ETHANOL

AS A VECTOR OF DEVELOPMENT: Challenges and Opportunities

BNDES
BRAZILIAN DEVELOPMENT BANK

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1. Renewable energy and development

Brazil is a leading international player in bioenergy and is set to remain so in the years to come, given the country´s natural resources, its vast accumulated experience in agriculture and industrial processing of sugar and ethanol and in the development of associated technologies.

The purpose of this document is to present Brazil´s strategy for ethanol which consists of using this sector as one of the country's vectors for long-term development. The text is organized in brief topics, which taken together, offer the evidence and arguments that justify this strategy. Topics covered include : land occupation and food supply; energy; the environment; employment and technological development. The final chapter outlines the Brazilian strategy and its goals.

When considering renewable energy sources as a vector of development, Brazil must take advantage of the opportunities created by its abundance of natural resources, extensive territory and technological capabilities, together with the environmental benefits derived from ethanol production. Few countries in the world have Brazil's potential not only to promote development on a more sustainable basis, but also to use the path to sustainability as a means for economic and social development.

The Federal Government is implementing a concerted strategy involving the private sector, academia and civil society with a view to sustainably and competitively stimulating the bioenergy economy in Brazil. This strategy recognizes environmental challenges and incorporates solutions to lead the country as a promoter of both Brazilian and global sustainability.

In a broader sense the success of the biomass economy, today largely driven by bioenergy, will create real and widespread opportunities for the development of various industries such as capital goods, ethanol-chemicals, automotive, aeronautics[2], foodstuffs, pharmaceuticals, plastics and environmental protection. In this effort, technological research and development are essential. Information technology, nanotechnology and biotechnology are the basic competencies that must be developed to support efforts in the bioenergy and biomass segments. These areas of specialization, and their development and application, are also indispensable for the progress of agribusiness and activities related to environmental protection.

These are the long-term prospects that guide the establishment and implementation of the Brazilian strategy for development of bioenergy and the biomass economy. It includes:

- Consolidate the country's leadership in ethanol;
- Develop cellulosic ethanol;
- Develop agrobiotechnology and nanotechnology; and
- Develop correlated industries.

2. The ethanol industry: the context

The ethanol industry is well developed in Brazil, given both the country's natural characteristics and its vast agricultural and industrial experience in the sugar-ethanol sector.

Brazil conducted its first tests mixing ethanol and gasoline in 1925. Nevertheless, the Brazilian fuel ethanol industry gained impetus only in 1975 with the launch of the National Ethanol Program (Programa Nacional do Álcool – Proálcool). The objectives were:

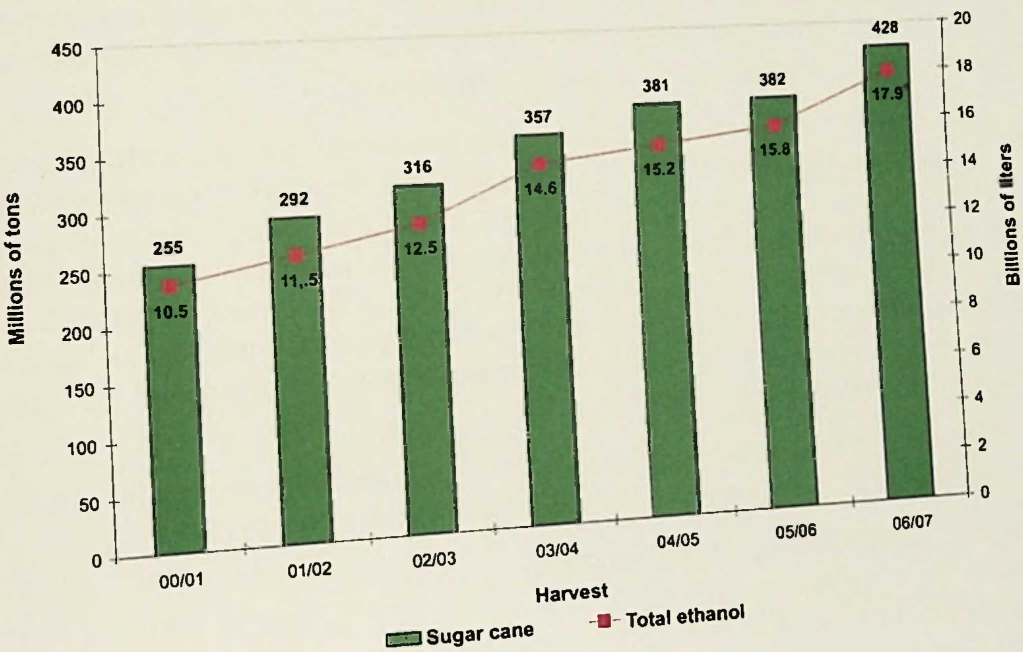
[2] Brazilian aeronautics company Embraer has developed the first aircraft powered by 100% hydrated ethanol, the Ipanema (EMB-202). The plane has received several international awards including one from "Flight International" in the category of General Aviation (June 2005) in Paris and "Scientific American 50" (December 2005) as one of world's best inventions of the year. The company has also announced the development of the first flexfuel aircraft in partnership with an Italian company.

(i) To establish a mandatory gasoline/ethanol mixture on the fuel market, and
(ii) To stimulate the development of ethanol-powered vehicle engines.

In the second half of the 1990s, the country adopted several measures flexibilizing fuel market regulations. These culminated in 2002 in the complete liberalization of prices throughout the production and commercialization chain.

Local auto manufacturers began making flexfuel cars in 2000, running on any mixture of ethanol and gasoline with automatic real-time adjustment of the engine. Currently, nine multinational automakers installed in the country produce 100 different models of flexfuel vehicles. Between 2003 and 2007, 3.55 million flexfuel vehicles were sold, bringing their market share to 89.3% of all new car sales in the first half of 2007. The growing use of flex vehicles impacted the trend of sugarcane and ethanol production, as can be seen in Graph 1. Ethanol production has increased 70% in the last six years.

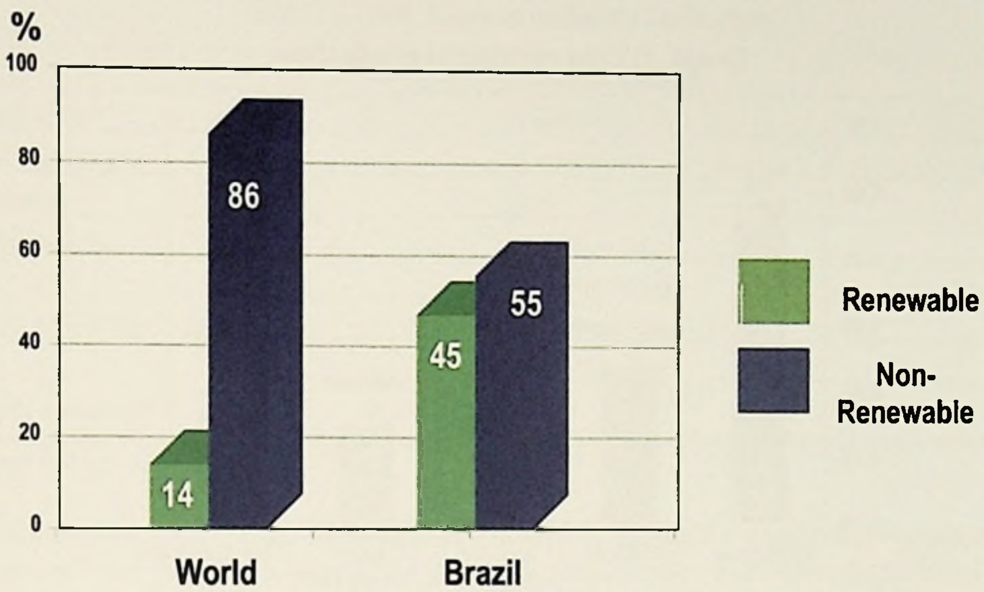
Graph 1: Growth of Sugarcane (in millions of tons) and Ethanol Production (in billions of liters) 2000- 2006



Source: DCAA/SPAE/MAPA

The substantial participation of renewable energy in the Brazilian energy matrix reflects the expansion of the ethanol industry:

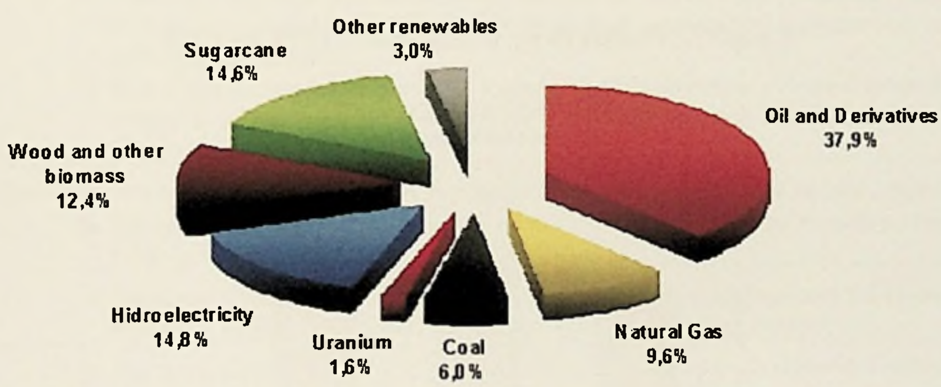
Graph 2: 2006 Energy Matrix – Brazil and the World



Source: Ministry of Mines and Energy – National Energetic Balance (2007)

Sugarcane energy is responsible for one third of renewable sources. In 2006, sugarcane accounted for 14.6% of the energy grid, just below hydroelectricity (14.8%) among other sources (Graph 3).

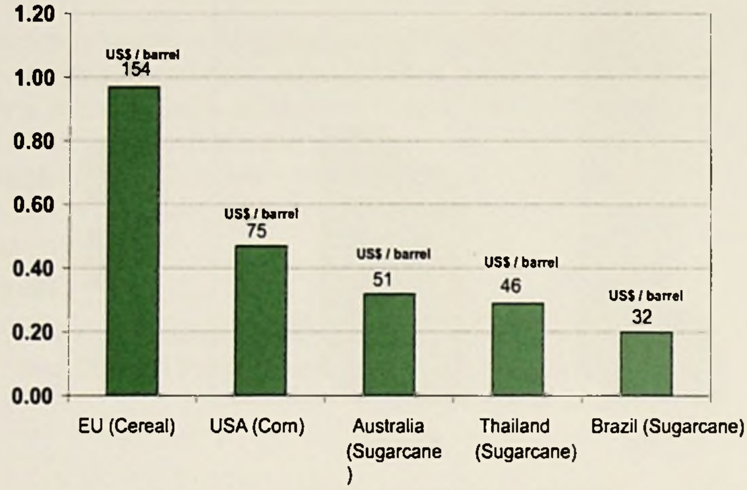
Graph 3: Brazilian Energy Matrix – 2006



Source: Ministry of Mines and Energy – National Energetic Balance (2007)

It is worth mentioning that the expansion of the Brazilian ethanol industry has occurred competitively, as illustrated in Graph 4:

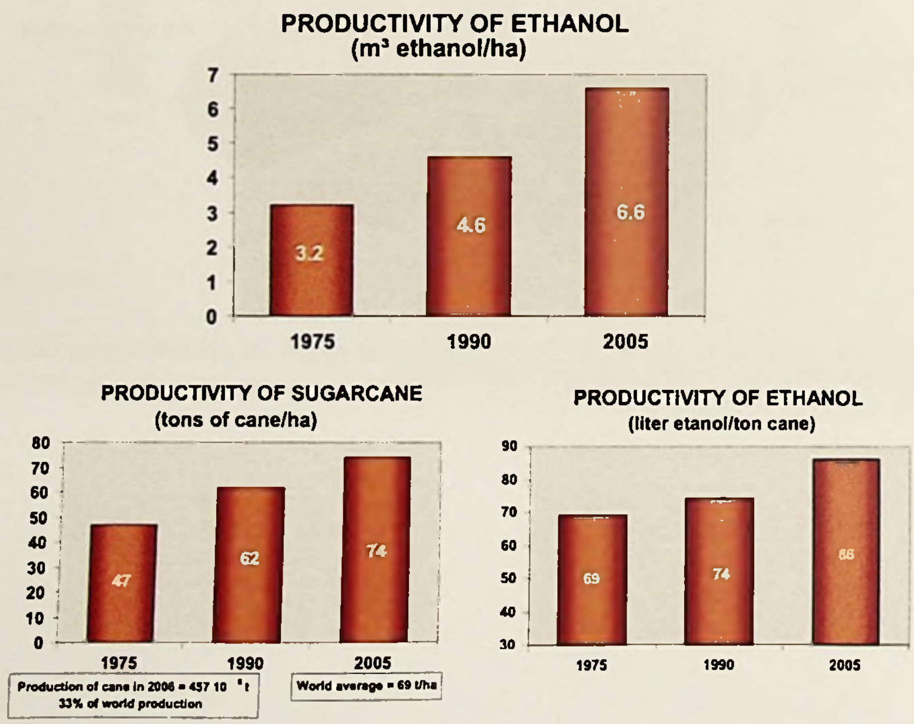
Graph 4: Cost of ethanol production



Source: DATAGRO (*in* "New trends to the ethanol supply chain in Brazil", Simoes, R.B., Master Thesis, Universiteit Van Tilburg, Holland, July 2006)

This competitiveness is derived in part from the country's long term experience in the systematic production of ethanol. The result has been significant productivity gains, both in sugarcane cultivation and the industrial processing to obtain ethanol.

Graph 5: Productivity of ethanol – 1975 to 2005



The ethanol industry's main indicators for 2006 are detailed in Table 1 below:

Table 1: 2006 Ethanol Industry Indicators

Planted area	3 million hectares
Jobs in the harvest*	1 million
Direct and indirect jobs*	3.6 million
Mills/distilleries	355
Production capacity	20 billion liters
Production	18 billion liters
Gas stations with ethanol pumps	95% of all gas stations
Exports	3.4 billion liters

Source: MAPA, MME, MDIC

* Employment statistics include the total number of workers involved in sugar cane planting and processing in mills that produce both sugar and alcohol.

It is important to note that the use of ethanol as a biofuel is also being undertaken by other countries. Many have defined goals to reduce their gasoline consumption and have established targets for ethanol usage, as outlined in Table 2.

Table 2: Prospects for ethanol usage in diverse countries

Country/bloc	Targets
USA	• Legal requirements will result in consumption of at least 28,35 billions of liters of biofuels starting in 2012. The government, however, has set the goal of reducing by 20% gasoline consumption in the next ten years (5% with energy efficiency and rationalization measures and 15% by replacing it with ethanol). As a result, potential ethanol demand will be 80 billion liters per year. • Part of this demand will be met by imports. Caribbean countries export ethanol to the United States under the Caribbean Basin Initiative (CBI), with a share up to 7% of the American domestic market.
European Union	• The target for 2010 is to have renewable fuel account for 5.75% of consumption. • The tendency is for internal production to rise, supplemented by imports preferably of raw materials.
China	• The target for 2020 is to consume 16 billion liters of fuel ethanol and 5.5 billion liters of biodiesel. In 2006, the country produced 5.3 billion liters of ethanol.
India	• The 5% mixture of ethanol in gasoline (E5) is mandatory in 10 states (0.4 billion liters of ethanol).
Japan	• The target is to use E10 in 10 years. • The target for 2030 is to reduce the dependency on petroleum from 98% to 80%.
Peru	• The target is to use E7.8 in 2010 (107 million liters)
Colombia	• E10 is mandatory.

Source: President´s Office, Brazil

3. Availability of land and food supply

In the debate surrounding ethanol production, it is frequently mentioned that there could be competition between sugarcane and food for land usage and that there would be a negative impact of the expansion of sugarcane planting on the environment, particularly in the biomes of the Amazon Forest and the Pantanal wetlands.

This concern is relevant but groundless if expansion is correctly planned and conducted as it is the case. Brazil still has an abundance of available land and the country's strategy will be implemented in such a way that the expansion of sugarcane and ethanol production will occur without jeopardizing the environment or food production.

The debate surrounding the conflict between biofuel and foodstuff production is a very real one in other countries. In the United States, the increase in ethanol production – which is primarily based on corn – has used larger and larger quantities of grains and the effects have been felt in the price of the commodity.

In Europe, this situation is similar. Several countries like Sweden and Germany have considered increasing ethanol production using wheat. In France, ethanol production is based on beet molasses.

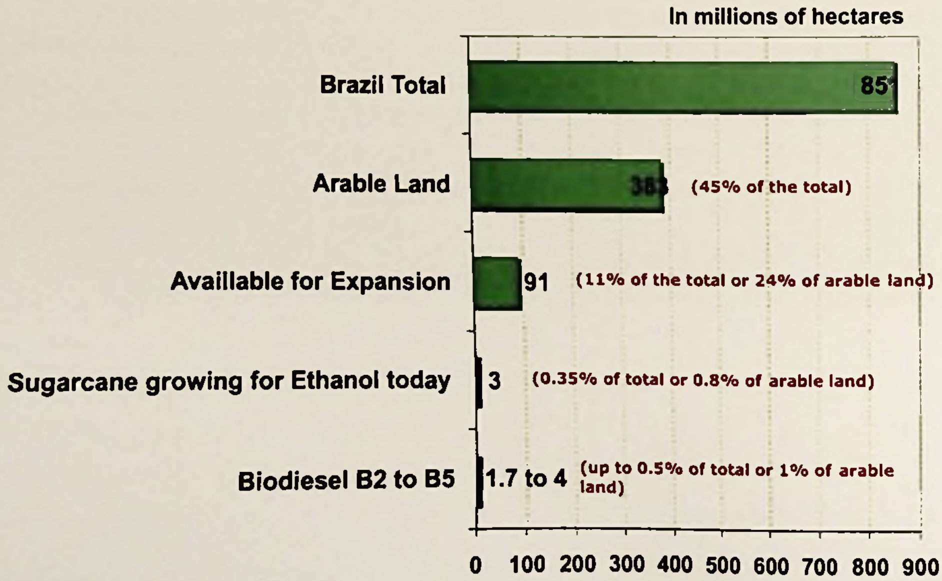
This theme has become part of the international debate essentially because of the situation in developed countries. In Brazil, however, the context is entirely different.

Currently, sugarcane ranks fourth among Brazilian agricultural activities, by area of occupation, and 14th worldwide (FAO, 2003). Brazilian farmland is mainly occupied by pasture. After livestock, soybean and corn are the segments utilizing the most Brazilian land.

It has to be highlighted that, although there is plenty of land available, Brazil's grain production growth is based on productivity rise. In comparison, grain production went from 57,9 millions of tons in the 1990/91 season to 130,5 millions of tons in the 2006/07 season, while cultivated area went from 37,9 million hectares to 46 million. That means a 85% rise in productivity (source: CONAB-MAPA).

Graph 6 presents the data for Brazilian arable land. It is clear that sugarcane does not occupy a very great area. Although it is the fourth largest agricultural activity, in terms of area, sugarcane occupies just 0.35% of the total country and 0.8% of Brazil's total arable land. Nevertheless, expansion will require incorporation of new areas.

Graph 6: Brazil – arable land



Source: President's Office, Brazil

According to the Ministry of Agriculture, Livestock and Supply, Brazil has some 91 million hectares of arable land available for expansion. Beside, 200 million hectares are pastures, of which some 50 million hectares are degraded. It is worth noting that Brazilian ranching offers significant potential for productivity gains. This should allow for increased density of land occupation, so freeing up pasture areas for other crops.

The conclusion is thus that there is sufficient land for significant expansion of sugarcane growing. The outlook becomes even more optimistic when it is factored in the likely prospect for technological progress, using virtually the entire sugarcane biomass for production of ethanol. This could drastically reduce requirements for growing areas.

In short, given Brazil's land availability, it is highly unlikely that the country will experience the same type of competition between bioenergy and feedstock crops that may be seen in other countries.

4. Agroecological zoning and the Socio-Environmental Certification

Despite the ample availability of arable land, careful attention must nevertheless be paid to the type of occupation in available regions and to the problems associated with expansion of occupation in specific biomes (the Amazon region, the Cerrado woodland-savannas and the Pantanal wetlands, etc...). In this respect, the expansion of ethanol production must follow parameters for preservation, sustainability and recovery of Brazilian ecosystems.

As seen above, ethanol expansion should occur preferentially in areas or pastures that have already lost their cover of native vegetation. Nevertheless, land occupation in Brazil is subordinated to legal instruments that designate protected areas, and provide Integrated Environmental Analysis and, principally, Economic Ecological Zoning (ZEE).

It is worth pointing out that the current varieties of sugarcane – which will be widely used over the next four to five years – require soil and climatic conditions that are not found in the biomes that predominate in the Amazon and Pantanal. There is, therefore, a natural barrier to planting there.

On the other hand, sugarcane growing could eventually result in the relocation of other crops. For example, the pressure caused by the increased demand for ethanol could induce expanded sugarcane growing into areas currently occupied by soybean, so pushing this crop into new agricultural regions. There is, however, no evidence of such a process. Because land is widely available, this movement may take place without affecting sensible ecosystems or even endangering areas of preservation.

In five to six years, however, the current sugarcane varieties could be substituted for varieties with less sucrose and greater humidity requirements. This could present a threat to regions near or bordering the protected biomes, although the lower concentration of sacharosis increases transport and industrial processing costs.

It is clear that the economic-ecological zoning is essencial to ensuring the preservation and sustainability of Brazilian ecosystems as ethanol production expands.

In this respect, Brazil is implementing an agroecological zoning to support this process of ethanol expansion. One instrument of this zoning policy is the production and use of maps with descriptions and analyses of potential for different varieties of sugarcane. These maps distinguish four types of areas:

(i) Existing sugarcane and ethanol production areas;
(ii) Induced (priority) areas;
(iii) Regions suitable for planting, based on agroclimatic conditions; and
(iv) Legally or environmentally restricted areas.

Besides zoning, Brazil is creating a Socio-Environmental Certification. In addition to meeting other environmental and labor requirements, to obtain the associated certification a producer must have proper licensing and resolve environmental liabilities. Other social and environmental standards established by the certification will be discussed later in this document.

This careful attention to the type of occupation in new areas does not exclude the requirement that all sugarcane expansion projects preserve native vegetation around river catchment areas and in legal forestry reserves. And for areas already being farmed, reforestation requirements have to be observed.

The participation of the productive sector and licensing agencies is essential to the recuperation of Permanent Preservation Areas (vegetation around river catchment areas, water sources, hilltops, lake and lagoon shorelines, etc) and Legal Reserve areas. Legal reserves represent a certain percentage of a rural property that must be set aside as protected forest. Normally, this percentage is 20%, but can be as high as 80% in the Legal Amazon area and 35% in the savanna-woodlands of the Legal Amazon.

Brazil's environmental bodies in conjunction with productive sectors are preparing to establish procedures for compliance with legal reforestation and preservation requirements. Licenses for agribusiness projects will incorporate these procedures. Environment benefits should include water resource preservation, erosion control, reducing sedimentation and preserving biodiversity.

In addition to the positive environmental impact, these measures will guarantee the role of Brazilian ethanol as an agent of reforestation for native species.

5. Power generation and energy efficiency

One of the major challenges facing the expansion of the ethanol sector in Brazil is installing units that offer (a) higher levels of energy efficiency, and (b) potential to sell excess electric power resulting from cogeneration using bagasse and cane straw. In this way, expansion of ethanol production can also contribute to the country's electricity generation requirements.

Almost two-thirds of the potential total energy of sugarcane is contained in the bagasse and cane straw. With utilization of this biomass and with greater efficiency in the use of steam in industrial processing, more electric power can be generated for external sale.

Table 3 presents the main data on power generation from sugarcane bagasse. Currently the country's installed capacity of thermoelectric plants using sugarcane bagasse as fuel is 2,800 MW. However, depending on the co-generation technology adopted, it is estimated that installed generation capacity could reach 20,000 MW.

Table 3: Power generation from sugarcane bagasse

Installed capacity at all thermoelectric plants	20,900 MW (21% of national total)
Installed capacity at thermoelectric plants using sugarcane bagasse	2,800 MW, of which: – 554 MW exclusively for internal production – 2,000 MW independent power production
Estimated potential for installed capacity	20,000 MW
Commercialization of energy	1234 MWh in power auctions from December 2005 to July 2007

Source: ANEEL (2007)

The country is currently creating a favorable institutional and regulatory framework to take advantage of this potential with norms that foster cogeneration and stimulate the use of cutting-edge technology and the mechanization to harvest and process straw. Regulations and improved credit conditions are encouraging sector entrepreneurs to adopt turbines with 60 – 90 Bar boilers, whose higher pressure allows for more efficient burning of the bagasse.

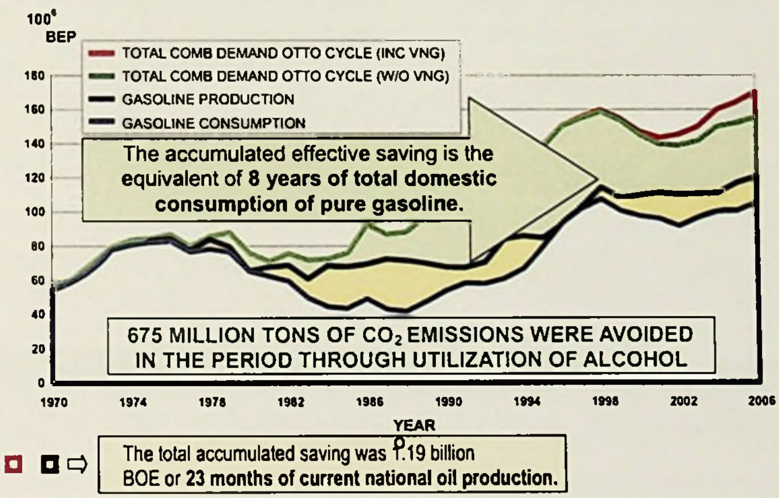
6. Greenhouse gas emissions and the energetic balance

Ethanol and sugarcane bagasse have contributed to the reduction of Brazil's greenhouse gas emissions. Ethanol is a substitute for gasoline, while bagasse substitutes fossil fuels (oil) to generate steam which is used as thermal energy in the ethanol production process, as mechanical energy in powering machines and to produce electric power.

It is currently estimated that by substituting gasoline (containing 25% anhydrous ethanol) with hydrated ethanol and also by substituting fuel oil with bagasse, Brazil avoids emissions equivalent to 2.6 tons of CO_2 emissions per m^3 of anhydrous ethanol and 1.7 tons of CO_2 per m^3 of hydrated ethanol.

Just with the utilization of ethanol, Brazil has avoided emissions estimated at 675 million tons of CO_2 from entering the environment, as shown in Graph 7:

Graph 7: Demand for auto fuel



Source: MME – BEN (2006)

With respect to the total energy balance in the production of ethanol from sugarcane, Brazil currently enjoys a renewable energy production/fossil inputs ratio averaging 8.3, on a scale of 8 (mechanized harvesting) to 9 (manual harvesting). This is based on the average in the country's main sugarcane growing region, the Center-South. Table 4 shows the composition of the energy balance in Brazil, and the projection for 2020.

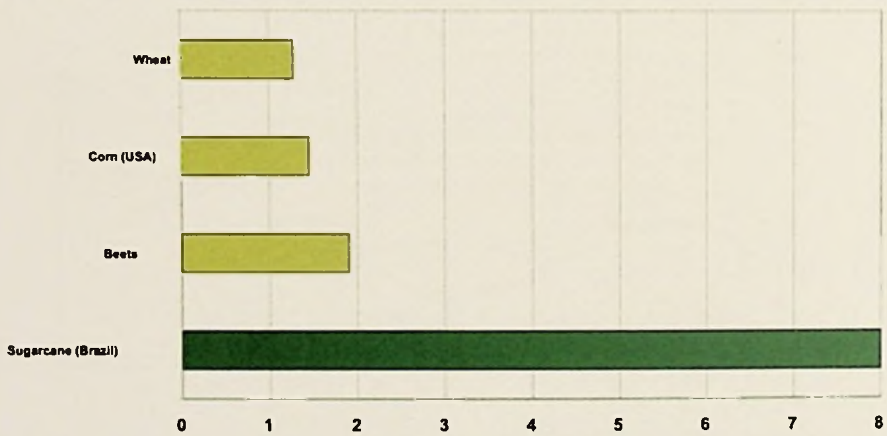
Table 4: Energy balance in ethanol production – 2004 to 2020

Item	Average values (MJ/tc)			
	2004		2020	
	Input	Output	Input	Output
Agriculture	201.7		191.0	
Industry	49.4		43.1	
Ethanol produced		1,920.9		1,919.7
Bagasse / straw		169.6		0.0
Surplus energy		0,0		776,5
Total	**251.1**	**2,089.5**	**234.1**	**2,696.2**
Production / consumption	**8.3**		**11.5**	

Source: Macedo, 2004 and Seabra, 2006
Obs.: MJ/tc = Mega-joule per ton of sugarcane.

At the moment, the world has no other production system that even approaches these values. The same ratio for corn-based ethanol production in the United States is more controversial, oscillating between 1.1 and 1.4. Graph 8 shows the energy balance in ethanol production using different raw materials.

Graph 8: Energetic balance in the production of ethanol 2006



Source: F.O.Licht (2006)

The ratio is so much better for sugarcane because the bagasse can also be used to produce energy. The same is not true for corn. By introducing higher pressure boilers and utilizing the energy contained in the straw, the excess energy supply can be substantially increased, pushing the renewable energy/fossil input ratio up to between 11 and 12.

In short, ethanol is an important way to prevent greenhouse gas emissions. Sugarcane-based ethanol has the highest energy balance of all raw materials. The energy obtained from the fuel is 8.3 times greater than that consumed in making the fuel.

7. Facing social-environmental challenges

Without a doubt, old practices no longer satisfy the modern demands of the ethanol industry and Brazil is committed in continuously improving the economic, environmental, social and energetic indicators of sugarcane and ethanol production.

Historically, sugar and ethanol create three main sources of pollutants: (a) the practice of burning the fields before harvesting the cane; (b) atmospheric emissions from cogeneration units (heat and electricity) burning bagasse; and (c) liquid effluents, mainly from waters used to wash sugarcane and the vinasse slurry from distilleries. Additionally, there are environmental impacts on water resources and due to use of fertilizers and insecticides.

a) Vinasse

Modern sugar-ethanol mills have made remarkable advances towards resolving these problems by reusing byproducts of the productive process that were formerly discarded.

Thirty years ago, the most visible environmental problem related to ethanol production was vinasse, an acid byproduct that previously found its way into rivers and lakes, causing serious pollution levels in Brazil's Southeast and Northeast. Today, vinasse is utilized mainly as a fertilizer in the harvest. Bearing in mind the limits for this type of utilization, linked to the soil and groundwater, an alternative is the biodigestion of vinasse to produce biogas. This fuel can be used as thermal energy or to generate electricity.

b) Burning

To deal with atmospheric emissions, some State governments in Brazil are establishing deadlines to end the tradition of burning sugarcane before harvesting, a practice that generates large quantities of particle matter. In São Paulo, the cutoff date for burning has been brought forward from 2021 to 2014 in areas where mechanized harvesting is possible. For areas that cannot be mechanized, the deadline is 2017. The most modern harvest techniques are mechanized and do not rely on burning.

In January 2007, the National Environment Council (CONAMA) published Resolution No. 382/06 to regulate atmospheric emissions from fixed sources. The resolution establishes monitoring criteria, as well as standards and emission limits for particle matters, nitrogen oxides and carbon monoxide.

c) Water use

It is also relevant to consider the important reduction in water use in ethanol production plants, principally by limiting sugarcane washing and using closed-circuit water systems.

The program to reduce water usage has been stimulated by restrictions, including the introduction of charges for water usage. It is based essentially on the optimization of processes (dry cleaning) and internal reutilization of water, and has cut from 5 m^3 to 1 m^3 the volume of water used to process each ton of sugarcane in some producing unities, according to calculations by NIPE/Unicamp.

d) Use of fertilizers

Thanks to technological progress, the sector expects to see a reduction in the quantity of chemical fertilizers used, an input that can represent 35% of production costs. The current (2006) average utilization is 200 kg of NPK per hectare, according to Embrapa. The most important raw material is nitrogen and special effort is being made to develop its biological fixing process, as it happens with leguminous plants.

The Socio-Environmental Certification

Brazil is establishing high socio-environmental standards for bioethanol production. To this end, as mentioned above, the government is creating a Socio-Environmental Certification , which will be awarded only to producers who comply with the following environmental requirements:

- Proper licensing, and resolution of environmental liabilities;
- Rational water and energy use, with sustainable use of other natural resources;
- Reducing pollutant and greenhouse gas emissions; and
- Giving preference to already occupied areas, with low productivity and/or environmental degradation.

Prerequisites for labor relations include:

- Compliance with the national collective labor agreement. This stipulates that workers shall be properly registered and that employers respect for all labor laws, with proper health standards and transportation for workers, among other things. Region-specific requirements will have additional clauses.

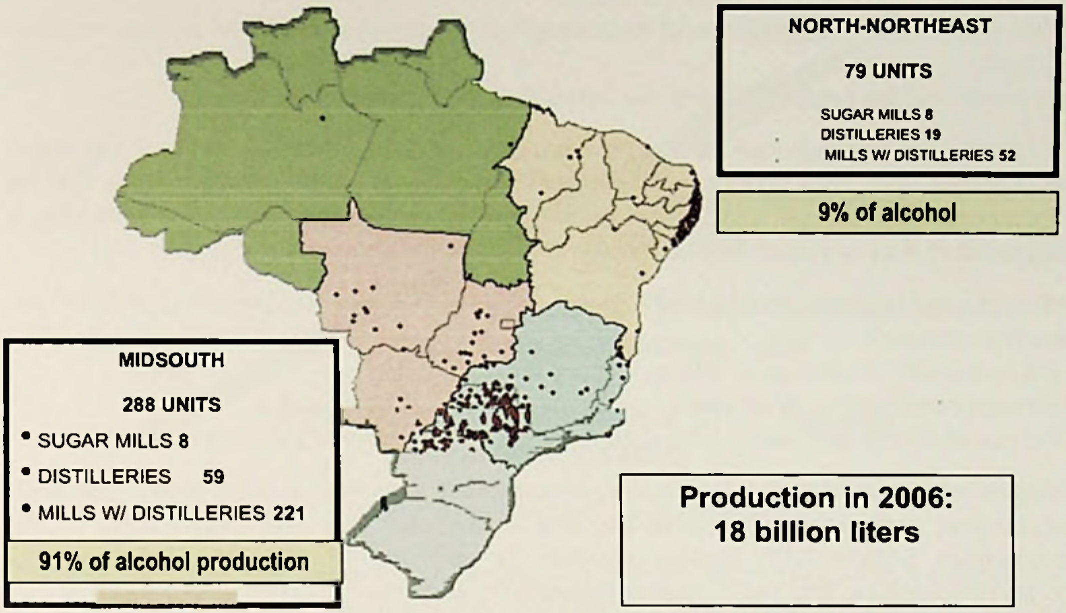
The certification will thus indicate which producers meet good socio-environmental standards for criteria of sustainability, labor conditions and environmental norms.

The expectation is that the Socio-Environmental Certification becomes an important differential for producers, stressing the compromise, both from the government and the private sector, to look for alternatives that are socially as well as environmentally sustainable. This will hopefully ensure foreign partners, strengthening the process of setting up an international market for ethanol.

8. Socio-economic impacts and regional development

Production of biofuels is an opportunity to raise income, reduce inequality and promote national development. In Brazil, sugarcane and ethanol production is largely concentrated in the state of São Paulo (roughly 65% of national production) and in the Center-South (85% of total) – see the following map:

Figure 1: Location of sugar/ethanol mills in Brazil



Source: MME, MAPA, UNICA (2007)

The expansion of sugarcane is today occurring in the Center-South, particularly in the "Triangle Region" in the West of Minas Gerais State, Southern Goiás and Mato Grosso do Sul. Nevertheless, there are adequate growing areas for sugarcane expansion in the Midwest, Northeast and North.

Ethanol production has a significant impact on the expansion of income, job creation[3] and surplus energy generation. Therefore, if sugarcane growing expands in the Northeast and Midwest, it will help promote a reduction in regional inequality. The direct and indirect effects will be concentrated in local markets, even if the Southeast is responsible for a great part of indirect and induced effects on the production chain, since it is the most developed region in the country.

Given the potential for income generation, ethanol is expected to increase per capita income in those of the country's poorest regions that produce it. Ethanol production will thus favor a reduction in the regional disparities and improve the distribution of income.

9. Ethanol: a future commodity

Despite its privileged position in the world ethanol market, Brazil is aware that certain mechanisms must be created in order for other countries to become producers and consumers of ethanol. The governments of Brazil, China, India, South Africa, the United States and the European Union launched the International Biofuels Forum in March 2007. This initiative springs from an understanding that it is necessary to expand international cooperation to foster dialogue between large biofuel producers and consumers to help increase the efficiency of production and distribution of these fuels on a global scale.

The Forum will last for one year and will be structured as a series of regular meetings between participants. Workgroups will be organized to examine topics of interest. The following themes will be covered:

- Developing international norms and standards for biofuels;

[3] The expected jobs increase will occur despite mechanization of sugarcane, because it takes into account the total impact (direct, indirect and induced).

- Infrastructure and logistics;
- Matters related to international trade in biofuels;
- Information exchange on scientific and technological progress (second and third generation biofuels); and
- Initiatives involving the organization of the 2008 Biofuel Conference in Brazil.

The goal of creating an international market for ethanol is relevant. Although ethanol has major commercial potential, it is not a product with defined international parameters that allow it to be traded on exchanges around the world. In order for ethanol to become a global commodity, a homogenous product that is traded internationally, the following steps are necessary:

- Standardize ethanol in the context of international trade with established metrological standards and reference material;
- Create the possibility of storing or selling in standardized units;
- Market development with a diversity of producers and consumers; and
- Create the possibility of delivering on a date agreed upon by buyers and sellers.

When creating an international market for ethanol, it is important to include a vision of environmental and socio-economic sustainability, because the idea is to create jobs and employment in less developed countries. Sustainability implies a system for verifying the production system, with certification and traceability. This must be established in the commercial arena with general norms for the continent.

10. Technical progress guaranteeing energy and food security

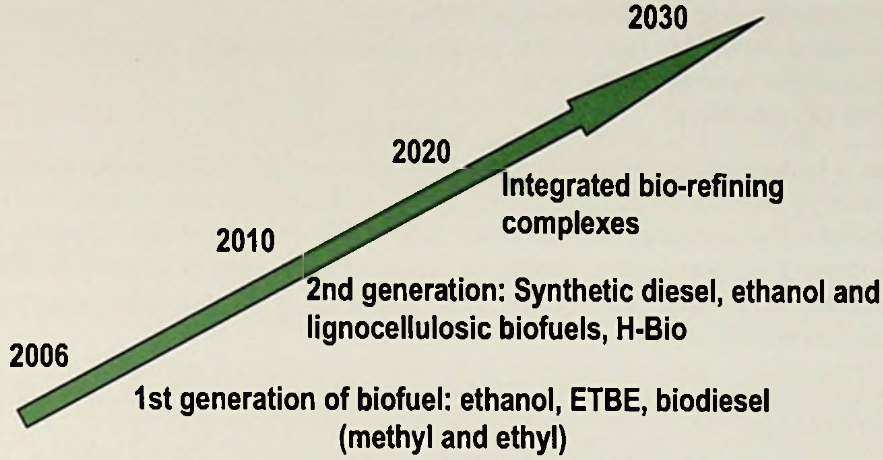
It is possible to foresee the day when technological barriers will be overcome and innovative processes for obtaining ethanol from lignocellulosic materials – extracted from bagasse, grasses and other vegetable residue – will be ready for commercialization.

Hydrolysis technologies may broaden the spectrum of biomass suitable for ethanol production. Another option is conversion of lignocellulosic biomass to produce synthesis gas (a mixture of hydrogen and carbon dioxide, mainly) and subsequent conversion to diesel, methanol and other fuels.

Although these technologies are not yet commercially viable, significant investments have been made to this end. Economies of scale from the expansion of biofuel consumption could decisively contribute to competitiveness of hydrolysis and of gasification with subsequent conversion to liquids.

Figure 2 presents the international trends for technological progress in the biofuels sector through 2030, according to estimates by the European Union's Biofuels Research Advisory Council:

Figure 2: International trends – 2006 to 2030



Source: BIOFRAC – EC (Biofuels in European Union: a Vision for 2030 and Beyond)

The new processes will allow for an increase in biofuels production without major expansion of planting. In short, lignocellulosic ethanol will allow for a combination of energy and food security. This is decisive especially for the United States and Europe. As mentioned before, several developed countries have difficulty in finding areas to expand crop growing to produce ethanol without affecting areas dedicated to production of foodstuffs, so generating a potential conflict between food and energy security.

Although Brazil has land available for the expansion of sugarcane growing and ethanol production under prevailing technological standards, the development and implementation of new hydrolysis and gasification technologies for bagasse and straw is a central element of Brazil's strategy for developing bioenergy. The country is equipped to meet the challenge and technological progress will confer greater competitiveness on the ethanol industry, generating positive impacts for environmental responsibility, the development of correlated industries and national development in general.

11. Brazil's strategy and expected results

The Brazilian strategy for the energy sector envisages:

- An increase in the share of biofuels in the national energy matrix;
- Environmental protection;
- Energy security; and
- Protection of consumer interests.

Nevertheless, Brazil has the capacity to not only stimulate development on a more sustainable basis, but also to use sustainability to promote economic and social development. This document has described the basis of the Brazilian strategy, which incorporates ethanol as a vector in the country's long-term development process.

This concerted strategy involving the private sector, academia and civil society seeks to sustainably and competitively stimulate the country's bioenergy economy. The strategy recognizes and incorporates solutions to the socio-environmental challenges. More specifically, it aims to:

- Consolidate the country's leadership in ethanol;
- Develop lignocellulosic ethanol;
- Develop agrobiotechnology and nanotechnology;
- Develop correlated industries like capital goods, ethanol-chemical, automotive, aeronautics and pharmaceuticals, among others; and
- Promote social development.

Brazil today has a mature ethanol industry with a long history. In 2006, production reached 18 billion liters. Although the country has sufficient arable land for significant expansion of sugarcane, and competition between bioenergy and feedstock crops is improbable, Brazil is aware of potential risks and it has created agroecological zoning to support the process of ethanol production and expansion. Expansion of ethanol will comply with standards of preservation, sustainability and recovery of Brazilian ecosystems.

Ethanol has proven to be a significant tool for reducing greenhouse gas emissions. Through utilization of ethanol alone, Brazil has avoided emissions of an estimated 675 million tons of CO_2. Sugarcane offers the best energetic balance of all raw materials currently used to produce ethanol. The energy contained in a given amount of sugarcane ethanol is 8.3 times greater than the energy consumed in making that amount. The ethanol industry also contributes to electricity generation. Brazil is currently adopting measures to expand from 2,800 MW to 20,000 MW its installed capacity for surplus energy generation using bagasse, so making the sector's overall energy balance even better.

Brazil is committed to continuously improving its economic, environmental, social and energetic indictors for sugarcane and ethanol production. As a way of establishing standards for bioethanol production, Brazil is creating a Socio-Environmental Certification that will certify a producer's compliance with sustainability, labor and environmental criteria.

Brazil sees biofuels as an opportunity to raise living standards, reduce inequality and promote national development. Depending on the regions chosen for this expansion, ethanol can be an important instrument for reduction of inequality in the country.

In the international arena, Brazil, in March 2007, together with China, India, South Africa, the United States and the European Union launched the International Forum of Biofuels. This initiative stems from a vision that it is necessary to intensify international cooperation to foster dialogue between large biofuel producers and consumers with a view to contributing to an increase in the efficiency of production and distribution of these fuels on a global scale.

With regard to technological development, international trends suggest that lignocellulosic ethanol will be adopted around 2010, with integrated biorefineries around 2020. Lignocellulosic ethanol will allow for a combination of energy and food security which is decisive particularly for the United States and Europe.

Brazil will continuously pursue the development of new technologies as part of its bioenergy strategy. The country is prepared for this challenge and recognizes that technological development will mean greater competitiveness for the ethanol industry and have positive impacts on environmental responsibility, for the development of co-related industries and for the country's overall development.

Based on this development strategy, the Brazilian government is projecting significant investments through 2010 in new mills and distilleries to produce ethanol and in infrastructure to transport the fuel, as shown in Table 5:

Table 5: Targets for the ethanol sector

Program	Unit	2007	2008-2010	Total
Ethanol	Production (billion l/year)	19.1	23.3	–
	New mills	17	60	77
	Investment (R$ billion)	2.67	9.42	12.09
Pipelines - ethanol and multifuel	Km of pipeline	0	1,150	1,150
	Investment (R$ billion)	0.02	4.09	4.11

Source: Casa Civil (2007)

New plants will be able to produce an average of 100 million liters/year each.

In this way, Brazil is giving an example of how to use a specific asset, combined with the benefits derived from its physical size and natural resource endowments, to drive national development in an innovative and contemporary manner. It is innovative because the strategy of utilizing ethanol as a vector of development is rooted in Brazil's long history in the sector and is building upon technological progress. Contemporary, because the Brazilian strategy is a firm, concrete and proven demonstration of the country's contribution towards meeting the socio-environmental challenges now facing the planet.

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