rustic plant and of easy adaptation to a great variety of soils and climatic conditions, there was always interest in fostering this kind of plantation. In the specific case of the familiar agriculture from the Northeast, where the workforce is restricted to the family members, the culture acquires an important social role, enabling the earning of income to cover the expenses of the household.

Table 14 – Chemical Composition of the Oil

Fatty acid	%
Ricinoleic acid	84-91
Oleic acid	3.1-5.9
Linoleic acid	2.9-6.5
Stearic acid	1.4-2.1
Palmitic acid	0.9-1.5

a) Size and Structure of Farms

Productivity of the culture is variable, being able to reach up to 2,000 kg per hectare of seeds, in the case of isolated farming, and from 1,000 to 1,200 kg per hectare of seeds for farming associated to beans. The grains are stored in bags of 60 kg and the commercialization is effected by middlemen or directly to the processing industries. The initial industrialization is carried out by grinding companies for the extraction of the oil from the seeds. In small facilities, the castor plant oil is extracted in presses of the screw type "expeller"; in the industrial processes of large scale, the extraction is carried out by solvents.

The profile of producers from the Northeast is complex; it is possible to characterize them in general terms as being constituted by numerous families, of low educational level, with the largest illiteracy rates of Brazil. Many sub-regions do not have the minimum basic infrastructure.

b) Availability of Area for Energy Crops

Despite the enormous area available, the castor plant culture is only representative in specific areas of the State of Bahia. This is possibly due to the irregular regimen of rains that is characteristic of the region, which transforms the castor plant planting into a high risk investment.

c) Potentials for biofuels in blending or pure

There are some difficulties for the competitive use of castor oil as a raw material for biodiesel production. For instance: limitation due to its viscosity - 11 mm²/s; excess of pressure (break of the injection equipment). There is a breaking danger of any injection equipment if viscosity exceeds the one of the diesel. As alternative its use could be restricted to maximum use of B20.

Another concern related to the use of castor oil refers to its energy balance which is relatively of low value. A definite evaluation of the energy balance for cator oil production is necessary. According to unpublished studies by F. Kaltner et coll. Castor oil presents a negative energy balance (1:1,3 considering a productivity of 1500kg seeds /ha). Other studies indicate a positive energy balance of low value anyway (less than 2:1). See for instance article by Segundo Urquiaga, Bruno José Rodrigues Alves and Roberto Michael Boodey published in *Revista de Política Agrícola* (jan-fev-mar 2005), in Portuguese.

Current situation

Over the years, the national production of castor oil has been the object of accentuated instabilities (see Tables 15 and 16). Among several reasons that could explain this situation, the following are included:

- Disorganization and inadequacy of the production system: use of inappropriate seeds; difficulty in obtaining and lack of improved seeds; use of inadequate cultural practices; etc
- Disorganization of the internal market: few agents act in the commercialization and the number of buyers is equally restricted
- Low prices paid to producers
- Problems with the credit offer and technical support
- In the cultivation places, lack of culture rotation practices

Table 15
CASTORPLANT- BRAZIL
Production - Crops 1994/95 & 2003/04
1,000 x ton

REGION - UF	1994/95	2003/04	2004/05
NORTH	-	-	-
NORTH EAST	43,2	103,3	143,3
CENTRAL WEST	-	-	-
SOUTH EAST	1,0	2,8	4,6
SOUTH	-	-	-
NORTH/NORTH EAST	43,2	103,3	143,3
CENTRAL SOUTH	1,0	2,8	4,6
BRAZIL	44,2	106,1	147,9

source: CONAB

Table 16
DIAGNOSTIC OF THE CASTOR PLANT PRUDUCTION IN BRAZIL

	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005
Production (ton x 1000)	35,1	47,6	42,2	40,5	53,2	70
Imports (ton x 1000)	3	0,2	0,6	0,1	1,6	1
Exports (ton x 1000)	10,5	14,3	6,4	3,7	0,7	4,5
Dom. Disappear (ton x 1000)	26,7	30,6	35	38,4	53,1	65
Ending Stock	2	5	6,5	5	6	7,5
Harvested Area (ha x 1000)		209	172	136	134	165
Yield - Seeds (ton x 1000)		0,56	0,58	0,53	0,58	0,91

Source:Oil World 2005

All links of the productive chain need to be developed. Now, it is more coherent to highlight institutions of excellence in the generation of technology in the castor plant culture. In São Paulo, in spite of the lack of resources of the last decades, the Agronomic Institute of Campinas – IAC (Instituto Agronômico de Campinas) carries out systematic work. In Bahia, the Company of Agricultural Research - EPABA (Empresa de Pesquisa Agropecuária) is a reference. In the federal sphere, EMBRAPA Algodão, located in Campina Grande in Paraíba stands out as an irradiating pole of science and technology.

Table17

CASTOR PLANT SEEDS CRUSHING INSTALLAED CAPACITY IN BRAZIL			
Company	Location	Installed Capacity ton/day	Region
SECOL	Montes Claros –MG	90	Southeast
PETROVASF	Itacarambi – MG	10	Southeast
RETORNO – Transports	Janaúba – MG	60	Southeast
PALMA – CRISTI	São Francisco – MG	30	Southeast
COOPAGRO	Montes Claros - MG	30	Southeast
BOM BRASIL	Salvador – BA	200	Northeast
BRASIL WAY	Feira de Santana – BA	200	Northeast
CANDEEIROS	Iuiu – BA	5	Northeast
CERALIT	Campinas – SP	300	Southeast
source: EMBRAPA 2000			

Nowadays, the installed production capacity of seed crushing (Table 17) only allows the supply of the domestic market for conventional use. There are no inactive crushing facilities of castor plant. There are no productive industries of castor plant oil in the semi-arid Northeast. What we can infer with absolute certainty is that it is necessary to include an esterification project in each industry, as well as facilities with equivalent capacity for seed crushing.

d) Products and By-products

The by-product of the castor oil extraction, called ungreased pie, has an immediate use as organic fertilizer, providing the improvement of the physical properties of the soil as well as nutrients for the plants. Average chemical composition of castor seeds can be seen in Table 18.

Table 18 – Castor Plant Seed Chemical Composition

Average chemical composition of the seeds
Humidity: 5.5% **Crude Oil: 48.6%** **Crude Protein: 17.9%** **Crude Fiber: 12.5%** **Ashes: 2.5%** **Carbohydrates: 13.0%**

4.1.3 Palm tree – “Elaeis guineensis jacq.”

The large-scale planting of the African palm tree “dendezeiro” started in Malaysia in 1960. It was responsible for the production of 34.5 million tons of palm oil in the 2004/2005 crop and is expanding fast. The palm and palmkern oils produced from that culture are widely used for human nutrition in the following forms: margarine, vegetable creams, industrial fats and kitchen oil. These oils are also important raw materials for soap, ink and oil-chemical industries. Nowadays, ninety-five per cent (95%) of the world plantations are located at the longitudinal range of 10^o north and south of the Equator. Most of the production (80%) is concentrated in Malaysia and Indonesia.

Few economic options offer an assured permanent income for the Amazonian population without environment aggression. The palm tree culture appears as an excellent option, with great capacity to generate jobs and income. Each ten hectares planted creates one direct job. Palm tree can be cultivated on poor soils, like the majority of the Amazonian land. It quickly establishes a tree cover and mimics tropical rainforest, protecting the soil against lixiviation and erosion. Thus, the palm tree culture restores the climatological hydric balance and contributes to fix CO_2 and liberate O_2.

Estimates claim that there are 20 million hectares deforested and this land was mostly abandoned after an aggressive short-lived cycle of exploration of forest resources and soil nutrients. Nowadays, these areas are degraded and lack economical activities. The palm tree appears as the most indicated culture to recover degraded areas in those regions whose weather is appropriate for the culture.

Palm tree culture demands integration of agricultural production with industrial processing. This is because fruits acidify quickly and have to be processed within 24 hours after being harvested. That is why it is necessary to install the oil extraction plant physically close to the planting area. The specific feature of this culture focuses the job and income creation on the planting area.

35 years after beginning the research and planting, Brazil has its own technology to increase the planted area of this culture, which produces up to 5 tons of oil per hectare/year.

Table 19 – Properties and Characteristics of Palm Oil

ITEM	MEAN	RANGE
Slip Melting Point °C	34,2	31-38
Titre °C	45.0	42-46
Relative Density 50°C/ Water at 25°C	0,8927	0,892-0,893
Iodine Value - Wij's	52,9	51-55
Saponification Value mgKOH/g oil	195,7	190-202
Fatty Acid %	<3,0	

Current situation

Despite the huge potential for palm oil planting, Brazil does not occupy a prominent position in the world context when it comes to palm oil production. In Latin America, the country stands behind Colombia, Costa Rica, Honduras and Ecuador. In 2004, Brazil produced about 132,000 tons of palm oil in almost 60,000 hectares (less than 0.1% of the potential area). It is an insignificant amount when compared to the biggest producer: Malaysia produced 13.8 million tons.

The Brazilian Palm oil production is dominated by one large-scale player: Agropalma, in Pará state. The number of small and medium-scale producers is quite low (See Table 20). In the year of 2005, only eight extraction plants in three Brazilian states remained active.

Table 20

Brazilian Palm Oil Production (2004)

COMPANIES	1983			2004		
	AREA (ha)	PROD. (t)	SHARE (%)	AREA (ha)	PROD. (t)	SHARE (%)
PARÁ	12,360	9,915	7.51%	51,891	120,287	91.14%
CRAI/AGROPALMA	710			35,332	94,805	71.83%
DENPASA	5,061	9,915	7.51%	742	0	0
CODENPA	2,299		0	700	3,500	2.65%
DENTAUÁ	950		0	3,500	6,500	4.92%
PALMASA	0		0	4,100	6,200	4.70%
REASA/MARBORGES	2,540		0	3,317	9,282	7.03%
YOSSAM	0		0	4,200	0	0
DENAM	800				0	0
AMAPÁ	3,560	0	0.00%	0	0	0.00
CODEPA/COPALMA	3,560	0	0	0	0	0
BAHIA	5,150	7,876	5.97%	5,800	11,300	8.56%
JAGUARIPE				0	0	0
MUTUPIRANGA				0	4,800	0
OLDESA	2,150	3,700	2.80%	4,000	4,100	3.11%
OPALMA			3,16%	1,800	2,400	1.82%
ROLDÕES			0	0	0	0
AMAZONAS	500	0	0.00%	1,610	400	0.30%
CAIAUÊ				1,200	0	0
EMADE	500	0	0		0	0
EMBRAPA (R&D Area)				410	400	0.30%
TOTAL	21,570	17,791	100.00%	59,301	131,987	100.00%

Sources: Agrianual FNP 2005, Marborges 2005

With more than 90% of the national production, Pará is the most important Brazilian state in palm oil. Bahia appears at a distant second position, producing only 9% in 2004.

The palm oil production is focused on the "Agropalma" company, which is responsible for 72% of the national production.

a) Potentials for biofuels in blending or pure

The energy balance of palmoil has a very high value (1:9.6 - best case to 1: 5.6 - poor case related) and is, from this point of view, the crop with the best potential for biodiesel production in Brazil.

b) Size and Structure of Farms

The African palm agro-industry needs a great amount of manpower to treat the harvested fruits within 24 hours. That makes it necessary to implement independent production modules whose size should be limited by the maximum distance between the planting area and the extraction industry. There is an economical size of planting areas to be taken in account, indicated for instance as the two following models:

Model 1 "Small Farmers"

Planting : 2,000 ha in individual modules with 10ha area (200 families per project)
Crude Oil Extraction Industry: 12 tffbh (twelve tons of fresh fruit bunches per hour).

Model 2 - "Plantations"

Planting: 5,000 to 6,000 ha (five to six thousand hectare area).
Crude Oil Extraction Industry: 36 tffbh (thirty-six tons of fresh fruit bunches per hour).

c) Availability of area for energy crops

From the agroclimatic zoning point of view – not considering environmental factors or other use-restraining factors – the total potential area for palm crop consists of approximately 70 million hectares. This area is distributed according to the following Table 21.

Table 21 – Potential Area – Palm Crops by State

State	Nº ha (millions)
Acre	2.5
Amapá	0.5
Amazonas	54.0
Bahía	0.9
Pará	5.0
Rondonia	2.0
Roraima	4.0
Tocantins	1.0
Total	**66,0**

Source: VEIGA et al. (2000)

In the Amazonian area, the states of Pará, Amazonas and Amapá have about 3 million hectares of altered/deforested areas immediately available and fit for palm crops. Those areas are located close to the capitals and already have basic infrastructure (Harbors, Highways, Energy, etc.) ready to establish a great palm oil production program. Once established, this program would have competitive advantages over major global producers. Those areas are located in regions where the land has been used for agriculture since the 19th century, with a high population density and low economic indicators.

The best areas in the Amazon for Palm plantation have INCRA settlements, for which a large-scale strategic program should be considered in terms of regional and global policy, thanks to the sustainability perspectives of this business. An exemple is the Program PROBIOAMAZON, from the Ministries of Agrarian Development and Science and Technology, which needs decision and support for its implementation in areas of INCRA settlements in the Amazon. Table 22 shows some data on settlements, presently established in 3 Amazon states with potential for plantation.

Table 22 – INCRA Settlements in Amazonian States

(Source: IBGE)

State	Number of Settlements	Area ha x 1,000	Modules	Harvest Potential (modules x 10 ha)
Pará	15	105	2,628	26,280
Amazonas	9	1,109	10,800	108,000
Amapa	4	120	2,100	21,000
Total	**28**	**1,334**	**15,528**	**155,280**

4.1.4 Sunflower oil (helianthus annus)

The sunflower is a native plant of the Americas, which was used as food by the American Indians, mixed with other vegetables. In the 16th century, the sunflower was taken to Europe and Asia, where it was used as an ornamental plant and vegetable as well. In the Soviet Union the first sunflower improvement in order to produce genotypes with high oil contents took place. Since then, with the consumption growth of edible oils, the worldwide production of sunflower has been developing, being led by the Soviet Union, United States, Argentina and China.

Nowadays, the sunflower occupies the fourth place as source of edible oil, followed by the soybean, palm and rapeseed. As a proteic source, the sunflower is also classified as the fourth option for animal ration and human use. A great deal of research into the use and processing of sunflower protein has been carried out, and countries like the United States, France, Italy and Canada already have industries producing flours, concentrates and isolated proteins.

The great importance of the world sunflower culture is due to the excellent quality of the edible oil that is extracted from its seed. It is an economical and rustic cultivation that does not require specialized machinery. It has a short vegetative cycle and adapts perfectly to soil conditions and even mixed climate. For its appropriate cultivation the same knowledge and machinery are necessary used in the corn, sorghum or soybean cultures.

The sunflower promotes a considerable recycling of nutrients because its roots are of the rotating type in addition to the organic matter left in the soil when the plant dies. The stems can originate material for coverage and, together with the leaves, it can be ensilaged and develops into green manure.

From the flowers, 20 to 40 kg of honey/hectare can be extracted. They originate the seeds, which can be consumed by both human beings and animals.

Oil of excellent nutritional qualities can be extracted from the seeds, and mainly due to the high content of linoleic acid, it is recommended for preventing cardiovascular diseases and the treatment of multiple sclerosis.

In addition, sunflower is also an important source of proteins for animal feeding. The combination of sunflower and soybean peels is very effective, because sunflower is insufficient in lysine and rich in sulfur, while soybean presents the reverse composition.

Furthermore, sunflower is an important feeding source for cattle in the silage form. It is also used in green manuring, due to its fast initial development and its allelopathic effect on a large number of invaders, its efficiency in the recycling of nutrients and also for being a protecting agent of soils against erosion and invaders infestation. Therefore, it is recommended for rotation of cultures.

a) Sunflower Planted Area and Production in Brazil

Table 23 – Sunflower – Brazil			
Planted Area - Crops 1994/95 & 2003/05			
1,000 x há			
REGION - UF	**1994/95**	**2003/04**	**2004/05**
NORTH	**-**	**3,8**	**-**
NORTH EAST	**-**	**-**	**-**
CENTRAL WEST	**-**	**43,5**	**43,5**
SOUTH EAST	**-**	**2,0**	**2,0**
SOUTH	**-**	**7,3**	**7,3**
NORTH/NORTH EAST	**-**	**-**	**-**
CENTRAL SOUTH	**-**	**52,8**	**52,8**
BRAZIL	**-**	**52,8**	**52,8**
source: CONAB			

b) Sunflower Production

Table 24 – Sunflower - Brazil			
Production - Crops 1994/95 & 2003/05			
1,000 x ton			
REGION - UF	**1994/95**	**2003/04**	**2004/05**
NORTH	**-**	**-**	**-**
NORTH EAST	**-**	**-**	**-**
CENTRAL WEST	**-**	**68,6**	**68,8**
SOUTH EAST	**-**	**3,0**	**3,0**
SOUTH	**-**	**10,4**	**10,4**
NORTH/NORTH EAST	**-**	**-**	**-**
CENTRAL SOUTH	**-**	**82,0**	**82,2**
BRAZIL	**-**	**82,0**	**82,2**
source: CONAB			

Sunflower Energy Balance

It is necessary to study the energy balance for the production of biodiesel out of sunflower in Brazil. The only reference known by the Authors is from a study made by David Pimentel and Tad W. Patzek. According to this study the use of sunflower for biodiesel production presents two main problems: the relatively low yields of oil crops ranging from 1,500 kg/ha; sunflower averages 25.5%. In addition, the oil extraction processes for such specie is highly energy intensive. Therefore, these crops are poor producers of biomass energy.

Other Species of oil plants

There are other plants which can be used for biodiesel production, like Fodder radish (raphanus sativus l.) and Jatropha (Jatropha curcas L.). They can be used in some particular regional programs and deserve more studies.

5. Biodiesel production

5.1 Definition

“Biodiesel” designates a group of esterified vegetable oils produced from different oil-containing crops, most importantly rapeseed, soybean, sunflower and palm. In common parlance, abbreviations like “RME” — for rapeseed methyl ester, the variant for which the most data exist — are used to describe these esterified oils. Table 25 shows relevant data of the most promising species of vegetable oil plants, such as crop period, oil content, efficiency in t / hectare. Esterification offers a low-cost way to transform vegetable oil molecules into molecules similar to the diesel hydrocarbons.

With properties very similar to those of fossil diesel, biodiesel can go almost directly into existing diesel vehicles and it mixes with fossil diesel in any ratio; its energy content is a little (about 8%) lower, but it has higher fuel density and better ignition qualities with its higher cetane number.

Biodiesel production begins with pressing the crop, which yields a liquid oil fraction to be converted and a first by-product, oil cake, used as cattle feed. After filtering, esterification provides a low-cost way to transform the large-branched molecule structure of the extracted oils into smaller, straight-chained molecules similar to the hydrocarbons in the diesel boiling range. During esterification, the addition of a monovalent alcohol, usually methanol, replaces the trivalent alcohol glycerin, which gives methyl ester and releases glycerin, a second by-product used in the pharmaceutical and cosmetics industries.

Biodiesel can be handled and used safely, thanks to extensive experience in handling stems from the oils used in the food sector and the esters employed as feedstocks in the detergent, cosmetics and soap industries. Biodiesel causes less health risk to humans and animals than fossil diesel and present less danger to the environment because of its biodegradability.

Due to the automobile fuel consumption profile, which has diesel oil as the main item, biodiesel is the biomass by-product with the best potential to be used as a replacement for fossil fuels.

Since 2002, Brazil has been implementing a national program of biodiesel production and utilization, specially on small rural properties based on family agriculture at the North and Northeast regions. The program recommends transforming biodiesel through the ethyl route.

Despite the incentives given to small rural producers, the competitiveness and quality of biodiesel production at small-area industrial plants are not properly evaluated according to the ANP-National Petroleum Agency defined standard. The same lack of evaluation affects the by-products and industrial waste final destination when it comes to the ethyl route.

Table 25 – Vegetable Oils for Biodiesel Production - Respective Crop Period & Yields

(Source: EMBRAPA)

Plant	Oil origin	Oil content (%)	Months of harvesting	Oil yield (t/ha)
African Palm	Pulp	26	12	3.0-6.0
Babaçu	Pulp	66	12	0.4-0.8
Sunflower	Seed	38-48	3	0.5-1.5
Rapeseed	Seed	40-48	3	0.5-0.9
Castor	Seed	43-45	3	0.5-1.0
Peanuts	Seed	40-50	3	0.6-0.8
Soybeans	Seed	17	3	0.2-0.6

5.2 Current Situation

Biodiesel in Brazil is in the initial phase of production, with the production chain being structured and looking for the best solutions from the economical, social and environmental standpoint.

Federal Law Nº 11.097 from January of 2005, establishes the roadmap for the commercial use of this new biofuel in the country. The time schedule under this Law was later modified (September 2005), so that it will be mandatory to add 2% mixture (B2) of biodiesel to conventional diesel from 1st January, 2006. The obligation is restricted to biodiesel volume produced by companies which have obtained the Social Seal.This means a potential market of about 800 Million liters of biodiesel (B100) per year. From 2013 on, a further mandatory step of 5% mixture (B5) will be considered, meaning a firm market of 2.4 Billion liters per year.

However, it is considered an immense challenge to reach those volumes of production with the required quality to the end-consumer.

Aiming at reaching the production goal for B2, a first electronic auction has just been realized (23rd November, 2005), under responsibility of the National Petroleum Agency (ANP), for purchasing biodiesel produced by industrial plants awarded with the “Social Fuel” seal. The Federal Government goal of purchasing 70 Million liters, to be delivered from January to December of 2006, has been reached. In this first round, 65,500 families were benefited.

Eight biodiesel producers participated in the auction, offering a total of 92.5 Million liters, from which 70 Million liters were bought from four producers, namely: Brasil Biodiesel

Matriz (from Floriano, State of Piauí), 38 Million liters; Granol (Campinas, São Paulo), 18.3 Million liters; Soyminas (Cassia, Minas Gerais), 8.7 Million liters and Agropalma (Belém, Pará), 5 Million liters. The buyers of the biodiesel offered in this auction were the producers and importers of diesel according to their participation in the market: 93.3% for PETROBRAS and 6.6% for the Alberto Pasqualini Refinery (REFAP), owned by Petrobras.

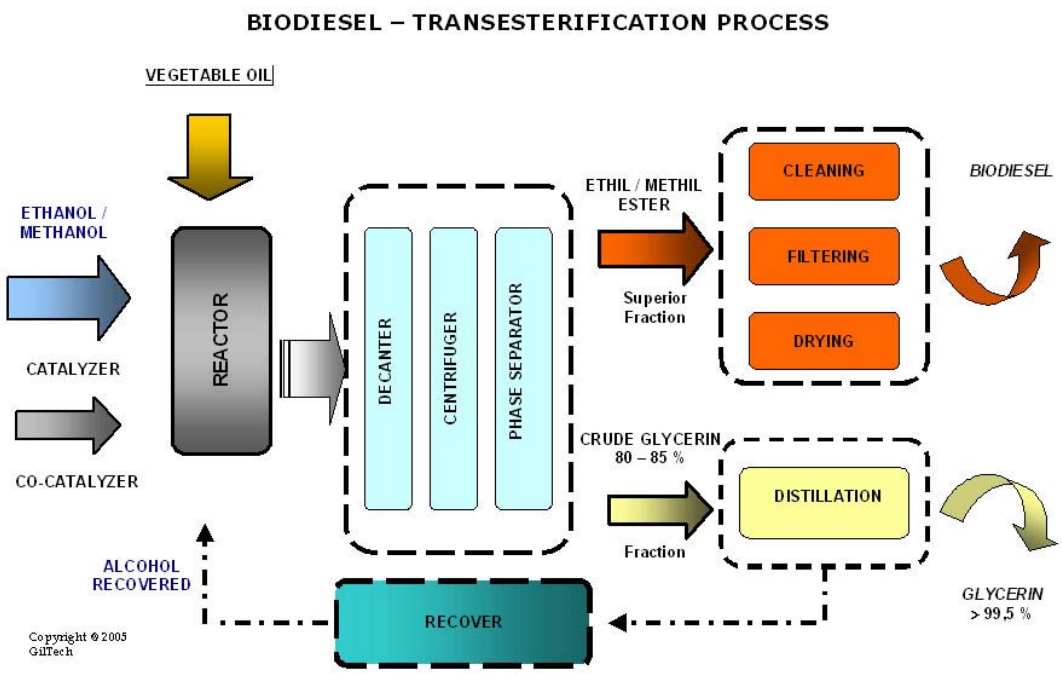
The opening price of the auction was defined at R$ 1.920 / liter (about US$ 0.83 / liter) and in relation to the final average price of R$ 1.905 there was a reduction of almost 1%.The price includes the Federal tributes incident on biodiesel (PIS/PASEP and COFINS) but without ICMS, which varies according to each State of the Federation.

The price of produced biodiesel is, therefore, much higher than the price of conventional diesel. The Brazilian government when designing its policy for this sector created the social seal for biodiesel production. It is a valid policy, mainly for a country with severe social imbalance, and especially at the very beginning of the program implementation, as biodiesel production needs the support of subsidies to survive. The production chain has, however, to commit itself to aggregate value, resulting in productiveness, in order to reach its own sustainability.

5.2.1 Processes

Biodiesel can be esterified using either the methyl alcohol/methanol “Methyl Route” or the ethyl alcohol/ethanol “Ethyl Route” as reagent. Production through the methyl route is commonly used and there are hundreds of production plants operating worldwide. Brazil, which is a huge ethanol producer, stimulates the use of this reagent as a standard for its program. Large-scale commercial production using “Ethyl Route” has not been tested yet. Since the Brazilian Program recommends biodiesel production through the ethyl route but does not make it mandatory, the market will have to define the technology to be used, especially for the first phase of the industrial and technological development.

Figure 21



Despite the environmental advantage of ethanol, as it is a vegetable-origin product, over methanol which is mainly produced by natural gas, the biodiesel production technology through the ethyl route currently presents a series of challenges that will have to be solved in order to allow large-scale utilization. It is timely to remember that the unconverted product becomes a hard-to-handle industrial waste.

Table 26 – Properties of processes methyl and ethyl esters

Property	Methyl Ester	Ethyl Ester
Conversion: Oil → Biodiesel	97.50%	94.30%
Total Glycerin on Biodiesel	0.87%	1.40%
Viscosity	3.9Cst @40ºC	7.2% more than methylic
Δ % power opposed to diesel	< 2.5%	<4%
Δ % consumption opposed to diesel	> 10%	> 12%

Source: Cadernos NAE ,Vol 2, 2005

5.2.2 Biodiesel B100 Specification – ANP, American and European

The mixing obligation is based on the Brazilian Biodiesel specification demand, according to ANP's Administrative Rule number 255, from September 15th, 2003. (Table 27)

Table 27 — Biodiesel specifications – Brazil – Others

PROPERTIES	ANP	American ASTM D- 6751		European pR EN 14214	
	LIMITS	LIMITS	*METHODS*	LIMITS	*MÉTHODS*
Flash Point (ºC) min.	100	130	D 93	101	ISO / CD 3679
Water and sediments (%vol.) max.	0.05	0.05	D 2709	-	-
Viscosity cin. 40ºC (mm^2/s)	2.5 to 5.5	1.9 to 6.0	D 445	3.5 to 5.0	EN ISO 3104
Sulphated Ashes (%m/m), max	0.02	0.02	*D 874*	0.02	ISO 3987
Sulphur (%m/m) max	0.001	0.05	D 5453	0.001	EN ISO 14596
Corrosivity to copper 3h – 50ºC, max.	1	3	D 130	1	EN ISO 2160
Cetane number min.	45	47	D 613	51	EN ISO 5165
Cold Filter Clogging Point (ºC) max.	(1)	------	D – 6371	-	-
Carbon residue (%m/m) max.	0.05	0.05	D 4530	0.3	EN ISO 10370
Acidity (mg KOH/g) max	0.8	0.8	D 664	0.5	prEN 14104
Free Glycerin (%m/m) max.	0.02	0.02	D 6584	0.02	prEN 14105/14106
Total Glycerin (%m/m) max.	0.38	0.24	D 6584	0.25	prEN 14105
Appearance	LII (2)	-	-	-	-
Distillation 95% of the recovered, (ºC), max.	360	360 (90% rec.)	D-1160	---------	--------
Specific mass at 20ºC (kg/m^3)	850 – 900	-	1298/ 4052	860 to 900 at 15ºC	EN ISO 3675/12185
Methanol or ethanol content (%m/m) max.	0,5	-	-	0.2	prEN 14110
Iodine value max	Annotate	-	-	120	prEN 14111
Monoglycerides (%m/m) max.	1.00	-	D 6584	0.8	prEN 14105
Diglycerides (%m/m) max	0.25	-	D 6584	0.2	prEN 14105
Triglycerides (%m/m) max.	0.25	-	D 6584	0.2	prEN 14105
Alkaline metal content (Na + K) (mg/kg) max.	10	-	-	5	prEN 14108 prEN 14109
Ca + Mg (mg/kg)	----	-----	-----	5	prEN 14108 prEN 14109
Phosphor content (mg/kg) max	10	-----	D 4951	10	prEN 14107
Oxidation stability at 110ºC, (h) min.	6	----	To be defined	6	Pr EN 14112
Contaminants (mg/kg), max.	-----	------	-----	24	EN ISO 12662
Éster (%m/m), min.	----	------	-------	96.5	pR EN 14103
Methyl Esters from linoleic acid (%m/m) max.	-------	-------	--------	12	pR EN 14103
Polyunsaturated (> 4 double bindings) max.	-------	--------	--------	1	Being elaborated

Source: ANP

1) It must abide by the clogging point limits established by the administrative rule number 310/01 from ANP, reported in Table II of this administrative rule. (2) Clear and impurity-free.

No matter which technological route is chosen, only in this decade, Brazil is investing in the engineering process and technological development to integrate productive systems, especially for large-scale industrial plants. The country has not disseminated the technological skills needed to the extent of the proposed program on the equipment industry.

Analysis of the beforementioned technological routes is at present object of study commissioned by NAE – Brazilian Government Strategic Matters Kernel – which is responsible for studies in order to estabish the Brazilian Biodiesel Program.

5.2.3 Technological routes and productivity

The current capacity of vegetable oil ester production in Brazil is shown below (Item 5.2.6). Installed industries focus on refined vegetable oil sludge recovery. These companies mainly use fatty acids resulting from refined vegetable oil as raw material and have the current main goal of adding value to this waste instead of producing biodiesel. There are some few exceptions like ECOMAT and Brazil Biodiesel.

In general, the Brazilian Biodiesel Program at this phase is directed exclusively to the vegetable oils esterification process. There is no planning in order to integrate the productive chain in its several instances (seeds, fertilizers, defensives, industrial inputs, oil-extraction industry, esterification, distribution infrastructure). The whole program is addressed to the compulsory mixture nature, not worrying about production costs or sales. Energy balance studies are still precarious, especially considering the particularities inherent to each project when it comes to the consumers market. No efficiency evaluation has been performed at any part of the productive chain and the same applies to the full analysis of the fuel life cycle starting from different oil crops mixed. The program has social inclusion as its core strategy but shows no concerns over the "vegetable oil" agribusiness obstacles.

5.2.4 Production Chain

Biodiesel production chain includes several steps, such as: agro-industrial up to the raw oil production, industrial for ester production and preparation of blends, distribution logistic and commercialization. This is in fact a complex chain that involves different sectors of the economy and investment agents to reach the consumer with biofuel quality and competitiveness, aiming at local, regional and export markets.

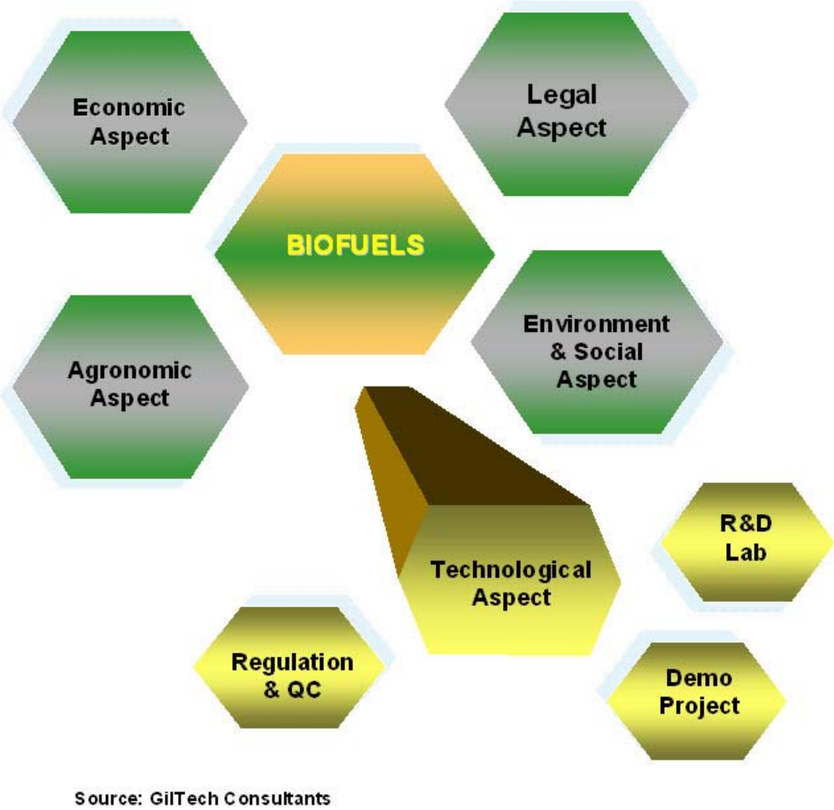
The agro-industrial step mainly demands quality agricultural areas and seeds to guarantee productivity and to reduce production risks, considering the fact that the raw material is responsible for about 80% of biodiesel production costs.

In the industrial step, the risk is in the selection of process technology, on adequate scale, in the inputs and storage quality and distribution of main product – biodiesel, and also of the aggregation of value to the process sub-products, in order to have a guaranteed market that helps to cover fixed processing costs.

The commercialization step, according to the present Brazilian Government policy, is considered as optimization strategy and use of liquid fuels storage units in states and ports

– existent and planned – considering the mixture perspective of 2% and 5% to conventional diesel to be attended.

Figure 22 – Biodiesel Program – Integrated Strategy of Planning and Management



The possible sustainability of the biofuel business is, in general, based on the close and simultaneous verification of the following aspects: legal, economical, agronomic, socio-environmental and technological, which includes research and development efforts, implementation of demonstration and regulation projects associated to fuel quality (Figure 22).

5.2.5 Industrial Plants – Characterization & Routes

The technological selection and size of the biodiesel production units depend essentially on the particularities of the purchase contract, either for local supply, regional or for export, in the medium or long term. Contract price and other conditions, as a result of market negotiations should guide the decision-making process at the investment and technological content levels. It is up to the licensing and financing bodies to analyze the efficiency of the productive processes, including public policy of support to the official laboratories and universities to establish partnership, acting in network, to guarantee the continued development of production and end-use technologies.

Biodiesel production directed to the market regulated by the National Petroleum Agency ANP needs plants with great production capacity. This is necessary for the high costs of modern processes to be absorbed, which ensure high conversion rates. The quality control to guarantee the specification is only feasible in plants of certain size.

It is important to remember that even for projects with social labeling, the market is only guaranteed if the biodiesel meets the specification. This is also true for projects directed to the export market.

5.2.6 Industrial Plants – Current Situation in Brazil

Table 28 – Production Capacity (planned) (Source: ANP)

Enterprise	Deliverer of		Location	Start of production	Production capacity		Main oil seeds
	Technology	Capital goods			Litres/day	Litres/year (Mill.)	
Agropalma	DEQ-UFRJ	Dedini	Belém - PA		16,000	8	Palm
Brasil Ecodiesel and Enguia Power	Tecbio and UFCE		Canto do Buriti - PI	08/2005	120,000	30	Castor
Brasil Ecodiesel			Maranhão		60,000	15	
Petroq. Capital (1)	USP – SP	Dedini	Charqueada – Piracicaba – SP	01/2005	300,000	80	Soybeans
	USP – SP		Indaiatuba – SP	06/2004	30,000	8	
Soyminas	Soyminas	Soyminas	Cássia – MG	09/2004	20,000	5	Various
	Soyminas		Rolândia – PR		30,000	8	
Ceralit	Soyminas	Soyminas	Campinas – SP		128,000	32	Various
	Soyminas	Soyminas	Cuiabá – MT		4,000	10	Various
Usinas novas	Soyminas		Various	12/2004	240,000	60	
Granol	Granol	Granol	São Simão – GO		400,000	100	
Ecomat	Tecpar	Tecpar	Mato Grosso		40,000	10	Soybeans
			Internal market	1,184,000	301		
			Export	300,000	80		
			Total	1,484,000	381		

Table 29 – Industrial Plants – Authorized Instalation / ANP (Source ANP)

Enterprise	Location	Authorized capacity (m^3/day)	Estimated annual capacity (10^3 m^3/year)
Soyminas	Cássia/MG	40	12
Agropalma	Belém/PA	27	8.1
Brasil Biodiesel	Tereseinha/PI	2	0.6
Biolix	Rolândia/PR	30	9
Brasil Biodiesel	Floriano/PI	90	27
Fertibom	Catandavu/SP	30	10
Renobras	Dom Aquino/MT	100	30

ANP, through public audience and auction to buy and sell biodiesel, is organizing and motivating producers, consumers and distributors for the new business of biodiesel, which will be stronger with the inclusion fo new participants after January 2006.

5.2.7 Costs and prices. Competitiveness.

The feasibility of biodiesel production is related to the production and sale costs of each vegetable oil. There are significant variations in costs for different vegetable oils and also their origin. As the final product – ester, based on all commercial vegetable oils, has application as biofuels, it is considered essential for competitive evaluation in the free market.

Table 30 — Energy Balance Comparison

	Output/Input (1)	Output/Input (2)	Output/Input (3)	Output/Input (4)
SOY OIL	2.5		3.2-3.4	1.43/ 2-3
PALM OIL	9.6	8.66		5.6
CASTOR OIL		<2.0	2.1-2.9	
MACAUBA				4.2
ETHANOL		8.06		
DIESEL OIL			0.83-0.85	
Rapesed Oil	3		1.2-1.9	2/mar

(1) The Oil Palm Industry - From Pollution to Zero Waste, Yussof Basiron and Ariffin Darus, 1995
(2) Produção de Biocombustiveis a questão do Balanço Energético , Urquiaga et all , 2004
(3)Jose Adolfo de Almeida Neto ett All, Balanço energético de Esteres etilicos e metilicos, 2004
(4) Cadernos NAE, número 2, 2005

The energy balance can indicate how competitive are the different vegetable oil species suitable for a certain area, enabling to establish production priorities when planning a sustainable mix of vegetable oils for regional production. (Table 30)

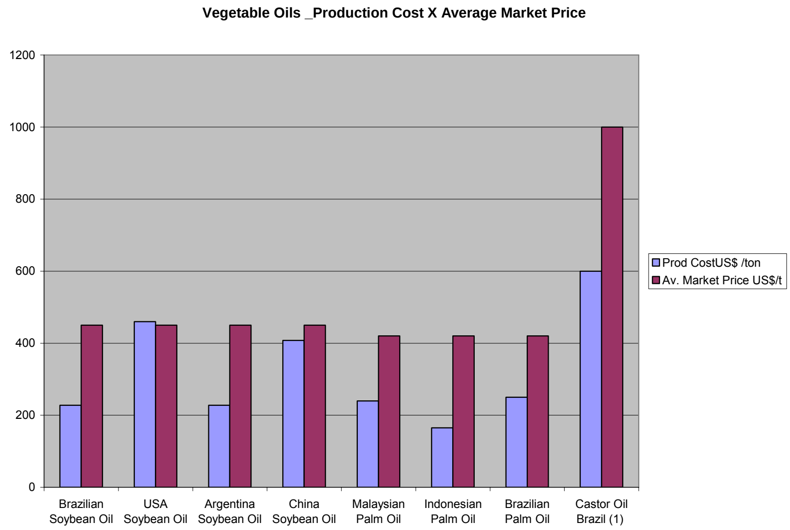
The theoretical potential or its closest proximity should motivate the entrepreneurs and researchers for the optimization of researches and technological innovation.

Figure 23 shows a comparison between production costs and final sale prices of some selected countries. China and United States have production costs incompatible with market price, which makes their production dependent of subsidies.

Castor oil has the highest production cost and market value, which makes its use as biodiesel restricted to subsidized programs.

From the economic standpoint, soybean and palm oils are the only ones with production potential for biofuels at prices competitive with petroleum diesel.

Figure 23
(Source: Kaltner, F. J., unpublished)



From the above data, a simulation was carried out for the production cost of biodiesel with two possibilities:

a) Vegetable oil cost equal to biodiesel production cost. This indicator is important to verify the real production cost of biofuel, but does not represent the real selling price.

b) Vegetable oil cost equal to the average vegetable oil selling price in the market. This price reflects the real cost of production because it takes into consideration the financial return of the oil production.

Biodiesel Production Cost - Price in US$ (1 t Oil = 1100 liters):

- Methytl Ester Process: US$ = 85,00/t
- EthylEster Process US$ =110,00/t

Production cost per liter (values in US$ / l) for biodiesel produced from :

- methyl process:
  palm oil, 0.30; soy oil, 0.28; castor oil, 0.62
- ethyl process:
  palm oil 0.33; soy oil, 0.31; castor oil, 0.65

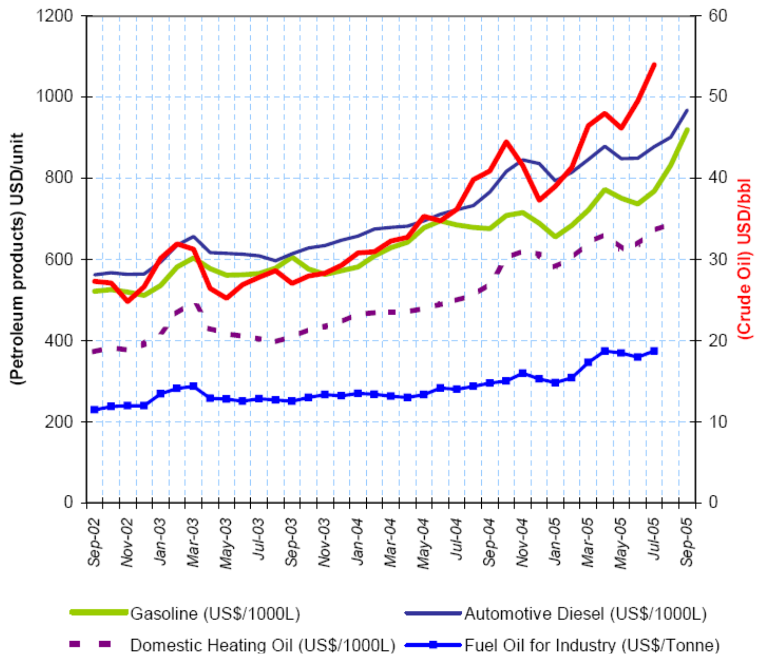
Note: crude oil cost in US$/ t is 250 for palm, 228 for soy and 600 for castor plant.

Opportunity costs in US$/ l are:

- methy process:
  palm oil, 0.46; soy oil, 0.49; castor oil, 0.99
- ethyl process:
  palm oil, 0.48; soy oil, 0.51; castor oil,1.01

Note: oportunity cost of crude oil in US$/ t is 420 for palm, 450 for soy and 1,000 for castor plant.

Figure 24 – Selling Prices of Fuels in the International Market
(Source: International Energy Agency)



The selling prices of conventional diesel oil in the international market show the potential that biodiesel production has in that market, in the short term, mainly if this product has a standardized regulation for the commodities market, indicating lower risks to entrepreneurs.

Diesel oil price in developed countries oscillates between US$ 0.12/liter – USA to US$ 0.47 – Germany/UK, which confirms that even with present oil prices, from the economic point of view, this product is not competitive in these markets. (Figure 24)

In the Brazilian market it is necessary, according to legislation rules, to include the following taxes: PIS + COFINS = R$ 0.222/ litro = US$ 0.09.

Legislation permits for the North and Northeastern Region the following rebates:

- Small Producer – 100% reduction of PIS – COFINS, results in zero taxation
- Medium Producer – 68% reduction of PIS – COFINS results in R$ 0.07 or US$ 0.03 per liter
- Big Producer – 32% reduction of PIS – COFINS results in R$ 0.15 or US$ 0.07 per liter

To the obtained value it is necessary to add 25% of ICMS, in average, minimum value charged for transactions between states (maximum, 30%).

Estimated Cost of Biodiesel for Retailer, Per Region and Type of Producer
Opportunity Cost ,Methylic Route (R$ / liter)

Table 31 – Case 1 Castor Oil

Farmer Origin	North/Northeast	Other -Brazil
Family Agricultur	0,99	-
Medium Farmer	1,02	-
Plantations	1,08	1,21

Table 32 – Case 2 Soybean Oil

Farmer Origin	North /Northeast	Other -Brazil
Family Agricultur	-	0,58
Medium Farmer	-	0,58
Plantations	-	0,58

Table 33 – Case 3 Palm Oil

Farmer Origin	North /Northeast	Other -Brazil
Family Agricultur	0,46	-
Medium Farmer	0,49	-
Plantations	0,53	-

Source: GilTech consultants (unpublished)

The calculated values show with no doubt that, a competitive castor oil is in difficulty in the Brazilian market, apart from what is defined by the social quota B2 and B5 of the Government Program.

The cost of castor oil biodiesel is more than double that of palm oil and soybean oil. It is also clear that, the utilization of the ethyl route, considering the present stage of technological development, reduce competitive industrial biodiesel producer.

Therefore, it can be said that, the maximum potential for the castor oil plantation, in the Northeastern Region, is of 540,000 hectares in projects with social labeling, conditioned to reach the projected productivity. That area is the one necessary for the production of 5% biodiesel demanded by that Region itself. The production cost of castor oil biodiesel is so high that it can not be competitive with soybean, even under the present legislation, with soybean paying for all tributes and social costs.

The calculated values, again, reinforce the potential of biodiesel production from palm oil.

The production integration under the technical and economical standpoint is suitable for big producers of soybean and alcohol, but does not enlarge the condition nor bring any gain of energy efficiency or industrial costs reduction.

The ideal is the production of biodiesel to be concentrated nearby the bases of fuel distribution, with infra-structure available to supply ethanol or methanol just-in-time and to store the biodiesel produced.

5.2.8 Overview and analysis of existing policy instruments

The Program of Production and Use of Biodiesel was launched in October 2002, promoting investments in technological research for the ethyl route in Brazil.

Aiming at to contribute and to enlarge competitive biodiesel against petroleum biodiesel a policy of differentiated incentives was established directed to the North, Northeast and Center-West Regions, especially connected to the social inclusion guaranteed for the vegetable oil production from small rural producer. In addition, the state governments through their regional programs are promoting incentive conditions to production and use of biodiesel by means of tax reductions and financing possibilities through regional funds. This represents comparative advantages to consumption and export of biodiesel from these regions in comparison with the South and Southeast Regions.

The Federal Government, by means of *Medida Provisória* 214/04 delegated competence to ANP, the National Petroleum Agency, to regulate the production chain and use of biodiesel. The implementation of a legal market will be followed-up by the National Council for Energy Policy - CNPE with the aim of insuring the insertion of biodiesel in the transport fuel matrix of the country and to promote export market development of liquid biofuels. A first step of establishing the legal market is the introduction of biodiesel mixture to the conventional diesel up to 2%.

Therefore, the tributary model is regulated by that *Medida Provisória* which establishes mechanisms to promote social inclusion by the production of social biodiesel from family agriculture, according to the rules of PRONAF – the National Program for Family Agriculture. The tributary rules of the Biodiesel Program with reference to social taxes PIS and COFINS determine that they should be charged only once and that the contributor is the industrial producer of biodiesel. The government also established differentiated tax percentages for the states of the North and Northeast and by vegetal oil type. For intensive agriculture the reduction of fiscal charges is partial. Tax reduction is of 67% for all producers who do not have differentiated benefit; 77.5% for the biodiesel produced in the North, Northeast and Semi-Arid Regions using castor oil or palm oil as raw material; 89.6% for family agriculture and 100% reduction for biodiesel produced from castor oil or palm oil, supplied by family rural workers of the North, Northeast and of Semi-Arid Regions.

The ANP Resolutions in turn regulate the activity of biodiesel producer , the rules of commercialization and the biodiesel technical specification, based on the North-American and European specifications and considering the peculiarities of the different vegetable oils produced in different regions of the country.

The financing for biodiesel projects can be obtained from credit lines of BNDES – National Bank for the Economical and Social Development, which launched in 03 of December, 2004 a Program of Financial Support to Biodiesel Investments. It is possible to finance all phases of biodiesel production up to 90% of projects with the Social Seal and to 80% for the other ones.

Considering the legal market perspective for biodiesel, according to the established in MP 214/04, in the first phase of the Program, a 2% displacement of petroleum diesel means that the national production of biodiesel should be about 800 millions of liters, for the period 2005/06. As the internal production of diesel is to the order of 34.5 billion liters per year, to complement the supply with net importation of diesel of 3.7 billion liters per year – 10% of the consumption – will result in a total apparent consumption of diesel of 38.2 billion liters per year, giving a forecast consumption of 40 billion liters in 2005.

Gains in the Brazilian foreign currency with the prospective reduction of oil and oil product imports, including diesel, represents about US$ 160 Millions per year by displacing 2% of petroleum diesel by biodiesel and US$ 400 Million by displacing 5%.

The Ministry of Agricultural Development has a policy of promoting family agriculture for the production of biodiesel with a fund of R$ 100 Million for 2004/05 by means of PRONAF. Those are subsidized lines with especial interest rates, which put family agriculture in position of competitive advantage in the North in relation to the South. That kind of incentive is mobilizing state programs for biodiesel production; as is for instance the one of Rio Grande do Sul, which involves more than 20 municipalities in cooperative production.

Regulatory Marks Schedule

Law 11.097 / 2005: establishes a minimum percent for blending biodiesel with diesel, and the monitoring follow-up of the new Biofuel in the Brazilian internal market

Table 34 – Regulatory marks

2005 to 2007	2008 to 2012	2013 later	2020
2% Authoritative	2% Obligatory 5% Authoritative	5% Obligatory	20%
Potential Market	Firm Market	Firm Market	
800 M litre/year	1 Bi litre/year	2,4 Bi litre/year	

Source: MME

6 Production potential of biodiesel

Large-scale production of soybean biodiesel is not recommended from the point of view of energy balance. The only soybean agro-business sub-product that can be used as fuel is the vegetable oil. There are no detailed studies in Brazil about this subject, but the considerations below, about soybean for USA conditions, can be used as an estimate for the Brazilian conditions. The real conversion rate is 1.4 to 1, which is very low for a program of biofuels production. [4]

However, due to its importance, level of organization and processing installed capacity, the soybean biodiesel can be important in a large program. The soybean agro-business could be used as a structural chain for the whole Brazilian biodiesel program. That question should, however, be better studied as soybean production has been growing fast in Brazil and occupies its space in the world market due to the increase of demand for protein meals, which in fact is the true vocation of that plantation. The present Brazilian vegetable oil matrix concentrated on soybean does not make any sense, when potential production of the various types of vegetable oils is evaluated. The need to increase the production of other species from which vegetable oils are produced is real, including from the point of view of food security.

A program of biofuels should also be thought of as an inductor of changes in the matrix, as the energy balance shows a total inaptitude of soybean to produce biofuels. The fact that soybean the sole organized chain does not justify their utilization in the implantation of a program whose legislation has strong social scope.

Table 35

Potential for a B2 Situation						
Region	Diesel Consumption (billion l)	Vegetable Oil – B2 (million l)		Area for oil production – B2 (1,000 ha)		
		Veg. Oil	Alcohol	Sugarcane	Oleaginous	
South	7,200	144	14	2.5	240	Soya
South East	15,840	317	32	5.9	528	Soya
North East	5,400	108	11	2.8	216	Castor plant
North	3,240	65	6	1.6	14	Palm plant
Central-West	4,32	66	9	1.5	144	Soya
	36,000	720	72	14	1,142	
Source: EMBRAPA				*Total: 1.3 million ha*		

Table 36

Potential for a B5 Situation						
Region	Diesel Consumption (billion l)	Vegetable Oil – B5 (million l)		Area for oil production – B5 (1,000 ha)		
		Veg. Oil	Alcohol	Sugarcane	Oleaginous	
South	7,200	360	36	6.1	600	Soya
South East	15,840	792	79.2	14.8	1,320	Soya
North East	5,400	270	27	7.0	540	Castor plant
North	3,240	162	16.2	4.0	36	Palm plant
Central-West	4,32	216	21.6	3.7	360	Soya
	36,000	1,800	180	35.7	2,856	
Source: EMBRAPA				*Total: 2.9 million ha*		

Table 37

Potential for a B100 Situation						
Region	Diesel Consumption (billion l)	Vegetable Oil – B100 (million l)		Area for oil production – B100 (1,000 ha)		
		Veg. Oil	Alcohol	Sugarcane	Oleaginous	
South	7,200	7,200	720	122.9	12,000	Soya
South East	15,840	15,840	1,584	296.4	26,400	Soya
North East	5,400	5,400	540	139.8	12,000	Castor plant
North	3,240	3,240	324	79.5	720	Palm plant
Central-West	4,32	4,32	432	75.0	7,200	Soya
	36,000	36,000	3,600	*713.6*	12,000	
Source: EMBRAPA				*Total: 7.3 million ha*		

Despite Brazilian biodiesel presently having no possibility of entering in the European market, it has an enormous potential in the internal market and for exportation to countries that have no appropriate lands for growing oleaginous plants or their own sources of fossil fuels, as in the case of Japan.

The most important market now is the use as additive (it increases the lubricity) of diesel oil with low sulfur content as requested by the new environmental rules to take effect in the first world, they also substitute petroleum in petrochemical production, an advantage that other alternative sources do not do. From this viewpoint the biofuel market is limitless and it does not depend on additional environmental protection programs.

Soybiodiesel — Potential for blended or pure biofuels

Besides the fact that the energy balance of soybean seems to have a rather low value (1:1.44), considering the potential of other oil crops, the soy oil has strong restrictions by the auto industry due to some specific physical chemistry properties like the high iodine index and the low oxidation stability, by reducing the motor performance and damaging some engine parts.

Soy Biodiesel Limitations:

- Main limitations for usage: low stability to oxidation
- Effect: Injection System Corrosion; Formation of soaps
- Alternatives: Use of additives; Use of Blends
- Restrictions: The use in applications with stops (stand-by generators, harvesting machines, industrial machines, etc) is not recommended)
- Limitations for Diesel Motorization: Aging of parts and pieces
- Effect: Corrosion of metallic parts; Corrosion of FIE
- Corrosive acids (formic and acetic)
- Acids with greater organic molecules (similar to fatty acids)
- Polymerization of products
- Deposits and precipitation, especially of fuel mixtures
- Clogging / wearing of injection nozzles
- Film formation by soluble polymers in hot areas
- Potential problem of lubrication

Castor biodiesel — Potentials for blended or pure biofuels

To substitute 1% of diesel oil with biodiesel from castor oil (320,000 tons), an aditional harvesting of 427,000 hectares (1) will be necessary. The only relevant by-product will be the meal resulting from seed crushing.

Through the harvesting of castor plants, 20 tons of biomass per hectare are produced. This biomass is incorporated directly to the soil as fertilizer.

The additional crushing will result in 333,000 tons of cake.

Castor cake is toxic and cannot be used in livestock or human feeding, the cake can be used as fertilizer and additional production does not have any market impact.

There is indication that the energy balance of castoroil may have a low value (1:1,3 considering a productivity of 1500kg seeds /ha).

Castor seed has an average productivity of 700 kg/ha in Brazil. Considering this productivity, the energy balance might be negative. Therefore, new agricultural production systems need to be developed to substitute successfully fossil fuel with biodiesel from castor oil.

Problems Related to Castor Plant Biodiesel:

- Oleaginous – CASTOR PLANT
- Limitation: Viscosity - 11 mm^2/s
- Effect: Excess of pressure (break of the injection equipment)
- Alternatives: Maximum use of B20; use of mixture of biofuels and adequacy of the equipment for use.
- Restrictions: Breaking danger of any injection equipment if viscosity exceeds the one of the diesel.

Nowadays, the installed production capacity of seed crushing only allows the supply of the domestic market for conventional use. There are no inactive crushing facilities of castor plant. There are no productive industries of castor plant oil in the semi-arid Northeast. What we can infer is that it is necessary to include an esterification project in each industry, as well as facilities with equivalent capacity for seed crushing. The existing crushing companies are situated away from the production areas of seeds. Therefore, there is a situation of economical unsustainability and of unbalance, due to the high power consumption, especially in transports.

Palm Biodiesel — Potentials for biofuels in blending or pure

The energy balance of oilpalm has a very hight value (1:9,6 - best case to 1; 5,6 - poor case related), and is the crop with the best potential for biodiesel production in Brazil.

The relevant by-products considering an additional harvest to displace 1% of diesel oil in Brazil, it will be necessary to plant an additional 80,000 hectares. The biomass by - products produced will be utilized as fertilizer and for energy production. The most relevant are:

Table 38 – Relevant palm oil by products

Description	Quantity	Application
Palm Kernel Oil	40,000 t	Edible/Premium Biodiesel
Mesocarp Fiber	1,200,000 t	Energy Generation
Palm Kernel Shell	500,000 t	Energy Generation
Palm Kernel Meal	60,000 t	Fertilizer/Livestock feed
Empty Bunches	2,200,000 t	Fertilizer/ Energy Generation
POME – Mill Effluent	1,100,000 m³	Fertilizer

Table 39 – Energy production Capacity with by-products of Palm Oil Process

Steam Turbine Type	Biomass Feed	Produced Electricity (KWe)	Surplus (Kwe)
Monostage 3kgf/cm² backpressure	65%F+C	1,000	200
Multistage 3kgf/cm² backpressure	100%F+C	1,930	1,138
Multistage Condensate Extration	100%F+C+CV	5,615	4,823

F= Fiber C = Shell CV= Empty Bunches

Source: Veiga et all

Using the biomass obtained by a 1000 ha plantation in a simple multistage steam turbine is possible to produce 204 kWh per 3750 h/year, equivalent as 156 days.

Palm Oil production for B1 has a potential to produce continuously 16MWh of Electric Energy during 5 months at year.

In spite of the fact that Brazil is nowadays known as the world leader in liquid biofuels production and consumption, the Nobel Prize Winner in Chemistry, Allan McDiarmid, speech in Brasília, during the 3ª National Conference on Science Technology and Innovation, sponsored by the Ministry of Science and Technology, in November 2005, about the present relevance in the production and distribution of renewable energies. He said, “The future of the world depends on renewable energies. Clean energy production results in water economy to the plantations, and with more water in plantations we can minimize the social and economic differences and violence”.

The new reality is that Brazil must maintain the competitiveness in the domestic, local market, expanding the Proálcool know-how to produce liquid biofuels and to warrant this competitiveness to the global market for the vegetables oils and biodiesel, in a sustainable perspective of quality and economic conditions.

7 Main actors

7.1 Governmental institutions

Before launching the Biodiesel program this year, a lot of federal ministries and agencies already had been involved in planning and preparing this program. It was created an Interministerial Executive Commission (CIBE) in which are represented 12 federal ministries and which is headed by a secretary of the Presidency. This commission is responsible for elaborating, implementing and monitoring the program and proposing legislative acts.

Due to the structure of the program, the federal Ministries of Agriculture (MAPA), Rural Development (MDA), Energy (MME) and Science (MCT) are the most important ministries integrating this commission. As there are still some important technological problems that need to be solved, the MCT has to finance, to stimulate and to coordinate national research work. The MDA has the important role to give o the companies, which are producing biodiesel with raw material planted by small family farmers, a social seal so that they can profit from tax reduction. The federal ministry of agriculture (MAPA) shall organize the agricultural and industrial production chain and the commercialization of the biodiesel. It is representing important vegetable oil producers, which claim that tax reductions are granted only to small farmers.

The Ministry of Energy (MME) is in charge of introducing biodiesel into the national energy matrix. For this means the National Council for Energy Policy (CNPE), linked to the MME, can change the time schedule of the different volumes of biodiesel added to fossil diesel. ANP is the other federal agency subordinated to the MME that is responsible for the regulation of the biodiesel market, as biodiesel producers have to submit their plants to an authorization process executed by ANP. This agency also established the technical specifications that have to be met by the biodiesel and realized the virtual auction of biodiesel with a social seal in November.

There are two state enterprises that play an important role, when considering the strong social appeal of the biodiesel program. The one is the national development bank BNDES that has a special credit line for financing biodiesel projects at different levels, on agricultural level as well as on storage level. The other is the federal oil company Petrobrás that still has a monopoly in the refining market (>98% market share), so that refineries owned by Petrobrás had to buy the Biodiesel that was sold by auction in November. The company therefore has the crucial role to overcome some obstacles when introducing biodiesel with a social seal into national fuel market.

7.2 Private sector

There are twenty private enterprises that are producing biodiesel or plan to start production within the next year. However ten of these already received the social seal by the MDA, but only five have been authorized by ANP to produce biodiesel. Soyminas and Agropalma were the first in April this year to become authorized by ANP. Soyminas produces biodiesel from sunflowers, soy and fodder radish in Minas Gerais and is owned by the group Biobras that also holds a unit (Renobras) in Mato Grosso and plans to construct further plants in these two states. Production capacities of each of these units don't exceed 30 Mill. L/year. Agropalma is producing biodiesel (production capacity: 25 Mill. l/year) from sludge of palm oil refining in Belém, in the state of Pará. The company Brasil Biodiesel produces biodiesel in the Northeastern state of Piauí. Its plant has a capacity of 25 Mill. L/year and because it's the only plant that will use mainly castor oil from small farmers it has received much attention during the last time.

However as the plants of these companies don't exceed 50 Mill. L/year, it is difficult to name some main actors so far. There are several plants under construction with production capacity of more than 100 Mill. L/year up to 300 Mill. L/year. Most of these plants are located in the state of São Paulo but it remains unclear when they will start operation.

There are also some pressure groups; some of them founded recently like Abiodiesel, which try to unite biodiesel producers. As there are only few producers right now, it remains unclear whom they are representing. Until now, traditional associations of the vegetable oil sectors seem to be of more importance, as there are Abiove (Brazilian Association of Vegetable Oil Industry), who is representing the big soy oil producers like ADM, Bunge and Cargill.

PART 3

POTENTIALS IN RELATION TO SUSTAINABILITY TARGETS

1 Food security and energy provision

1.1 Competition/synergies between specific food and energy crops bottlenecks/restrictions for energy crops/area

Brazil still presents a very low utilization rate of lands. Agriculture today uses only 7% of the Brazilian surface (sugarcane 0.6%): most of the territory is occupied by pasture (35%) and forest (55%). Total available areas can also be evaluated or exemplified by a close look into Table 40, which shows a comparison of land use and vegetal oils production in selected countries. Published studies show that the recent agricultural expansion has occurred mainly by the conversion of existing inactive pastures, as a function of productivity gains of the cattle sector rather than by actual exploitation of new lands. Brazil still has many pasture areas to recycle in this way. Therefore, there are available areas in sufficient quantities for all sort of agriculture, with no need for competition.

Table 40 – Vegetable Oil Production& and Land Use – Selected Countries

Country	Área km^2 x 1,000	Population Million	Short Cycle Crops %	Permanent Crops %	Vegetable Oil Production t X 1000
Brazil	8,500	186	6.96	0.9	7,401
USA	9,170	295	19.13	0.22	15,514
Germany	350	82.5	33.9	0.59	3,800
Malaysia	329	23.9	5.5	18.0	17,123

Source (Indexmundi.com/oilworld)

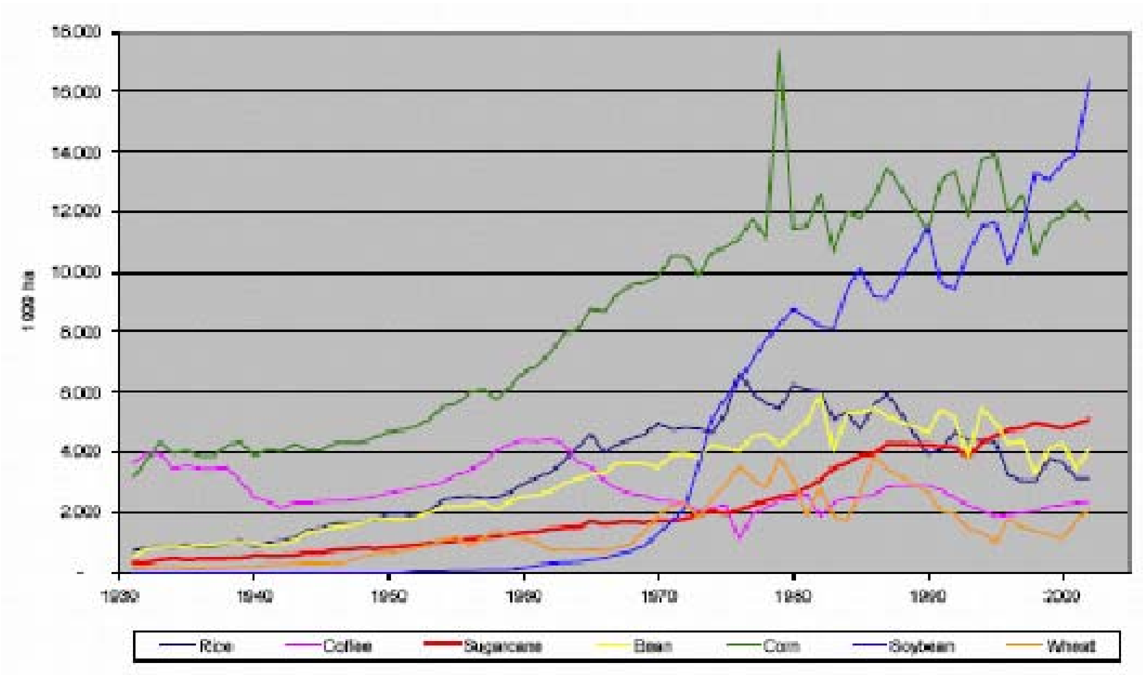
Sugarcane Case

When discussing food security and energy provision, the first point to be understood by all interested parties should be that land area to be used for biofuels must not be based on deforestation or competition with food production. For such understanding to materialize it is necessary to look continuously for efficiency improvements in all aspects of the agricultural, industrial and commercialization phases.

The evolution of sugarcane and of ethanol production in Brazil, as it was indicated in Part 1 of this Report, shows considerable increase in productivity. In the agricultural phase alone, the productivity increased 33% in the period 1975-2000. Average productivity of sugarcane in the country was around 65 t/ha, by 1998, but as high as 100-110 t/ha in the State of São Paulo (60% of Brazilian production). This allowed the growth of sugarcane production without excessive land-use expansion. [11]

During every harvesting season, 20% of the sugarcane crop is cut and replaced with other crops such as beans, corn and peanuts, etc. Food crops are not being affected by sugarcane growth (Figure 25). Sugarcane plantations have, in the last 25 years, preferentially expanded in areas in the Central-South, previously used for cattle and away from ecologically sensitive areas. New agriculture frontiers were very little involved in such expansion. [10, 11]

Figure 25 - Harvested area of different cultures along the years, in Brazil (Source: IBGE)

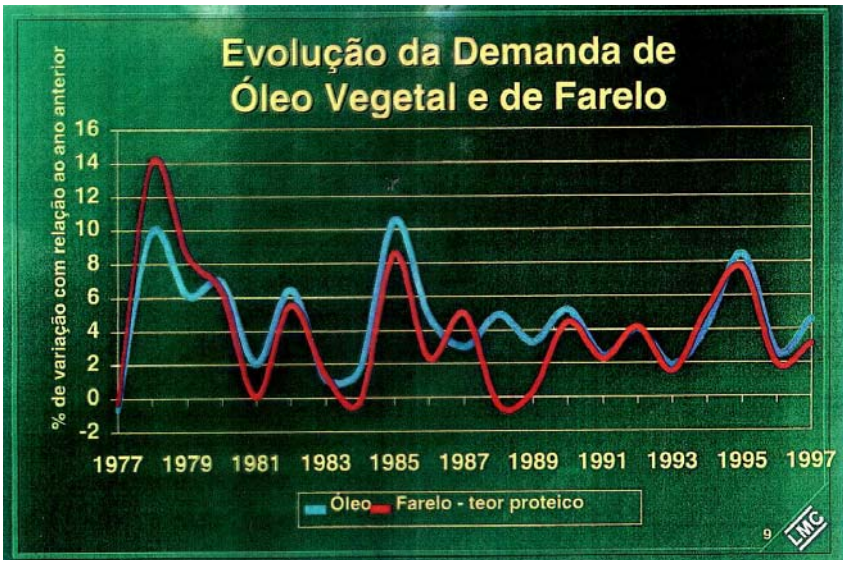


Vegetable Oil Case

Vegetal oil crops for use as biofuels are only possible when there is a market for all sub-products obtained in their chain. In this case, grain plantations that produce protein meals for use as large-scale human and animal food, as is the case of soybeans and sunflowers, deserve special attention.

It is possible to infer from Figure 26, obtained from data published by *Oilworld* that the market for vegetable oils and protein meal have a similar rate of increase. This shows a tremendous potential for the excess production of meal to lead to a market rupture, as a result of a plantation program for those grains to attend the biodiesel market, because the market reacts negatively to any stock increase with low prices.

Figure 26 – Evolution of Oil & Meal Demand



The main vegetable oil plants with use as food, suffer strong pressure for expansion of production, as a function of the increase of the world food market and, therefore, it would need additional efforts to direct new producers to the energy market.

From the point of view of food security, lands should not be used for plantations of food grains in a biodiesel program, because such crops have very low energy balance and need primary inputs that have better application in food production.

Under the Brazilian legislation, there is no restriction as to location of areas to extend the agricultural frontier. Legal restrictions there only exist for the areas per se.

In Amazonia there is no legislation covering the antropized areas, so they have the same legal restrictions than native forest areas. This does not obstruct production, but limits the land use for planting to 20% of the property area.

Cerrado is an ecologically sensitive region having an extremely high biodiversity, which may suffer negative impacts both due to the soybean production rate and methods employed in its expansion.The impact on the gallery forests of the Cerrado, which is the habitat of half of the Brazilian endemic species and of a quarter of the threatened species, is among the most harmful ones. The expansion of the agricultural production in these areas of ecologically complex ecosystems may result in irreversible damages.

The main bottlenecks are the lack of rules for land use and challenger of the low educational level of the Brazilian rural producer in that area.

With the lack of agricultural zoning of the areas available for production, expanding the agricultural border and the antropized areas of the Amazonian States, implied in the legal prohibition of contracting agricultural insurance, cropping in expansion areas becomes a high risk activity, because the whole financial loss in case of failure falls to the farmer. Usually the small rural producer has as warranty just a minimum purchase price to the limit of the production cost.

For expanding of oil palm culture there are other bottlenecks such as:

- Lack of researches throughout chain
- Lack of qualified researchers
- Lack of qualified workers
- Production of selected seeds

2 Environmental Aspects

2.1 Energy and Carbon Balances

Ethanol

One ton of sugar cane is equivalent to 1.2 barrel of petroleum. That is, 5 million hectares of plantation can produce the equivalent to 300 million barrels of petroleum, or 820 thousand barrels equivalent per day. Brazil needs 1.7 million barrels of oil per day. Today, ethanol production corresponds to 15.4% of the Brazilian vehicular fuel matrix.

The net energy balance in the ethanol production, including the agricultural and industrial phases, shows a positive relation of 9.2 to 1, between the energy available in the produced fuel and the consumed energy in the production phase. Considering the conditions of the technological optimization of the production process there is an evident growth to 10.2 in the energy balance (Table 41). Efficient industrial processes and a current yield of up to 85 tonnes per hectare result in an amount of more than 7,000 litres of ethanol per hectare (US corn to ethanol: 4,000 l per ha).

Table 41 — Ethanol – Energy Balance

SUGARCANE BIOENERGY

Ethanol Production - Energetic Balance

Process	Energy Flux - MJ/t sugarcane	
	Medium	Best Value
Sugarcane Production	202	192
Agricultural Operation	38	38
Sugarcane Transportation	43	36
Fertilizers	66	63
Limestone / herbicides	19	19
Seedlings	6	6
Equipments	29	29
Ethanol Production	49	40
Electricity	0	0
Chemical Inputs/ Lubricants	6	6
Buildings	12	9
Equipments	31	24
Total Energetic Consumption	251	232
Energetic Production	2,089	2,367
Ethanol	1,921	2,051
Exceeding Bagasse	169	316
Net Energetic Balance	8.3	10.2

Source: Macedo, 2002

Comparing to the ethanol produced in the USA from corn as raw material, which relation is 1.3 only, ethanol from sugarcane produced in Brazil is highly superior from the point of view of the relation of renewable energy obtained and fossil energy expend.

The life cycle analysis of ethanol production demonstrates a net contribution on the CO_2 uptake of 46.6 million tons equivalent per year, or 12,75 million tons of carbon per year, meaning around 20% of the total fossil fuel emissions in Brazil. The avoided emissions of greenhouse gas due to the replacement of gasoline by anhydrous ethanol are 2.7 kg of CO_2/litre.

Biodiesel

Energy consumed in all phases of fuel production, added to the raw materials and equipments necessary for the production of the fuel in question, should be less than the energy made available by the fuel produced.

Several evaluations of the energy balance of biodiesel have been made for soybean and rapeseed as raw materials under European and American conditions, always resulting ratios for production/consumption of between 2 to 3. For Brazilian conditions, there are studies indicating this ratio as 1.42 for soybean. For palm oil and “macaúba”, the ratio would be 5.63 and 4.20, respectively. Those values confirm the excellent potential for palm trees as raw materials for biodiesel production. More studies are, however, necessary for the various species in Brazil.

2.2 Impact on biodiversity, water, soil, forestry and nature conservation

For decades, especially in the beginning of expansion of sugarcane plantations and the sugar and alcohol industry, several environmental impacts were identified. The main problems were: (i) pollution of the water resources; (ii) destruction of the gallery forest with negative impacts on the aquatic and terrestrial biodiversity and (iii) great emission of particulates, in the form of charcoal, due to sugarcane harvest burning practices.

Recently, with improvements in legislation and environmental enforcement, those problems were minimized thanks to the significant expertise developed in terms of: (i) controlled vinasse ferti-irrigation practice, reducing the needs for potassium fertilizers; (ii) filter cake totally used in soils (reducing 50% of phosphorous mineral fertilization needs); (iii) reduction of pesticides via biocontrol; (iv) control of ethanol plant industrial emissions; (v) adequate zoning and severe land control, being mandatory to preserve riparian forests and other natural ecosystems. [7, 10]

Biodiversity – Brazil has the largest biologic diversity in the World (Amazon Forest, Atlantic Forest, *Caatinga* and the *Cerrado*), with an estimated flora of 50 to 60,000 angiosperm species. Priorities of biodiversity were defined mainly between 1995 and 2000 and established within the National System of Units of Conservation.

From the original area covered by the different ecosystems in Brazil, variable proportions remain, not always known due to the lack of precision of existing estimates (see Table 42).

For socioeconomic development to cope with environmental preservation is not a simple task. More and more the development and implementation of strategies well suited to sustainable development will be based on the management of knowledge, including recent advances in technology of information and communication, including an intensive and high-tech monitoring by satellite, for example of the Amazon region.

Table 42 – Brazilian Ecosystems: original area, present cover units of conservation
Source: IBGE

Ecosystem	Original (% of country)	Remaining Cover (% of original)	Protected Areas (% of original)
Amazon	49.29	85	4.83
Cerrado	23.92	20	1.71
Atlantic Florest	13.04	7	0.72
Caatinga	9.92	32	0.69
South Fields	2.02	1.98	0.27
Pantanal	1.76	7	0.57

The expansion of agriculture in the last 40 years has occurred mostly in degraded areas of pasture and “dirty fields”, and not in areas of forest. The expansion of sugarcane plantations into areas of *Cerrados* was relatively small; expansion in the last 25 years has essentially been in the Center-South, far away from the Amazon, Atlantic Forest an Pantanal.

For the next years, the increase of sugarcane plantations should occur with the replacement of other cultures and pastures or recycling degradated areas. [7]

Water – Brazil has the highest availability of water in the world, with 14% of the surface water. However, agricultural irrigation is very small in the country, approximately 3.3 Mha, against 227 Mha in the world, due to the high cost of the investment involved.

Sugarcane, practically, is not irrigated in Brazil, except for small areas, where supplemental irrigation is necessary. Efficient methods such as sub-superficial droppings and others, are under evaluation.

The levels of intake and effluent of water for industrial use have been substantially reduced in recent years. From an intake of about 5 m³/t of cane (in 1990 and 1997) a new level of 1.83 m³ was reached in 2004, according to a sample survey made in São Paulo. The level of re-use is high – the total use was 21 m³/t of cane, in 1997, and treatment efficiency of the effluent was above 98%. It seeams to be possible to reach values close to 1 m³/t of cane (intake) and zero effluent with optimization in the re-use and use of residual water in ferti-irrigation.

Even then, the technology for cleaning the raw cane was substituted for dry cleaning, without liquid effluents, reducing the water demand and minimizing the loss of sugar in this process.

In general, environmental problems with water quality due to irrigation, such as nutrients and defensives inflow and erosion, and due to industrial use are not found (this is particularly true for the State of São Paulo, responsible for 60% of the Brazilian production). From this aspect, EMBRAPA classifies sugarcane in level 1, with no impact on water quality.

The areas of permanent preservation (APP), related to the gallery forests, cover 8.1% of sugarcane planted area in the State of São Paulo (3.4% with native forest and 0.8% were re-forested). There is in progress a project in São Paulo, with support of GEF (World Bank), which has the aim of recovering the gallery forests, protecting rivers and water flows and in the long term promoting the recovery of the vegetal biodiversity.

Although the sugarcane industry was seen as pollutant to water resources there are today technological advances, permitting considerable water savings and treatment of liquid effluents. An example is what has been done in Costa Pinto Mill, in Piracicaba-SP, which implemented a system of water de-pollution by using natural techniques of *constructed wetlands.* The final effluent goes through filtering soil cultivated with rice plants, reaching excellent levels of water quality. [14]

Soil – Sugarcane crop has expanded to more degraded or poor areas, mainly ex-extensive pastures. It contributes to soil recovery, adding organic matter chemical-organic fertilization, contributing to improve its physic-chemical conditioning and incorporating soils to the Brazilian agricultural area, improving the green areas near the cities. This is because there is no restriction for sugarcane production related to climate and soil quality, in the Southeast and Centerwest region, which expands the perspective that sugarcane is a good alternative to recuperate old pastures and degraded areas.

Sugarcane in Brazil is recognized today for having relatively small soil loss by erosion (as compared to soybean culture, for instance). This situation is even improving with the progressive increase of the harvest without straw burning and with techniques of reduced soil preparation, leading to very low values or losses, comparable to those obtained with direct plantation in annual crops.

Palm oil has similar characteristics, and is recognized as a permanent culture, 20 years, that result in small loss from erosion. It includes the opportunity to cultivate food at same time (for example tropical bean).

The combination of different vegetal oil plants in the same area of cultivation, increased by the possibility of rotation, aggregates the value of nutrients, contributing to soil recover, adding organic matter and chemical-organic fertilization, contributing to improve its physical-chemical conditioning.

3 Socioeconomic and Macroeconomic Aspects

3.1 Employment Effects

Social impacts are the main concerns when studying biofuel crops in developing countries like Brazil, which have high inequality in social and economic aspects. They are even subjects for tough discussions as they may affect the stability of highly subsidized and less efficient agricultural sectors in the developed world, which in a way live a long-term unsustainable situation.

The unemployment rate in Brazil has remained steady during recent years, between 9 and 10%. The main problems are the quality of jobs and the need for reduction of the social inequities. The increase in income did not bring reduction in the social inequities. Rural people working with sugarcane crops have higher wages than the ones working with crops of coffee, corn and citrus, but less than soybean, which in turn is highly mechanized, with more specialized jobs.

The economical and social benefits of sugar cane agro-industry in Brazil are strongly influenced by the decentralized generation of direct jobs, reaching 60,000 rural producers. Those small to medium producers supply around 17% of the Brazilian total production, in more than 960 municipalities. All rural employees have all rights determined by the Brazilian legislation. There is, however, a concern that the social benefits of the temporary workers are not often conceived as legally stablished by the federal legislation.

Salaries and benefits for the employees are 3.5 times more than the national minimum salary (now equivalent to US 83.62) in the crops – where the workers have a low level of skill and school education – and 5.3 times higher in the industrial businesses. Most of the agricultural producers, small and medium owners, are remunerated according to a parametric formula that takes into consideration the total sugar content of the raw material, the sugar and alcohol prices in the internal and external markets. The value paid for the sugar cane in Brazil means 60% of the industry profits. In the State of São Paulo, during the harvest of 2003/2004, the producer earned an average of US$ 10.35 per ton of sugar cane provided to the industrial facilities.

Employment generation in rural areas

- Palm oil: 0,2 jobs per ha
- Castor oil: 0.3 jobs per ha
- Soya: 0.07 jobs per ha

Table 43
Source: EMBRAPA

Area and Employment Generated to substitute 1% of diesel consumption in Brazil = 320,000 t, selected crops.			
	Soy oil (500kg/ha)	Castor oil (750 kg/ha)	Palm oil (4,000 kg/ha)
Area (ha x 1,000)	640	427	80
jobs	44,800	128,100	16,000

The job generation in biofuel production programs is variable according to the agriculture business studied and technology selected. The table below summarizes the impact on the agricultural jobs and profits by the planting of selected oleaginous plants; castor and oil palm were considered as family agriculture.

Table 44 – Agricultural Gains

CROP	Castorseed 1	Castorseed 2	Palm 1	Palm 2
Productivity t /hectare	1.1	1.1	25	20
Production Cost R$-ha	450.00	450.00	3,475.00	2,780.00
Total Income R$	555.50	632.50	3,950.00	3,160.00
Liquid Income /ha	105.50	182.50	475.00	380.00
Liquid Income for 10 ha - R$	1,055.00	1,825.00	4,750.00	3,800.00
Employment / 10ha	3	3	2	2
Rental /Employment / 10ha - R$	351.00	608.00	2,375.00	1,900.00

Castorseed 1 = Cost/productivity in PB, Income =Min. Guaranteed Price = R$ 30.30 per 60 kg
Castorseed 2 = Cost/Productivity in PB, Income =Market Price in July 2005 = R$ 34.50 per 60 kg
Castor seed area is united with Caupi beans seed where add. 500 kg/ha
Notes: Castor seed Price - July 2005
Castor Oil price (12 month average) = US$ 955.00 /t
Source - Agrianual 2005 / Embrapa

The table refers to the value obtained by selling the agricultural product as raw material for the oil industry.

The evaluation of job generation does not reflect the quality of jobs. The obtained data shows that, in conventional systems of familiar agriculture usually the jobs have very low profits. It is necessary that production efforts in small properties are accompanied by programs for workers qualification and illiteracy eradication, basic education, modern agricultural techniques, administration and social organization to make possible the formation of cooperatives which organize scale production.

Even for the cultures without vocation for programs of family agriculture it is necessary to introduce modern techniques of handling and mechanization, with reduction of the number of jobs but with quality earnings for the remaining jobs.

The Brazilian program of biodiesel production steps B2 and B5 do not have the potential to change in a substantial way the economic picture of the poor areas in the North and Northeast of Brazil. The total value added to regional GDP, does not change the social indicators.

The next table reinforces this evaluation of the Brazilian Social Policy, showing the comparison between value of B2 Brazil production -, GNP Brazil - GNP Northeast - GNP North - New Employments - Profits - Bolsa Família policy - Crude Oil Royalties.

Table 45 – Biodiesel Results x Social Public Policies
(Source: Kaltner, F.J., unpublished)

Social Program –Year 2004	Income in R$ Millions- Year 2004	GNP %
Bolsa Familia	**572,00**	**0,037**
Bolsa Escola	**1,430,00**	**0,094**
PETI –Children Workers erradication	**400,00**	**0,026**
Biodiesel Brazil B2	**750,00**	**0,050**
Royalties – Fossil Fuels –Brazil – Northeast	**617,00**	**0,041**
GDP	**1.514.924,00**	**100**

The sale value of biodiesel to substitute 100% diesel in Brazil represents 2.5% of GNP. The fact that net income in the castor oil agricultural cycle is below than US$ 2.00 per day causes concern: it shows that the social focus of poverty reduction aimed by the Brazilian program based on this oleaginous plant is difficult to reach.

The production of palm oil presents reasonable incomes to the producer, but it is advisable that small producers also participate in the earnings of the oil production step and not only as a simple raw material supplier to the main oil production players.

The Brazilian program of biodiesel has a strong focus on small farmers' production with special tax exemption in most cases. Castor and palm trees are the main crops identified with potential for family agricultural production.

However, it is necessary to do much more than seed distribution and minimum prices warranty. It is necessary to organize these producers through production cooperatives, to educate and qualify them for production and to supply credit compatible with the activity, etc. Partnership between MDA and Brazil Biodiesel is an attempt to reach this goal. A program of biodiesel production must necessarily be complementary to the national land use reform program, so that the lands destined to this program have a rational use.

The area for production of castor oil plant biodiesel is characterized by a high number of small properties. Several programs are already being developed in the Northeast region. These programs usually consist of free distribution of seeds and nothing contributes to the solution of the serious problems of low productivity and low level of the rural worker's qualification.

The best areas for the planting of Oil Palm in the Amazonian States are the INCRA settlements in which a program could be initiated. In the table below, we present a summary of data on existing establishments in 3 states of the Amazon with potential for cultivation.

Table 46 – Available Area in INCRA Settlements

State	Number of Settlements	Area ha x 1,000	Modules	Harvest Potential (modules x 10 ha)
Pará	15	105	2,628	26,280
Amazonas	9	1,109	10,800	108,000
Amapa	4	120	2,100	21,000
Total	**28**	**1,334**	**15,528**	**155,280**

Considering the current Embrapa capacity for seed production, to plant this land would take 10 years.

The areas around great cities of the Amazonian states, also offer good conditions for the implantation of palm oil farms. In the area contained inside within a 200 kilometer radius of the city of Belém, more than 2 million hectares of land with potential are available. This area, where 90% of the current Brazilian palm oil production is concentrated has a reasonable basic infrastructure: ports, highways, electric power, great number of small properties and the farm workers necessary for this culture.

Soy cultivation and other oleaginous grains need big areas and result in low job generation. It favors the land concentration, but does not present any advantage for socialization of its use.

3.2 Impact on Foreign Exchange Balance

The replacement of gasoline by ethanol represented an important economy of foreign currency for Brazil. The avoided imports between 1976 and 2004 represented savings of US$ 60.7 Billion (Dec 2004 US$). Considering the interest rate on the external debt, the economy was US$ 121.3 Billion. Just for comparison, the Brazilian foreign currency debt was US$ 49.4 Billion (Oct 2004) or simply US$ 24.2 Billion if the IMF loans were excluded.

The most important impact on external trade, by expanding the Brazilian biofuel production program is the growth of destilled fossi lfuel products for export. The success of PROALCOOL has transformed Petrobras into the largest export company, selling the surplus gasoline. On the other hand, Brazil has discovered new sources of fossil oil which will permit to produce exportable excedents with economical values higher than a biofuel program.

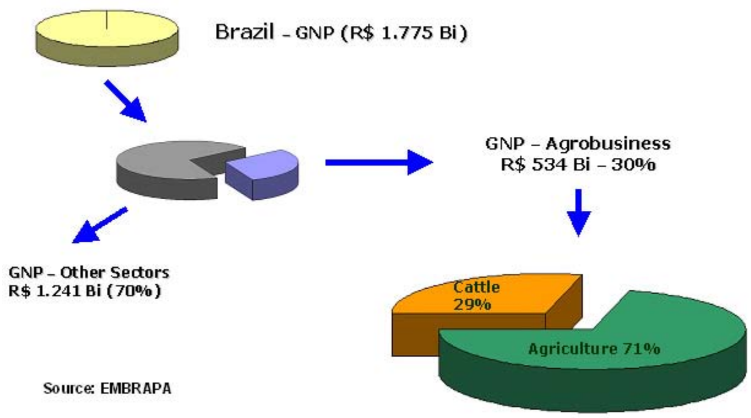
Evaluation of the potential market to sell biodiesel in Europe shows concerns that Europe may be self-sufficient in the production and therefore there will not be market for the product from other countries.

In EU+27 live 8% of the world population and there are available 8.5% of the world arable lands. The European program foresees for 2010, the production of 7.3 million tons of rapeseed oil in 5.2 million hectares of land. This corresponds to 4.5% of the appropriate area for available agriculture in EU. The potential of available lands made calculations for this new agribusiness is of the order of 12 million hectares, therefore the program has an enormous space to grow without vegetable oil import , is generating local jobs. The rhythm of implantation of the program is fast and the production increases 25% a year.

The technical specification for biodiesel adopted in Europe is another excludent factor for the Brazilian exportation, because the only oleaginous that atttend 100% the specification is the colza. Brazil does not have traditional production and considering the existent commercial varieties these oleaginous can be planted only in the Southern Region of Brazil.

Actually Agribusiness is the most important economic activity, acts about 40% of the Brazilian exports (US$ 40 billion), is responsible for 30% of GDP (R$ 534 billion) and for the generation of 37% of jobs (17.7 million).

Figure 27 – Agricultural % In GNP - Brazil



The balance of Brazilian trade practically double in the period 2000 - 2005 and the imports remained close to US$ 5 billion.

3.3 Most Favorable Technology Option in line with the sustainability Criteria

The final evaluation of biofuel competitiveness results from the analysis of the availability and cost of raw materials and inputs, logistics and infrastructure; technological solutions; land, sanity and climate characteristics; economic and social sustainability; national policies and capital (credit, financing and guarantes).

All of the agricultural cultures and production systems studied and selected for this document have sustainability as long as they are implanted in accordance with modern technical and economical criteria. In spite of some potential agricultural chains being more sustainable, biofuel production always needs to be evaluated in a regional context of production and consumption. The most sustainable biofuel is produced near to the consumption place, being considered as a premise for a positive energy balance and criterion for environmental and socio-economic sustainability.

The supply of biofuel production, especially biodiesel, to the transport market demands the execution of rigid technical specifications. The quality control has a very high cost for production in small mills.

Biodiesel production at this stage should be prioritized via methylic route as it is of mature technology and is less expensive, despite the fact that ethanol route is more environmental sound.

The use of crude oils, especially palm oil and native oils, should be motivated in Amazonia with the diffusion of diesel engine conversion kit technology.

From the sustainability aspect, biodiesel production should have a special focus, planting oil palm in antropized land around the great urban centers and or in the INCRA settlements in Amazonia.

3.4 Socio-Economic Aspects

The economical analysis indicates that the current program of biodiesel production in Brazil hardly will change in the medium term the macro economical situation and life quality in the North and Northeast areas of Brazil and that in a short time there will be no surplus production for export.

3.5 Cost-Effectiveness and/or profitability

According to the IEA World Energy Outlook 2005, the average IEA crude oil import price is now assumed to ease to around $35 per barrel in 2010 (in year-2004 dollars) as new crude oil production and refining capacity come on stream. It is then assumed to rise slowly to $37 in 2020 and $39 in 2030. In nominal terms, the price will reach $65 in 2030. Brazilian ethanol is considered competitive with gasoline for the oil price at US$ 25 / barrel onwards.

The biodiesel competitiveness must be evaluated considering the diesel price in the market and the opportunity costs in the alternative markets. The Brazilian biodiesel production plan implies on following factors concerned to the continental extension of the country, the differences and peculiarities of the infrastructure in the different regions:

- Inputs and raw-materials, like vegetable oil availability
- Production costs
- Production scale
- Social and economic, strategic advantages
- Externalities
- Logistics and facilities optimization

Considering the social program, biodiesel production is advantageous only for palm oil, but investment demands the previous solution of the problems presented. The production of castor oil plant biodiesel starting from projects with small producers presents a high risk due to: the present low productivity obtained, small income per hectare, the climatic risks because the culture presents great susceptibility to rain cycle change and the quality of the biodiesel and byproducts.

Biodiesel production starting from oleaginous grains of the alimentary chain should not be motivated because it presents problems under all of the aspects analyzed in this study.

PART 4

SYNTHESIS OF SYSTEM ANALISYS STUDIES/ENERGY SCENARIOS

1 Introduction

Primary energy demand presents a vertiginous growth to attend the needs of mankind for different end-uses – transportation, electricity generation, heating and all kinds of industrial transformation. The way this energy is being used certainly poses a big challenge, as to reach more efficiency and less environmental impact. Coal, oil and natural gas are the primary energy sources of the modern era.

The use of energy around the world is very uneven: on average a citizen in the United States consumes per year 35 times more electricity and 17 times more total energy than an Indian citizen. In the aggregate form, average per capita consumption in the OECD countries is almost 5 times higher than in the rest of the world.

One naïve solution to this problem is to propose an increase in energy consumption in the developing countries. This could be done to some extent but would not be viable in the long term. If all the population of the world were to reach the level of consumption of OECD countries, global consumption would increase threefold.

The consequence of that is that fossil fuel reserves, which are limited, would be consumed very rapidly. In addition, pollution at the local, regional and global level would increase rapidly and jeopardize the conditions of the environment we live in.

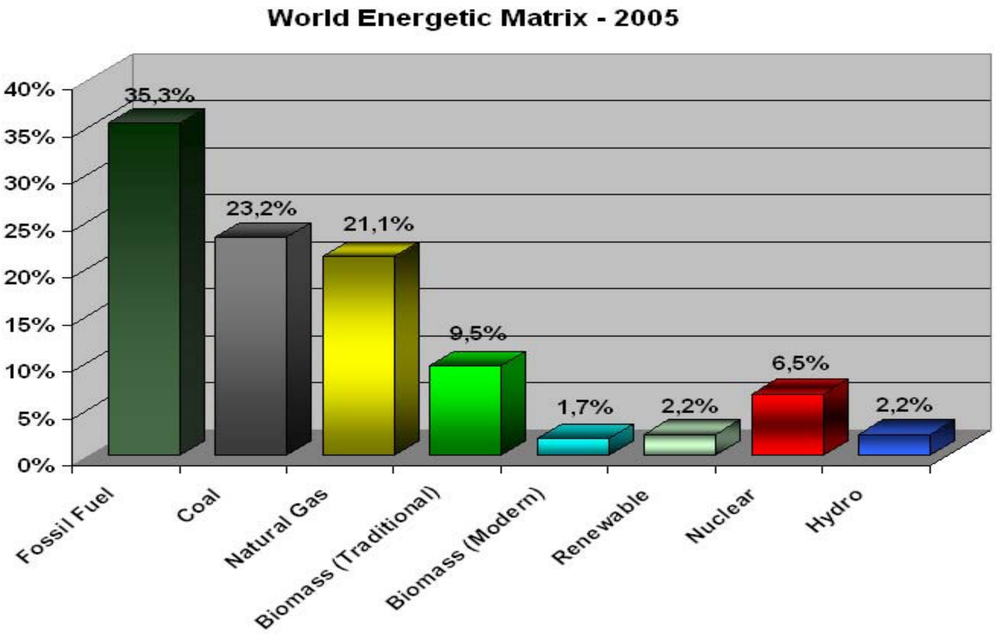
2 Future demand for fuels

According to the IEA World Energy Outlook 2005 recently published: global energy needs are likely to continue to grow steadily for at least the next two-and-a-half decades. If governments were to stick with current policies – the underlying premise of the Reference Scenario – the world's energy needs would be more than 50% higher in 2030 than today. Over 60% of that increase would be in the form of oil and natural gas. Middle East and North Africa (MENA) share of global oil and gas output would grow substantially, as long as MENA countries invest enough in energy production and transportation infrastructure. But the global trends in the Reference Scenario would raise several serious concerns.

Climate-destabilising carbon-dioxide emissions would continue to rise, calling into question the long-term sustainability of the global energy system. And the sharply increased dependence of consuming regions on imports from a small number of MENA countries would exacerbate worries about the security of energy supply.

Presently, fossil fuels are responsible for about 80% of the world energy matrix, as can be seen in the following Figure 28.

Figure 28 (Source IEA)

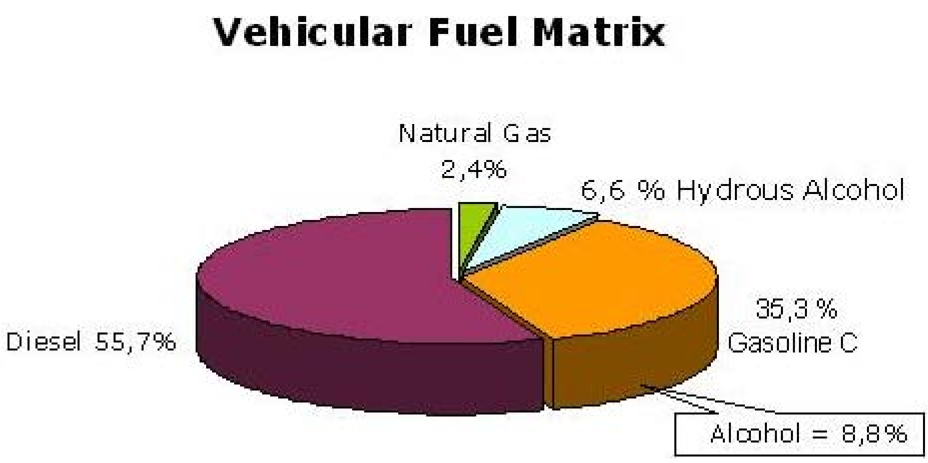


And 80% of this energy has its use concentrated in only ten countries. In Brazil, 43.6% of energy supply comes from renewable sources. The Brazilian emissions of carbon-dioxide to the atmosphere due to fossil fuel use are 0.41% of total world emissions, while the U.S.A., China, Germany, Russia and Japan are responsible for 65% of those emissions.

In the period 1973 to 2000, the world consumption of oil in transport has increased its participation in the energy matrix from 43% to 58% (source: IEA). The energy consumption of the transport sector, up to the year 2030, will increase at the rate of 3.6% per year in the developing countries and at the rate of 1.4% per year in the developed countries, as visualized for the world transport matrix (source: WBCSD – 2004).

Biofuels are already responsible for 15.4% of the Brazilian matrix of vehicular fuel (Figure 29). This fact is due to ethanol production and use in transports. Brazil has reached self sufficiency in the supply of fossil fuel. However, it is still dependent of imports of about 6% of petroleum diesel and 38% natural gas to attend its needs.

Figure 29 (Source: MME/BEN)



Liquid Bio-fuels (Ethanol) in Brazil	15.4%

According to recent projections made by the Ministry of Mines and Energy – MME and PETROBRAS, the consumption of fuels in Brazil is expected to increase up to the year 2020 as shown in Table 47

Table 47 – Projection of fuels consumption in Brazil up to 2020

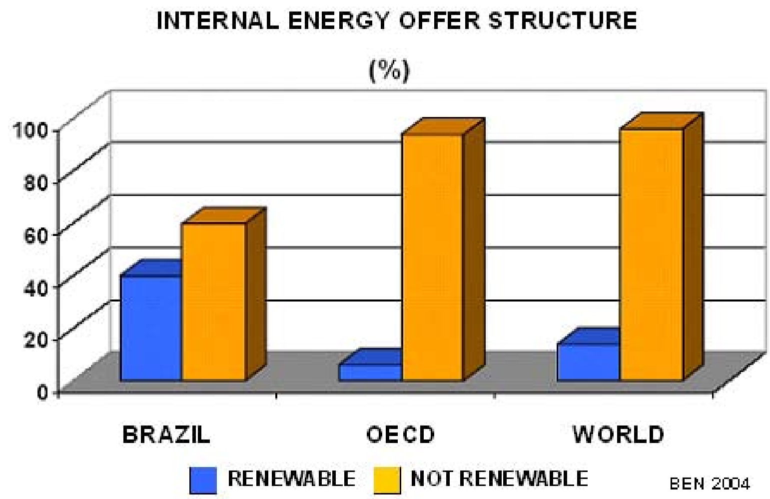
Fuel	Unit	Consumption 2003	Projection 2010	Projection 2020
Gasoline C	m³/yr	21,634,511	25,005,880	32,958,944
Diesel	m³/yr	34,117,328	44,748,721	63,122,491
LNG	10³ x m³/yr	1,315,460	7,099,972	10,014,801

Source: MME

Renewable energy will play an important role in the future. The abundance of renewable energies worldwide creates new perspectives for emerging countries to be introduced in the global scene and for developed countries to reach sustainability. The reduction in political tensions as a result of the introduction of renewable energies is, undoubtedly, a strong contributor to the aim of achieving peace in the world with environmental sustainability and social justice.

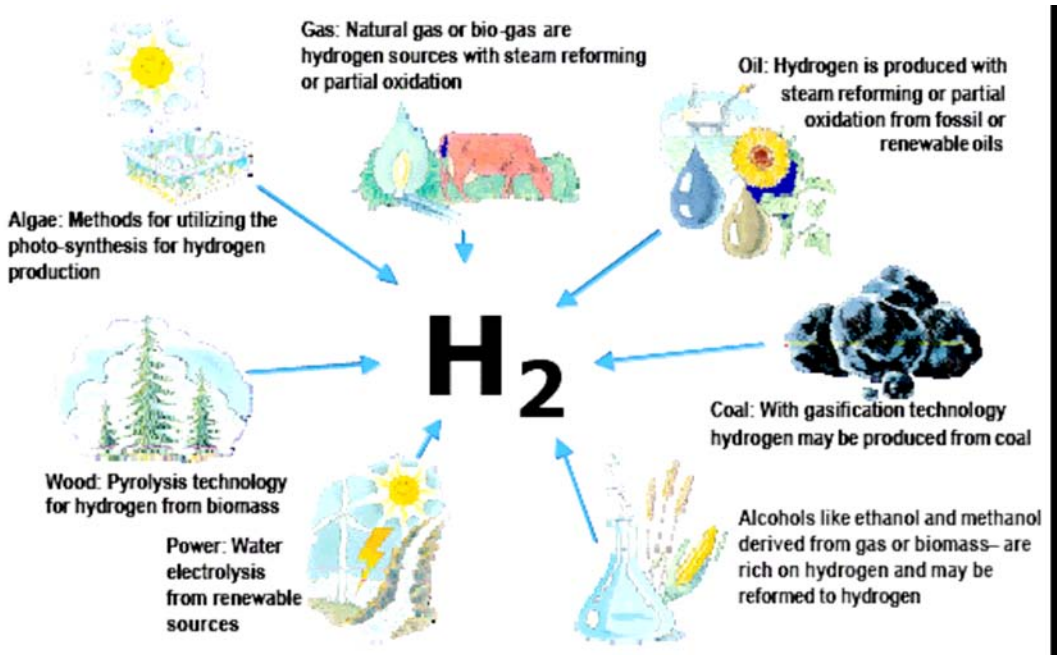
Biomass fuel from the tropical regions could mean a counterpoint to the eminence of difficulties caused by the present rise in the petroleum price and by the decline in competitiveness of other fossil sources.

Figura 30



Most of the developed countries, especially the United States, are looking for a future economy of hydrogen as the promising substitute of the petroleum economy. In this scenario, hybrid vehicles are seen as the transition option for transport until the full implementation of a hydrogen economy, estimated to occur after about 30 years. Brazil does not need that option. For Brazil the transition to hydrogen is to be made by ethanol. Brazil has a great potential for hydrogen production from biomass in opposition of fossil fuel.

Figure 31 – Some feedstock and process alternatives (Source: Hydro)



The Brazilian market for biofuels has been consolidated in the last 30 years with the ethanol program PROÁLCOOL. The more recent strategies for Fuel Cell and Biodiesel Programs, launched in 2002, are to develop technologies for production of hydrogen by ethanol reform and, also, biodiesel from different vegetable oils using ethanol in the trans-esterification process. Also, many projects are in demonstration phase to recover methane (biogas) from organic residues, domestic and sanitary origin, with the aim of using fuel cell technology to produce electricity. The priority is to search hydrogen from renewable sources, especially from biomass and or hydroelectric power plant.

3 Potential for blended or pure biofuels

The Brazilian fleet of light vehicles totals today around 18 million units, which utilizes nearly 27.5 billion liters of fuel per year: 16 billion liters/year of gasoline “A” and 11.5 billion liters/year of hydrated and anhydrous ethanol. Pure gasoline “A”, pure, is the refining standard. In downstream, the so-called regular gasoline contains a mixture of 25% of anhydrous ethanol. For each liter of pure gasoline, another 0.72 liters of alcohol fuel is consumed in Brazil. Brazilian vehicles are equipped with engines that can operate with regular gasoline, hydrated ethanol and “flex fuel”, either gasoline or hydrated ethanol or a mixture in any ratio.

Presently, Brazil imports around 6% of its needs for petroleum-diesel and 38% of natural gas, and exports 11% of gasoline and 16% of alcohol from its total production. The fuel market indicates that 70% of the vehicle sales are flex-fuel type. By 2006, tri-fuel (alcohol + gasoline + VNG) will be offered to the market.

Table 48

BRAZIL – Fuel Dependence Production & External Trade - 2004					
Fuel	Production Mil m^3	Imports Mil m^3	Exports Mil m^3	Imports % of demand	Exportas % of demand
GASOLINE A	18.583	-	1.960		11%
DIESEL	38.535	2.630	-	6%	
ALCOHOL	14.600	-	2.380		16%
NATURAL GAS (1,000 m^3/d)	36.286	22.096	-	38%	

Dependence

Self sufficiency

Source: ANP / MAPA

The tendency in Brazil, however, is to use natural gas mainly in the industrial sector and to use liquid biofuels blended with petroleum diesel and gasoline in transportation. So, it is believed that pure biofuel will only be used in dedicated fleet belonging to agro-industrial and private or public service companies.

The competitive solution to meet the fuel demand is, therefore, to mix biofuels with fossil fuels, which will make the market sustainable until advanced technology brings a new stage of competitiveness.

4 System analysis results: Biomass for transport or power plants

Biomass can be used efficiently for both transport and for power plants, which are not mutually exclusive. It is expected that biomass will have increasing participation in the transportation matrix, either though ethanol, biodiesel or hydrogen.

In turn, the urgent need to guarantee new primary sources to produce electric energy for the coming years has induced the government authorities responsible for the energy sector to give priority to the rational exploitation of biomass residues from the sugar cane industry, wind energy and small-hydro-plants.

This insertion of renewable energy agents in the scope of the electric sector is favored by the existence of independent producers and by the distribution of energy generated. The programs PROINFA and *Luz para Todos* (Light for Everyone) have set purchase quotas of renewable energy as well as established rules for the new producer units' installations with an indirect incentive policy to the national production of equipment and systems that use efficient energies such as sun, biomass, wind and hydro resources.

Biomass fuel derived from sugar cane is composed of bagasse, tips, straws and vinhoto, which can be addressed to electric energy generation, with more efficient technologies, such as high-pressure boilers, condensation turbines and gasification.

It shoud be stressed that, already in 2004 the sugar cane production, whose potential energy is 1.2 barrels of oil per ton, represented about 14% of the primary energy in the country. The energy production of this segment was 200,000 barrels/day of ethanol and of 16TWh of electric energy, the latter being mainly for self-consumption. The revenues from the electric energy produced by the sugar cane industry represented in 2004 about 2.3% of the GNP, a figure that can grow significantly through more efficient use of the above mentioned technologies.

The biomass of tips and straws produced from sugar cane, if utilized in about 50%, represents a surplus of 120kWh/ton of the processed cane. From this market perspective, the sugar cane industry presents a great potential of expansion. In 2010, it would be necessary to process about 560 million tons of sugarcane, from up to 70 billion kWh which could be efficiently generated.

Transformed vegetable oils can be used directly for electricity production. Since 1994, the *Programa Trópico Umido* – MCT have confirmed the good experience in using palm oil to produce electricity in an isolated community. Presently, the conversion kit technology for diesel engines is being developed with different Brazilian vegetable oils.

5 Impact on international trade

The Brazilian production of biofuels (ethanol, crude vegetable oils or biodiesel) for export will contribute to the quality and competitiveness of fuel blending in international trade. There is no doubt that another important contribution is to the world environmental improvement by helping developed countries to cope with their obligation to reduce greenhouse gases.

On the other hand, this commerce will be biased by cooperation in technology transference, among investors, the industrial sector of biofuel producers, inputs and machinery systems.

At this early stage of biodiesel production, it is not possible to safely foresee how it can impact the international market. However, ethanol production for export is estimated to increase up to about 5.5 billion liters per year by 2010. This would mean the entry of at least US$ 1 billion of foreign currency.

In item 3.2 of Part 3, it was mentioned the impact biofuel commerce may have over the Brazilian foreing exchange balance. This is an important impact to be taken into account because it shows that emerging countries like Brazil can by means of the biofuel trade improve their share in the international market.

PART 5

SYNTHESIS: RECOMMENDATIONS FOR DECISION-MAKERS

1 Recommendations for Brazil

The Brazilian program for biodiesel has a strong focus on small farmer production with special exemption from most taxes. The castor oil and palm oil plant cultures are the main crops identified with potential for family agriculture production. However, much more than seed distribution and minimum price warranty are necessary. It is necessary to organize those producers through production cooperatives, to train and qualify them for the production and supply compatible credit for their activities, etc.

It is necessary to strengthen the programs of genetic and phyto-techniques of castor oil developed by EMBRAPA, in order to increase the offer of genetic material – higher number of varieties and commercial hybrids – with improvements in productivity and of the production systems used in the country. EMBRAPA should also work on the development of new varieties of African palm, increasing its germo-plasm bank and improving the resistance of these plants to plagues and diseases.

Public-Private-Partnerships (PPPs) rules go slowly into the Federal Congress, after three years of discussions. Fortunately, the present version of the law respects the foundations of fiscal responsibility legislation and bids. In the area of the state governments, projects of PPP or simple concessions already show how possible is to improve the infra-structure by opening responsibly space to the private sector.

To adequately organize the biodiesel production chain, It is strongly recommended that Brazil makes an effort to join government and private groups, investors and small producers, into a model of Public Private Partnership (PPP) with well defined rules, where each actor may have the following general role:

- Government. The government agencies should help with financing funds, technological support, provision of the necessary infrastructure and policies related to social and economical development and provide means for better education and environmental skills. Government should guarantee the buying and selling of production according to pre-fixed rules related to quality and economic return. It is fundamental that the Government provides technical assistance and innovation development to the small producers in order to assure quality and productivity, with environmental commitment.

- Private Sector. Investors and industrial players, involved in the final production, distribution and exportation, are requested to help the feedstock supplier to attain progressive gains of productivity, as vegetal oil are responsible for about 80% of the production cost of biodiesel. The private sector is co-responsible with the government to drive further technological development, speeding up the learning curve and strengthening the producers of related goods and services.

- Small Farmers. They are responsible for the crop and harvest of biodiesel feedstock according to the planned contracted conditions. They should organize themselves as cooperatives of small producers in order to attend to the final product constraints and support the continuous technical capacity building of the producers.

As to sugarcane plantation expansion to cope with the increase in demand, the government should oblige all actors involved to enforce social and environmental legislation.

1.1 Shaping the National Market

The national market for biodiesel is defined and limited by the related legislation as can be inferred from that described previously in this report. The mandatory mixture of biodiesel to conventional diesel, entering into effect in January 2006, gives the right dimension to the market. The blend of 2% of biodiesel with petroleum diesel dispenses the need to retrofit the conventional diesel engines already in use in Brazil, as is the case in countries that already use the fuel. In an official letter to the Government, the National Association of Motor Vehicle Manufacturers (Anfavea) has assured consumers that factory warranties for diesel engines will cover running on B2. Captive fleets can test biodiesel with higher mixture content to conventional diesel (B20?) and electricity generaton in remote communities like those in Amazonian Region could use B100, bringing an excellent contribution for the future use of higher percentages of biodiesel to diesel.

The very first externalities visible by the consumer, such as the lubricating effect and of the positive environmental impact in urban centers, can help in accepting the burden of a more expensive product.

The crucial question of subsidies has to be the object of understanding between producers and government, but the government has to show that its strategy to create a market for biodiesel is based on reduced fiscal impact and burden to the final consumer.

1.2 Supporting the National Industry

It is important to reinforce the knowledge base that already exists and to promote basic studies and technological development, in order to give effective consistency to the biodiesel implementation program in Brazil. Such measures are important to improve the production processes as much as to promote applied research into end-use engines.

It is also necessary to promote the local manufacturing industry of equipment, systems and implements for the productive chain of the vegetable oil industry, especially in the North and Northeast of Brazil, where the proposition is to produce biodiesel with social seal.

1.3 Export Opportunities

Export market opportunities for ethanol do exist either to supply countries which are open to use biofuel directly, in blends of ethanol content higher than 70% (United States and Sweden), or in blends up to 10% (South Africa, Australia, India, Japan China and others).

Brazil is a potential exporter of biodiesel, which is already in commercial use in the United States and the European Union. Due to limitations for production growth in Europe, Brazilian biodiesel enjoys an unprecedented opportunity to build market share in the

European continent. However, for this to become a reality it is necessary that technical specification for biodiesel adopted in Europe be modified. As was mentioned before, the European biodiesel specification is an excludent factor for the Brazilian exportation, because the only oleaginous that atttend 100% the specification is the colza. Brazil does not have traditional production by such route and considering the existent commercial varieties that oleaginous can be planted only in the Southern Region of Brazil.

The EU aims to ensure that 2% of all fuel consumed in the region is renewable by 2005. But, it has limited land area available for growing rapeseed, the main feedstock produced in Europe. The industrial capacity is also insufficient to meet the stipulated demand. Despite these constraints, the proportion of renewable fuels is set to reach 5.75% by 2010 according to EU Directive 30, ratified by the European Parliament in May 2003.

However, because of the restrictive specifications and public national policies of biofuel programs existing around the world, there is no organized market for biodiesel exports at this moment. The market is seeking less expensive crude vegetable oils but to give priority to a certain market one has to consider the present foreign policies.

The international trade in biofuels, however, still faces high barriers from developed countries. There are several problems that limit the expansion of biofuels to developed countries:

(i) they are almost exclusively dependent on internal producers (even in countries not naturally endowed for the growth of biomass);

(ii) restrictive regulations (e.g. limits on blends), often based on not entirely justifiable environmental reasons; and

(iii) R&D support directed preferentially to “clean fossil fuels”, which will maintain unsustainable consumption patterns.

Biofuels are affected by protective legislation and are subjected to the rules currently under discussion in World Trade Organization - WTO. This includes negotiation on certain trade and environment issues, starting with the aimed for liberalization of trade in environmental goods and services (EGS). It is therefore necessary to define the scope and clarify existing WTO provisions in order to clearly consider biofuels as EGS, and thereby make it possible for them to benefit from progressive world trade liberalization. [10]

1.4 Policy Strategies and Institutional Framework

1.4.1 Monetary incentives: taxation, subsidies

The tributary rules of the Brazilian biodiesel program, as related to the social taxation of PIS and COFINS, establish that such taxes as charged only once and that the contributor is the industrial producer of biodiesel. The approved rules establish that a reduction of 67% in the taxation is due to producers that do not have differentiated benefits; 77.5% for the biodiesel made in the North and Northeast Regions and in the Semi-Arid Region, but using castor oil and palm oil as feedstocks; 89.6% for family agriculture, and 100% reduction for biodiesel produced from castor oil and palm oil, supplied by family agriculture and from the North, Northeast and Semi-Arid Regions.

1.4.2 Market Introduction Strategies/Support

Biodiesel program in Brazil is based in mandatory rules for replacement of the petroleum diesel. On the other hand, biodiesel prices are still much higer than the conventional diesel. So the market strategy should be to show to the consumer the advantages of the externalities visible by him, such as the lubricating effect and of the positive environmental impact in urban centers, which can help in accepting the burden of a more expensive product.

1.4.3 Regulatory Instruments: Compulsory Blending/Substitution

As mentioned before, Brazil has already established regulatory instruments, including compulsory blending and replacement rules. Commercial use of biodiesel is, therefore, governed by a specific regulatory framework that intends to make biodiesel competitive with petroleum diesel, taking into account the wide variety of oilseeds available, and including measures to guarantee supply, compliance with fuel quality standards, and the Government’s social inclusion policy.

The regulatory framework is made up of laws and decrees dealing with biodiesel-diesel percentage blends, forms of use and taxation. The tax rules include differential rates depending on the oilseeds used, where they are grown, and whether they are produced by large agri-business concerns or family farmers. Biodiesel feedstocks and the fuel itself are exempted from Industrial Products Tax (IPI).The Program has also instituted a “Social Fuel” seal.

Guidelines on production of biodiesel and percentage blends with petroleum diesel were established by the CNPE and implemented via two specific resolutions issued by the National Petroleum Agency (ANP). They regulate the activities of biodiesel producers, set out specifications for the new fuel, and establish the distribution portion of the value chain. ANP has also revised 18 resolutions on liquid fuels to adapt the rules and regulations in force to the introduction of biodiesel.

2 Demands on developed countries

2.1 Shaping their National Markets

The European Parliament has recognized the role of bioethanol as a leading contender to complement and replace gasoline as an energy source. However, local legislation limits biofuels use and barriers need to be overcome to allow real market penetration of bioethanol in the European Union. The same should apply to the biodiesel market. [10]

Developed countries and international organizations such as the OECD and UNCTAD have a key role to play in defining the scope and clarifing existing WTO provisions in order to clearly consider biofuels as EGS, and thereby making it possible for them to benefit from progressive world trade liberalization, as foreseen in paragraph 31 of the WTO's Doha Declaration.

Multilateral Environmental Agreements (MEAs) such as the Kyoto Protocol or targets for renewables are very important driving forces to achieving sustainable development through the increased use of biofuels.

Ethanol and biodiesel accounted for less than 1 per cent of gasoline and diesel consumption in the EU, in 2000. Production capacities are, however, rising fast. Meeting objectives such as the proposed EU indicative target of 5.75 per cent oil displacement by 2010 will require large-scale, rapid investment in conversion facilities, and this represents quite a challenge. To meet this target, governments will have to act aggressively, creating a climate for increased production or import of feedstocks and encouraging rapid investment in conversion facilities. Domestic production will not suffice to meet this target and the EU's Common Agricultural Policy might have to be revised. Increased crop production for biofuels may lead to reductions in other agricultural subsidies.

Therefore, there is an excellent market for Brazil in Europe. Market barriers should be removed for this to become reality. A more general commitment to market access is one of the foundations of the Doha Development Round agenda. It includes supporting the accelerated liberalization of trade in green goods of special interest to developing countries. Biofuels offer a unique opportunity to simultaneously enhance exports from developing countries, promote rural development, diversify sources of energy supply, meet Kyoto Protocol reduction targets and promote real investment through the Clean Development Mechanism. [10]

2.2 Supporting their National Industry and Investing in Brazil

Germany is one of the countries that have a great tradition of investment in Brazil. Especially in the industrial sector, such as vehicle manufacture, metallurgy of iron and steel, electrical and medical equipments and telecommunications, etc. The German economy has a partnership with Brazil.

To expand the alcohol sector, foreign investments will certainly be necessary. To develop the biodiesel productive chain Brazil will need process and equipment technology, especially for larger industrial plants, know-how on planning and capacity building and direct investments. Efforts for opening the German market to Brazil by removing import barriers would also be welcome.

2.3 Promoting Opportunities For German-Brazilian Collaboration

There are many aspects where Germany could work to speedup the Brazilian biodiesel program. For instance: i) making revision of biodiesel standards to accept other vegetal oils as raw material; ii) by rethinking present trade strategy: importing palm oil and/or re-exporting soybean oil; iii) financing biodiesel plants in Brazil, to meet local/export demand; iv) rethinking present strategy for biodiesel: less political and more scientific approach; v) Develop tailor-made technologies as alternatives to present ones, non economic or capital intensive.

2.4 Coherence With Policies For International Cooperation [10]

The full potential and advantages of renewable energies are hindered at present because the costs of fossil fuels do not reflect their full cost. They are subsidized in several parts of the world and the “externalities” associated with them, such as additional health and environmental costs, are not taken into consideration.

Policies for biofuels usually focus more on side effects, such as local agricultural subsidies or improved R&D, than on the central focus, which is the fast improvement in the learning curve through liberalized international trade and exploiting the full potential of biofuel production in developing countries.

Removing subsidies from fossil fuels would make renewables (mainly biofuels) competitive in many areas. Generally speaking, the use of renewables might benefit from multilateral and regional cooperation, and the realistic implementation of WTO's Doha Work Programme and the 2002 WSSD Plan of Implementation.

2.5 Common Standards and Codes of Practise, Tariffs and Trade Rules

To have common standards and codes of practice is considered of fundamental importance to permit a competitive market, permitting countries like Brazil, which has comparative advantages for biofuel production, to become world suppliers. The same is true for tariffs and trade rules under discussion in the WTO.

2.6 Capacity Building and Awareness Raising, Institutional Issues

Capacity building and awareness raising are challenges Brazil has to face. They are areas that it is believed Germany could help with, so as to establish correct strategies by bringing its experience in dealing with these subjects.

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LIST OF ABBREVIATIONS

ABiodiesel	Brazilian Association of the Biodiesel Industries
ABIOVE	Brazilian Association of the Vegetable Oil Industries
ACP	Africa, Caribbean and Pacific
ALCOPAR	Association of the Alcohol and Sugar Producers of Paraná
ANFAVEA	National Association of Motor Vehicle Manufacturers
ANP	National Petroleum Agency
APP	Areas of Permanent Preservation
BNDES	National Bank for Economic and Social Development
CENAL	National Executive Commission for Alcohol
CIDE	Contribution for Intervention in Economic Domain
CIMA	Interministerial Council for Sugar and Alcohol
CNAL	National Council for Alcohol
CNPE	National Council for Energy Policy
COFINS	Contribution for the Financing of the Social Security
CONAB	National Company of Supply
CTC	Centre for Sugarcane Technology
DHR	Dedini Fast Hydrolysis
EBA	Everything But Arms
EBAPA	Bahia Enterprise for Agriculture and Farming Research
EMBRAPA	Brazilian Enterprise for Agriculture and Farming Research
EU	European Union
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GNP	Gross National Product
IAA	Sugar and Alcohol Institute
IAC	Agronomic Institute of Campinas
ICMS	Value Added Tax
IEA	International Energy Agency
IMF	International Monetary Fund
INCRA	National Institute for Colonization and Agrarian Reform
IPI	Federal Tax over Industrialized Products
MAPA	Federal Ministry of Agriculture, Stock Farming and Supply
MCT	Federal Ministry of Science and Technology
MDA	Federal Ministry of Rural Development
MEA	Multilateral Environmental Agreements
MENA	Middle East and North Africa
MME	Federal Ministry of Mines and Energy
MP	Provisory Measure
MTBE	Methyl Tertiary Butyl Ether
OECD	Organization of Economic Cooperation and Development
PIS	Contribution for the Social Integration Program
PROÁLCOOL	National Alcohol Program
PROBIOAMAZON	Program for Energetic Biomass Production in Amazonian Settlements
PROINFA	National Infrastructure Program
PRONAF	National Program for the Family Agriculture
RIDESA	Universities Network for the Development of the Sugar and Alcohol Sector
RME	Rapeseed Methyl Ester
UDOP	Union of the Distilleries and Mills of Western São Paulo
UNCTAD	United Nations Conference on Trade and Development
ÚNICA	Sugar Cane Agro Industry Union of São Paulo
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

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Goverment & Public Agencies

República Federativa do Brasil: http://www.brasil.gov.br/
MME: http://www.mme.gov.br/
MCT: http://www.mct.gov.br/
MAPA: http://www.agricultura.gov.br/
MMA: http://www.mma.gov.br/
MDA: http://www.mda.gov.br/
MDIC: http://www.mdic.gov.br/
ANP: http://www.anp.gov.br/
PETROBRAS:
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INT: http://www.int.gov.br/
EMBRAPA: http://www.embrapa.br/
CONAB: http://www.conab.gov.br/
INCRA / SADE: http://www.incra.gov.br/sade/default.asp
IBGE: http://www.ibge.gov.br/
IPEA: http://www.ipea.gov.br/
BNDES: http://www.bndes.gov.br/
Banco do Nordeste:
http://www.banconordeste.gov.br/intro2.html
SEBRAE: http://www.sebrae.com.br/
FINEP:
http://www.finep.gov.br/
ELETROBRAS: http://www.eletrobras.gov.br/
CATI: http://www.cati.sp.gov.br/novacati/index.php
IAC: http://www.iac.sp.gov.br/
PORTAL DO BIODIESEL:
http://www.biodiesel.gov.br/
Portal Biodiesel Brasil: http://biodieselbrasil.com.br/
Portal MB: http://mbdobrasil.com.br/html/index.php
COPPE / UFRJ: http://www.coppe.urfj.br/
ESALQ: http://www.esalq.usp.br/
CLUBE DE ENGENHARIA:
http://www.clubedeengenharia.org.br/
UFPR: http://www.ufpr.br/
USP: http://www2.usp.br/publishing/insite.cgi
UFLA: http://www.ufla.br/
CEF: http://www.caixa.gov.br/
CNI: http://www.cni.org.br/
IPEA: http://www.ipea.gov.br/
PEASA: http://www.peasa.ufpb.br/

Private Associations

FBDS - Fundação Brasileira para o desenvolvimento Sustentável: www.fbds.org.br
UNICA: http://www.unica.com.br/pages/home.asp
ABIOVE: http://www.abiove.com.br/
ALCOPAR : http://www.alcopar.org.br
ABOISSA : http://www.aboissa.com.br/
COPERSUCAR: http://www.copersucar.com.br/

IEA:
http://www.iea.sp.gov.br/out/index.php
CENBIO: http://www.cenbio.org.br/
CNA: http://www.cna.org.br/
AEA: http://www.aea.org.br/br/default.asp
OILWORLD: http://www.oilworld.biz/
GRANOL: http://www.granol.com.br/telas/links.php
ABIMAQ: http://www.abimaq.org.br/
BM&F: http://www.bmf.com.br/
CEBDS:
http://www.cebds.com/
Worldwatch Institute: http://www.worldwatch.org/
BRASIL ECODIESEL: http://www.brasilecodiesel.com.br/
LAMNET: http://www.bioenergy-
lamnet.org/
FAO: http://www.fao.org/

Industries & Producers

DEDINI: http://www.dedini.com.br/
DELPHI:
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MARBORGES:
PALMASA:

ANNEX 1

NATIVE CROPS – WILD GROVES

The most important reference report on oleaginous plants in Amazônia was published in 1941 by Celestino Pesce. He identified 116 plants with potential to produce edible oil.

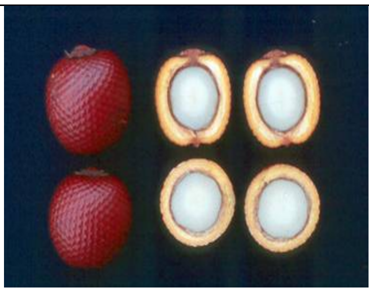
Recently Embrapa researchers Carvalho, J.E.U. and Farias Neto, J.T have presented the study *"Oleaginous Fruits of Amazon with Potential for Biodiesel Production"* (only available in Portuguese), in which they identified native plants with more potential to be used for biodiesel production.

Information is insufficient about native species, mainly of palm trees. Some available information is presented here.

BABAÇU – *Attalea speciosa M..*

- Nut Oil Yield : 66,2%
- Max Production Obtained by year: 10.000.000t (in the 80's)
- Native Areas : 17.000.000 ha (MA, PI, CE, PA, BA, MG)
- Extractivist Activitie

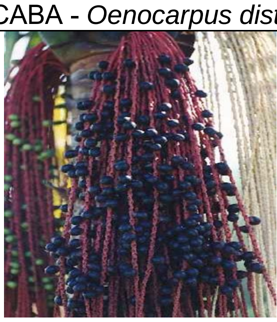
BURITI - *Mauritia flexuosa*



Oil Yield (Dry Basis)
Nut: 1,7%
Pulp: 35,7%
Shell : 4,0%

Fruit Composition
Shell: 22,2±2,8 %
Pulp: 25,0±4,5%
Endocarp + Nut: 37,1±5,8 %
Other Structures 15,7±3,2 %
Crop: JAN – JUN
Productivity: 15 – 20 t/ha
Production Begin: 7 to 8 years after planting

BACABA - *Oenocarpus distichus*



Limitations to use as biofuel
- Hight Carbon residues
- Hight Viscosity

Fruits
Average Weight....................................2,0 g
Shell+ Pulp..............................38,0 %
Endocarp + Nut.................62,0 %
Oil Yield (Shell + Pulp)........26,2 %
Crop : January to April
b) Estimated Produtctivity: 12 a 15 t/ha

TUCUMÃ – *Astrocarium asculeatum*

Fruits:
Average Weight..................................34,5 ± 10,2g
Shell...15,4 ± 3,7%
Pulp..49,6 ± 3,7%
Endocarp +Nut............. .34,1 ± 6,6%
Oil Yield – Dry Basis (%)
Pulp: 33,0
Nut: 36,5
Crop : February to June
Estimated productivity: 30 t/ha

PUPUNHA - *Bactris gasipaes*

Oil Yield:
Pulp: 8,8% a 21,0% (Clement et al., 1998)
Nut: 7,5% a 44,7% (Serruya & Bentes, 12985)
Shell: 24,3% a 26,6% (Serruya & Bentes, 12985)

INAJÁ - *Maximiliana maripa*

Fruit
Average Weight: 24,2 g
Shell: 19,6±1,6%
Pulp: 38,0±4,0
Endocarp+ Nut: 33,9±4,9
Oil Yield:
Shell: 11,7%
Pulp: 36,3%
Nut: 60,6%

PATAUÁ - *Jessenia bataua*

Limitations to use as biofuel

- Hight Carbon residues
- Hight Viscosity

Fruit
Average Weight....................................9,9 ± 1,6 g
Shell..17,7 ± 1,6 %
Pulp..18,6 ± 2,0 %
Endocarp + Nut.................63,7 ± 3,2 %
Oil Yield
Pulp...................31,0%
Nut.............0,7 %
Crop: October to March
Estimated Productivity: 5 a 7 t/ha

UCUUBA – *Virola surinamensis*

<table>
<tr><td></td><td></td><td>Fruit
Average Weight ; 1,7g
Shell: 17- 19%
Oil Yield :
Nut : 58-60%</td></tr>
<tr><td></td><td colspan="2">MACAÚBA – Acrocomia aculeate/ Mucajá – Acronomia sclerocarpa</td></tr>
<tr><td></td><td></td><td>Fruits
Average Weight...................................18,0 g
Shell+ Pulp.............................60,0 %
Endocarp + Nut.................40,0 %
Oil Yield
Pulp.......33,0 %
Nut....... 54,0 %</td></tr>
<tr><td></td><td colspan="2">MURUMURU - Astrocaryum murmuru</td></tr>
<tr><td></td><td></td><td>Fruit
Average Weight...................................12 g
Shell...50 -55 %
Nut... 50-45 %

Oil Yield
Nut............40-42 %
Crop: January to June</td></tr>
<tr><td></td><td colspan="2">Caiaué</td></tr>
<tr><td></td><td></td><td>Fruits
Average Weight...................................6,5 g
Pulp.............................26,0 %
Endocarp…. …………58%
Nut................. 16,0 %
Oil Yield
Pulp........47,0 %
Nut ……..35,0%</td></tr>
<tr><td></td><td colspan="2">Bacaba</td></tr>
<tr><td></td><td></td><td>Fruits
Average Weight...................................2,0 g
Shell+ Pulp.............................38,0 %
Endocarp + Nut.................62,0 %
Oil Yield (Shell + Pulp)........26,2 %
Crop : January to April
b) Estimated Produtctivity: 12 a 15 t/ha</td></tr>
</table>

ANNEX 2

MOST PROMISING VEGETABLE SPECIES
(Complementary information)

1 Soybean (Glycine max)

1.1 Soil and climatic requirements

With the proliferation of breeding programmes directed to soybean and consequent production of cultivars adapted to varied environments, the range of soybean is now virtually possible in all regions of Brazil. Basically a warm temperature, short day plant, it has been adapted from sea level to 3.000 m, with day varying from 12 to 16 hours.

Soya breeding has been expanded quickly in Cerrados of Brazil. Most of the soils in the Cerrados are classified as tropical soils, or Oxisols. The two largest areas in the world with these soils are in the Amazon Basin in South America and the Congo Basin of Africa.

Oxisols are highly weathered soils with low native fertility, low organic matter, and high acidity. Aluminum toxicity is often the major limiting factor for crop production in very acid soils. High aluminum toxicity inhibits root development.

Many native Cerrados plants have high tolerances to aluminum toxicity. The process of how aluminum toxicity occurs in the plant is not well understood. However, much research is underway in Brazil to find ways to overcome these root development problems.

The soils in the Cerrados are very fragile. The high rainfall in the Cerrados creates significant risk of soil erosion. Some of the areas have significant slopes, in rise and in length. Producers use no-till and terracing to minimize erosion problems.

1.2 Inputs

Seeds

Soybean agribusiness has a large and organized chain of seeds suppliers and researchers. The seed quality evolution is fast and gave immediately solutions for the disease and productivity necessities.

Fertilizers

The low pH of the soils reduces the availability of phosphorus and increases the availability of aluminum and iron. That is why some had believed that the Cerrados soils would never be productive. Soybeans require large amounts of phosphorus compared to corn and wheat. Phosphorus stress on plants usually occurs in the seedling stage when roots have not developed enough to supply all the needed phosphorus. The addition of lime and phosphorus minimizes the aluminum toxicity and increases productivity. It should be possible for those soils to produce even greater yields in the future as producers have an expanding selection of adapted plant varieties and a better understanding of soil chemistry.

Brazil has large supplies of lime. When the government tried to stimulate agricultural growth in central Brazil in the 1970s with loans and grants, a key factor in deciding where to target these new growth areas was the location of low cost lime.

Nitrogen requirements are substantially met from action of Rhizobium bacteria in the root nodules, and it has been calculated that fixation from this source can provide sufficient nitrogen for bean yields of 4.000 kg/ha, with fixed nitrogen amounting to 180 kg/ha.

Potassium is required during vegetative growth. Soybean growth need some minor elements as Magnesium, Manganese and Sulphur.

Weed Control

Farmers in Brazil tend to have fewer weed problems than in the U.S. because the land has been cultivated for fewer years. Almost all farmers have switched to no-till, which will increase weed pressure over time. Chemicals used on Brazil soybeans include Treflan, Classic, Cobra, Reflex, Basagran, Pursuit, Poast and Select, along with others used in the U.S. for control of weeds.

Chemical weed control costs about $15 to $20 an acre and gives reasonable broadleaf and grass control. There are several weeds that current chemicals do not control well. Warm temperatures after the soybean leaf canopy has fallen encourage end-of-season weed growth. This late season growth has very little, if any, yield impact. But it can be a challenge to harvest crops with young growing green weeds. A major concern is the growing number of herbicide-resistant weeds. Many of the chemicals used for weed control have the same chemistry and the same mode of action. Continued and repeated use of the same chemistry places tremendous selection pressure on the weeds to develop resistance. Rotating crops and chemical modes of action will minimize the probability of developing resistant weeds. Chemical carryover is less of a problem in the Cerrados because of its warm soil temperatures and high rainfall.

Machinery

Massey Ferguson appears to be the dominant tractor brand in Brazil. Case -- IH and Deere under the brand name SLC, appear to be increasing their market shares. A major factor in tractor competition is who can expand output in Brazil to avoid the 15 percent import tax. Most of the planters in southern Brazil are no-till, set up for five-rows of corn on approximately 36-inch rows. Add-on units allow planting soybeans in 18-inch rows. New planters are larger with more units and air-metering systems. Traditional sprayers, foggers and aerial application are used for spraying. Labor costs are low enough to encourage substitution of labor for machinery.

2 Castor plant – "Ricinus communis l."

2.1 Soil and Climate Characterization

The Brazilian Northeast Region where the castor oil production in Brazil is concentrated is constituted by 9 States: Bahia, Pernambuco, Alagoas, Paraíba, Sergipe, Rio Grande do Norte, Ceará, Piauí and Maranhão.

The Northeast Region presents a tropical and semi-arid climate, with pluvial precipitations frequently very low and concentrated during few months of the year. The interior of the region, known as "Sertão", is inhabited by farmers of low income. The land is punished by the strong sun that is characteristic of the low latitude. The less favorable areas for agriculture are occupied by an aggressive and adapted vegetation called "caatinga".

Climatic and edaphic conditions adequate for the ricin culture:

- average temperature of the air varying between 20 and 30°C
- pluvial precipitation superior to 500mm in the rainy period
- altitude between 300 and 1,500m
- soils of a sandy to argillaceous texture, well drained and without salinity or sodic problems

From the total area of the Northeast of 1,555,001 km^2, 75% can be classified as having a semi-arid climate. The hydro balance is almost always negative resulting from precipitations inferior to 800 mm; insolation of 2,800 hours/year; annual medium temperatures between 23 and 27°C; evaporation around of 2,000 mm/year; and medium air humidity of 50%.

Rotation of Cultures: the castor plant must not be planted for more than two years in the same place in order to avoid the increase of the incidence of *fungus* diseases, mainly fusariosis, which, when occurring during germination, can destroy the culture. The suitable cultures are: corn, peanut and green fertilizers.

Appropriate conditions for the cultivation of the castor plant are found in several municipal districts of the Northeast, in all states, including areas where the culture does not have cultivation a tradition yet, such as Maranhão and Sergipe. The brightness and the temperature are enough in almost the whole Northeast.

By the criteria used by Embrapa, 458 municipal districts with aptness for the cultivation of the castor plant in dry conditions in the Brazilian Northeast were identified. The State of Bahia, the major national producer, has the largest area proper to the cultivation of the castor plant with 190 municipalities identified.

Due to the great non-uniformity of the rainy season of the northeast semi-arid properties, the planting period vary from November to April.

Number of Municipal Districts by States Adequate for Castor Plant Cultivation

State	Total of Apt Municipalities
ALAGOAS	9
BAHIA	190
CEARÁ	74
MARANHÃO	12
PARAIBA	50
PERNAMBUCO	50
PIAUI	42
RIO GRANDE DO NORTE	28
SERGIPE	03

2.2 Inputs

Planting

The castor plant planting requires soil correction (liming) 90 days before the planting and the application of phosphatic and nitrogenized fertilizers and potassium during the planting and growth phase of the plant.

In order to achieve a productivity compatible with the objective of a production program of biofuels, it is necessary to use quality seeds. Embrapa developed and supplies seeds with these requirements and in the state of Rio Grande do Norte, company Santana Sementes produces quality seeds.

Machines for harvesting and beneficiation

The suppliers of machines are not specific. They sell machines that serve a lot of purposes. For separation of the castor plant seeds, however, machines are manufactured and sold for coupling to the tractor that separate the seeds from the berries.

The crushing of castorseed in small scale, suitable for small producers, is processed using expeller press with significant energy consumption (125 kW/t). For large scale production, the applicable technology is extraction by solvent.

3 Palm tree – “Elaeis guineensis jacq.”

3.1) Agroclimatic viability

Only the Amazonian region and a narrow range of the Bahia coast answer favorably to the ecological demands of the palm tree culture in Brazil.

When it comes to the climatic aptitude, three classes of areas can be found at the Amazonian region:

- Suitable climatic areas where the plant finds all the possibilities for good development
- Marginal climatic areas where one or more climatic factors limit good culture development
- Inapt climatic areas, where adverse climatic factors forbids the culture implementation

The aptitude maps represent only a preliminary sign of areas capable to receive palm tree plantings. They are based on thermal and hydric condition studies. Some restricting aspects are not considered, such as: topography, soil, environmental laws, forest reserves, indigenous reserves, infrastructure, manpower availability, etc.

The 100% suitable climatic condition is also utopian, since many areas labeled as suitable suffer with excessive rain – which is also disregarded by those studies.

Nowadays, with 35-years’ commercial palm tree culture experience in the Amazon, it is well-known that palm trees have a good productivity in areas with moderated hydric deficit. Maps were elaborated after the data referenced below.

Pluviosity

Above 2,000 mm/year regularly distributed over the year with no hydric deficit.

It is an important parameter, which seems to be crucial for the palm oil culture to be successful. Even more than the rainfall volume, its regular distribution over the year is essential for good productivity. The species tolerates no longer than three months with less than 100 mm of rainfalls.

Insolation

Over 2,000 hours per year. It's also well distributed over the year.

Light intensity is closely related to the plant photosynthesis activity, which is a crucial condition for its productivity. Areas with luminosity lower than 1,500 hours/year are believed to be inappropriate for palm tree culture development. Under those conditions the tree cannot fully develop its productive potential. Sunlight efficiency reflects negatively on the fruit oil content and on maturation uniformity. This uniformity has influence over the product quality.

Temperature

Average between 24ºC and 28ºC (75.2ºF to 82.4ºF) with monthly absolute minimal not less than 18ºC (64.4ºF). This minimal temperature is considered critical for good species development. Palm trees are very sensitive to low temperatures, which causes a clear visible decrease in young plants growing pace and determine a large production fall in adult ones. Low temperatures along with dryness considerably aggravate the problem, causing physiological disorders in young or adult palm trees. These disorders have a major influence over the foliate emissions and, consequently, over the number of bunches.

Relative Humidity

Monthly average must be between 75 to 90%.

Topography

The terrain used for the palm tree cultivation must be flat or have a slight steepness to make bunch collection and handling, and drainage production easier. A steepness over 10% begins to compromise the economical profitability.

Soil Physical Structure

A good performance of the palm tree culture requires deep, well-drained and not compacted soilsup to 1.50 m from the surface. It happens because the palm tree fasciculated radicular system is extremely sensitive to compact soils.

Soil Chemical Composition

Palm trees are very tolerant to soil chemical features, having a smooth adaptation even on washed soils with low base saturation. Nutritional deficits are easily corrected by means of routine manuring methods with periodic corrections based on foliar diagnostic analysis. The analysis is made by collecting samples at various portions in order to assure a rational nutrition for palm trees.

The palm tree adapts itself well to acid soils and develops normally over a pH range from 4 to 6.

The palm tree culture appears as a highly recommended option for agricultural use of the Amazonian poor latosols. The results obtained in the state of Pará assure a palm tree successful cultivation in areas with similar weather and soil conditions.

3.2 Inputs

The main inputs used in palm oil agro industry are:

Germinated Seeds

It's the most important chain input. An appropriate seed choice, according to the weather and soil conditions at the project implementation site, is crucial for a successful enterprise.

Commercial production seeds are divided in two categories, according to the genetic base of male genitors "La Mé" or "Yagambi". Female genitors have the same "Deli" origin. Seeds produced by French-originated programs are of the "Deli X La Mé" kind.

English-originated programs are "Deli X Yagambi" type.

At large-scale plantations, seeds of various sources are generally used.

Brazilian Embrapa has one of the most complete African palm tree germplasm banks and a seed production center at the Manaus facility. Embrapa products have shown excellent results in the Pará state. Besides Embrapa, CEPLAC-BA has a germplasm bank at Uma station, which is currently being reactivated for seed pro: Costa Rica, Malaysia, Papua New Guinea, Colombia, Zaire, etc.

Embrapa and Ceplac have very low production capacity where limits the growing of planted area using seed from these sources in a maximums of 12,000 hectares per year.

Fertilizers

The main elements used in the palm tree agricultural cycle are Nitrogen, Phosphor, Potassium, Magnesium and Boron. The main suppliers in the Pará state are Takenaka and Fertimar companies. Due to transportation costs these inputs can be 15% more expensive in Pará than in the South/Southeast region.

Defensives

Defensives are used in small-scale on the palm tree culture and have no further impact on production costs. Formicides, raticides and insecticides are necessary.

Diesel Oil

Handling a modern project involves using a considerable amount of tractors, trucks and utility vehicles. This makes diesel oil consumption relevant for the production final cost. All Diesel oil consumed at the enterprise can be replaced by Biodiesel.

Electrical Energy

All the necessary electrical energy is produced through self-generation using fibers and peels – industrial process by-products – as fuel. A reserve group engine generator is necessary solely to attend low consumption or production stoppage periods.

Considering an additional harvesting of 80,000 hectares to produce 1% of diesel oil replacement in Brazil with palm oil, various biomass by products utilized as fertilizer and energy production will result. The most relevant are:

Products & Sub products

Description	Quantity	Application
Palm Kernel Oil	40,000 t	Edible/Premium Biodiesel
Mesocarp Fiber	1,200,000 t	Energy Generation
Palm Kernel Shell	500,000 t	Energy Generation
Palm Kernel Meal	60,000 t	Fertilizer/Livestock feed
Empty Bunches	2,200,000 t	Fertilizer/ Energy Generation
POME – Mill Effluent	1,100,000 m³	Fertilizer

Sorce: Kaltner, F. J - 2003

Energy production Capacity with by-products of Palm Oil Process

Steam Turbine Type	Biomass Feed	Produced Electricity (KWe)	Surplus (Kwe)
Monostage 3kgf/cm² backpressure	**65%F+C**	**1,000**	**200**
Multistage 3kgf/cm² backpressure	**100%F+C**	**1,930**	**1,138**
Multistage Condensate Extration	**100%F+C+CV**	**5,615**	**4,823**

F= Fiber C = Shell CV= Empty Bunches
Source: A. S. Veiga et all

Using the obtained biomass in 1,000 ha plantation in a simple multistage steam turbine is possible to produce 204 kwh per 3750 h/year , equivalent as 156 days.

Palm Oil production for B1 has a potential to produce continuously 16MWh of Electric Energy during 5 months at year.

3.3 Economic Module Template

Model 1 "Small Farmers"

Planting : 2,000 ha in individual modules with 10ha area (200 families per project)
Crude Oil Extraction Industry: 12 tffbh (twelve tons of fresh fruit bunches per hour).

Model 2 - "Plantations"

Planting: 5,000 to 6,000 ha (five to six thousand hectare area).
Crude Oil Extraction Industry: 36 tffbh (thirty-six tons of fresh fruit bunches per hour).

Farm Enterprise Gross Margin, Costs and Benefits

Planting in the Amazonian conditions – two 6,000 hectares modules with a total area of 12,000 hectares and two Crude Oil Extraction Industries with capacity to produce 36 tffbh (thirty-six tons of fresh fruit bunches per hour) – considering the before mentioned premises of production and productivity, shows the results according to a Kaltner et all study in 2003. The gross margin is usually related as 10% of the Total money Input.

Annual Production, Productivity

The maximum annual productivity considered is 26 tffbh/ha, with a crude palm oil CPO content of 22% and Palmkern Oil (PKO) of 2%.

The considered production cycle corresponds to an average annual production of 4 (four) tons of crude palm oil + 1 (one) of palmkern oil per hectare a year, during the planting life cycle.

Maximum productivity is 5 (five) tons of oil per hectare.

Total Cost of Implementation – Agroindustry

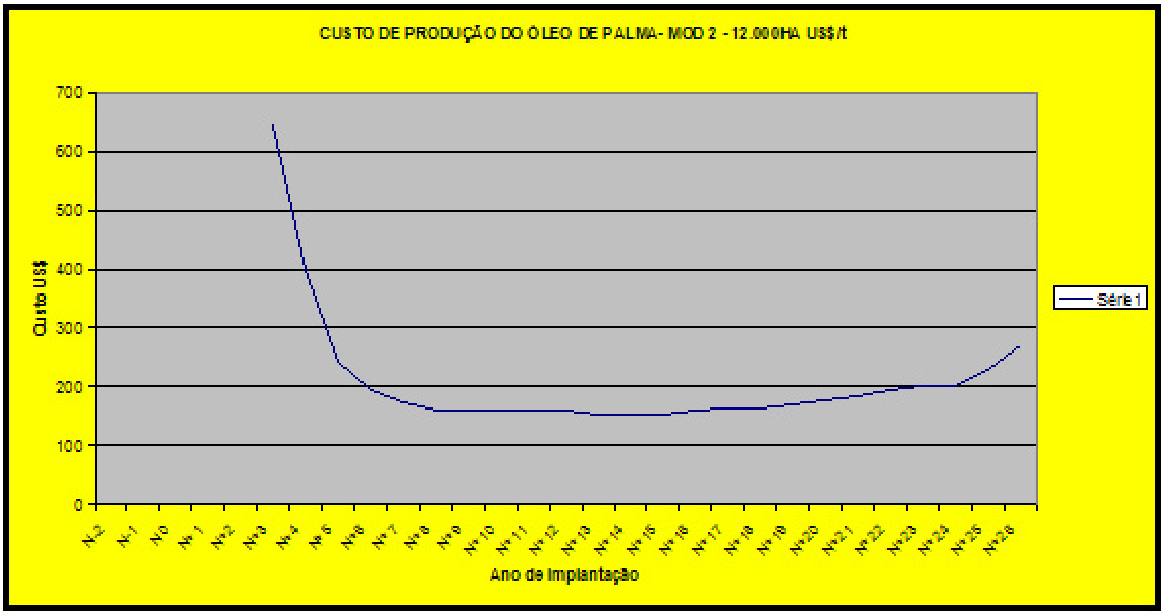
Description	Amount of Modules	Cost/Module US$	TOTAL US$
Land	**02**	**1,200,000**	**2,400,000**
Planting implementation	**02**	**8,628,000**	**1,256,000**
Equipment and agricultural infrastructure	**02**	**2,991,000**	**5,982,000**
Extraction Industries	**02**	**4,711,500**	**9,423,000**
Administrative Infrastructure	**01**	**1,636,105**	**1,636,105**
Investment Total			**36,697,105**

Estimated Productivity

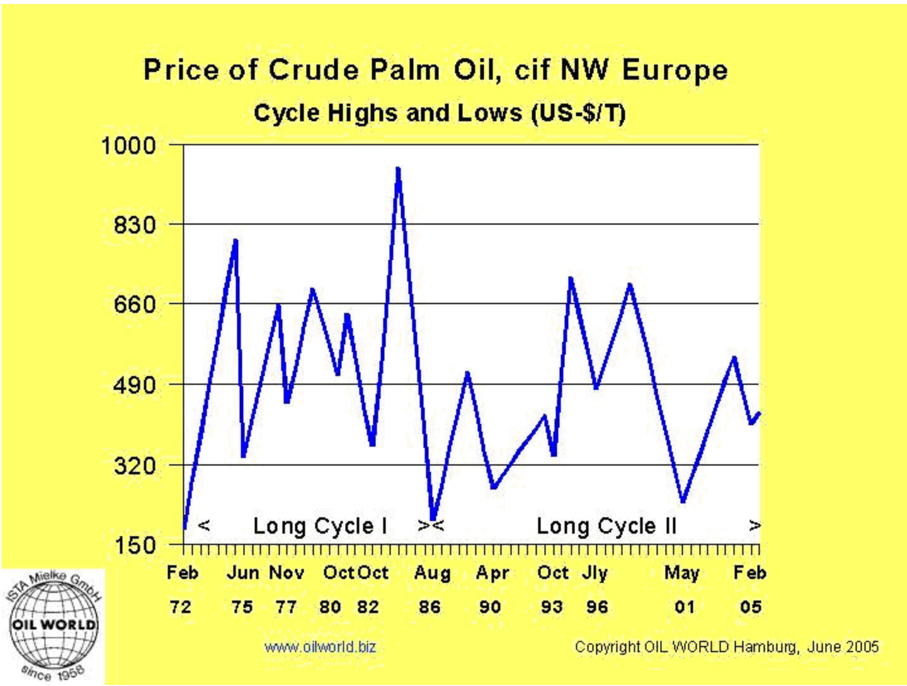
PRODUCTION PROJECTION					
YEAR	t bunches by ha	YEAR	t bunches by ha	YEAR	t bunches by ha
N-2	0.00	**N+8**	25.00	**N+18**	22.00
N-1	0.00	**N+9**	25.00	**N+19**	20.00
N 0	0.00	**N+10**	25.00	**N+20**	18.00
N+1	0.00	**N+11**	25.00	**N+21**	17.00
N+2	0.00	**N+12**	25.00	**N+22**	16.00
N+3	5.00	**N+13**	25.00	**N+23**	15.00
N+4	10.00	**N+14**	25.00	**N+24**	15.00
N+5	15.00	**N+15**	25.00	**N+25**	10.00
N+6	20.00	**N+16**	22.00	**N+26**	10.00
N+7	25.00	**N+17**	22.00		

The oil palm production cost is very stabile during the twenty years of effective production lifecycle (from the fifth to the twenty fifth year).

Enterprise Model for a 12,000 Hectare Area – Oil Production Costs



Palm Oil International Selling Prices - Confirm The Enterprise Potential



4 Sunflower oil (helianthus annus)

The Seed

The sunflower fruit, also called achene, is constituted by the pericarp (peel) and by the seed.

The peel is formed by three layers: external, intermediate and internal.

The seed is constituted by the tegument, endosperm and embryo. In general, the fruit or achene is commonly known as seed.

According to its use, there are two types of sunflower seeds: oily and non-oily.

The non-oily seeds are bigger, black, with stripes, have a thick peel (from 40% up to 45% of the seed weight), which is easily removable.

Also called as "confectionery varieties", the non-oily seeds are toasted, wrapped and consumed by human beings as almonds, mixtures of rapeseeds, cakes and "snacks", or as ration for birds.

The oily seeds are smaller and their peels are well adhered, representing from 20% up to 30% of the seed weight. The oily seeds are economically more important and from them the sunflower peel and its derivatives are produced, after oil extraction.

Chemical Composition of the Seed

The chemical composition of the seeds of any genotype varies widely according to the production place, climate and fertilizers and even according to the position of the seed in the chapter.

In botanical terms, the sunflower seed is constituted by pericarp (peel) and by the seed itself (pulp). The hybrids currently cultivated have up to 25% of peel and 75% or more of pulp.

The yield of the fruit oil or the whole seed is from 48 up to 52%.

The objective of the sunflower production is the elaboration of eatable oil and the use of the extraction by-products, such as: pie, "expeller" and / or flours for balanced rations for animal feeding.

More than 90% of the sunflower worldwide production is destined for the elaboration of eatable oil, and most of the remaining 10% for feeding of animals (birds) and direct human consumption. The sunflower oil is considered extremely digestible. The drying potential of the eatable oils is determined by their iodine index. This index is the indicator of the amount of oxygen that the oil can absorb until reaching its total saturation. Technically, this index is determined when verifying how many grams of iodine are absorbed by 100 grams of oil.

Industrialization

In order to obtain oil, before starting the extraction process, it is necessary to peel the seeds leaving approximately 7 up to 10% of peels adhered to the pulp, which allows the oil to slip into the pressed mass. The eliminated peels are usually used as fuel for boilers.

The achievement of crude oil, which must follow the refinement stage, varies according to the method used. The oldest and less efficient system is the one that uses the discontinuous press or simple extraction by press.

The method known as continuous press substitutes the previous one. Nowadays, the most used one is the combined method: continuous presses and, later, use of solvents, which wash the pressed material obtaining the oil by means of dilution and chemical distillation (the by-product obtained is known as extraction flour).

The sunflower oil obtained from the seeds has a small percentage of waxes derived from the peels of the seeds. In order to achieve a very refined and clear oil, the waxes must be eliminated by the process of "winterization" or centrifugation.

Sunflower oil

The sunflower oil is considered to be one of best nutritious characteristics in relation to other eatable vegetable oils, mainly due to its high content of linoleic acid.

It is among the best eatable vegetable oils and a gram of it can provide 8.8 calories, from which the organism can assimilate 98%.

Its high content of linoleic acid makes it the most recommendable in the prevention of cardiovascular diseases produced by excess of cholesterol.

The sunflower oil is considered semidrying and extremely digestive, which can be determined by its high rate of Iodine. "The higher the index of Iodine, the higher will be the content of linoleic acid." The yields of the crude oil by solvent extraction range from 40 up to 54% in a base of dry matter.

Being the healthiest in its segment, it contains in its structure the highest content of polyunsaturated fats and of linoleic acid as well.

In the middle of 1993, the consumption of the sunflower oil was of 4 thousand tons, amount that was surpassed in 1997 to 40.9 thousand tons due to the differential reduction of the soybean price. Based on this demand, Brazil had to import the raw material in order to meet it. Argentina stands out among the greatest exporters of this product.