Inter-American Institute for Cooperation on Agriculture

AGROENERGY AND BIOFUELS ATLAS OF THE AMERICAS

I. Ethanol

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Foreword

This document is the first of a series on the current state of agroenergy and bio-fuel production in the Americas.

This volume presents information about the current state of and outlook for ethanol production in several countries of the Americas.

The second volume of the Atlas will deal with the subject of biodiesel production, while the third and last in the series will focus on agroenergy in the western hemisphere.

This document was produced at the request of the Inter-American Ethanol Commission, which, after it was created in December 2006, invited the Inter-American Institute for Cooperation on Agriculture (IICA) to be one of its strategic partners in the hemisphere. The Commission prepared and sent IICA a questionnaire about the current state of ethanol production in the Institute's member countries, with a view to ascertaining the different strengths and circumstances of each one.

IICA actually went beyond its original brief and hopes this publication will give readers a grasp of the situation regarding ethanol from a technical, apolitical standpoint. The aim is for all of us, working together, to make this increasingly important product a means of improving the standard of living of rural communities throughout the hemisphere.

The Institute wishes to thank all those who helped prepare, publish and launch this "Atlas of Agroenergy and Bio-fuels in the Americas-Ethanol", especially the Institute's 34 Offices in its Member States.

Special thanks must go to the IICA Offices in Nicaragua and Colombia, which played a key role in systematizing the data and in preparing and publishing the document.

1 Introduction

The end of the use of fossil fuels as a source of nonrenewable energy, primarily petroleum and its byproducts, appears to be in sight; over the medium term, it is unlikely that there will be sufficient quantities of these fuels to meet world demand. This situation, together with the environmental pollution and global warming generated to a large extent by the use of fossil fuels, poses a problem but at the same time provides an opportunity to harness renewable sources of energy.

Biofuel production has awakened great interest around the world because of developments on the economic, social, environmental, institutional and political fronts. On one hand, high oil prices mean that countries that are not self-sufficient in fossil fuels must spend a portion of their foreign exchange earnings on imports of hydrocarbons. At the same time, there is the social aspect of diversifying energy sources by using local resources and generating employment through greater demand for labor to produce those resources. This type of fuel is also less polluting and has less impact on climate change than fossil fuels.

In the short term, moreover, political events can have a decisive influence on oil extraction activities in the countries with the largest reserves, and this has an immediate effect on fuel prices and on the cost of agricultural and industrial production and services. The fact is that every increase in oil prices sparks concerns over its impact on overall economic growth[1].

The agricultural sector has great potential as a supplier of feedstock for generating energy, including the production of solid fuels (wood, plant charcoal and agroindustrial processing wastes), gaseous (biogas) or liquid fuels such as ethanol and biodiesel. It is on these last products that this document will focus, especially ethanol.

The ethanol industry in Latin America and the Caribbean is based primarily on the supply of sugarcane as a feedstock. Sugarcane producing and processing activities have experienced technological leaps, raising the productivity of agriculture and industry around the world. This progress can be seen in the fact that yields now exceed 100 metric tons per hectare. Sugar production has thus become more efficient.

Latin America and the Caribbean currently enjoy a good outlook in the sugar market, with the new opportunities offered by the international ethanol market, especially in the United States and Europe. Sugarcane already makes an important contribution to energy supply through the use of bagasse, and the prospect of using ethanol as a fuel opens up even greater opportunities

1 *SAGPyA (Argentina) and IICA, 2005.*

in Latin America for enhancing the economic, social and environmental impact of this crop.

Moreover, many countries of the region have broad expanses of land suitable for agriculture that have already been cleared and that are not being used for food production. Those lands are suitable for the cultivation of the African palm, which is the highest-yielding oil crop, by area, for producing biodiesel.

This document is the first in a series designed to publicize the development of the agroenergy and biofuels industry in Latin America and the Caribbean, as part of an observatory that IICA has developed for monitoring this progress, consistent with the mandates received from the Institute's member countries.

The document is based on responses that IICA Offices in the member countries provided in 21 questions. It seeks to provide a perspective on the current and potential output of feedstocks for ethanol production, with a particular emphasis on sugarcane and the state of the art in ethanol production, and the regulatory framework for its use as fuel in countries of the region.

The document is divided into two parts. The first provides an overview of sugar and ethanol production in Latin America. The second focuses on the status of agroenergy and biofuel production, broken down by country. In both cases, data is presented on gasoline consumption in the region, the minimum surface area required to produce E10 ethanol, the regulatory frameworks governing production, the use and management of biofuels, the research under way aimed at improving sugarcane and ethanol production, other crops that could be used to produce ethanol besides sugar, the interest that governments and the private sector have shown in promoting biofuel production and use, and the willingness of national institutions to associate themselves with the Inter-American Ethanol Commission.

2

Production of Ethanol in the Americas: General observations

2.1 Gasoline consumption and land area required for E10 ethanol production

Gasoline consumption in the region[2] is 635.7 million cubic meters (m^3). The biggest consumer countries are the United States (86.2% of the total), Mexico (6.21%), Brazil (2.52%), Venezuela (2.0%), Colombia (0.7%) and Argentina (0.7%), while the remaining countries account for 1.67% (see Table 1, Annex 1).

Currently, a portion of the feedstock produced by the 8 million hectares under sugarcane production in the region is being used to produce 33.6 million m^3 of ethanol. That production falls short of what would be required to use an E10 mix (10% ethanol, 90% gasoline) in every country in the region. To satisfy that demand would require 10.4 million ha of sugarcane, devoted 100% to ethanol production.

The sugarcane cultivation frontier could be expanded to this extent, bearing in mind that the available farming area is 585 million ha. Such an expansion would offer opportunities for greater investment in rural areas of Latin America and the Caribbean, and have a major impact on job creation, since it is estimated that every hectare of sugarcane generates one job in farming and in industry[3]. Further evidence that such an expansion of the sugarcane frontier is possible comes from data on the area potentially available for the crop, as well as the margin that exists for increasing productivity.

This means that if a further 2.4 million hectares were planted (barely 0.41% of the farmland available in the region), it would be possible to meet the E10 needs of all the countries and create 2.4 million jobs, thus making a practical and direct contribution to the creation of employment and living standards in rural areas. Preferably, the land used should be not suitable for food production.

Brazil alone could double its output of sugarcane and could improve its productivity to levels such as that of Colombia, which is one of the highest in the region and the world (see Table 2, Annex 1). Moreover, some countries have significant room for improving productivity in their sugarcane plantations, by making greater use of mechanization and irrigation. Countries such as Argentina, Ecuador, Nicaragua and Costa Rica have great room for improving the level of mechanization and expanding the irrigated area devoted to sugarcane (see Table 3, Annex 1).

[2] *The Americas, excluding Canada.*
[3] *La importancia de los biocombustibles en Colombia. Hernán Martínez Torres. Ministry of Mines and Energy of Colombia. Bucaramanga, May 18, 2007.*

In terms of industrial capacity, expanding ethanol production is feasible to the extent that the region has installed a sugarcane milling capacity and is developing a major distillery industry (see Table 4, Annex 1).

2.2 *Energy and environmental balance of the crops used to produce bio-fuels*

Concern about high oil prices and energy self-sufficiency are factors that affect the development of the countries. Many of them have the potential to produce bio-fuels because the tropical and subtropical crops used have a better energy and environmental balance than the crops that grow in the countries of the Northern Hemisphere.

	Ethanol		Biodiesel	
Energy balance (units of energy generated for each unit of non-renewable energy used)	Wheat	2	Sunflower	3.2
	Beet	2	Canola	2.7
	Corn	1.5	Soybean	3
	Sugarcane	8.3	Palm	9
Environmental balance (GHG emissions per ton of oil, in equivalent on of CO_2)	Beet	2.17	Soybean	2.6
	Wheat	1.85	Canola	1.79
	Sugarcane	0.41	Palm	1.73
	Straw	0.33	Wood	0.27

Source: ADEME, European Commission[4]

2.3 *Public policy for biofuel production*

A key aspect in promoting the production and consumption of biofuels has to do with the adoption of public policies, in other words, the rules of the game enforced by government and its role in promoting an area that is relatively new in all developing countries. We refer here, *inter alia*, to mandatory biofuels consumption policies, support for production and R&D, trade policies and any technical standards established.

The leading ethanol producing countries, such as USA, Brazil, Colombia, Argentina and Mexico, have a regulatory framework for the

production, use and management of ethanol. They establish percentages for the gasoline-ethanol blend and have various kinds of incentives for their production. In Latin American countries that do not have a regulatory framework there are now legislative initiatives that are or soon will be in the process of parliamentary review.

The most common element in biofuels policy in countries of the region is the effort to guarantee domestic demand for producers by requiring a progressively higher mix of ethanol in gasoline. In some countries, these measures are accompanied by specific production incentives and controls over domestic prices for ethanol, tied to international oil and sugar prices, and in some cases, the opportunity costs[4].

There are wide differences among countries in the degree of blends required, depending on the age of the ethanol production industry. For example, Brazil has set 20% levels for the entire country, and Colombia's blend requirements range from 5% to 65%. (Table 5, Annex 1).

2.4 *Research and development on ethanol and sugarcane*

Generally speaking, all countries in the region have agricultural research centers that conduct research into various aspects of feedstock production for biofuels, and the private sector plays a major role in these institutes (see Annex 2). Yet research and innovation for ethanol production is limited to a few countries, such as USA, Brazil, Mexico, Colombia and Argentina, while countries with fewer possibilities such as those in Central America, Belize and Panama require technical cooperation from more developed countries in this regard (Annex 2).

In traditional sugarcane producing countries, research focuses primarily on increasing agricultural output and productivity, and on certain aspects of the ethanol production process, seeking to enhance their capacity to supply their domestic ethanol markets and to participate in the international market.

There is great interest in all countries in seeking alternatives to corn and sugarcane for ethanol production. Such alternatives include sugarbeets, yucca, sweet sorghum, and caña panelera ("brown sugarcane", usually grown on small-scale farms).

Agricultural research into the production of biofuel feedstocks is

[4] *In this case, the opportunity cost is the profit that national producers make, or the loss they incur, if they use the sugar they normally export as raw material for the production of a new good or to reduce imports of fossil fuels for domestic consumption.*

focused on developing varieties, especially of sugarcane, that will produce greater yields, and on evaluating other feedstocks, such as corn, sweet sorghum, yucca, dairy byproducts and beets, and testing to determine the energy performance of ethanol-gasoline blends (Table 6, Annex 1.)

The private sector is making an important contribution to such research, especially in institutions affiliated with sugarcane and sugar producers' associations and, in some cases, in publicly owned oil companies.

The most important technological development over the medium term has to do with producing ethanol from cellulose. The industry is confident that within five to ten years this technology will have advanced to the point where industrial output is feasible, and this will expand the feedstock base significantly. In that case, new farming crops (plants with high cellulose production potential), agricultural wastes, wood and even municipal garbage could form the basis for producing ethanol. Countries such as Chile, which has a long tradition in exporting wood products (11.6% of total exports), will have an industrially viable opportunity in the ethanol market. Canada is a leader in R&D into technologies that could promote this development.

Another relevant factor is Venezuela which, despite its enormous oil reserves, has introduced R&D programs in the production of sugarcane and soybeans with a view to producing not only food but also biofuels. Brazil and Argentina are cooperating in these initiatives, which are also being driven by concerns over the environmental pollution created by fossil fuels.

Long-standing sugarcane producing countries are now researching tools to increase agricultural output and, in the process of ethanol production, are seeking to enhance their capacity to supply this market. At the same time, there is the need to develop technologies that will be readily accessible for all producers. Meanwhile, countries that do not have sugarcane potential are building on their strong points, such as their geographic positioning for exporting or using other crops and their residues (Table 6, Annex 1).

2.5 Degree of interest in government and the private sector in promoting programs for ethanol production and use

Generally speaking, there is high interest among governments of the region in promoting programs to produce biofuels (Table 7, Annex Table 1). Even countries that do not yet have a specific regulatory framework still have an incentive to promote programs of this kind.

Strategies for rural development, poverty alleviation and food security increasingly look to biofuel programs as an activity that could contribute significantly to achieving the goals and objectives of social and economic programs. The private sector (primarily sugar growers and distillers) are making or planning investments to expand installed capacity to supply the ethanol market. Private business sees this as a great opportunity for reviving agricultural output and expanding the distilling business (see Annex 3).

2.6 *Willingness of national institutions (public and private) to join the Inter-American Ethanol Commission*

Public institutions are prepared to participate in the Inter-American Ethanol Commission. This is particularly true of research centers, universities and competent authorities such as ministries of agriculture and energy. As for private sector, the view is positive: nevertheless, some entrepreneurs are skeptical, because most sugar refineries conduct their own research and development into new products and there are many strategic partnerships among them. Others, however, see it as an opportunity to acquire related knowledge (see Table 8, Annex 1).

3

Status of and outlook for Agroenergy and Biofuels in the Americas

Actual situation and perspectives per country

3.1 ARGENTINA

The potential for producing biofuel feedstocks is quite favorable for various crops in Argentina. This is one of the countries with the best conditions for generating this new source of renewable energy in a competitive manner. There is great interest in the domestic and international private sector in investing in the production of biodiesel in Argentina.

The private sector has shown its interest through investments in small and medium-scale enterprises, targeting among others the European market. It should be noted that many plants were already in operation in advance of legal regulation, even without tax incentives.

An interesting case in point is the initiative of farmers of the Argentine Direct Sowing Association (AAPESID) of the Province of Buenos Aires, which announced the launch, in late 2006, of a 15,000 liter-a-day plant devoted primarily to self-consumption (*El Cronista*, Dec. 9 2006).

The passage of Law 26,093 in April 2006 marked the culmination of a process that began in 2004. Its objective is to capitalize on Argentina's potential for the development of biofuels, considering that diesel consumption in Argentina currently stands at around 11 billion liters.

The agriculture sector, taken as a whole, is one of the country's biggest gasoil consumers, accounting for 39% of total consumption. The law sets a target blend of 5% (E5), which will be mandatory as of 2010. At that time, domestic gasoline consumption is expected to be around 4 billion liters, meaning that demand for ethanol would amount to 200 million liters.

a) Total area planted in sugarcane and current yields

Sugarcane production was 18.8 million tons in the 2004/2005 harvest, equivalent to 296,790 ha, and was concentrated in three provinces of Northwest Argentina (Table 1).

Table 1.

Distribution of sugarcane production in Argentina

Tucumán	64%
Jujuy	23%
Salta	12%
Rest of the country	1%

b) Total land area available for growing sugarcane.

For the 2005/2006 season, Tucuman had 203,170 ha under cultivation. At peak production, sugarcane occupied some 250,000 ha. Of these, some 30,000 have been replanted with lemon trees, making it difficult to revert to sugar. According to provincial government sources, a further 100,000 ha could potentially be planted in sugarcane, displacing other crops. Private-sector data suggest that there are lands in lower rainfall areas planted in other crops

that could potentially be switched to sugarcane, but they would require additional irrigation and they are exposed to frost. Under favorable price conditions this could be profitable, but if the market drops such output would not be competitive.

The capacity of Salta and Jujuy to extend their sugarcane plantations is more limited, since the best lands, and those closest to the refineries, are already being exploited. The constraints on expansion have to do primarily with low rainfall. According to private-sector data, the available area in the provinces of Salta and Jujuy is around 120,000 ha. The greatest expansion possibilities are in the north of Salta, in the Tabacal zone. In Jujuy, the greatest potential is in the north, although this would imply the replacement of existing crops or the cultivation of new land, in some cases degraded. One of the key factors for future expansion will be progress in genetic improvement to adapt the crop to marginal areas.

There is no detailed information on the expansion potential in other provinces that contain the remaining 3% of sugarcane plantations. However, these areas pose greater risks than those currently under cultivation. The sugar refinery in the province of Missiones recently announced a project to create another sugarcane area in that province that would enlist tobacco growers now cultivating 5000 ha.

In light of the foregoing, the available area for sugarcane in Argentina can be estimated at around 435,000 ha.

c) Total sugar production, and sugar production per hectare

Total production of sugarcane in Argentina stood at 2,165,019 TMVC tons in 2005, and the yield per hectare in that year was 7.29 TMVC tons.

d) Mechanization and irrigation

In Salta and Jujuy, harvesting is generally mechanized. Most refineries use combine harvesters: 40% of independent sugar growers are fully mechanized, and the remaining 60% use the semi-mechanized system.

80% of sugarcane production in Tucuman is mechanized, considering all stages of production including the harvest. The only activity with major manpower demand is planting. In technical terms, 20% of the planted area needs to be renewed.

In Tucuman, 27% of the area is irrigated, but most of the 200,000 planted hectares need only a small water supplement to achieve a good level of production, and consequently there is no justification for major investment in irrigation.

Production in the north (Salta and Jujuy) is 100% irrigated. There, irrigation is essential because rainfall is inadequate to meet the needs of sugarcane. The integrated refineries apply advanced technologies that allow for rational use of water, such as drip irrigation, spraying and discontinuous flow, although gravity-fed irrigation (furrows or perimeter

ditches) is the most widely used system. Independent growers have less efficient systems for management and distribution of irrigation water.

Tucuman has a monsoon regime. Rainfall is concentrated in the summer, and there is virtually no precipitation during the winter. This is fortunate for sugarcane, because rain comes at the time of greatest growth, and the dry winter and spring weather facilitates continuous harvesting. In the potential sugarcane zone, annual rainfall varies between 800 and 1300 mm. In Salta and Jujuy, rainfall is insufficient to meet the needs of sugarcane.

e) Ethanol production (per hectare and per ton of sugar) and costs

The average agricultural yield nationwide is 660.5 l/ha of ethanol, rising to 935 l/ha from molasses at the integrated refineries of Salta and Jujuy. One ton of molasses is estimated to produce 240 to 260 liters of alcohol.

Alcohol production from sugarcane juice (recognizing that 1 ton of sugarcane yields 75 to 80 l of alcohol) is 5000 l/ha, at the average national agricultural yield, and 7500 l/ha in the refineries of Salta and Jujuy. Ethanol output per ton of processed sugar is 500 l.

f) Installed industrial capacity

In Argentina there are 23 refineries with an installed daily capacity of 1.5 million liters of alcohol and with an annual potential production of more than 400 million liters of alcohol.

Table 2.

Distribution of sugar refineries in Argentina

Tucumán	15
Jujuy	3
Salta	2
Santa Fe	2
Misiones	1

g) Research and development institutes working on ways to improve production of sugarcane, sugar and ethanol

- ***National Institute of Agricultural Technology (INTA)***

The objective of INTA's sugarcane research is to improve the competitiveness of Argentina's sugar industry and increase significantly the output per unit of area over a five-year span. To this end it has the following R&D programs: genetic improvement, integrated sugarcane disease and pest management, and the development of safe and sustainable production technologies.

With financial support from provincial governments, the Ministry of Science and Technology, universities and technical assistance agreements, INTA is also sponsoring the NOA (Northwestern Argentina)

integrated sugarcane project, the general objective of which is to improve sugarcane productivity and competitiveness within a sustainable framework. The project includes activities in the following fields:

- Development of knowledge and new technologies.
- Development of new varieties (clones).
- Broadening of the genetic base.
- Integrated disease and pest management.
- Procedures for providing disease-free genetic materials.
- Dissemination of good management practices.
- Training and work planning and organization in different harvesting systems.
- Development of complementary productive alternatives for SMEs.
- Alternative uses of sugarcane.

"Obispo Colombres" Experimental Agriculture Station (EEAOC)

EEAOC is an entity of the provincial government of Tucuman with the mandate to resolve farming and livestock production and processing problems in the province through scientific research. It has a specialized sugarcane section that is pursuing the following programs:

1. Sugarcane agronomy

This includes the following projects:

- Agronomic management of registered seed beds using in-vitro plantlets.
- Feedstock quality and sugar production.
- Planting and crop management.
- Green cane management.
- Ecophysiology of sugarcane.
- Productivity of sugarcane.

2. Genetic improvement of sugarcane

This includes the following projects:

- Management and use of genetic resources (introduction of foreign germplasm and sanitary quarantine; collection and selection of progenitors).
- Crossings, obtaining botanical seed and raising seedlings (induced flowering, directed crossings, and obtaining botanical seeds; obtaining and growing individual plantlets).
- Clonal selection (individual plantlets; intermediate clonal stages; comparative tests of domestic and regional varieties).
- Evaluation of diseases and pests in the last stages of selection (disease research; pest research).
- Assessment of the agronomic and industrial performance of commercial varieties and advanced clones (determination of the industrial quality of commercial varieties and advanced clones).
- Applied genetic research (selective quality assessment of progenies in stage 1 of selection).

Development of molecular markers of agronomic interest (evaluation and characterization of genetic diversity; search for molecular markers associated with high-quality sugar genes; obtaining transgenic plants potentially tolerant of low temperatures).

3. Industrial processing of sugarcane

This includes the following projects:

- Studies on sugarcane processing.
- Energy use in the sugar industry.
- Sugarcane derivatives and byproducts.
- Laboratory certification.

Other agencies involved in sugarcane RND

- Colonia Santa Rosa Experimental Station (Salta). This is a private undertaking of the North Argentina Regional Sugar Center. It has a genetic improvement program designed primarily to obtain sugarcane varieties adapted to the ecological conditions of Northern Argentina. It also conducts research into pathologies and biotechnology.
- Faculty of Agronomy of the Universidad Nacional de Tucuman: sugarcane research, and human resource development.

h) Other feedstocks available for producing ethanol

The following table shows figures on the production of other raw materials for use as ethanol feedstocks in Argentina.

i) Regulations governing the mix of ethanol and gasoline

Law 26,093 establishes a 5% blend of bioethanol in gasoline. Other legislation provides for production incentives and sets the physical and chemical requirements of ethanol.

The approval of Law 26,093 in April 2006 marked the culmination of a process that began in 2004. Its objective is to capitalize on Argentina's potential for the development of biofuels, considering that diesel consumption in Argentina currently stands at around 11 billion liters.

The agriculture sector, taken as a whole, is one of the country's biggest diesel consumers, accounting for 39% of total consumption. The law sets a target blend of 5% (E5), which will be mandatory as of 2010. At that time, domestic consumption of gasoline is expected to be around 4 billion liters, meaning that demand for ethanol would amount to 200 million liters.

j) Government and private sector programs for the production and use of ethanol in fuels

In general, there is a high level of interest on the part of government and private institutions in promoting ethanol

Table 3.

Corn (maize) production in Argentina

CORN	2004-05	2005-06	2006-07E
Area (ha.)	3,403,837	3,190,440	3,530,000
Production (tn.)	20,482,572	14,445,538	21,600,000
Agricultural yield (tn/ha)	7.36	5.90	n/d
Potential agricultural yield	The current harvest is generating an average yield of around 8,5 tn per hectare (34% of harvestable area). There has been a significant jump over the previous crop year, thanks to greater use of technology. This investment trend is expected to continue, particularly with high corn prices, and over the medium term yields should continue to rise significantly.		
Current industrial yield (lts/tn)	360		
Production per hectare of ethanol from corn (lts/ha)	2340 lts/ha (average yield from last three crop years)		

Table 4.

Sorghum production in Argentina

SORGHUM	2004-05	2005-06	2006-07E
Area (ha.)	617,452	577,010	720,000
Production (tn.)	2,894.250	2,327.865	3,300,000
Agricultural yield (tn/ha)	4.69	4.03	n/d
Potential agricultural yield	s/d		
Current industrial yield (lts/tn)	360		
Production per hectare of ethanol from sorghum (lts/ha)	1580 (average yield from last three crop years)		

and biofuel programs, reflecting the country's available natural resources. The development of biofuels production in Argentina is expected to help improve the competitiveness of Argentine agriculture, reduce carbon emissions, and capitalize on the potential of the agricultural sector to position itself as an energy source, thereby generating investment, employment and value added and creating opportunities for agricultural SMEs and for regional economies.

In addition to establishing "captive demand" through the mandatory blending of both gasoline and gasoil, Law 26,093 establishes a promotion system with the following incentives for producing ethanol and biodiesel:

- Investment in capital goods and infrastructure: early VAT refund, or accelerated depreciation against income tax.
- Goods devoted to projects approved by the Application Authority are excluded from the deemed minimum income tax base.
- Fossil fuel tax exemption: water infrastructure rate (naphtha and CNG); tax on liquid fuels and natural gas; tax on the transfer and import of diesel.
- The Application Authority guarantees that installations authorized for blending can acquire biodiesel and ethanol from beneficiary vendors at benchmark prices until available output is exhausted.
- Promotion of crops, SMEs, and technology research and transfer: specific programs sponsored by the Ministry of Agriculture, Livestock, Fisheries and Food (SAGPyA) to promote crops earmarked for biofuels production, so as to encourage productive diversification; the Ministry of SMEs and Regional Development will promote the acquisition of capital goods by SMEs for use in producing biofuels, with a view to achieving regional balance; the Ministry of Science, Technology and Innovation will sponsor research, cooperation and technology transfer between SMEs and member institutions of the National Public System of Science, Technology and Innovation, through specific programs.

These promotional programs apply to projects established in Argentina and devoted exclusively to this activity, with majority ownership by national, provincial or municipal governments or individuals or companies engaged primarily in agriculture that have accessed the promotional program. Benefits under that program are to be established annually in the budget, and are to give priority to promoting (a) SMEs; (b) agricultural producers; (c) regional economies. The Application Authority may establish quotas for distributing the benefit in favor of regional economies (no less than 20% of total demand in biofuels).

Under SAGPyA there is also the National Biofuels Program, which provides active support through promotion, advisory services and technical assistance.

k) Annual gasoline consumption

Annual gasoline consumption in Argentina is 4,229,421 m_. Argentina is a net exporter of gasoline: in 2006, imports represented 0.8% of domestic consumption.

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3.2 BELIZE

The development of agroenergy and biofuels is a fairly recent phenomenon in Belize. Yet the situation is changing gradually, and policies and major private sector players are exploiting alternative energy sources that will be more economical and more sustainable than fossil fuels. The effort is being led at the national level by the Belize Sugar Industries (BSI) company, which is exploring alternatives for diversification that would help the industry become more competitive over the long term.

Belize has no policy or legislation on agroenergy and biofuels. The government is aware of the need for policy and legislation, and has some basic guidelines governing investments in this area. Those include environmental sensitivity and contributions to alleviating poverty and promoting rural development.

The most important initiative in the use of agroenergy and biofuels in Belize was the signature of an agreement between BSI and BEL (Belize Electricity Limited) to establish a 25 MW power plant. That plant will use bagasse to generate electricity. The project is expected to reduce energy imports from Mexico by at least 50%. Operations are scheduled to begin in 2009. BSI is also experimenting with forage species selected for their potential use in producing ethanol.

The main challenge to the development of agroenergy and biofuels in Belize has been to identify appropriate equipment and technology. Production falls short of milling capacity, which is 1.2 million tons per year, and technical and financial support for small producers will be needed to achieve this target.

a Area planted in sugarcane and current yields

In 2006 Belize had 24,281 ha in sugarcane, with an average yield of 64 tons per hectare.

b) Area available for growing sugarcane

There are 36,422 ha potentially available for planting sugarcane.

c) Sugar: production, yield and costs

Total sugar production in Belize in 2006 was 170,000 tons, with a yield of 4.41 tons per hectare.

d) Regulatory framework for mixing ethanol and gasoline

Belize has no policies or legislation relating to the issue of agroenergy and biofuels.

e) Government and private programs for production and use of ethanol in biofuels

The government entity involved in the negotiations between BSI and BEL is the Public Utilities Commission, the regulatory body for all utilities in Belize. The government is aware of the need to develop policies

and legislation and is interested in establishing some basic guidelines for any investment in this area. These include environmental sensitivity and the need to contribute to poverty reduction and rural development.

As already mentioned, the most important development related to the use of agroenergy and biofuels in Belize has been the signing of an agreement between Belize Sugar Industries Limited (BSI) and Belize Electricity Limited (BEL) to establish a 25 MW power plant. That plant will use bagasse to generate the electricity needed for BSI to convert the country's surplus sugar production into biofuels. The financing for the project is in place and construction will begin in 2007. The plant will be operational in 2009.

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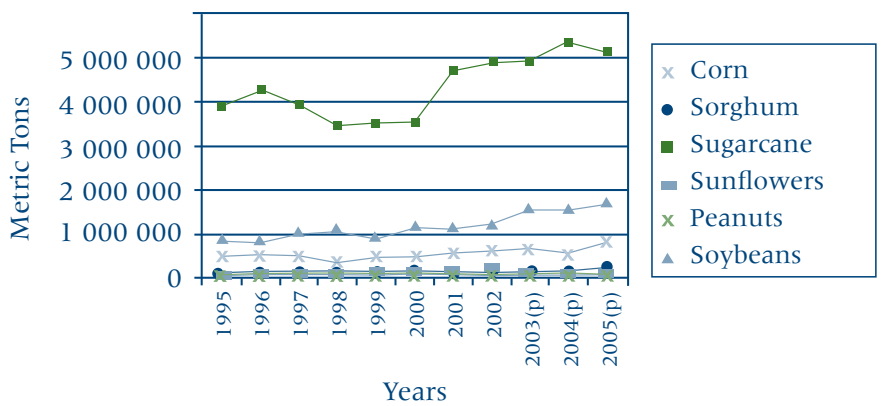
3.3 BOLIVIA

a) Area planted in sugarcane and current yield

The area planted in sugarcane amounts to 105,000 ha. Sugarcane production, the levels of which were always the highest in the country's agricultural output, grew steadily between 1994 and 1997, but output declined thereafter until 2001. Sugarcane yields were 44.74 MT/ha, again the highest for any crop in the country, and have risen steadily, except for the years 1992, 1993, 1997 and 2000.

Figure 1.

Production per crop year, by crop, 1995-2005 (in metric tons).



b) Sugar production, yield and costs

Total sugar production in Bolivia is 510,000 tons (2006), with a yield of 6.8 tons per hectare.

c) Installed industrial capacity

At the present time there are 15 ethanol distilleries under construction. The official distillers, Húngaro SA and Destilería Guabirá, do not have sufficient output to meet demand, and there is consequently a need for further investment and legislation. The Roberto Barbery Paz sugar refinery has a capacity to process 115,000 tons of sugar and 12,000 tons of ethanol. The Guabirá distillery, one of the oldest companies in Bolivia, is located in the eastern region of Santa Cruz and produces refined sugar, alcohol and fertilizers, in addition to ethanol.

d) R&D institutes working on ways to improve cane, sugar and ethanol production processes

Bolivia has a small biofuels research program. The departmental universities are examining energy trends and are conducting studies on natural gas and oil.

e) Regulations governing the mix of ethanol and gasoline

The national government promulgated Law 3546 of November 28, 2006, creating the agroindustrial complex known as "Complejo Agroindustrial de San Buenaventura", and declaring that company to be a national priority "for the production of sugar, biofuels based on ethanol, anhydrous alcohol and dehydrated alcohol, as well as the production of African palm for the production of oil and biodiesel, and sources of renewable and compatible energy within the context of ecologically sustainable production defined by its characteristics as a corporation of a public social nature."

f) Government and private programs for production and use of ethanol in biofuels

The current government's policies are promoting a switch in the country's energy mix, with the gradual replacement of liquid fuels such as gasoline, diesel and GLP by natural gas, which is cleaner, more efficient and offers lower operating costs.

g) Annual gasoline consumption

Bolivia produced 16.9 million barrels of oil in 2004 (46,448 barrels per day), and consumption is 9,137 barrels per day. Gasoline consumption in Bolivia is 763,400 m^3.

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3.4 BRAZIL

The first references to use of vegetable oils as fuels in Brazil date from the 1920s. In 1950 studies were conducted on the use of oricuri palm, castor bean and cottonseed oil in 6-cylinder diesel engines.

Beginning in the 1970s, when the world energy picture shifted abruptly and it became urgent to reduce dependence on imported oil, research into vegetable oils was given a new boost.

In recent years, with the new appreciation of environmental aspects and the sustainability of energy systems, there has been a revival of interest in biofuels in Brazil. A number of institutions have moved into research in this field, and government has taken action. In 2002 the Ministry of Science and Technology instituted the "Pro-biodiesel" research and development network, with representatives of the academic world, government, the automotive industry and potential producers of biodiesel to promote development of the biodiesel industry under Brazilian conditions.

The government of President Luiz Ignacio Lula da Silva, through the National Program for Production and Use of Biodiesel (PNPB) has organized the production chain, established financing facilities, structured the technological base, and promulgated a regulatory framework for the new fuel.

Brazil is exploiting less than a third of its arable land, which represents the world's greatest frontier for agricultural expansion. Its potential is around 150 million ha, of which 90 million are new frontiers and the other 60 million are lands devoted to pasturing that could be brought under cultivation in the near future. The biodiesel program is targeted only at lands that are unsuited for food crops.

Brazil has comparative advantages in production and could create competitive advantages that would make it a world leader in the biomarket and in the international market for renewable energy. Brazil's first comparative advantage is that it can incorporate new areas into energy agriculture with limited environmental impacts and without competing with food crops. A second comparative advantage is the ability to produce several consecutive crops a year; a third is its location within the equatorial zone, where intense solar radiation favors bioenergy production.

Following are the main features of the oilseed crops that contribute to the production of biodiesel in Brazil.

Castor bean ***(Mamona)***. The area planted in castor bean is estimated at approximately 160,000 ha. Brazil is the third-largest exporter.

Sunflower seed. Biodiesel could prove the salvation of sunflower farming in Brazil.

African oil palm. No other species produces so much oil per hectare as the African oil palm. Its productivity is 10 times that of soybeans.

Cottonseed. This is beginning to attract the interest of major corporations, including foreign ones.

Peanuts. This plant originated in South America. São Paulo is the major producing state in Brazil.

Pinhão manso **(Physic nut)**. This crop thrives in sandy and low-fertility soils, and provides an option for the country's lagoon regions.

In terms of agroenergy in the Brazilian energy matrix, that matrix has historically had a high share of renewable energy, reaching 44% versus the world average of 14%. This fact reflects the high share of hydroelectricity, at 14%, and of biomass, at 29.1%. The high share of biomass is due to the growth of ethanol production, promoted by the 1975 National Alcohol Program, the main purpose of which was to reduce dependency on fuel imports.

Another market for biomass emerged as a result of Law 11,097 of 2005, which created a biodiesel market for the next eight years.

a) Area planted in sugarcane and current yields

Brazil currently has 5.8 million ha planted in sugarcane, producing about 408 million tons a year, making it the largest producer in Latin America. The yield per hectare is approximately 77 tons.

b) Area available for growing sugarcane

Depending on the outlook for ethanol production in Brazil, it is estimated that some 12 million additional hectares could be devoted to sugarcane.

c) Sugar: production, yield and costs

In 2005, Brazil produced 29,500,000 tons of sugar.

d) Ethanol: production (per hectare and per ton of sugar) and costs

Ethanol production per hectare is 6500 to 7000 liters, for a total output of 15.8 million m_ a year in 2005/2006, and for the following harvest a production of 16.8 million m_.

e) Installed industrial capacity

The current installed industrial capacity for ethanol production in Brazil is estimated at 18 billion liters. Considering that domestic consumption in 2005 was around 13.5 billion liters (12.5 billion liters for fuel and one billion for industrial purposes), the availability for export is between 2 billion and 2.5 billion liters of ethanol, depending on total output in 2006 and any inventories accumulated.

If we look at total production capacity, we would have a potential to export 4.5 billion liters. If domestic

consumption remains at its current level we could project that in six or seven years, Brazilian exports of ethanol could stand at between 5 billion and 6 billion liters. In fact, domestic production will have to reach 20 billion liters in order to meet growing domestic demand, which is being driven upwards by "flex fuel" vehicles.

f) Research and development institutes working on ways to improve processes for producing cane, sugar and ethanol

EMBRAPA consists of 40 industrial units that represent a pool of more than 2000 researchers working on various topics, products and ecosystems, including agroenergy. In May 2006, by means of Board of Directors Resolution 61, EMBRAPA established a new official entity, in response to the growing need for alternative energies worldwide and to promote the production of agricultural feedstock for development of the industry in Brazil.

g) Other feedstocks for producing ethanol

Brazil has a great variety of substitute products for the production of ethanol, despite the fact that it is Latin America's largest producer and exporter of sugarcane-based biofuels. The most important of these alternatives are sorghum, wheat, potatoes, sweet potatoes and cassava. Production levels are high, especially for wheat, but yields for all these products are low, except for potatoes, where recent years have seen yields greater than 11 tons per hectare.

Table 5.

Brazil: Output in Yield of Potential Agricultural Feedstocks for Ethanol Production

Feedstock	2000	2001	2002	2003	2004	2005
Production						
Sorghum	779608.00	914.380.00	786.757.00	1,804.920.00	2.158.872.00	1.520.539.00
Wheat	1,661.526.00	3.364.950.00	3,105.660.00	6.153.500.00	5.818.846.00	4.658.790.00
Potatoes	484.443.00	484.599.00	498.046.00	533.165.00	538.503.00	538.503.00
Yield						
Sorghum	1.48	1.88	1.88	2.39	2.32	1.93
Wheat	1.56	1.95	1.48	2.4	2.1	1.97
Potatoes	11.03	11.35	11.35	11.5	11.5	11

Source: FAO

h) Regulations governing the mix of ethanol and gasoline

The "Pro-Alcohol" program is also considered a milestone in legislation on agroenergy. The decision to pursue ethanol production from sugarcane, considering the price of sugar, was a political and economic one that involved additional investments. That decision was taken in 1975, at a time when the federal government, through this program, decided to promote the production of alcohol as a substitute for pure gasoline, in order to reduce oil imports that then were weighing heavily on the country's external trade balance. At that time the price of sugar on the international market was falling rapidly, which made it worthwhile to switch to the production of sugar for alcohol.

The Brazilian alcohol program, "Pro-Alcohol", can be described in terms of five distinct phases:

1. 1975 to 1979: initial phase

Efforts focused above all on the production of anhydrous alcohol or absolute alcohol for blending with gasoline. In this phase, the main effort lay with the distillers that joined the program. Alcohol production rose from 600 million liters a year (1975-76) to 3.4 billion liters a year (1979-1980). The first cars powered exclusively by alcohol appeared in 1978.

2. 1980 to 1985: the consolidation phase

The second oil shock (1979-80) tripled the price of a barrel of oil, and petroleum purchases came to represent 46% of Brazilian imports in 1980. The government then decided to take steps to implement the Pro-Alcohol program. Agencies were created such as the National Alcohol Council (CNAL) and the National Executive Commission on Alcohol (CENAL), to move the program forward. Alcohol production reached a peak of 12.3 billion liters in 1986-87, exceeding by 15% the initial target set by the government (10.7 billion liters) per year by the end of the period. The proportion of alcohol-powered cars in the total fleet of four-stroke (Otto cycle) vehicles produced in the country rose from 0.46% in 1979 to 26.8% in 1980, and reached a peak of 76.1% in 1986.

3. 1986 to 1995: the stagnation phase

Beginning in 1986, the international oil market picture changed. The price per barrel of crude oil fell from a level between US$30 and $40 to between $12 and $20. This new era, called the "counter oil shock", jeopardized programs for the substitution of fossil fuels and the efficient use of energy throughout the world. The effects began to be felt in Brazilian energy policy in 1988, and coincided with a time of scarce public funds for subsidizing programs to encourage energy alternatives. This led to a significant decrease in the volume of investment in domestic energy production projects. The supply of alcohol could not keep pace with the growing demand, sparked by sales of alcohol-powered cars, which accounted for more than 95.8% of

all four-stroke vehicle sales on the domestic market in 1985.

The low prices paid to alcohol producers following the abrupt fall in international oil prices (which began at the end of 1985) stifled any increase in internal output. On the other hand, consumer demand for ethanol continued to rise, because its prices remained relatively attractive compared to those for gasoline, and because there were lower taxes on alcohol-powered vehicles, in comparison with those that ran on gasoline. This combination of stagnant alcohol production and rising demand, driven by market forces and the government intervention measures described above, sparked a supply crisis in the inter-harvest period of 1989/90. It should be noted that the run-up to the supply crisis was a discouraging time both for alcohol production, as noted, and for the production and export of sugar, for which prices were at that time set by the government.

i) Government and private programs for production and use of ethanol in biofuels

Brazil spends less than 1% of its GDP on research and development, according to World Bank and UNESCO estimates (2003).

The country has a large number of government agencies and foundations promoting R&D in potential productive sectors. A great many private companies are involved in the biofuel area.

j) Mechanization and irrigation

The southeastern part of the country is dominated by technically advanced commercial farming using mechanized sewing and harvesting systems. This area receives most of its rainfall in summer, winter and in temperate climates [sic]. Winter irrigation therefore allows up to twice the normal harvest for crops such as cotton, cereals and sugarcane. Supplementary irrigation is also used as necessary during the summer.

The northeastern part of the country has semi-arid areas where sugarcane is grown. Rainfall is distributed irregularly over the year, varying between 750 mm and less than 250 mm. This region has the country's poorest farmers. The scarcity of resources is such that the area lacks advanced harvesting systems, and most harvesting is done manually. The majority of farmers grow food for their own use.

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3.5 CANADA

Canada has not yet moved into biofuel production, although its farms produce raw materials that could be used as feedstock for both ethanol and biodiesel. The IDB notes that, if the industry is to thrive and biofuels are to become an economically strategic sector, Canada will need to offer adequate incentives and define a strategy to make the industry competitive with neighboring countries to the south.

It was only in 2002 that the provincial ministers attempted to reach agreement on renewable energy portfolio standards and to decide how developing technologies could be incorporated in the energy and agriculture sector for diversifying the country's energy mix. Despite these efforts, no agreement was reached, and there is still a wide variety of programs, policies and incentives in place in the different provinces.

After broad national consultations, the federal government announced the Climate Change Plan for Canada, which promotes steps to improve the efficiency of vehicles manufactured in the country, increase the blend of ethanol in gasoline, and boost production of biodiesel to 500 million liters by 2010. This plan also provides funding during 2003/2007 to address technical and market barriers to development of a biodiesel industry based on low-cost feedstocks such as canola and animal lipids (Canadian Biodiesel Initiative).

There is also an Ethanol Expansion Program that provides federal funding to six ethanol production projects in the provinces of Ontario, Manitoba and Alberta, with the target of achieving an E10 blend in 35% of gasoline consumed in the country by 2010. Currently, the level of the blend to be imposed under the 2006 Clean Air Act is being debated. A 5% standard blend, for which there is broad political consensus, would create demand for 3.1 billion liters a year, i.e., twelve times the current national output.

In short, most federal government assistance is targeted at farmers and rural communities for developing local biofuels businesses, and at feasibility studies for the production of such fuels. The provinces, for their part, are focusing on incentives in the form of tax exemptions, and some provinces, including Saskatchewan, Manitoba and Ontario, are applying mandatory gasoline-ethanol blends. Following are some of the main features of ethanol and feedstock production in Canada.

a) Area, production and yields of cereals

Canada's ethanol production is estimated at around 250 million liters, derived 93% from three cereals: corn (73%), wheat (17%) and barley (3%).

b) Ethanol production (per hectare and per ton of cereal) and costs

Canada does not produce sufficient feedstocks to satisfy demand, and biofuel consumption is still low. Domestic ethanol production, estimated at 250 million liters a year, represents only

0.7% of total petroleum consumption. In 2005, Canada imported 152 million liters of ethanol, most of it from the United States.

c) Installed industrial capacity

There have been some major investments in recent years in biofuels production and related technology in Canada. Of particular note are developments in the production of cellulose ethanol. A partnership between the multinational Shell Oil and PetroCanada is building a demonstration plant for transforming biomass into ethanol in Ottawa, slated to process 30 tons a day of feedstock, and the government is investing some $218 million in a full-scale cellulose ethanol plant that will come on stream in 2007.

A Canadian company is in the process of selling patented technology for producing cellulose ethanol to a Chinese firm, and investments are being made in the development of biofuels based on alfalfa, canola and animal fats.

d) Regulations governing the mix of ethanol and gasoline

Three provinces have such regulations.

e) Research and development

Canada is making the necessary S&T investments that will turn it into a leader in biofuels technology. Following are some of the main institutions involved in this effort:

Natural Resources Canada (NRCan). This agency assists Canadian innovators in the private and public sectors to commercialize their renewable energy technology ideas. In particular, it is supporting efforts to produce ethanol from agricultural wastes such as straw and chaff and forestry wastes such as wood chips and sawdust, as well as municipal wastes.

The Canadian Energy Technology Centre, CANMET, is an organization devoted to promoting clean energy science and technology through programs and trade missions, and hosting foreign delegations. It has created trade promotion offices in Poland, Mexico and India to promote Canadian technologies abroad, and to provide support for clean development mechanisms (CDM) and joint implementation projects to reduce greenhouse gas emissions.

The Office of Energy Research and Development (OERD) manages the government's energy S&T activities. It provides funding and works with 12 federal departments and agencies. It also collaborates with other levels of government, the private sector and the academic world, and represents Canada on the Committee on Energy Research and Technology of the International Energy Agency.

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3.6 CHILE

Chile does not produce sugar and, consequently, there is no information on areas and yields, production costs, or irrigation systems and mechanization for this product. Nor is there as yet any regulatory framework governing the production and consumption of ethanol in the country, or its use for blending with gasoline, and no research centers are currently studying the feasibility of ethanol production and marketing. Nevertheless, in the energy area, and specifically in the generation of energy from renewable sources, the government and the private sector have given some attention to the production of renewable energy from agricultural feedstocks. There is also an interest in finding other uses for the country's agricultural output, in order to accelerate industrial and agricultural development and generate greater returns for producers.

a) Area available for growing feedstocks

The potential area available for producing ethanol is estimated from substitute products classified for generating ethanol, since there is no sugar production. It is estimated that 150,000 ha could be devoted to producing around 457,000 m_ of ethanol from wheat, oats, corn, potatoes and beets, in that order: these are crops that produce high yields and could serve as feedstock for generating energy. Of these products, corn has been identified as the most feasible for producing ethanol in Chile.

b) Ethanol production

There is still no production of ethanol in Chile. In terms of demand, however, studies suggest that that introduction of a mandatory 5% blend in gasoline would create demand for 157 million liters of ethanol by 2010 and 176 million liters by 2014[4].

c) Availability of substitute feedstocks for producing cane, sugar and ethanol

Although Chile does not produce sugar, it has other products that could be used as ethanol feedstock, including wheat, oats, corn, potatoes and beets. In the 2005/2006 crop year, there were 618,340 ha planted in these crops.

d) Research and development institutes working on ways to improve the production of ethanol

Chile is just starting down the road to biofuels production, and its contributions to R&D in this area are modest to date. Nevertheless, the Ministry of Agriculture, through the Agricultural Innovation Foundation (FIA), recently earmarked $1 million for such purposes[5].

The FIA studies focused on the potential use of corn and sugarcane as ethanol feedstocks, with an initial 10% blend in gasoline.

4 *Garten Rothkopf, A Blueprint for Green Energy in the Americas. Inter-American Development Bank. Chile*

5 *ibid.*

There is another public entity, the Technological Innovation Fund for the Bio Region, that has focused its work on the development, production and marketing of bioethanol from forest biomass (wood and byproducts).

e) Government and private programs for the production and use of ethanol in fuels

One of the five strategic themes of the current government's agricultural policy is "to contribute to the generation of renewable energy sources". Consequently, the Ministry of Agriculture (MINAGRI) has focused its efforts on: (a) moving decisively to create the conditions for the development of bioenergy in the country, as a national priority, (b) bringing together all the stakeholders in this area, compiling all the existing initiatives and experiences, and adding the necessary determination to implement this strategy, which holds great potential for the country.

This initiative is being driven by two bodies. An inter-ministerial commission has been created, consisting of the ministries of agriculture, mining, energy and economy, and a public-private committee has been established, to draw up a technical, economic and legal proposal in this area.

The current government has also issued recommendations to encourage biofuel production. These include the introduction of specific taxes [sic] for producers, and a regulatory framework that will guarantee demand. It also notes that it would be economically more efficient to import biofuels from producing countries such as Brazil and Argentina.

In terms of private initiatives, the Brazilian oil company Petrobras has announced its interest in investing in an ethanol plant in Chile.

Government energy policy

- ***Main thrusts.***
- Promote investment.
- Stable rules of the game.
- Adaptability to changing circumstances.
- ***Objectives***
- Security of supply.
- Economic efficiency.
- Sustainability.
- ***Security of supply***
- Diversification of the energy mix.
- Diversification of sources.
- Greater degree of independence.
- ***Economic efficiency***
- Promoting competition.
- Efficient regulation.
- Efficient use of energy.
- ***Sustainability***
- Safeguarding the environment.
- Adequate offsets and mitigation.
- Promotion of social responsibility.

Lines of action

- Environment: environmental impact analysis of biofuels and their blends (CONAMA and Ministry of Transport will conduct a study to measure engine efficiency and polluting emissions).
- Definition of product type and quality:
  - Establish national quality standards.
  - Define treatment as an additive or fuel.
  - Define a mandatory biofuel content in conventional fuels.
- Agricultural policy for biofuel crops:
  - A matter to be defined and explained by the Ministry of agriculture.
  - Taxation: definition of a biofuels taxation policy

Technical standards

- Regulate use of biofuel by type of user.
- Establish safety measures for production, distribution, transportation and use of ethanol and biodiesel and possible blends with conventional fuels (fuel tanks, filler hoses, blending, transfers, safety distances, own consumption etc.).
- Registration of facilities (disincentive for informal facilities or adulterated products).

Automotive regulations

- Establish vehicle models that can use E5, E10, E100, B5, B10, B20, B100.
- Standardization of emissions from vehicles using biofuels —"green seal".
- Training in technical review plants.

f) Annual gasoline consumption

In 2006, gasoline consumption in Chile was 3 million m^3, and this is estimated to rise by 600,000 m^3 by 2014.

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3.7 COLOMBIA

Colombia is one of Latin America's largest and most efficient producers of two materials that are enormously important in the future production of biofuel. These are sugar and palm oil. The country produces exportable surpluses of both these products, and their use in the production of biofuels for the domestic and international market holds out a major opportunity for new business, employment, and wealth creation.

In addition, the country has great possibilities for expanding its agricultural frontier in these two products, and in other products such as corn, soybean, and yucca. This potential has created great expectations and has sparked much private investment. It has also led the government to create a suitable regulatory framework and incentives and to adopt promotion policies that should have a swift impact on growth in this sector.

Table 6.

Colombian sugar harvest, 1991-2005

Year	Ministerio de Agricultura	Asocaña	**Harvested**
	Harvested	**Planted**	
1991	112,640	160,291	124,043
1992	142,224	165,226	126,912
1993	175,731	178,534	124,707
1994	154,461	181,063	133,729
1995	179,206	181,893	163,694
1996	180,391	184,039	178,025
1997	184,992	192,793	170,151
1998	174,445	196,276	173,700
1999	205,044	197,353	167,099
2000	217,570	193,996	184,986
2001	203,069	189,811	176,828
2002	218,706	205,555	165,732
2003	212,651	198,038	170,662
2004	203,384	197,013	174,096
2005*	212,446	200,218	176,366
Growth(%)	**3,8%**	**1,5%**	**2,8%**

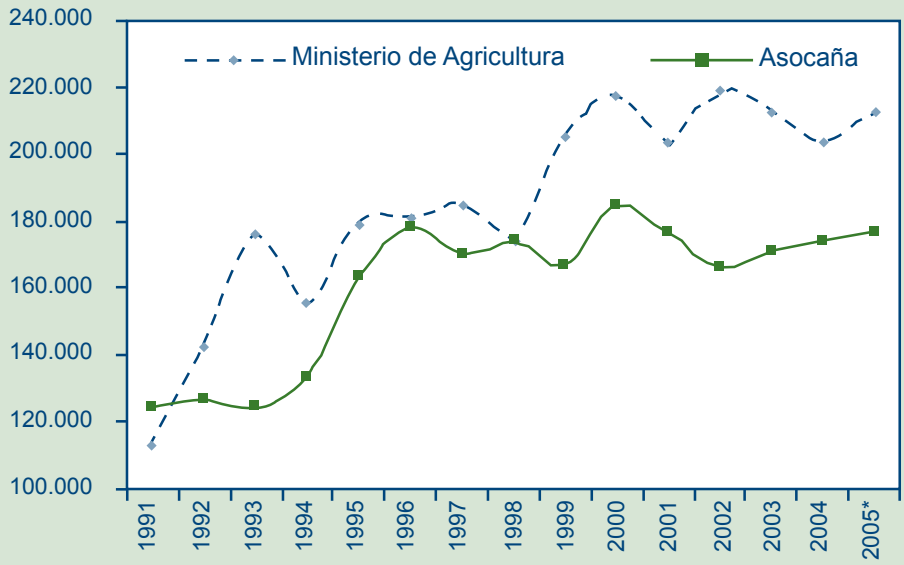
a) Area planted in sugarcane and current yields

For calculating the area planted in sugarcane, and the harvest, there are two sources of information, one public and the other private: the Ministry of Agriculture and Rural Development, and the Colombian Association of Sugarcane Growers (Asocaña), respectively. The area planted in sugarcane grew between 1991 and 2005, according to both sources, the Ministry's figure shows an average annual growth rate of 3.8%, from 112,640 ha in 1993 to 212,446 ha in 2005, while the Asocaña figure shows lower growth, averaging 2.8%, with the planted area rising from 124,043 ha in 1991 to 176,366 ha in 2005 (see Table 6 and Figure 2).

According to Asocaña, cane yields per hectare and sugar yields per ton of cane have been rising, in the first case from 116.99 MT in 1991 to 122.9 MT in 2005, for an average annual growth of 0.1%. Sugar productivity in terms of tons of sugar from tons of cane rose from 11.158% in 1991 to 11.7% in 2005, for an average annual growth rate of 0.4% (Table 7).

Figure 2.

Sugarcane harvest area in Colombia (ha)



Source: Ministerio de Agricultura (2005), Asocaña (2005).

Table 7.

Sugarcane harvest yields in Colombia between 1991 and 2005 (tons/ha)

Año	Tons of cane per hectare harvested	Tons of sugar per hectare harvested	% Sugar/ cane
1991	117.0	12.2	11.2
1992	121.4	12.4	11.6
1993	130.9	11.9	11.0
1994	129.5	11.0	11.1
1995	108.9	11.0	11.4
1996	101.3	11.1	11.7
1997	105.0	11.8	11.8
1998	105.9	11.6	11.3
1999	116.1	11.9	11.4
2000	105.8	11.0	11.5
2001	102.9	12.1	11.9
2002	121.9	13.4	11.8
2003	125.6	12.8	11.7
2004	126.7	12.8	11.8
2005	122.9	13.1	11.7
Growth %	0.1%	0.8%	0.04%

b) Area available for growing sugarcane

Estimates suggest that the sugarcane frontier could be expanded by some 200,000 ha.

c) Sugar production, yield and costs

According to Ministry of Agriculture figures, sugarcane occupied 8.1% of the area planted in permanent crops, and 4.5% of the total planted area in Colombia. This is less than the area planted in *caña panelera* ("brown sugarcane"), which occupied 11.7% of the area planted in permanent crops and 6.5% of the total planted area. Sugarcane accounted for 14.3% of permanent crop production, by value, and 9% of total agricultural output.

d) Mechanization and irrigation

Sugarcane cultivation is completely mechanized, thanks to the flat topography. Soil and climatic conditions, and the network of access roads, among other factors, allow harvesting and milling throughout the year, facilitating crop specialization, and producing one of the highest productivity rates in the world. The Colombian sugar industry is thus progressing steadily towards an increasingly sophisticated system that achieves maximum crop efficiency through the use of modern technologies and more productive cane varieties that are well adapted to local conditions.

According to Cenicaña, 95% of the area planted in sugarcane is irrigated.

Table 8.

Sugar production in Colombia 2000-2006

Year	Total sugar production (mtrv)*	Total sugar production per hectare harvested (metric tons)
2000	2.391.324	11,14
2001	2.244.756	11,95
2002	2.528.756	13,46
2003	2.649.966	13,08
2004	2.741.363	12,96
2005	2.683.215	13,05
2006	2.415.117	n.d.

**Metric tons raw value*

e) Ethanol production (per hectare and per ton of sugar) and costs

Asocaña estimates annual gasoline consumption in cities of more than 500,000 inhabitants and their metropolitan areas (Bogotá, Medellin, Cali, Barranquilla, Cartagena, Pereira and Bucaramanga) at 76.7 KBD[6] (12 million liters a day). Thus, bearing in mind existing legal provisions, 7.67 KBD (or 1.2 million liters) of anhydrous alcohol per day would be required for a 10% blend in gasoline.

This means that to cover annual demand for these seven cities would require 5.93 million tons of sugarcane, representing a planted area of approximately 54,000 ha.

If all gasoline sold in the country were to be blended, this would require 1.4 million liters a day of anhydrous alcohol, implying annual sugarcane production of 7 million tons and a planted area of 63,000 ha.

Studies by the Ministry of Agriculture and Rural Development estimate that, based on current demand, ethanol production will rise by some 75% to the year 2010, from 1,370,000 liters a day to 2,400,000, and there are expected to be around 28 distilleries. The Ministry of Mines and Energy estimates that the first two years of production will be devoted exclusively to the domestic market, and that as of 2008 production will be sufficient to cover domestic demand and leave room for exports (Table 8 and figure 2).

6 *Kilo-barrels a day.*

Table 9.

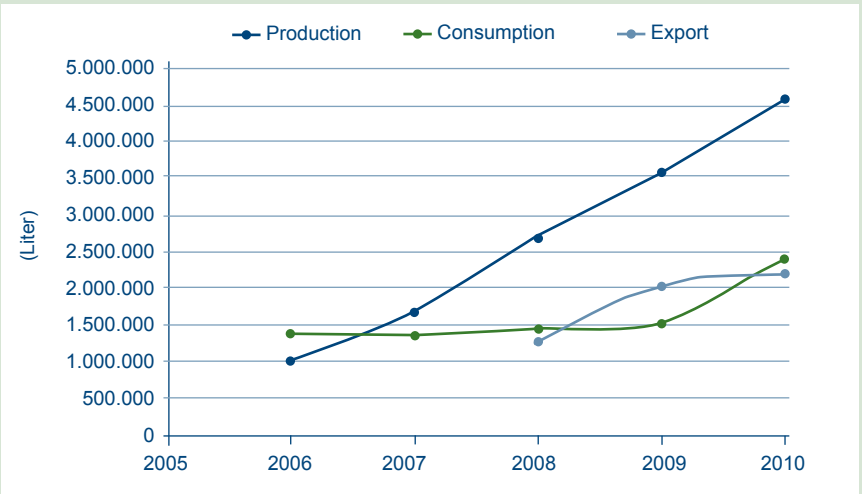
Estimated production and consumption of ethanol in Colombia

	2006	2007	2008	2009	2010
Hectares	**43.000**	66.000	108.000	146.000	193.000
Liters per day	**983.000**	1.670.500	2.677.200	3.548.400	4.574.000
Number of plants	**6**	9	15	21	28
Consumption (l/day)	**1.370.000**	1.370.000	1.430.000	1.510.000	2.390.000
Exports (liters)			**1.247.200**	**2.038.400**	**2.184.000**

Source: Ministry of Mines and Energy

Figure 3.

Projected Output and Consumption of Ethanol.



Source: data from Ministry of Mines and Energy.

As noted above, the first alcohol factories started operation in October of last year (Incauca and Manuelita), and they produced a total of 27.4 million liters in the last three months of the year. In February and March of this year, plants at the refineries began operation, increasing the fuel alcohol supply capacity. During the first seven months of the year these refineries sold slightly over 148 million liters of alcohol (Table 10 and Figure 3).

According to Asocaña they will sell 122 million liters during the remainder of the year, bringing the total for 2006 to 270 million liters of alcohol.

Table 10.

Cane milling, sugar and fuel alcohol production

Month	Production		
	Cane (Tons)	Sugar (mtrv[7])	Alcohol (thousands of liters)
Oct-05	1.884.271	234.609	2.794
Nov-05	1.744.281	201.349	12.255
Dec-05	1.653.948	190.290	12.338
2005	**21.784.805**	**2.683.215**	**27.387**
Jan-06	1.694.824	179.919	13.698
Feb-06	1.812.300	208.278	16.381
Mar-06	1.964.267	211.444	20.105
Apr-06	1.631.500	163.502	25.799
May-06	1.689.423	165.715	25.208
Jun-06	1.541.843	152.046	21.035
Jul-06	2.022.385	222.004	24.791
2006	**12.356.542**	**1.302.909**	**147.017**

Source: Asocaña 2006. Informe Trimestral de Mercadeo.

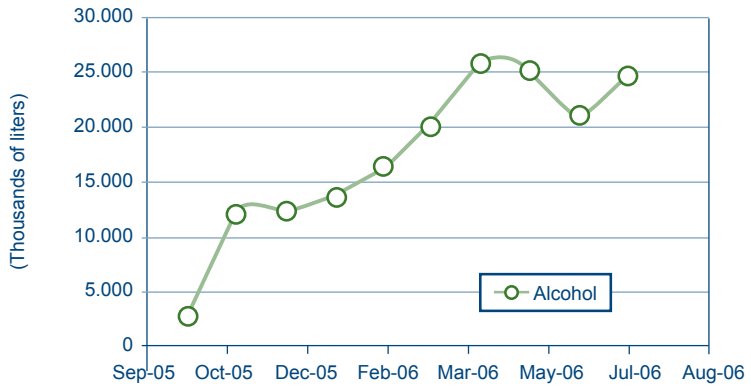
The production and marketing of ethanol has been of benefit to the government, producing firms and farmers alike. For the government, it has meant investment in new jobs, and changes in tax policy to reduce income taxes for ethanol producers (exemption), and raising them for activities that pose a risk to the environment. Similarly, there has been an improvement in the trade balance, with lower imports of fossil fuels, and higher investment in rural infrastructure.

Sugarcane producing firms, industrial complexes and farmers have benefited from the incomes generated by the production and distribution of cane and ethanol. The sector will grow further, generating greater productive capacity and thus bigger surpluses. Asocaña estimates that 450,000 ha are planted in sugarcane in Colombia, 250,000 of this total in the Cauca Valley. Cane production is expected to increase in the rest of the country, as the number of ethanol factories grows.

7 *mtrv: metric tons raw value, weight in terms of unrefined sugar.*

Figure 4.

Cane milling, sugar and fuel alcohol production.



Source: Asocaña 2006. Informe Trimestral de Mercadeo

f) Installed industrial capacity

The country's 14 sugar refineries have a milling capacity of 80,000 tons of cane per day, divided between the production of alcohol and sugar.

Pursuant to Law 693 of 2001, the first fuel alcohol plants have been established in the Cauca Valley, where the Incauca plant began operations on October 28, 2005. This was followed later in the same month by the Providencia plant, and in March of this year by the Manuelita, Mayagüez and Risaralda plants. These five refineries[8], the first to install distilleries in their plants, have a total output capacity of 1.5 million liters a day[9], involving investments of around $80 million (although the Ministry of Mines and Energy[10] reports investment at around $100 million: see Table 11).

[8] *Jorge Bendeck, President of the National Biofuels Federation, estimates that the current production of 1,000,000 l/day of fuel alcohol at the five ethanol refineries in the Cauca Valley is the equivalent of discovering an oilfield producing 16,500 barrels a day. Source: Revista Dinero, Edición 257.* La Fiebre del Etanol.

[9] *Still more ethanol is needed. Output from the existing plants is equal to 57% of the demand generated by imposing a 10% ethanol blend for gasoline, which currently applies only in Bogotá, the Cauca Valley and the coffee belt. A further 600,000 l of ethanol per day would be needed to cover the entire territory. Ibid.*

[10] *Memorias al Congreso Nacional 2005 –2006.*

Table 11.

Investment and production capacity of sugarcane processing plants

Department	Investor	Investment (US $ million)	Capacity (Lts./day)	Date of startup
Cauca	Ingenio del Cauca	20	300.000	October 2005
Valle del Cauca	Ingenio La Manuelita[13]	14.3	250.000	October 2005
Valle del Cauca	Ingenio Mayagüez	18.2	150.000	March 2006
Valle del Cauca	Ingenio Providencia	13	250.000	March 2006
Risaralda	Ingenio Risaralda	14.2	100.000	February 2006

Source: Ministerio de Minas y Energía, Asocaña, Revista Dinero and Diario Portafolio.

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

Cenicaña is a private, nonprofit R&D corporation founded on September 6, 1977 at the initiative of the Sugarcane Growers Association of Colombia (Asocaña). Between 1978 and 2004, the Colombian sugar agroindustry increased its productivity from 0.64 to 1.08 tons of sugar per hectare per month, and the percentage of sugar recovered from each ton of milled cane rose from 10.58% to 11.8%.

These increases can be attributed to the development and adoption of technologies suited to local conditions, and to the improvements that have been made by refineries and cane growers in upgrading and managing their production facilities.

Varieties of sugarcane

At the end of 2004, the Cenicaña Colombia (CC) varieties and the varieties imported and evaluated by the VIC Center were being planted in 92% of the area devoted to sugarcane in the Cauca Valley. The CC varieties accounted for 73% of the harvest in 2004, with additional output of 1.2 tons of sugar per hectare in comparison with other varieties harvested that year.

In December 2004 the CC 85-92 variety was first in terms of area planted, with 109,859 ha representing 56% of the total area in sugarcane. The harvest from this variety in 2002 produced 11.4 tons of additional cane per hectare and 0.3 additional points of sugar yield, compared to the other varieties harvested that year.

11 *Output will increase to 300,000 liters a day.*

Biotechnology

Cenicaña is steadily incorporating biotechnology advances in the growing of sugarcane for the characterization and genetic improvement of varieties, and to detect patterns of genetic variability in pathogens and insects of economic importance. In October 2003, plants of the CC 84-75 variety that were transformed with the introduction into their DNA of a gene resistant to the yellow leaf virus were under observation in the biosafety greenhouse at the experimental station.

The third approximation in agro-ecological zoning for sugarcane growing in the Cauca Valley and the characterization of the technological profile of refineries and cane growers uses basic information to enhance the efficiency of research and to steer the transfer of technology towards the development of sustainable and competitive agriculture at each site.

Efficiency in water use

Research into the water requirements of sugarcane and the rational use of water has helped to reduce the number of irrigation procedures in each crop year by 50%, thereby cutting water consumption and cane production costs.

Clean technologies

The selection of varieties that are resistant to most diseases, together with the development of integrated pest and disease management systems, is minimizing the use of chemical products.

Available knowledge on nutrition and fertilization of sugarcane in soils of the Cauca Valley is being used to adapt recommendations on the application of chemicals. Experimentation with new varieties in different soils serves to identify the most appropriate timing and dosing in each situation, leading to more rational use of fertilizers.

To conserve and improve the natural properties of soils, byproducts such as cachaza (raw rum) and cinders are being applied, harvest residues are incorporated, and the effects of mechanization and runoff waters are controlled.

Advances in the production of green-harvested cane include the selection of suitable varieties and the development of agronomic management and harvesting technologies. The sector is steadily increasing the area managed with this system, without losing productivity or profitability.

For measuring sucrose in the refining process, clean analytical methodologies are used that include clarification of samples through the use of healthy, nonpolluting products.

Reducing sucrose losses

Thanks to the characterization and control of sucrose losses between harvest and crystallization, the refineries have reduced total losses by 50% in the last five years. Efforts include logistical aspects and the use of methods for monitoring and determining sucrose, such as near infrared analysis. Control procedures have also been established in

the clarification, filtration and crystallization stations.

Process engineering

Ongoing support for the refineries and the development of computerized process evaluation systems have helped to increase the efficiency and capacity of the milling process, to make power measurements and adjustments, and to evaluate the efficiency of boilers and condensers in the factories.

Standardized measurements

In association with Cenicaña, the refineries have implemented procedures for standardized measuring, so that there is now a system for exchanging information with unified indices.

h) Availability of other feedstocks for producing ethanol

The most promising products for making ethanol, in addition to sugarcane, are caña panelera and yucca, for which Table 19 presents data on area planted, production and yields.

Sugarbeets

With respect to other feedstocks for producing ethanol, the country has been experimenting with a range of sugarbeet seed varieties that can produce yields greater than 170 tons per hectare, with the highest sugar extraction percentages, and this could lead to the production of alcohol in volumes 3 times higher than those obtained from milling sugar.

On the industrial side, the tests were supported by the Swedish firm

Table 12.

Ethanol feedstocks 2000-2005

Product	Variable	2000	2001	2002	2003	2004	2005
Sugarcane	Area (hectares)	217.570	203.069	218.706	212.651	203.384	212.446
	Production (mt)	2.812.709	2.410.836	2.881.661	2.776.776	2.702.863	2.855.283
	Yield (MT/ha)	12.928	11.872	13.176	13.058	13.289	13.440
Caña Panela	Area (hectares)	214.582	222.204	243.118	246.057	249.384	243.866
	Production (mt)	1.301.503	1.434.828	1.587.893	1.657.431	1.696.186	1.697.114
	Yield (MT/ha)	6.065	6.457	6.531	6.736	6.802	6.959
Yucca	Area (hectares)	179.348	190.97	172.124	174.444	176.811	179.912
	Production (mt)	1.792.382	1.980.110	1.779.250	1.840.717	1.943.098	2.073.130
	Yield (MT/ha)	9.994	10.411	10.337	10.552	10.990	11.523

Source: Evaluaciones agropecuarias. Ministerio de Agricultura y Desarrollo Rural (MADR)

Chematur Engineering, and will be supplemented by ABB, a company well known for its work in the energy field. The first plant will be located in Boyacá, involving an investment of some $80 million beginning in 2007.

Yet the most important aspect may have to do with the socioeconomic impact on people who will have to settle around the industrial complex and plant the thousands of hectares that will be needed to produce sufficient sugarbeets to bring ethanol production to at least 250,000 liters a day.

The project calls for producing food concentrates and diversifying farming through the rotation of crops, including sugarbeets.

Sweet sorghum

Although sorghum *(Sorghum bicolor)* is better known as a cereal, its sweet variety is used primarily as fodder. Its intense photosynthesis produces leafy stalks of up to 5 m in height that make excellent fodder. The stalks also contain a great deal of sucrose that can be extracted as brown sugar or distilled to produce ethyl alcohol. Sweet sorghum has been called "the camel of crops" for its great adaptive capacity, its resistance to drought and to saline-alkaline soils, and its tolerance of flooding.

According to FENALCE 2006, sweet sorghum is a promising crop, not only for its economic value - biomass productivity (20 to 50 tons of dry matter per hectare) and other products such as grain, sugar and liquid cellulose - but also because it has been converted in some countries into a renewable energy source, because of its capacity for ethanol production. Following are some of the agronomic, industrial and environmental advantages identified in Colombia for this purpose:

- Vegetative period of three to four months.
- Low water demand.
- Tolerant to drought and to acid and saline soils.
- Photoperiod insensitive (Atlantic Coast).
- Easy mechanization and seed production.
- Low production costs.
- Shoot management possibilities.
- Grain harvest possibilities.
- High CO_2 capture capability.
- Production costs per liter are potentially the lowest of any biomass.
- Fermentation efficiency greater than 90%.
- Waste residues have cellulose levels similar to those of sugarcane bagasse.
- Use of residues as animal feed or in paper production.
- 25% reduction in pollution from the ethanol industry compared to using molasses.
- Produces less stillage.

Yucca

In 2006, the Ministry of Agriculture and Rural Development approved a project to produce fuel alcohol from yucca. According to the project's promoters (Clayuca), the feasibility of using it for producing fuel alcohol has been tested and it is estimated that it will generate 30 tons of root per hectare, from which 5000 liters of ethanol could be produced. With sound crop management, careful selection of varieties, and adequate climatic conditions, yields of between 140 and 170 liters of ethanol per ton of fresh yucca root are possible. Accordingly, a distillery will be built with a capacity of 800 liters per day of anhydrous alcohol.

The project will cost an estimated US$200,000 and will make yucca an efficient production crop that is competitive and sustainable and will improve incomes and living standards for farmers. The agroindustrial projects planned for the departments of Sucre, Guajira, Córdoba, Cesar, Atlántico and Meta are seen as sound strategies to enhance the production and consumption of ethanol in the country.

Caña panelera

One of the most important projects underway is to be found in the Rio Suarez Valley, involving research into the viability of ethanol plants, examining the impact on the social and economic situation in the region (living standards, development, security, environment). The expected production capacity from these plants, as noted above, is between 150,000 and 300,000 liters per day, which would require approximately 30,000 ha of sugarcane.

CORPODIB (Corporation for Industrial Development of Biotechnology and Clean Production) is one of the agroindustrial clusters now in production in this part of the country. The project calls for construction of an ethanol plant using Brazilian alcohol distillation technology, with a capacity of around 300,000 liters a day, using *caña panelera* as feedstock, which will require the planting of 15,000 ha of cane. The investment is expected to cost around $45 million.

i) Regulations governing the mix of ethanol and gasoline

The country has a broad regulatory framework governing the use, production and distribution of biofuels, including laws, decrees and resolutions, among which are the following:

Law 693 of 2001 (September 19), issuing rules on the use of fuel alcohol, and creating incentives for their production, marketing and consumption. Under this law, fuel used in metropolitan areas with more than 500,000 inhabitants must have oxygenated components such as fuel alcohols. It sets a term of five years for gradual introduction of the standard, starting with the most densely populated centers with the greatest atmospheric pollution.

Resolution 0447 of 2003 (April 14) of the Ministry of Environment, Housing and Territorial Development. This establishes environmental quality criteria for liquid and solid fuels used in commercial and industrial ovens and boilers, as well as in internal combustion engines, for which it sets technical and environmental requirements for fuel alcohols and oxygenated fuels beginning in 2005. The proportion of water in anhydrous alcohol must not exceed 0.4%.

Resolution 18-0687 of 2003 (June 17) of the Ministry of Mines and Energy, issuing technical regulations to Law 693 of 2001 with respect to the production, storage, distribution and blending of fuel alcohols and their use in domestic and imported fuels. It also sets the percentage of ethanol to be blended with gasoline at 10%.

Law 863 of 2003 (December 29), establishing taxation and customs rules and controls for encouraging economic growth and reordering the public finances. Article 11 provides a tax exemption for fuel alcohol used for blending with gasoline for automotive vehicles.

j) Government and private programs for production and use of ethanol in fuels

The government interest in promoting the production of biofuels is clear in the strategies proposed by the Ministry of Agriculture, summarized below:

Ministry of Agriculture and Rural Development

To achieve energy security in case the country should cease to be self-sufficient in hydrocarbons, biofuels represent an alternative for which Colombia has numerous comparative advantages. Considering the environmental, economic and social benefits, the development of fuel alternatives to oil is a clear priority.

In addition to the environmental and security advantages for fuel supply, noted earlier, biofuels represent a new activity for agriculture, using lands not needed to produce food, and encouraging employment in the countryside.

To capitalize on the advantages offered by biofuels in the agricultural sector, there is a need for new and more productive crops with lower production costs. As for the future, it is important to recognize that ligno-cellulose materials hold greater potential for producing bioethanol. Many products with high cellulose content that could be used for these purposes are generated as residues from farming and forestry activity: these products not only have no value in the context in which they are produced, but they can also cause environmental problems during disposal.

If agriculture-based biofuels are to be a real energy alternatives, they will not only have to have characteristics equivalent to those of fossil fuel but they must also be produced with a

positive energy balance, and marketed at a cost similar to the petroleum derivatives they are to replace. The main drawback in marketing these fuels for transportation is the high cost of production.

A number of actions on different fronts must be taken to promote the biofuels sector:

- **Information.** Information strategies must be developed, targeted at consumers as well as at marketers and other sectors. These campaigns must include issues such as the environmental, economic and social benefits of biofuels, regulations governing their use, quality standards, etc.
- **Improving production and organization.** Improving production processes and reducing the costs of producing biofuel will depend essentially on enhancing productivity in the production of feedstocks, and this will require research into technologies for growing crops that produce these feedstocks, and transferring technology to producers. Similarly, attention will have to be paid to organizing producers so as to guarantee sustained output and a stable supply of feedstock for biofuels.
- **Research and development.** Bearing in mind the country's geographic situation, it is essential to conduct research on alternative crops to be used as feedstock for biofuels; the performance of biodiesel in different climatic zones of the country; and cold-climate emissions from palm oil biodiesel. The fuel alcohol production process needs further development as well, including pretreatment and enzyme hydrolysis of cellulose, finally uses of lignin, etc.
- **Marketing**. There is a need for thorough market studies, at the domestic and international levels, for different sources of feedstock and different types of biofuel.
- **Economic measures.** Biofuels are currently being produced from traditional crops, such as sugarcane, cereals, sugarbeets, rapeseed, and sunflowers, that have been selected and improved for food production (rather than for energy use), and their price is set in that market. This means that biofuels are not competitive, and must be exempt from taxation if they are to be marketed in competition with fossil fuels.
- **Standards and regulations.** To encourage biofuel production effectively, there must be a stable economic framework of legislation and regulations to guarantee the security of private investments. At the same time, there must be clarity about the external factors that require government intervention to ensure that the benefits of the biofuel strategy will be transmitted directly to the productive sector. There must also be clear rules governing land ownership and title.

The agricultural export strategy, 2006-2020

Preparation of the export strategy began with work by the National Planning Department on the *Visión Colombia II Centenario: 2019, Aprovechar las Potencialidades del Campo* ("Vision of Colombia for its second centenary, 2019: capitalizing on the potential of the countryside"). This strategy has selected export products from the agriculture sector, in light of market opportunities for each product, its competitiveness indicators, and the requirements for gaining admission to international markets. On the basis of this information, and in consultation with the associations involved, 10 groups of products were identified as export priorities. These include:

Biofuels: ethanol produced from sugarcane, *caña panelera* and yucca, and biodiesel from palm oil.

Late ripening crops: palm oil, cacao, rubber, macadamia nuts, and cashews.

With the production of fuel alcohol, the Ministry of Agriculture and Rural Development and the industry associations have set goals for 2020, based on the targets established by Vision 2019, calling for increases in the area planted in sugarcane, *caña panelera* and yucca for producing fuel alcohol, and thereby expanding alcohol production.

The areas with the greatest potential for growing crops such as sugarcane, caña panelera and yucca were identified, and targets were set for 2020 for the number of hectares planted with these feedstocks for the production of biofuels.

The regional breakdown of fuel alcohol feedstocks, according to Asocaña and the biofuels federation (Fedebiocombustibles), should focus on the following departments (Map 1):

SUGARCANE

1. Valle del Cauca, Cauca, Caldas, Risaralda

CAÑA PANELA

1. Antioquia
2. Santander, Boyacá
3. Quindío, Tolima
4. Meta

YUCCA

1. Bolívar, Córdoba, Sucre
2. Meta

The domestic energy agenda

The Domestic Agenda represents a meeting of minds between the national government, territorial entities, the private sector, political players and civil society on the set of strategic actions that the country must take in the short, medium and long terms to improve the productivity and competitiveness of the economy. It involves three dimensions: regional, sectoral, and horizontal[12].

The Domestic Agenda establishes strategies and actions for improving competitiveness in the various economic sectors, and in the regions, so that the country can capitalize on the various integration treaties it has signed or is currently negotiating, while at the same time addressing the restructuring that some sectors will need in order to be competitive in the new trading context.

Biofuels are covered under the energy sector in the Domestic Agenda, which includes the following subsectors: hydrocarbons, liquid fuels, electricity, gas and coal. This sectoral agenda establishes five strategies, the second of which is the only one that relates to biofuels: "systems to maintain and promote investment, supply and demand in the energy field, and services to promote competitiveness." Two sets of needs relating to biofuels are identified (Table 13).

Table 13.

Provisions of the domestic agenda, energy sector, relating to biofuels

Strategy 2: Systems to maintain and promote investment, supply and demand in the energy field, and services to promote competitiveness	
Requirements and need	**Action**
a) A dynamic, predictable and long-term legal and regulatory framework to promote efficiency.	1) Exert effective control over illegal trading in fuels, biofuels and trademarks and over agents in the chain.
b) Proven reserves of hydrocarbons and other energy sources to meet long-term demand, in line with the principle of economic rationality. c) Long-term MADR strategy d) Sector outlook e) Minminas provisions governing blends and technical specifications	2) Promote development of the market for biofuels and other alternative fuels, as part of a comprehensive energy policy.

[12] *Source: www.dnp.gov.co October 2006.*

Quality provisions in the technical specifications for fuel alcohol are governed by Resolutions 447 of April 14, 2003 and 1565 of December 27, 2004 of the Ministry of Environment, Housing and Territorial Development and the Ministry of Mining and Energy. The latest resolution amends the previous one in part.

Private sector

FENALCE

The National Federation of Cereals and Legumes Growers, FENALCE, is a private nonprofit umbrella association that represents the growers of cereals and legumes in the country. With the support of the National Cereals Fund, FENALCE has been working in collaboration with Dr. Bellum VS Reddy, Ph D. in phyto-improvement, currently with the National Institute for Research into Semiarid Tropical Crops (ICRISAT). The Federation believes that sorghum cultivation can become a reality, and has signed an agreement for germplasm and technical advice from ICRISAT, as well as agronomic assessments of hybrids and varieties of sweet sorghum developed essentially for regions of India, the Philippines and Africa.

MAQUILAGRO

A very innovative project is being promoted by MAQUILAGRO which, after extensive research, concluded that the best feedstock is tropical sugarbeet. Since 2001 test seedings have been conducted in Boyaca and La Costa. A group of Colombian investors have been enlisted in the Maquiltec holding company, with the goal of building six alcohol plants based on sugarbeet, each costing US$40 million.

Work on the first plant will start within a month in Boyaca, and the goal is to begin construction every six months (with two more in Cundinamarca, and three in Cesar, Guajira and Magdalena). Each processor will require 4000 ha of sugarbeet and 2000 additional hectares for crop rotation. In total, 1.8 million liters of ethanol will be produced every day, and 108,000 jobs will be created, directly and indirectly.

CLAYUCA

The CLAYUCA company's project, which involves participation by Diligent Energy Systems of Holland, the Petrotesting group of Colombia, CIAT (International Center for Tropical Agriculture) and the Parque Cientifico Aeronauta, calls for a pilot distillery plant for close monitoring of elite clones of the yucca found in different regions of the country, in order to determine their efficiency as feedstock for producing ethanol. Another objective of the project is to evaluate the technical and economic efficiency of bioethanol in vehicles designed to function with three fuel options (gasoline mixed 85% with dehydrated ethanol, hydrated ethanol, and gasoline), known as "flex fuel vehicles", now available on the market.

PROJECT FEASIBILITY STUDIES

In addition to the projects already in production, there are some other initiatives under way to produce alcohol from sugarcane and other feedstocks such as yucca and sugarbeets. They are located in the departments of Santander, Boyacá, Meta, Córdoba, Cesar, Sucre and Bolívar (Table 14).

These projects are considered viable because they are close to the country's major urban centers, which will provide demand for biofuel, and because of the sugar growing tradition (Valle del Cauca, La Hoya del Río Suárez in Santander and Boyacá, Valledupar, the Llanos Orientales and the Department of Huila, among others). For each project, the goal is to achieve an average daily refining capacity of between 150,000 and 300,000 liters.

The Ethanol Consortium Board company (ECB SA) is heading up a project to build three plants in Sucre, Bolívar and Córdoba on the Caribbean coast, each with a capacity of 300,000 liters a day. [Of their combined output of 900,000 liters], 750,000 l[13]would be earmarked for

Table 14.

Investment and output capacity of plants under construction

Region	Investors	Investment (US$ millions)	Capacity	Expected date	Feedstock
Santander-Boyacá	Mieles S.A.		100.000 Lts/day		Sugarcane
Santander-Boyacá	Alcol S.A.	30	150.000 Lts/day	1st half 2008	Sugarcane
Meta	Petrotesting S.A.	8	20.000 Lts/day	December 2006	Yucca
Quindío	Gobernación		150.000 Lts/day		Sugarcane
Boyacá	Maquilagro/ Inverlink	45	300.000 Lts/day	1st half 2008	Sugarbeet
Sucre, Córdoba y Bolívar	Ethanol Consortium Board ECB S.A.	250	900.000 Lts/day	I and II half 2008	
Boyacá and la Costa	Maquiltec S.A.	240	1.800.000 Lts/day		Sugarbeet
Cesar	Sicarare		100.000	1st half 2008	Yucca

Source: Ministerio de Minas y Energía, Fedebiocombustibles, Revista Dinero y Portafolio

[13] *These quantities have already been sold to the Swedish firm Svensk Etanol Kemi AB, Sekab, one of the largest ethanol marketers in Europe, for the next 10 years. Thanks to this purchasing commitment, Deutsche Bank will finance the operation. Source: Revista Dinero Edición 257*

export, and the remaining 150,000 for the local market. According to an article entitled "The Ethanol Fever" published in Revista Dinero #257, the company expects to be delivering 300,000 liters a day by October 2008, and to reach 600,000 liters a day by April 2009, with 750,000 liters going to the external market and 150,000 for the local market in October of that year.

The firm Ethanol Consortium Board ECB SA is a joint venture of Colombian and international partners. The latter include Sekab; Unisystem do Brasil, a specialist in sugar syrup extraction technology; a high-tech firm making ethanol processing plants (from Spain); another specializing in large-scale sugarcane plantations (from the Philippines), and still another with experience in the operation and maintenance of industrial plants (from Scotland). The Colombian partners in the project include Grupo de Inversionistas de Colombia, headed by Juan Manuel Giraldo, and Ingeniería Zar.

In the year 2000 an engineer, Luiz Ricardo Roa, founded the company Alcoholes de Colombia (Alcohol S.A.) a pioneer in building alcohol plants in the Rio Suarez Valley[14]. The plant in Guepsa, Santander, has a daily production capacity of 150,000 liters and is planning to add another 150,000. For feedstock, it will draw upon 4000 to 8000 ha of *caña panelera*, of which there are 45,000 ha nearby.

This project, headed by Mr. Roa, was sold to domestic investors, and now has its own investment bank, with which it is promoting a similar project in Puerto Lopez, with expectations for Tolima and Norte de Santander as well. All of them will use sugarcane as feedstock.

When it comes to yucca[15], the Petrotesting de Colombia group, which is producing oil in Putumayo, has already secured financing for this business and is building a plant in Puerto Lopez, with a daily capacity of 20,000 liters of fuel alcohol, using 2000 ha of yucca as the feedstock.

[14] *President Alvaro Uribe attended the laying of the cornerstone last year. At that time he said: "nobody denies the feasibility and viability of fuel alcohol projects in the flatlands of the Cauca Valley and in the Risaralda refinery. But we need examples to show the country that areas with such topography are also feasible for small-scale sugarcane operations. We need this project to succeed, not only for the Rio Suarez Valley but also to set an example for other regions of Colombia, in the Cundinamarca slopes and at Vegachi in Antioquia, to cite only those two locations". Source: Revista Dinero Edición 257. La Fiebre del Etanol*

[15] *The research, conducted with 25 varieties of yucca and involving the investment of more than $1 million in the initial stage, shows that there are five classes that can produce ethanol, and that each hectare can produce between 25 and 30 tons. For every ton of yucca, between 180 and 200 l of ethanol can be extracted: this represents an advantage over sugarcane which, according to Kanayet (president of Petrotesting de Colombia) yields only between 70 and 80 l per hectare. Source: www.fedebiocombustibles.com October 2006.*

k) Annual gasoline consumption

Daily consumption of gasoline in Colombia in 2006 is estimated at 76,570 barrels (Table 22).

Table 15.

Annual consumption of gasoline 2000-2006

Year	Annual consumption of gasoline
2000	102.725
2001	92.248
2002	90.459
2003	88.612
2004	84.367
2005	82.618
2006	76.570

**Barrels per day*

Source: UPME, with information from ECOPETROL

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3.8 COSTA RICA

Hydrocarbon consumption stood at 16.6 million barrels in 2005, and if current trends persist it is expected to reach 20 million by 2019, in large part because of the unbridled growth of the vehicle fleet, which rose from 678,000 vehicles in 2000 to slightly over one million in 2006. The oil bill for 2006 is estimated at $1.3 billion

This situation obliged the government in recent years to implement a contingency plan, targeted specifically at reducing gasoline consumption by restricting vehicle circulation, accompanied by legal initiatives, program proposals and pilot projects to promote domestic production of biofuels, in an attempt to substitute them for oil imports, at least partially.

The National Development Plan 2002-2006 includes the objective of promoting pilot projects for the use of alternative fuels as a means of reducing external dependency. Similarly, the National Development Plan 2006-2010 calls for the agricultural sector to reap the economic and environmental benefits of biofuel and renewable energy management, by making sustainable use of the country's farming capacities and resources.

An executive decree of 2003 created the "MAG-MINAE-RECOPE-LAICA Technical Working Commission", or Alcohol Fuel-Ethanol Commission.

The year 2004 saw the creation of the Technical Working Commission for the Study of Biodiesel to promote strategies for the development of biodiesel produced from domestic feedstocks.

With a view to pooling the efforts of these two commissions, a 2006 executive decree abolished them and replaced them with the National Biofuels Commission. Its mandate is to propose legal reforms for introducing the production and use of biofuels, and to prepare a national plan with short, medium and long-term strategies in this area.

In December 2005 the Technical Working Commission for the Study of Biodiesel delivered its first research report, with the following recommendations:

- Establish new plantations of oil palm to meet a potential increase in demand.
- Include the promotion of biodiesel crops on the MAG agenda (Agro 21).
- Determine the economic, social and environmental feasibility of a program for biodiesel production.
- Encourage the use of biomass wastes for producing biofuel.
- Verify the technical specifications suggested by the commission.
- Production of ethanol and blending with gasoline up to 10%, and blending of biodiesel in diesel to the same proportion.

At the same time, the commission has designed a long, medium and short-term plan to modernize and strengthen the biofuels industry.

Among the actions under way, a pilot project was launched in February 2006 to distribute ethanol in the Pacifico Central region and Guanacaste (the Barranca distribution terminal for 12% of domestic sales). Sixty-four gas stations are offering a blend of ethanol with gasoline, between 5% and 8%, with the intention of evaluating the logistics and the handling of gasoline with ethanol, from the RECOPE facilities to point of sale. The idea is to disseminate this experience to the rest of the country, for which RECOPE is evaluating the technical aspects at its distribution terminals. Currently, ethanol production is concentrated in the distilleries of the TABOGA and CATSA sugar refineries, and the dehydration and rectification plant of LAICA. There are plans to begin distribution of gasoline with ethanol in 2008 and 2009, and the demand for ethanol is expected to increase from 88 million liters in 2006 to 153 million liters in 2018.

With respect to biodiesel, some private firms are conducting a pilot project with 133 buses in San Jose, mixing 30% of biodiesel with 70% diesel, with the expectation of replacing diesel completely in the short term. Other companies have introduced machinery targeted at small and medium-scale enterprises for producing their own biodiesel from vegetable oils. In addition, the Costa Rican Energy Institute is conducting tests for producing electricity in its thermal plants.

a) Area planted in sugarcane and current yields

Approximately 52,000 ha are currently planted in sugarcane, of which 48,000 (92.3%) are harvested each year.

b) Area available for growing sugarcane

This is estimated at approximately 45,000 hectares, of which 20,000 hectares have favorable conditions and the capacity for mechanization (fieldwork and harvesting). Another 15,000 hectares have certain limitations, although some of these could be overcome (topography, water, soils, mechanized harvesting, availability of labor, road infrastructure, distance to processing centers, etc.) and there is in addition a further 10,000 hectares with severe limitations (topography, excess or deficit of water, soil fertility, texture, mechanization, infrastructure etc.) where any such production would have to use highly traditional means. It is clear that the foregoing refers only to plantations devoted to production of ethanol and not necessarily to sugar, nor has the profitability and agroindustrial efficiency of those areas necessarily been established - that potential implies incorporating new, non-traditional localities from the North, Atlanta, Central and South region of the country

c) Sugar production, yields and costs

Sugar production for the 2005/2006 harvest is estimated at 75.3 tons per hectare.

d) Mechanization and irrigation

It is quite feasible to incorporate both new areas and traditional areas with mechanization potential for producing sugarcane intended for sugar as well as alcohol production. Obviously this will require the necessary conditions: credit, roads and operating infrastructure, etc.

Our estimates show that the country has approximately 20,850 irrigated hectares planted in sugarcane, representing 40.1% of the total planted area in the country. If we look only at the area that we estimate to have the potential for irrigation ("Dry Pacific" and Central Valley), this would cover approximately 64.5%.

The rainfall distribution pattern varies from year to year, within a broad range of 1300 to 4200 mm in the country's six producing regions. In general terms, we may safely say that rainfall is highly changeable and unbalanced over time, with the appearance of periods of intense drought, of varying intensity, that have a determinant impact on crop growth, especially during the months of May to July, and on the contrary, problems of flooding in the Puntarenas and Guanacaste (Dry Pacific) in the months of September to November, affecting maturation. In recent years, such behavior has appeared in other regions, particularly Turrialba and the South zone, and to some extent in the North zone (San Carlos, Los Chiles). It is important to note that it is not the quantity of rain that has varied so much as its distribution during the year. There is in fact a direct and determining relationship between productivity, agroindustrial yields and rainfall distribution, all of which interferes negatively in the final returns to the activity.

e) Ethanol production (per hectare and per ton of sugar) and costs

For the same harvest (2005-2006), sugar production was estimated at 382,824.4 MT, representing an estimated yield of 8.0 MT of sugar/ha.

That year saw the processing of 3,615,582 tons of sugarcane. Domestic ethanol is produced essentially from molasses, and so there is no direct relationship of factors. Efficiency is estimated at 5000 to 6000 liters of ethanol per hectare.

f) Installed industrial capacity

15 refineries are currently active. The milling capacity is estimated at 43,300 tons per day.

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

The leading organization involved in studies aimed at improving production processes in the domestic sugar industry is the Agroindustrial Sugarcane League (LAICA), which carries out its activities through specialized units: Sugarcane Research and Extension Services Directorate (DIECA), Punta Morales Port Unit, and the Technical Department. We may also mention the major efforts of the agriculturalandindustrialdepartments of the national refineries, particularly those producing alcohol: TABOGA and CATSA. Their performance is relatively good, although limited in the sense that there are no specific research and innovation programs exclusively devoted to such topics, because there are still no incentives for the domestic use of ethanol in blends with hydrocarbons. There are other initiatives underway in the public universities, which we cannot describe further for lack of information. The existing capacity in the sugar sector, at the national level, is considerable, because of the country's long tradition and experience in producing and exporting alcohol (ethanol).

h) Other feedstocks for producing ethanol

There is currently important production, but there is a still greater potential capacity and agricultural expertise in producing yucca, corn, roots and sugars and ligno-cellulose materials, among others. There is no specific information on these aspects.

i) Regulations governing the blending of ethanol with gasoline

The commission created by executive decree 31087 MAG-MINAE sponsored a pilot project which demonstrated effectively that the addition of anhydrous ethanol to gasoline in a percentage of 10% ("E10 fuel") has no negative impact on vehicle engines or on the environment.

j) Government and private programs for the production and use of ethanol in fuels

This situation obliged the government in recent years to implement a contingency plan, targeted specifically at reducing gasoline consumption by restricting vehicle circulation, accompanied by legal initiatives, program proposals and pilot projects to promote domestic production of biofuels, in an attempt to substitute them for oil imports, at least partially.

The National Development Plan 2002-2006 includes the objective of promoting pilot projects for the use of alternative fuels as a means of reducing external dependency. Similarly, the National Development Plan 2006-2010 calls for the agricultural sector to reap the economic and environmental benefits of biofuel and renewable energy management, by making sustainable use of the country's farming capacities and resources.

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k) Annual consumption of gasoline

Hydrocarbon consumption stood at 16.6 million barrels in 2005, and if current trends persist it is expected to reach 20 million by 2019. The oil bill for 2006 is estimated at $1.3 billion.

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3.9 ECUADOR

Ecuador has significant renewable and nonrenewable energy resources, including oil, which is the country's greatest source of foreign exchange revenues, and solar, hydro and bioenergy.

Energy demand in Ecuador is met primarily from hydrocarbons. Other energy sources such as hydroelectricity, wood and sugarcane, account for a very small share of the energy mix (see Table).

The energy mix in Ecuador

Energy source	Percentage
Oil	83%
Natural gas	4%
Hydro energy	7%
Wood	3%
Sugarcane products	3%

Source: OLADE, quoted by Acción Ecológica (1)

Biofuel production in Ecuador is minimal, in comparison with countries like Brazil. In 2005, the area planted in sugarcane was 135,000 ha, of which 75,000 were devoted to sugar production, 50,000 to "brown sugar" *(panela)* and rum products, and 10,000 to ethanol (100,000 liters a day). Palm oil, the primary feedstock for biodiesel, is produced in 11 of the country's 22 provinces. At the present time, 350,000 tons of oil are being produced from 207,000 ha of palm plantations: 200,000 tons of oil are consumed, and the remaining 150,000 tons are exported.

The existence of a significant quantity of land suitable for energy crops is Ecuador's main strong point. According to data from the Ministry of Agriculture, Livestock, Aquaculture and Fisheries there are 675,932 ha potentially available for growing sugarcane alone.

a) Area planted in sugarcane and current yields

In 2006, Ecuador had 78,000 ha in sugarcane, with an average yield of 78 tons per hectare.

b) Area available for growing sugarcane

According to data from the Ministry of Agriculture, Livestock, Aquaculture and Fisheries, there are 675,932 ha potentially available for growing sugarcane.

c) Sugar production, yield and costs

Total sugar production in Ecuador in 2006 was 510,000 tons, with a yield of 6.8 tons per hectare.

d) Mechanization and irrigation

Approximately 63% of the area planted in sugarcane is mechanized. Unmechanized fields are devoted to the production of sugarcane for processing into brown sugar and rum. Most of these areas are of irregular topography, making mechanization difficult.

The areas identified as potentially available are suitable by their topography for mechanization. The area that requires irrigation is not known for sure, but areas planted in sugarcane for processing into sugar, located along the coast and in the Andean region, are thought to be irrigated. This is 70% of the area that requires irrigation.

e) Ethanol production (per hectare and per ton of sugar) and costs

The yield of ethanol from molasses is estimated at 20 liters per ton of cane, or 1560 liters per hectare (a major portion of output). When ethanol is produced directly from sugarcane the yield is 70 liters per ton, equivalent to 5460 liters per hectare.

f) Installed industrial capacity

The installed capacity for producing ethanol is around 160,000 liters a day, meaning a normal capacity of 47,107,000 liters a year (assuming a reasonable rate of efficiency and actual working days during the year).

g) Research and development institutions working on ways to improve cane, sugar and ethanol production

The following research institutions are devoted to improving production processes for sugarcane and ethanol.

- *Petroecuador - Instituto de investigación.* It is responsible for conducting tests for implementing the ethanol-gasoline substitution program.
- *Centro de Investigación de la Caña de Azúcar del Ecuador.* This sugar research center is developing varieties and technologies for growing sugarcane, and is supported by the country's major sugar refineries.
- *Unión Nacional de Cañicultores del Ecuador.* The National Union of Sugarcane Growers is developing new varieties of sugarcane in its laboratories with a view to expanding areas planted in sugarcane.
- *Escuela Politécnica Nacional,* the National Polytechnic School. Its chemical engineering and mechanical engineering faculties have conducted research on processing sugarcane into ethanol and using other feedstocks and innovative technologies. It has long experience and a good track record in research.
- *Universidad Técnica del Norte.* Its agronomy and chemical industry faculties are conducting studies and practical projects, consulting services and extension services relating to production of ethanol from sugarcane.
- The German Social and Technical Cooperation Service (DED) supports biofuels projects as part of its work on the issue of sustainable management of natural resources.

- Private enterprise (sugar refineries and ethanol producers) also perform research to improve production processes.

h) Other feedstocks for producing ethanol

Other feedstocks that are or could be produced in Ecuador for making ethanol are bananas (discards or surpluses), sugarbeets, corn, yucca and residues from the paper and lumber industries (cellulosic wastes). Table 16 shows the area, the agricultural yield, and the alcohol yield of some of these products.

i) Regulations governing the mix of ethanol in gasoline

Ecuador has no regulations governing the mix of ethanol in gasoline. However, as part of the work of the Technical Committee of the Biofuels Advisory Council, a study is being conducted to help establish such regulations.

The Ministry of Energy and Mines has issued some technical recommendations that have served as the basis for establishing the proposed "Pilot Plan for Formulation and Use of Gasoline with Anhydrous Ethanol in the City of Guayaquil", designed to facilitate preparation of 5000 gallons a day of "extra" grade gasoline with ethanol (blend 95% gasoline plus 5% anhydrous ethanol), for marketing in the urban area of Guayaquil.

j) Government and private programs for production and use of ethanol in fuels

The current government of Ecuador has demonstrated its interest in promoting the use of renewable energy from various sources. In early March 2007 it confirmed its support for the "Pilot Plan for Formulation and Use of Gasoline with Anhydrous Ethanol in the City of Guayaquil", which was originally proposed in 2005 but has not yet been implemented for lack of a political decision and agreement among stakeholders.

Table 16.

Substitute feedstocks for the production of ethanol in Ecuador

Product	Area	Agricultural productivity mt/ha	Alcohol productivity lt/mt
Bananas	171,314	27.7	74
Sugarbeets		10-40	180
Yucca	24,931	5.6	180
Corn	101,935	2.37	400

The main alcohol producing firms in Ecuador (CODANA, SODERAL and PRODUCARGO) are interested in expanding their installed capacity to meet the ethanol demand arising from introduction of the biofuels plan.

Provincial governments and various business groups, including sugar refiners, are also interested in investing.

k) Annual consumption of gasoline

In 2005, Ecuador consumed 460,112,897 gallons of "extra" grade gasoline, for a value of $524,414,703 (at a pump price of $1.41 per gallon), and 125,108,620 gallons of "super" gasoline, for a value of $262,728,102 (pump price $2.10 per gallon). The projected demand for gasoline in 2008 is 627,606,000 gallons.

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3.10 EL SALVADOR

There are two clearly defined sectors producing biofuels in El Salvador. The first consists of large companies and refineries, and the second of small producers. The refineries and large companies are working on the production of ethanol for fuel. They have international contacts for obtaining technology and know-how. The most representative group are the sugar growers affiliated in the Agriculture and Agri-Ministry Chamber. Small producers are beginning to produce biodiesel from castor beans *(Ricinus communis)* and physic nut trees *(Jatropha curcas)*.

a) Area planted in sugarcane and current yields

The latest official data from the Agricultural Statistics Department for the harvest year 2003/2004 show that 92,910 *manzanas** were devoted to sugarcane, equivalent to 65000 ha. The area planted is estimated to have declined by approximately 372.6 ha in 2006. However, for 2007 is expected that the area planted will increase by 5000 *manzanas*. During the same harvest, the agricultural yield was reported at 34.93 tons per hectare.
[* 1 *manzana* = 0.7 ha]

b) Area available for planting in sugarcane

The potential increase in the area planted to sugarcane is about 30,000 *manzanas* (approximately 20,067 ha), without compromising the areas devoted to other crops. However, the President of El Salvador insists that there are 600,000 *manzanas* (419,338 ha) available in the country as a whole for this purpose.

c) Sugar production, yield and costs

Total sugar production for the 2003-2004 harvest was 497,000 ton, produced from 197,000 ha, with an average yield of 7.90 tons of sugar per hectare.

According to data from the Ministry of Agriculture and Livestock (MAG) the average cost of producing a ton of sugar is $1522.48 in the first year, $952.11 in the second year, and $859.29 in the third.

First-year costs are higher because of the expense of establishing a crop (preparing the soil, purchasing and sowing the seeds, etc.). In the second and third years, the activities are the same but the costs in terms of labor and fertilizer are slightly higher in the second year. In years four and five, the costs are still lower ($826 and $767 respectively). Over the five years, the average cost works out to approximately $985.38 a ton.

d) Mechanization and irrigation

The area planted in sugarcane in El Salvador is 100% mechanized, with the exception of harvesting, which for the most part is done by hand. However, mechanized harvesting is likely to arrive shortly because of the

growing scarcity of manpower. If new areas are brought under production, these will be covered 100% by mechanized planting systems.

With respect to irrigation, there are no current data on the irrigated area planted in sugarcane. A rough approximation, however, suggest that up to 5% of the total planted area receives some kind of irrigation (meaning supplementary watering by flooding, not programmed irrigation). Normal practice is to apply three or four irrigation cycles during the dry season.

High-tech irrigation, through spraying or drip systems, is very limited, and probably does not exceed 0.5% of the seeded area.

The incidence of rainfall has a direct impact on sugarcane production. However, there are no data for establishing a correlation between the volume of precipitation and sugarcane output. Because the sugarcane areas are located in the same climatic zone, they are also influenced by the same rainfall regime.

Average precipitation in El Salvador ranges from 1600 to 1800 mm in the sugarcane areas.

e) Ethanol production (per hectare and per ton of sugar) and costs

According to the country report, there are no local data on the production of ethanol, since no refinery devotes all of its activity to ethanol production. Around 2.5 to 3.5 gallons of molasses is needed to produce a liter of ethanol. According to data from Mexico, 26.62 gallons of ethanol can be produced from a ton of sugarcane, representing 1480 gallons of alcohol for each *manzana* planted.

As well, data from the only ethanol producer in the country (Ingenio La Cabaña) show that it is currently producing at costs above those normally reported ($0.40 to $0.45 a liter). The refinery reports that its costs are greater than normal, but that under proper production conditions they could be reduced to normal levels.

f) Installed industrial capacity

Currently, only the Ingenio La Cabaña is producing ethanol, and all of it is exported. Installed capacity at that refinery is 120,000 liters a day, with possibilities for expansion.

Considering a 10% blend of ethanol in gasoline for the domestic market, this would represent demand for 15 million gallons a year. With its current installed capacity, La Cabaña can supply 11,571,994 gallons of ethanol per year.

There is a project under way to establish an ethanol plant with a capacity of 300,000 liters a day, with support from Brazil and the United States. If it comes to pass, it would be producing 29 million gallons a year, thus generating an exportable surplus.

g) Research and development institutes working on ways to improve cane, sugar and ethanol production.

The country has no institute involved in sugar research and development.

h) Other feedstocks for producing ethanol

There are products with high sucrose content, such as sugarcane, molasses and sweet sorghum, that are adapted to conditions in the country, in addition to sugarbeets, which are not a traditional crop in El Salvador. Products with high starch content, including derivatives of corn, potatoes and yucca, could also be used.

In general terms, the country could produce many agricultural products that yield starch and sucrose. However, under current conditions, none of these products would be competitive with sugarcane, for reasons of energy yield and biomass output. Moreover, sugarcane has very low environmental impacts.

i) Regulations governing the mix of ethanol in gasoline

Ethanol has never been used domestically, because there is no law or regulation governing its use. However, a law is being prepared to regulate the use of biofuels. Work on the draft is 95% complete, according to the Ministry of Agriculture.

j) Government and private programs for production and use of ethanol in fuels

There is great interest on the part of the government in promoting a program to produce and use ethanol. El Salvador was selected from among 150 sugar producing countries for the US-Brazil pilot project. The presidents of both countries joined in announcing installation of a producing plant in El Salvador.

According to the presidential initiative on ethanol, production will be in private hands and will not be a government responsibility. In this case, the task of the State will be to support the search for financing from international agencies.

k) Annual consumption of gasoline

According to Ministry of Economy data, the country consumed 147,952,627 gallons of fuel in 2006, at a total cost of $279,520,089.56.

The ministry does not report prices at the pump, but rather international prices and their monthly variations. However, international prices serve as a benchmark for determining the value of oil imports and the selling price of gasoline at the pump: the country imports 100% of its fossil fuel consumption. On average, the consumer price of regular-grade gasoline is $2.97.

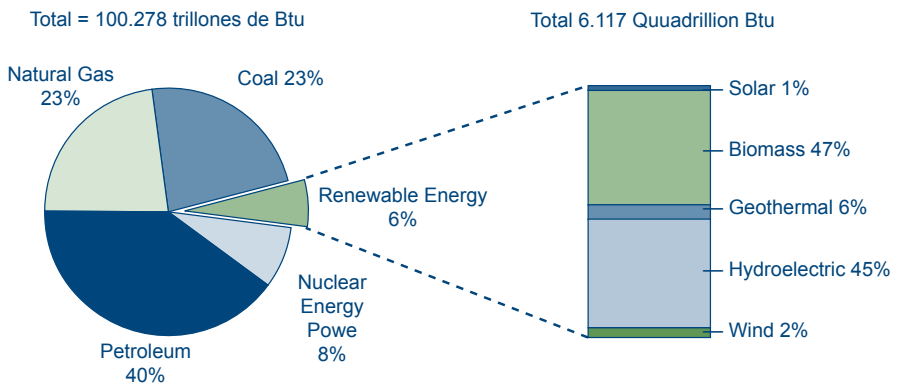
3.11 UNITED STATES

The most effective government policies that have expanded renewable energy production are non-agricultural policies. (i.e., Energy Tax Act of 1978 and the Energy Policy Act of 2005). Most agriculture-related policy has centered on food and feed supply availability. This section discusses recent trends in energy use in agriculture, renewable energy production opportunities, the policies that have helped foster those opportunities, and the prospects for renewable energy markets.

Since the energy crisis of the 1970s, developing new energy sources from the agricultural sector has been viewed as a way to expand the domestic energy supply and help mitigate U.S. growing dependence on imported oil. Including hydropower, renewable energy accounted for six percent of U.S. energy consumption in 2004, with energy from biomass contributing almost half of that total (Figure 5). Biomass energy is primarily produced from wood (70 percent) followed by waste (20 percent) and alcohol fuels (10 percent). While wood has provided most of the biomass energy over the years, ethanol has been the fastest growing renewable energy source over the past 10 years. Ten years ago ethanol's share of biomass energy was less than 4 percent.

Figure 5.

The Distribution of Renewable Energy Consumption in the United States, 2004.



Source: Department of Energy, Energy Information Administration

Government incentives encouraged investment in the ethanol industry and production grew rapidly throughout the 1980s and 1990s (Figure 6). In 2005, the ethanol industry produced 4 billion gallons of ethanol which is blended in 30 percent of the Nation's gasoline.

Biodiesel, which is just beginning to establish a market in the United States, is a biofuel substitute for petroleum diesel (Figure 7). Biodiesel is most commonly blended with diesel fuel at levels of 20 percent or lower. The majority of the 91 million gallons of biodiesel produced in 2005 came from soybean oil, although it can also be made from other oilseed crops, animal fats, and grease.

Figure 6.

U.S. Annual Ethanol Production, 1980-2005.

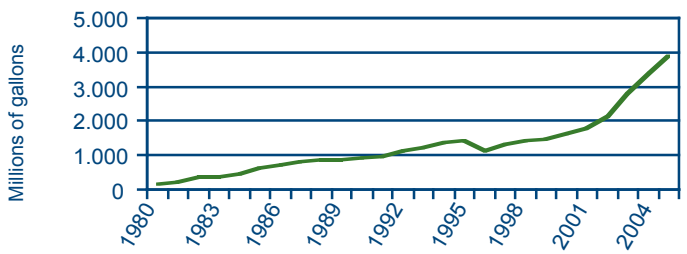
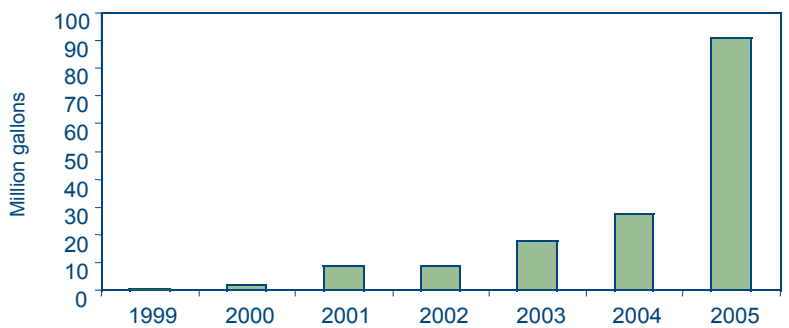


Figure 7.

U.S. Annual Biodiesel Production, 1999 – 2005.



The U.S. Department of Energy's (DOE) Energy Information Administration (EIA) estimates that the United States consumes about 140 billion gallons of gasoline and 60 billion gallons of diesel fuel per year. Therefore, in terms of their relative contribution to meet our transportation fuel needs, ethanol production met about 3 percent of gasoline consumption in the United States while biodiesel production met 0.15 percent of diesel fuel consumption in 2005.

Although ethanol growth has been impressive in recent years, ethanol accounts for about 3 percent of total annual gasoline consumption. About 14 percent of the U.S. corn crop was used for ethanol in 2005/06 and USDA projects 20 percent of U.S. corn production will be converted into ethanol in 2006/07. Clearly, the supply of corn is relatively small compared to gasoline demand, so other domestic sources of renewable energy must be developed to replace oil imports if the U.S. is to greatly reduce its dependence on imported oil. Biodiesel can extend the diesel fuel supply, but the supply of oil crops, animal fats, and other feedstocks are also relatively small compared to the diesel fuel market. Research may provide technological breakthroughs leading to a significant expansion in ethanol production. In the near future, ethanol's feedstock base could expand significantly with the advancement of technology that could economically convert switchgrass and other low-valued biomass into cellulosic ethanol.

The main aspects of the U.S. policy in support of biofuel development are as follows:

▲ ***Energy Policy.*** Much of the growth in corn ethanol production can be attributed to government incentive programs that began in the 1970s. The Energy Tax Act of 1978 authorized the motor fuel excise tax exemption for ethanol blends, providing ethanol blends of at least 10 percent ethanol by volume a $0.40 per gallon exemption from the Federal motor fuels tax. Since then, several statutes have extended the tax exemption for ethanol. Currently, Federal law authorizes a tax credit of $0.51 per gallon for ethanol through 2010. Legislation has also been passed to give income tax credits and loan guarantees to small ethanol producers.

The American Jobs Creation Act of 2004 granted biodiesel blenders a tax credit of $1.00 per gallon of biodiesel made from oil crops and animal fats and a $0.50 per gallon tax credit for biodiesel made from recycled fats and oils. Largely due to this tax credit and other government incentives, biodiesel production has grown from about 500,000 gallons in 1999 to 91 million gallons in 2005.

The Energy Policy Act (EPACT) of 2005 included several provisions to help diversify domestic energy production through the development of renewable fuels. EPACT mandates a renewable fuel phase-in called the renewable fuels standard (RFS), requiring U.S. fuel production to

include a minimum amount of renewable fuel each year, starting at 4 billion gallons in 2006 and reaching 7.5 billion gallons in 2012. EPACT also created the Cellulosic Biomass Program to encourage the production of cellulosic ethanol and fund research on conversion technology. Under this program, every one gallon of ethanol made from biomass, such as switchgrass, crop residues, and tree crops, counts as 2.5 gallons towards satisfying the RFS. EPACT also extended the biodiesel fuel excise tax credit through 2008 and authorized a $0.10 per gallon income tax credit to small biodiesel producers.

▲ ***Environmental Policy.*** There is a significant opportunity to reduce air pollution and greenhouse gas (GHG) emissions by replacing fossil energy with renewable energy. Ethanol was first used as a fuel additive in the late 1970s when the Environmental Protection Agency (EPA) began phasing out lead in gasoline and ethanol replaced lead as an octane enhancer. Provisions of the Clean Air Act Amendments of 1990 (CAA) established the Oxygenated Fuels Program and the Reformulated Gasoline (RFG) Program to control carbon monoxide and ozone problems created by motor fuels. Refiners blended cleaner burning oxygenates into gasoline to meet the new standards. Ethanol and a petroleum-based additive called methyl tertiary butyl ether (MTBE) became the two oxygenates most commonly used to meet the requirements mandated by the CAA. The use of MTBE is currently being phased out and replaced with ethanol after MTBE was found to contaminate drinking water. Recently adopted EPA diesel fuel standards that require refiners to remove most of the sulfur from diesel fuel could increase biodiesel demand. Since biodiesel contains no sulfur and is an excellent lubricity agent, refiners could blend biodiesel with petroleum diesel to help meet the new standards.

▲ ***Agricultural Policy.*** Agricultural policy has only recently been directed at energy conservation and renewable energy production.

▲ ***State Programs.*** There are also many State programs that encourage renewable energy use through tax credits, production incentives, and biofuel mandates. One of the first states to actively promote biofuels was Minnesota, which has consumption mandates for ethanol and biodiesel. Minnesota's two-percent biodiesel mandate, that became effective in 2004, created a 16 million gallon market for biodiesel. Almost every State has at least one renewable energy promotion program in place, and most have several.

Market Prospects

Over the years, government incentives have been necessary to help ethanol and biodiesel compete with less costly petroleum-based fuels. However, the recent surge in oil prices has made biofuels much more cost competitive and these industries are attracting new investment. The number of biodiesel plants is growing rapidly due to government incentives and high diesel fuel prices – the number of plants increased from less than 10 in 2000 to 65 plants in 2006, with an annual industry capacity of 395 million gallons. Another 58 plants are under construction or in the process of expansion, adding another 318 million gallons of capacity upon completion. Ethanol production has also been growing rapidly. In 2000, there were 54 plants with capacity of about 1.75 billion gallons per year. Currently, there are over 100 ethanol plants with a combined production capacity of over 4.5 billion gallons a year. An additional 30 ethanol plants under construction are expected to add annual capacity of more than 2 billion gallons.

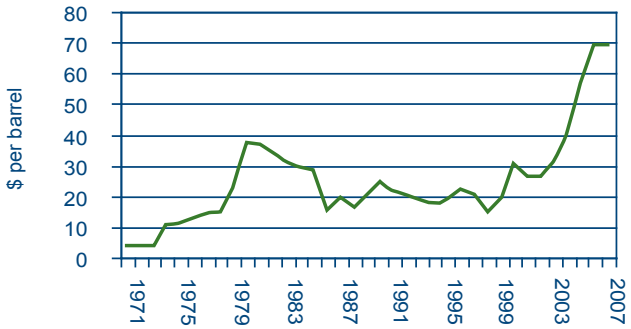
Ethanol and biodiesel production will continue to expand as long as government incentives continue and world petroleum prices remain high. World oil prices have increased sharply since 1999, when the annual average nominal price of West Texas Intermediate (WTI) oil jumped from $19.25 per barrel in 1999 to $30.29 in 2000 (Figure 8). Between 2000 and 2003, the average WTI price ranged from about $26 per barrel to $31 per barrel. In 2004, the WTI price increased to over $41 per barrel and the 2005 average WTI price increased to over $56 per barrel. EIA short-term projections indicate that the average WTI price for a barrel will climb to $69 in 2006 and remain at that level in 2007.

Higher crude oil prices have translated into higher wholesale and retail prices for gasoline and diesel fuel. EIA estimates that the average wholesale price for gasoline increased from $1.28 per gallon in 2004 to $2.04 per gallon in 2006. With cash and net feedstock costs for ethanol at about $1.00 per gallon, ethanol was not competitive with gasoline at 2004 prices without the income tax credit. However, with the recent increase in gasoline prices, corn-based ethanol is competitive with gasoline without the income tax credit.

Under EIA's long-term forecast, the real price of imported oil is expected to level-off after 2007 and perhaps show a slight decline by 2010. Nevertheless, world oil supplies are expected to remain tight as the demand for oil remains strong, keeping pressure on oil prices

Figure 8.

Annual Average and Forecasted U.S. Crude Oil Prices, 1971-2007.



through 2030. If future oil prices reflect EIA projections, biodiesel and ethanol production will continue to grow with the rate of growth depending on the level of oil prices, feedstock costs, and changes in technology.

Some aspects of the future development of technology for biofuel production that form part of the U.S. agenda are as follows:

USDA's Agricultural Research Service (ARS) is USDA's primary research agency. Specific energy-related work being conducted by ARS follows:

- **Better understanding of ethanol-producing bacteria.** The process of cellulose degradation is not well understood. This research provides new information on the regulation of cellulose degradation by an organism that shows particular promise for converting cellulosic biomass.
- **Improved organisms for ethanol production.** Inhibitors formed during pretreatment of lignocellulosic material reduce the performance of ethanol-producing fermentation organisms. ARS scientists are using a method called directed adaptation, developing strains of organisms that have enhanced ability to convert toxic compounds into less toxic compounds. Development of these more tolerant organisms is a significant step toward achieving the technology necessary for commercial production of ethanol from cellulosic plant material.
- **Key gene in cell wall biosynthesis identified.** There is a need to identify genes that regulate cell wall composition of alfalfa so that new varieties can be developed that have greater potential as biofuel feedstocks. ARS scientists identified and characterized a gene, UDP-sugar

pyrophosphorylase (USP), which plays an important role in cell wall biosynthesis in plants. The isolation of the USP gene and new knowledge learned about the protein it produces will allow cell walls of alfalfa plants to be modified to improve the value of this crop as a bioenergy feedstock.

a) Area planted in sugarcane and current yields

Sugarcane production in 2005-06 was equivalent to 387,250 ha, with a yield of 66.63 tn/ha.

b) Sugar production, yield and costs

Total US sugar production is 2,707,000 tons, with a yield of 6.99 tons per hectare. Ethanol is produced in the United States from corn at an average production cost of $0.29 per liter.

c) Ethanol production (per hectare and per ton of sugar) and costs

Despite the impressive growth of ethanol in recent years, it is estimated to account for only 3% of total gasoline consumption. Approximately 14% of the corn crop was used for producing ethanol in 2005/06, and USDA forecasts that 20% of American corn output will go to ethanol production in 2006/07. Clearly, the supply of corn is relatively small compared to the demand for gasoline, and so other domestic sources of renewable energy will have to be developed. Sugarcane is one of the most widely used crops for producing ethanol.

d) Installed industrial capacity

Ethanol capacity is growing rapidly. In 2000, there were 54 plants with a capacity of approximately 1.75 billion gallons per year. Currently there are more than 100 ethanol plants, with a combined capacity of more than 4.5 billion gallons per year.

e) Research and development institutes working on ways to improve cane, sugar and ethanol production

USDA's Natural Resources Conservation Service (NRCS) has several programs that affect energy use on farms and ranches. These programs include the Conservation Security Program (CSP), the Environmental Quality Incentives Program (EQIP), Conservation Technical Assistance (CTA), as well as other programs.

f) Availability of other feedstocks for producing ethanol

The United States expects to be using 25% of its corn harvest to produce 26.5 billion liters of ethanol by the year 2010, according to the agriculture and fisheries information bulletin for the United States and Canada.

Table 17.

United States. Production capacity, by state

State	Capacity MMGal/yr	% of capacity	No. of plants	% of plants
Iowa	1,606	33	25	24.5
Illinois	706	14.5	6	5.9
Nebraska	566	11.6	11	10.8
Minnesota	546	11.2	16	15.7
South Dakota	475	9.7	11	10.8
Wisconsin	193	4.0	5	4.9
Kansas	179	3.7	7	6.9
Indiana	122	2.5	2	2.0
Missouri	110	2.3	3	2.9
Colorado	93	1.9	3	2.9
Tenesse	67	1.4	1	1.0
North Dakota	51	1.0	2	2.0
Michigan	50	1.0	1	1.0
Kentucky	38	0.8	2	2.0
California	34	0.7	3	2.9
New México	30	0.6	1	1.0
Wyoming	5	0.1	1	1.0
Ohio	3	0.1	1	1.0
Georgia	0.4	0.0	1	1.0
TOTAL	**7,872**	**100**	**102**	**100**

Research may produce technological breakthroughs. In the near future other plant products, including switchgrass and cellulose, are likely to come into use for producing ethanol, and this will boost production significantly.

The production and consumption of ethanol both grew strongly last year. Production was up 23% between 2002 and 2006, while consumption rose 27% per year. This was due to the increase in the ethanol-gasoline mix from 1.5% in 2002 to 3.8% in 2006. Consumption reached 20.4 billion liters. This sizable increase can be attributed to government policies. First, the Renewable Fuel Standard (RFS), which created a guarantee for the market. Second, thanks to large tariff incentives, the United States has been able to invest heavily in the ethanol industry.

Table 18.

Feedstocks used for ethanol production

Crop	Capacity MM Gal/yr	% of capacity	No. of plants	% of plants
Corn [a]	4.516	92,7	85	83,3
Corn/milo	162	3,3	5	4,9
Corn/wheat	90	1,8	2	2,0
Corn /barley	40	0,8	1	1,0
Milo/barley	40	0,8	1	1,0
Beverage waste [b]	16	0.3	5	4,9
Cheese whey	8	0,2	2	2,0
Sugars and starches	2	0,0	1	1,0
TOTAL	**4.872**	**100**	**102**	**100**

Source: US EPA
[a] Includes seedcorn
[b] Includes brewery waste.

g) Regulations governing the mix of ethanol in gasoline

The growing production of ethanol mainly uses corn as feedstock. This fact may be traced back to government incentive programs that began in the 1970s: the principal incentive is the $0.40 a gallon tax exemption for the E10 blend. Since then, various laws have extended the tax exemption for ethanol. Currently, federal law authorizes a tax credit of $0.51 per gallon for ethanol until 2010. Legislation also provides benefits to small ethanol producers.

h) Government and private programs for production and use of ethanol in fuels

USDA's Natural Resources Conservation Service (NRCS) has several programs that affect energy use on farms and ranches. These programs include the Conservation Security Program (CSP), the Environmental Quality Incentives Program (EQIP), Conservation Technical Assistance (CTA), as well as other programs.

In August 2005, the Energy Policy Act was signed into law, which sets as the goal for 2012 the consumption of 28.4 billion liters of renewable fuels, or around 5% of the total amount of fuel expected to be consumed that year. However, the United States may set a higher target of 132.5 billion liters of renewable and alternative fuels for 2017.

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3.12 GUATEMALA

Guatemala's agricultural heritage yields a great variety of crops, including coffee, sugar, cardamom and bananas.

The sugar industry has been heavily involved in producing electricity at sugar refineries, and has installed cogenerators that run on bagasse, and take advantage of downtime during the off-season. Its relative importance in this respect can be inferred from the data on electricity production in the country. In 2001 this amounted to 5772.3 GWh, as can be seen from the table opposite. In terms of the power mix, hydroelectric power accounts for 39.2%, and internal combustion engines for 30.8%. Power stations using renewable energy account for 52.6% of the total. In terms of ownership, 35% of production is public, while the remainder comes from private generating firms. Currently, Guatemala exports 120,000 liters a day of fuel ethanol to the West Coast of the United States.

National Power Grid		
Production 2001 (GWh)		
Hydro	2.264,3	39.2%
Geothermal	193,7	3,4%
Steam plants	849.9	14.7%
Cogeneration	576.8	10.0%
Gas turbines	106.9	1.9%
Reciprocating motors	1.780.7	30.8%
Self-production	0.0	0.0%
TOTAL	**5.772.3**	**100.0%**

a) Area planted in sugarcane and current yields

Sugar is Guatemala's main export crop. The country has around 197,000 ha planted in sugarcane, and 72% of the crop is exported. Sugar represents 24% of the total value of agricultural output. For the period 2004-2005, production was 17.8 million tons, representing an average agricultural yield of 90.5 tons per hectare

b) Area available for growing sugarcane

There is currently no information on the potential area available for growing sugarcane in Guatemala

c) Sugar production, yield and costs

Total sugar production is 44.3 million quintals, equivalent to 2.01 million metric tons, representing a yield of approximately 10.2 tons of sugar per hectare. The cost of producing a ton of sugarcane is estimated at US$18.50.

d) Mechanization and irrigation

There is much uncertainty about the proportion of the area that could be mechanized, because most of the soils are not suitable for mechanization and would have to be conditioned through leveling and other work. There are some lands suitable for mechanized harvesting, but they are ignored because they tend to be sandy.

Harvesting would have to begin in the summer so that the machinery can enter the cane fields. Along the south coast, where production is concentrated, rainfall is fairly high, and the rainy season extends for five or six months, during which cane harvesting is difficult.

e) Ethanol production (per hectare and per ton of sugar) and costs

According to assessments based on the installed capacity of the country's existing distilleries and the level of sugarcane output, ethanol generation per hectare of sugarcane is estimated at 5,570 liters. The cost of producing a liter of ethanol is approximately US$0.321.

f) Installed industrial capacity

The industry consists of 15 sugar mills located in five departments. During the 2004-2005 harvest, these units, which own 197,000 planted hectares, produced 17.8 million tons of milled cane. In terms of ethanol production, there are now four distilleries with total capacity of 490,000 liters a day. The Destileria Bioetanol, associated with the Ingenio Pantaleon refinery, is the largest in the country and will use modern technology to produce 150,000 liters a day.

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

The Sugarcane Research Center (CENGICAÑA) is the main private institution engaged in the study and development of sugarcane varieties, integrated pest management technologies, fertilizers, irrigation and training. There is also the Guatemalan Association of Sugar Technologists (ATAGUA) and OCTAGON.

h) Availability of other feedstocks for producing ethanol

Corn is the principal substitute for producing ethanol. In 2005, there were 603,000 ha planted in corn, producing 1,072,310 tons. The yield has been constant over the last five years, at only 1.78 tons per hectare.

i) Regulations governing the mix of ethanol in gasoline

The Fuel Alcohol Act (Decree Law 1785 of February 21, 1985) and its Regulations establish standards for the production, storage, management, use, transport and marketing of fuel alcohol and blends.

On April 27, 2006, a draft Law 3469 was introduced to amend Decree Law 1785. allowing the use of alcohol. This included an official quality standard for blends with gasoline and made a 25% blend mandatory, but it did not produce the desired results. In general terms, this new initiative sought to lay the basis and establish the framework for a national program to oxygenate gasoline through domestic production of alcohol, which would be blended as an additive to the gasoline currently used in the country. In the end, the initiative was not approved by Congress.

Finally, on November 10, 2003, Congress approved the Law on Incentives for the Development of Projects in Renewable Energy, declaring the rational development of renewable energy sources to be an urgent issue of national interest. That law was finally approved on June 16, 2005, and established fiscal, economic and administrative incentives to this end.

j) Government and private programs for production and use of ethanol in fuels

The Ministry of Energy and Mines is responsible for Energy Policy, through the General Directorate of Hydrocarbons. In 2003 it took the initiative to launch a program, called "Bioenergy", for using agricultural products such as sugarcane and sucrose-rich fruits to produce ethanol, and vegetable oils for making biodiesel.

The government is providing support for ethanol production initiatives, and to promote the development of projects. However, it seems essential to establish a legal framework to guarantee the investments made by alcohol producers, to encourage them to get into the business, and also to establish the roles to be played in this field by the government (guarantees to facilitate the process) and the private sector, recognizing that the Fuel Alcohol Act alone is not enough.

k) Annual consumption of gasoline

Gasoline consumption in 2006 stood at 7,296,350 barrels, representing approximately 1,160,000 m^3. The country imports 100% of its gasoline.

3.13 HONDURAS

The biofuels business in Honduras is developing as a result of steadily rising fuel prices, and the awareness that combustion in conventional diesel engines and the harvesting or gathering of sugarcane generates negative environmental impacts, which have led some industries to invest in the search for alternative fuels. The public and private sectors have decided on the production, use and management of biofuels. The most active players in this area are: Corporación Dinant, Grupo Haremar de San Pedro Sula, independent producers, the Empresa Nacional de Energía Eléctrica (ENEE), and the Ministry of Agriculture.

a) Area planted in sugarcane and current yields

The area planted in sugarcane in Honduras is 88,120 ha, and the yield per hectare 73.12 tons.

b) Sugar production, yield and costs

Total sugar production in 2006 was 381,018 tons, and the yield of sugar per hectare was 4.32 tons.

c) Mechanization and irrigation

Around 90% of the area devoted to sugarcane is mechanized, but only 2.1% is irrigated. Rainfall in the sugar growing areas varies from 540 to 1200 mm.

d) Ethanol production (per hectare and per ton of sugar) and costs

There is no production of ethanol for fuel.

e) Installed industrial capacity

There are six sugar mills, with a combined milling capacity of 42,000 tons a day.

Table 19.

Refining capacity

Refinery	Capacity (Tons /day)
Santa Matilde	12,000
La Grecia	9,000
AZUNOSA	6,500
AYSA	4,500
ACHSA	4,000
Chumbagua	3,000
CATV	3,000
Total	42,000

Source: APAH

The Chumbagua, La Grecia and Tres Valles sugar mills have launched studies for producing ethanol and have taken steps to install two refineries in the Olancho region.

f) Research and development institutes working on ways to improve cane, sugar and ethanol production

The principal institutions with research programs for improving the production of cane, sugar and ethanol are:

- Universidad Nacional Autónoma de Honduras (UNAH). Theses have been produced for evaluating the use of ethanol in internal combustion engine, evaluating alternative methods for producing ethanol from the yucca, cheese whey, sorghum, potatoes, sawdust and wood, cabbage, corn and its residues, and evaluating agricultural yields of sugarcane as an economical industrial crop.

- Universidad de San Pedro Sula (USPS) maintains a documentation center with recent evaluations of agricultural production in the Sula Valley and the potential for producing ethanol from sugarcane.

- Escuela Agrícola Panamericana EAP has conducted research with its students on agricultural yields for sugarcane at various sites in the country.

- Fundación Hondureña de Investigación Agrícola (FHIA) conducts comparative studies on the adaptation of varieties in its research centers, associated with the Centro Agronómico Demostrativo del Trópico Húmedo (CADETH).

g) Regulations governing the mix of ethanol in gasoline

There is no legislation governing the quantities of ethanol that can be blended in gasoline. However, the National Congress is now considering an initiative submitted by the sugar producers' association for replacing up to 30% of gasoline with ethanol. The substitution can be total, provided the engine is lined with aluminum alloy.

h) Government and private programs for production and use of ethanol in fuels

The private sector and the government are interested in producing ethanol. This interest is being addressed in three stages: in the first stage, producers have undertaken to enhance productivity; the second phase involves cogeneration of electricity with bagasse, and is already underway; and the third stage calls for the experimental production of ethanol.

i) Annual consumption of gasoline

Honduras is primarily dependent on oil imports, and is vulnerable to international price fluctuations.

According to ECLAC, the values of imports are determined by the international price. In 2002 they amounted to $395 million (25% gasoline and 45% diesel).

In 2004, consumption of "superior grade" gasoline represented 54.88 million 159-liter barrels, and consumption of regular gasoline was 52.68 million barrels (Table 20).

Table 20.

Fuel consumption (millions of liters)

Fuel	2000	2001	2002	2003
Gasoline	110.4	116.5	116.8	57.1
Diesel	173.1	221.5	242.7	132.7
Other derivatives	149.9	175.2	181.3	95.3
Total	**433.5**	**513.3**	**539.8**	**285.2**

Source: ECLAC, 2006

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3.14 JAMAICA

Energy demand in Jamaica is among the highest in the Caribbean. The country is heavily dependent on fuel imports, but also has significant potential for producing biofuels, which could help to balance its energy mix.

The country's interest in developing biofuels is demonstrated by recent activities such as cooperation agreements with Brazil, the issuance of a regulation requiring a blend of ethanol with gasoline, and the forging of alliances by the national oil company, Petrojam, with international oil and biofuel partners.

a) Area planted in sugarcane and current yields

Jamaica has 40,000 ha planted in sugarcane.

b) Area available for planting sugarcane

Jamaica has a potential of 513,000 ha for planting sugarcane.

c) Sugar production, yield and costs

Sugar production in Jamaica in 2006 amounted to 167,000 tons, with a yield of 4.18 tons per hectare.

d) Ethanol production (per hectare and per ton of sugar) and costs

The country processed 22 million liters in 2005, slightly down from the 25 million liters in the previous year.

e) Installed industrial capacity

There are seven sugar refineries, of differing sizes, in Jamaica. The

Table 21.

Sugar refining capacity in Jamaica

Instalaciones	Rated capacity (tons of sugar)	Rated capacity (tons of cane)	Tons of cane/day
Frome	90,000	1,080,000	6,000
Monymusk	65,000	780,000	4,333
Bernard Lodge	50,000	600,000	3,333
Trelawny	30,000	360,000	2,000
St. Thomas	25,000	300,000	1,667
Appleton (Private)	50,000	600,000	3,333
Worthy Park (Private)	26,000	312,000	1,733
Total	336,000	4,032,000	22,400

Source: Loy and Coviello, 2005

industry has the capacity to produce 22,400 tons daily, which means that it can process 2.1 million tons of sugarcane in 94 days.

Ethanol production in Jamaica dates from 1985, when two producing plans were opened for export to the USA. Currently, production capacity is 52 million gallons of ethanol per year. The first plant, purchased from Conger in Brazil, was established in 1985, and has an annual capacity of 10 million gallons. The second plant, purchased from APV in the United States, was installed in 1986 and has a capacity of 42 million gallons per year.

f) Research and development institutes working on ways to improve cane, sugar and ethanol production

Petrojam began a pilot project in May 2006 on research into the most suitable ethanol-gasoline blend to be used in Jamaica's transportation fleet. The project employs motor vehicles from the Petrojam group and the Ministry of Industry, Technology, Energy and Commerce.

There are also other entities which conduct research in the field of agriculture, particularly sugarcane and associated processes.

g) Government and private programs for production and use of ethanol in fuels

Jamaica's last Energy Policy, which was developed in 1995, is aimed at diversifying the country's energy base and encouraging "the development of indigenous energy resources where economically viable and technically feasible, and to ensue the security of energy supplies".

Jamaica has also been looking at the possible use of alternative fuels, particularly indigenous fuels such as ethanol from sugarcane, to provide a portion of the petroleum products used in the transport sector from renewable sources.

Government policy calls for the use of ethanol as the octane enhancer in Jamaica's gasoline. However, for long-term financial viability, the local sugarcane industry would need the know-how and the technology to produce ethanol.

In partnership with Coimex of Brazil, Petrojam Ethanol Ltd in November 2005, invested US$10.5 million in a modernized plant, with a capacity to produce 150 million liters of ethanol from sugarcane feedstock

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3.15 MEXICO

Mexico's endowment in natural resources suggests that the country could develop a robust agroenergy and biofuels industry, helping thereby to reduce poverty in areas where fossil fuels are unaffordable. Although it is a net exporter of oil, it is estimated that biofuels development could displace up to 30% of the domestic consumption currently imported.

The Mexican government has expressed a desire to increase the share of renewable energy in the country's total energy supply from 3% at present to 8% by 2012. Studies estimate that bioenergy could supply between 54% and 85% of domestic energy needs: 27-54% can be derived from wood fuels, 26% from agrofuels, and another 0.6% from their byproducts.

Changes in legislation to ensure, in particular, a sustained flow of foreign investment, increased productivity and competitiveness for feedstocks, and compliance with the Kyoto Protocol are some of the aspects that Mexico must address if it is to become a competitive player in the global biofuels industry.

a) Area planted in sugarcane and current yields

The area currently planted in sugarcane in Mexico is 680,000 hectares.

b) Sugar production, yield and costs

Total production is 77.5 metric tons per hectare of cane, and the yield is 8.8 tons per hectare of sugar.

c) Mechanization and irrigation

30% of the area planted in sugarcane is irrigated.

d) Ethanol production (per hectare and per ton of sugar) and costs

Ethanol output per hectare is 4,659 liters and 52.8 liters per ton of sugarcane.

e) Installed industrial capacity

Milling capacity is 280,234 MT of cane per day, distributed among 58 refineries.

f) Research and development institutes working on ways to improve cane, sugar and ethanol production

There are isolated instances of research institutes or private firms that have projects to produce ethanol. However, these are minor and individual efforts.

We may mention the Autonomous University of Chapingo (UACH), the Monterrey Technology Institute (ITESM), the National Institute of Agriculture, Livestock and Forestry Research (INIFAP), and organizations such as the Farming Confederation of the State of Sinaloa (CADESS), a private firm in Cadereyta, Nuevo Leon, the National Autonomous University of Mexico (UNAM), the Environment Ministry, the Agriculture Ministry, and the Ministry of Mines and Petroleum, among others.

g) Availability of other feedstocks for producing ethanol

The first plant to produce ethanol using corn as feedstock is to be established in Sinaloa.

There is also the possibility of producing ethanol from sorghum, which is the second most important crop in Mexico, with around 6 million tons produced per year. Production costs for sorghum are lower than for corn, and it has the same starch concentration, making it a good alternative for producing biofuels.

h) Regulations governing the mix of ethanol in gasoline

Two bills have been drafted. The first, submitted by the Executive Branch, refers to a comprehensive long-term energy policy that would regulate and promote the use of renewable sources of energy in a manner compatible with the social and environmental setting. The second, submitted by the Legislative Branch, would promote agriculture by giving it added value through energy.

i) Government and private programs for production and use of ethanol in fuels

The government of the Federal District has declared its willingness to join forces with the federal government's energy authorities to design a pilot plan, with two purposes:

To support cane growers and the sugar industry. The plan would designate a large fleet of vehicles that would use gasoline blended with 10% anhydrous alcohol, and would establish a program to monitor emissions and verify engine performance, and evaluate parts subject to wear (elastomers). The plan would be supported by the Mexican Petroleum Institute, the PUMA University Energy Program and the National Polytechnic Institute's ESIME, among others.

j) Annual consumption of gasoline

Consumption of oil and gasoline in Mexico is 39,455 m^3.

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3.16 NICARAGUA

There are no legal barriers in Nicaragua to the production of agroenergy and biofuels. Any company seeking to enter the business must produce an environmental impact assessment, comply with formal registration requirements, and be domiciled and resident in Nicaragua. Relations between agricultural producers and processors are governed by the market.

The modern industry has been very successful in developing the industrial production of fuels such as diesel derived from such feedstocks as African palm, physic nuts and animal fats.

With its African palm program, Nicaragua is seeking to address other, no less important problems, such as rural unemployment, especially in the Caribbean region. This program is also considered to play a role in integrating the Pacific Coast with the Caribbean Coast of Nicaragua. Low land and labor prices in Nicaragua make the country attractive for foreign investment in this area.

Table 22.

Constraints and opportunities in Nicaragua

Limitantes	Oportunidades
• Lack of a regulatory framework governing the use and management of biofuels and agroenergy;	• Great interest on the part of the national government in producing biofuels. MAGFOR, CNE and the Autonomous Governments are supporting this initiative, led by IICA-Nicaragua;
• Land ownership problems, especially in the Caribbean region, where the greatest potential exists for growing palm nuts and tubers as feedstock for biofuels;	• There is demand for investment in planting palm trees and establishing facilities for extracting oil and producing diesel;
• Lack of research and centers working on agroenergy and biofuels.	• There is support for this initiative from international agencies and the Central American Bank for Economic Integration (CABEI);
• The role that Venezuelan oil is expected to play, and the mechanisms for its use and management, have not been clearly defined	• The government sees this as an opportunity for combating extreme poverty.

The main players involved in agroenergy are:

- In the public sector, the National Energy Commission, the National Assembly, the Ministry of Agriculture and Forestry (MAGFOR), the Ministry of Industry and Trade (MIFIC), the Regional Councils and Governments of the Autonomous Regions of the Caribbean Coast, the Ethnic Council for the Caribbean Region, and the Nicaraguan Institute for Agricultural Technology (INTA).

- In the private sector, Palmares del Castillo, Kubra Hill, Ingenio San Antonio, Ingenio Santa Rosa, entrepreneurs and producers.

There is currently no regulatory framework governing the production of bioenergy and biofuels. At the initiative of MAGFOR, a draft law and presidential decree governing production and the regulatory framework are being prepared.

a) Area planted in sugarcane and current yields

Nicaragua currently has 46,500 ha planted in sugarcane, with a yield of 101 tons per hectare.

b) Area available for planting sugarcane

The area potentially available for sugarcane is estimated at 150,000 ha.

c) Sugar production, yield and costs

Total sugar production in the country is 4.3 million tons. The cost of a metric ton of sugarcane is $19.80, and the cost of a metric ton of sugar is $13.00.

d) Ethanol production (per hectare and per ton of sugar) and costs

Ethanol production is estimated at 6,720 liters per hectare, and 58 liters per ton of sugarcane. The factory-gate cost is estimated at $0.248 per liter

e) Installed industrial capacity

Nicaragua has four sugar mills, with a combined installed milling capacity of 34,000 metric tons of cane.

f) Research and development institutes working on ways to improve cane, sugar and ethanol production

There is no research institute in Nicaragua working on the production of sugarcane. The sugar mills do their own research individually, and through alliances among themselves and with refineries in other countries.

g) Regulations governing the mix of ethanol and gasoline

There is no regulatory framework for ethanol blends. There are initiatives under consideration in the National Assembly.

h) Government and private programs for production and use of ethanol in fuels

The Government of Nicaragua is interested in promoting programs for production and use of ethanol. This is reflected in the visit of the Ministry of Agriculture and Forestry and the Minister of Energy and Mines to Brazil in March 2007.

The private sector is interested in producing ethanol, and has taken its own initiatives. The Ingenio San Antonio mill has made the first export of 3 million liters of ethanol to Europe. Representatives of the sugar industry consider that ethanol production could reach between 20 and 30 million liters a year.

i) Annual consumption of gasoline

The country consumes 1.6 million barrels a year, worth US$113.1 million.

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3.17 PANAMA

The national government is conducting analyses and exchanging information to determine the feasibility of using anhydrous ethanol and biodiesel as liquid fuels, which would present an opportunity for the country to diminish its energy dependency, reduce environmental pollution, diversify the energy mix, promote agriculture and agroindustry, generate new investment and new sources of employment, and promote profitable alternative crops.

Taking into consideration the volume of diesel consumption in Panama, the current administration is examining the possibility of producing biodiesel for use in 5% blends with diesel. Such a blend would imply demand for 9.5 million gallons of biodiesel a year.

Law 45 of August 4, 2004 establishes a system of incentives for hydroelectric generation and other new, renewable and clean sources of energy.

The national government, through the Ministry of Trade and Industry, has prepared a national policy on hydrocarbons and alternative energy (2005), in the context of Law No. 8 of June 16, 1987. Among other relevant aspects, this policy considers the need to be more efficient in the production and use of energy; sustainable exploitation of renewable natural resources, such as wind and solar energy; and the use of ethanol and biodiesel as fuels.

One study proposes using Caribbean pinewood as a feedstock, and recognizes the possibility of using other kinds of wood, grasses and vegetable wastes to generate ethanol. The project also involves generating electricity from bioethanol, both for operating the plant itself and subsequently (after some years) generating electricity for sale to the national grid or to local consumers.

Panama has a possibility of producing biodiesel from oil palm plantations: national output of palm oil has been very successful from the beginning.

a) Area planted in sugar and current yields

Current agricultural productivity in the Panamanian sugarcane industry is reflected in output of 56.8 tons of sugarcane per hectare, which is below the regional average of around 75 tons per hectare.

b) Installed industrial capacity

The sugarcane industry in Panama is the smallest in Central America. There were four sugar mills processing 2.56 million tons of cane and 153,700 tons of sugar in 2003-2004.

c) Research and development institutes working to improve cane, sugar and ethanol production

The Government of Panama is conducting many studies into the potential for renewable energy, including hydro, wind, solar, biomass, ethanol and diesel.

d) Availability of other feedstocks for producing ethanol

The country could produce anhydrous ethanol from various feedstocks such as sugarcane, tubers, cellulose materials and forest plantations, given the favorable climatic conditions. In the case of sugar, it is estimated that in order to cover the local market for anhydrous ethanol as a fuel in mixtures of up to 10% with gasoline would require initially some 15 million gallons annually, implying the planting of more than 11,000 hectares in sugarcane, with the possibility of generating more than 10,000 new jobs.

e) Regulations governing the mix of ethanol and gasoline

The government is conducting a pilot project for implementing the 10% ethanol blend in gasoline for 2008.

f) Government and private programs for production and use of ethanol in fuels

There is little in the way of biofuel development in Panama and producers and investors see the country rather as a distribution center for the export of renewable fuels.

The Ministry of Trade and Industry is sponsoring debate on whether to develop a domestic industry or to import ethanol for refining and re-export. It is also working to analyze available sources for the production of biofuels, and to identify the appropriate mechanism and incentives.

g) Annual gasoline consumption

With closure of the Colon refinery in 2003, the fuel market was supplied by imports at a cost of $492 million in 2002. Fuel prices are set by prices in the United States. The different sectors use a high percentage of oil-based energy, including power generation (18%), manufacturing (27%) and transportation (43%).

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3.18 PARAGUAY

A very favorable aspect for the development of agroenergy and biofuels in Paraguay is the number of plant species and varieties that, under local conditions, produce good yields and can serve as the basis for this kind of energy. Local studies show that sesame, soybeans, castor beans sunflowers, canola and peanuts are some of the species with good yields of oil that could be used to make biodiesel. There are also species such as sugarcane, cassava, corn, and sorghum for producing alcohol.

In the case of alcohol, there is a lack of financing for producing the feedstock and for the industry itself. Moreover, there is insufficient production of raw materials to meet the country's needs for sugar and alcohol at the same time.

With respect to policy for developing biofuels, Paraguay adopted a legal framework in 1999 to encourage the blending of fossil fuels with ethanol. That blend is currently 18%. Steps are also being taken to increase tax incentives.

a) Area planted in sugarcane and current yields

Sugarcane production has remained relatively steady in Paraguay in recent years. For the harvest year 2005-2006, output reached 3.2 million tons, 180,000 tons more than the previous year. The yield from the last harvest was 50 tons per day.

b) Area available for growing sugarcane

There is a long history of growing sugarcane in Paraguay and, according to the National Sugarcane Program, the area available nationwide amounts to some 450,000 ha. Expanding and strengthening the industry will require financing, assistance, organization and promotion, as basic ingredients.

c) Sugar production, yield and costs

According to the Paraguayan Sugar Center, total sugar output in 2006 was 131,198 tons, with an average yield of 5 tons of sugar per hectare, and approximately 92 kg of sugar for each ton of sugarcane milled.

Reports prepared by the Ministry of Agriculture show that the cost of producing a ton of sugarcane is US$13.7, and $427 for a ton of sugar.

The cost per hectare of production is higher in the first year ($1142), primarily because of the costs of soil preparation and sowing. In subsequent years the cost falls to $959.46.

d) Mechanization and irrigation

Approximately 35% of the total area planted in sugarcane is mechanized. Sugarcane mechanization includes machinery for preparing the soil and for harvesting. The sugar mills are for the most part the owners of such machinery: they use it for their own crops, and make it available to their cane suppliers.

The feasibility of extending mechanization to other planted areas and to those with the potential for planting will depend on the refineries, their financial capacity, and the profitability of such activity, as well as on the financing or lines of credit available to cane growers.

Irrigation. According to MAG data, the proportion of the sugarcane growing area that is currently irrigated is very small, at only 0.05% of the total area. This reflects in part the high costs that producers face in applying this technology.

Rainfall in the country's main sugar growing centers varies between 1600 and 1800 mm.

e) Ethanol production (per hectare and per ton of sugar) and costs

To meet demand beyond what the ethanol distilleries produce, the sugar mills earmark a portion of their output for producing alcohol. In 2006, total ethanol production was 45,383,231 liters, and 96% of this was produced by the six principal sugar mills: PETROPAR (40%), Azucareras San Luis S.A. (24%), Paraguaya S.A. (23%), Iturbe S.A. (6.7%), Guarambare S.A. (2%) and Friedmann S.A. (0.3%).

Ethanol output per hectare is approximately 3,750 liters. Some mills are producing sugar and alcohol as derivatives from molasses, at a yield of 15 liters of alcohol per ton of cane, while the distilleries that engage solely in producing alcohol from raw cane juice obtain a yield of 84 liters of ethanol per ton of sugarcane.

The country produces two kinds of alcohol (absolute and hydrated), with differing production costs. For absolute or dehydrated alcohol, the cost of producing 1 liter is $0.46. This kind of alcohol is suitable for blending with gasoline and can be used in any kind of gasoline-burning or four-stroke engine. Hydrated alcohol can be used without blending in four-stroke engines that have been

Table 23.

Production costs in the ethanol industry

Description	Quantity
Cost of land	US$200-1.000 /Ha.
Industrial yield	72-80 liter/ton milled
Average price of sugarcane	US$13.70/ton
Local price of ethanol	US$0.70/liter
Production cost (estimated)	US$0.30/liter
Margin (estimated)	US$0.40/liter

Source: Guillermo Parra Romero, REDIEX, 2006.

especially designed for its use, and has an average production cost of US$0.30 per liter.

On average, a new plant costs $50 per ton of cane milled per year, for plants with minimum capacity of 1 million tons a year. The following table summarizes the costs of the ethanol industry (Table 23).

f) Installed industrial capacity

There are 10 sugarcane processing plants with a total milling capacity that exceeds the availability of feedstock. In 2006, the milling capacity of those plants was 16,550 tons of cane per day, but in 2007 this capacity jumped by 175% to 29,050 tons per day (approximately 10,603,250 tons per year).

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

Research into the sugar production chain is currently focused on improving the productivity of sugarcane. The Ministry of Agriculture and Livestock, through the Sugarcane Department, conducts research into new varieties, practices for adapting varieties to national conditions, genetic research, production practices, etc.

Moreover, the MAG is the main national institution promoting agricultural research, through two departments: the Agricultural Research Department (DIA), responsible for research and generating knowledge and technology for resolving the environmental, social and economic problems associated with agri-food and farm production chains, and the Animal Research and Production Department (DIPA).

A number of sugar mills do their own research into genetics, new varieties, production technologies, machinery, and production processes, for both sugar and ethanol.

The cane growers of Guaira and Caazapa can also acquire propagation materials of good quality and genetic purity for the principal recommended varieties of sugarcane from the Campo Experimental de Caña de Azúcar de Natalicio Talavera, the Ingenio Azucarero de Iturbe refinery, the Cooperativa Yegros Ltda., and others.

h) Availability of other feedstock for producing ethanol

In addition to producing ethanol from sugarcane, Paraguay has the potential to produce alcohol from corn, cassava, rice and sorghum.

Corn and cassava are of great importance in the country's history. Corn has traditionally been produced by both small and large-scale growers. Rice is one of the most important products of domestic consumption, and its production is widely spread across the country.

For the 2005-2006 crop year the area planted (Table 24) in the first three months of the year generated an

Table 24.

Substitute products in Paraguay

Substitute feedstocks for producing ethanol: area, production and yield (2000-2006)						
Crop year	Corn			Cassava		
	Area planted (ha)	Production (tons)	Yield (tons/ ha)	Area planted (ha)	Production (tons)	Yield (tons/ ha)
2000-2001	406.365	947.167	2.33	243.075	3.586.005	15
2001-2002	382.737	931.720	2.43	235.484	4.008.171	17
2002-2003	382.736	931.722	1.43	284.383	4.668.804	16
2003-2004	440.000	1.120.000	2.55	306.000	5.500.000	18
2004-2005	400.000	830.000	2.08	290.000	4.785.000	17

Source: DGP/MAG 2006

increase of 33% in production, thanks to introduction of a new variety (*maíz zafriña*). For its part, cassava has made major inroads in agroindustry, primarily because of the impact of the starch industry, and occasional exports to Brazil.

i) Regulations governing the mix of ethanol in gasoline

A regulatory framework was established in 1999 governing the blend of fossil fuels with ethanol. There are four decrees and 15 resolutions governing the blend of alcohol in gasoline, which is currently set at up to 18%. Steps are also being taken to increase fiscal incentives. The following are the most important regulations issued in Paraguay:

- Decree 2162, establishing the blend of absolute ethanol in gasoline for marketing in the territory of the Republic, and other measures to this end.
- Decree 2266, amending article 1 of Decree 2162/99.
- Decree 2748, on the promotion of biofuels.
- Resolution 695, temporarily amending article 1 of Resolution 153/99, and setting the blend of absolute ethanol in gasoline at 16%.
- Resolution 248, regulating article 14 of Decree 7412/06, and establishing the percentage of blends of absolute ethanol in 85- and 95-octane gasolines.
- Decree 7412, regulating Law 2748/05, on the promotion of biofuels.

j) Government and private programs for the production and use of ethanol in fuels

With promulgation of the Biofuels Promotion Act, the private sector has taken initiatives for producing biofuels, although these are just beginning.

At the end of December 2006 the National Export Plan established the Sectoral Roundtable on Biofuels, within the Import-Export Network (REDIEX). It brings together public and private institutions and universities interested in the sector in order to pool efforts for improving the sector's competitiveness.

The Ministry of Industry and Trade also has a Fuels Department, reporting to the Undersecretary of State for Trade, which has the following specific functions:

- To serve as the national administrative body and to monitor implementation of trade policy instruments relating to fuels and derivatives.
- To coordinate with other agencies of the Ministry of Industry and Trade, and with other competent government institutions, with respect to the inter-agency program for control and supervision of compliance with existing standards, relating to products derived from petroleum, in order to guarantee the quality of the product marketed within the country.
- To prepare analyses, studies, opinions and consultations as necessary for updating existing rules, so as to adapt them to new market requirements, and to fulfill the functions established therein.
- To channel, through the appropriate mechanisms, the applications, requests, concerns and problems presented by the private or public sector with respect to trade policy in the area of fuels and derivatives.

The National Senate has presented a program for alternative fuels, with a view to developing and implementing a program of alternatives to fossil fuels. That program has two components:

- Production and use of alcohol produced from sugarcane and cassava.
- Promotion and use of biodiesel made from oils derived from castor beans, coconuts, rapeseed, peanuts, soybeans etc.

Despite the efforts of MAG to support crops such as sugarcane, they remain inadequate to support the ethanol production chain as a whole. Consequently, the public-private partnership established within REDIEX represents a significant government boost for strengthening activities and interagency integration for improving competitiveness in the different links of that chain.

k) Annual consumption of gasoline

Paraguay spends around $300 million a year on fossil fuel imports. The total amount of fuel (gasoline plus diesel) consumed in 2005 was 1,170,616,369 m³, of which 80% was diesel. 100% of gasoline consumed in the country is imported, for the country has no natural deposits of petroleum.

3.19 PERU

Peru is a country of great diversity that offers a variety of feedstocks for producing biofuels. Its tropical areas are suitable for producing biodiesel at low cost, because of climatic factors and the lower cost of land and labor. This is true of the Peruvian Amazon, which can achieve yields of 4500 liters per hectare of African oil palm.

Diesel consumption rose from 32,700 barrels per day in 1990 to 63,700 per day in 2004, and despite the inroads of natural gas, it is expected that demand will exceed 89,000 barrels a day by 2014.

a) Area planted in sugarcane and current yields

Sugarcane is planted in Peru along the coast, in the *selva* (jungle) and in the Andean valleys. However, it is along the coast where the greater part of the sugarcane area is located, because of its unique climatic and soil conditions that allow planting and harvesting throughout the year, and produce exceptional yields.

There is no specific production season, and sowing and harvesting take place throughout the year, providing the sugar mills with a constant flow of cane.

The area planted in sugarcane in Peru in 2006 was 66,162 ha, of which 36% belongs to independent producers. According to the Peruvian Association of Sugar and Biofuels Producers (APPAB), the national yield in that year was 110 tons per hectare, and output reached 7251 tons.

b) Area available for planting sugarcane

To achieve production at a sufficient scale to replace all the fossil fuel used in the country would require some 200,000 additional hectares of sugarcane, to produce 1.2 million gallons of ethanol per day.

There are two main areas suitable for sugarcane growing: the coast, with much land available for planting sugarcane, although there is the problem of water shortages, and the *selva*, which has great expanses of land that could be used for planting sugarcane, and also has marked seasonal rainfall, appropriate soils, and sufficient water from the rivers. However, there is no culture of planting this product, and unseasonable rains can lower the sucrose content of the cane.

In order to expand the area potentially available for growing sugarcane, both for human consumption and for the production of ethanol, the agricultural frontier will have to be expended onto untilled land, or sugarcane will have to replace other crops.

c) Sugar production, yield and cost

Sugarcane is grown in five departments. Roughly 79% of output is along the north coast. National sugarcane production for 2005 was 6,304,000 tons, down 9.2% from the previous year. La Libertad is the country's biggest producer, with 2,889,000 tons; Lima comes next, with 1,545,000 tons.

In Peru, sugar has a great economic and social impact in the valleys and towns along the coast, which depend almost exclusively on its production.

Commercial sugar production in 2004 was 305,292. According to be APPAB, sugar production now stands at 803,000 tons, representing a yield of 12.2 tons of sugar per hectare of cane.

The cost of producing a ton of sugar in Peru is estimated at $32.20 with standard technology, and $17.60 with advanced technology and irrigation.

d) Mechanization and irrigation

Sugarcane growing can be mechanized in terms of soil preparation, but harvesting is done manually because machinery can damage the plants and reduce yields for the following harvest. Manuel harvesting creates jobs working for firms with mills, those without mills, and for growers.

The main problem in expanding the frontier to other areas of Peru is the water factor. Sugarcane demands great quantities of water and so to expand planting will require irrigation systems to ensure sustainable production. This will demand financing through both public and private investments.

Companies and growers using irrigation systems are for the most part located in Lambayeque. Companies and growers in the valleys of Chicama, Nepeña, Huaura and Tambo use water from rivers sourced in the mountain, where the rainy season begins in December and ends in March. Given the shortage of water, companies irrigate with groundwater.

The coast region is extremely dry, with annual precipitation of less than 40 mm from Chimbote to Tacna, and 400 mm in the extreme north. Despite its aridity, some parts of the coast receive sufficient humidity from winter fog banks (the "*Garua*") to support vegetation, and they are suitable for growing sugarcane. In the Sierra, climatic conditions are determined by latitude, altitude, local winds and the sheltering effect of the Cordillera.

Generally speaking, temperatures decline as altitude increases, while precipitation declines from north to south and from east to west. During the rainy season (December to March) the highest precipitation is found in the north and along the east flank of the Cordillera. Temperatures vary little from season to season, and the daily fluctuation (up to 22°C within a single day) is much greater than the seasonal change. The jungle or *Montaña* zone has a hot, humid tropical climate with precipitation throughout the year, although it is particularly intense between December and January, and there is very little seasonal change in temperature.

e) Ethanol production (per hectare and per ton of sugar) and costs

Peru is not a producer, but it is estimated that the costs of producing ethanol from sugarcane would be slightly higher than those in the previous case; this would have to be verified through research. The following estimates, based on preliminary data, offer a benchmark:

Table 25.

Ethanol production costs in Peru	
Required feedstocks (MT cane/m³ ethanol)	14.29
Sugar price delivered to mill (US$/MT)	15
Cost of feedstock (US$/m³ ethanol)	214.35
Processing costs (US$/m³ ethanol)	54
Total cost (US$/m³ ethanol)	266.35
Total cost (US$/gallon)	1.02

Source: CONAM

As can be appreciated, the cost of the feedstock has a high impact on the total cost of the product and its final cost is estimated at $1.02 per gallon, equivalent to $0.27 a liter.

f) Installed industrial capacity

Peru has 10 sugar companies located along the coast, with a total area of 110,827 ha and a planted area of 74,285 ha. Currently, the sugar industry has a maximum milling capacity of 37,300 metric tons of cane per day.

The San Jacinto mill, for example, has introduced major technological innovations such as low-pressure drip irrigation, chemical ripening (which allows cane growth to be regulated thereby accelerating the concentration of sucrose), and a new machinery inspection center, among others.

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

Actually, companies are doing R&D directly, with the advisory of international experts, specially companies with strategic partners (Laredo y Cartavio). The main institutions which work on R&D in order to improve production processes of cane, sugar and ethanol are:

- **Asociación Peruana de Productores de Azúcar y Biocombustibles (APPAB)**: This is a private institution formed by the 10 sugar mills in Peru. It conducts research in areas such as sugarcane production and biofuels, and through situation and outlook reports it monitors the 10 sugar mills and the current status of sugarcane production in Peru. It is also performing studies on the production of ethanol as an alternative to fossil fuels.

Table 26.

Sugar refining capacity in Peru, 2004

Sugar refining capacity in Peru 2004				
Company	Total area (ha)	Cane area (ha)	Milling capacity (t/day)	Actual milling (t/day)
Casa Grande	29.394	12.000	9.000	4.000
Laredo	5.080	4.687	2.000	1.500
Cartavio	6.566	6.254	5.000	2.500
Pomalca	15.819	12.495	3.500	2.000
Pucalá	8.530	6.866	3.500	2.000
Tumán	12.311	8.200	4.000	2.200
San Jacinto	10.422	7.231	2.800	2.000
Paramonga	8.396	6.566	3.500	2.800
Andahuasi	4.617	2.705	1.000	(-)
Chucarapi	1.794	1.256	500	369
Total	**110.827**	**74.285**	**37.300**	**20.653**

Source: USDA Foreign Agricultural Service 2004

- **Consejo Nacional del Medio Ambiente (CONAM)**, the national environmental authority. Its mandate is to plan, promote, coordinate, supervise and oversee the environment and the natural heritage of the nation. It has nationwide programs for biodiversity, biosafety, and biofuels, among others.

- **Universidad Nacional Agraria La Molina (UNALM).** The Renewable Energy Laboratory (LER) is an academic, research and service unit of the Department of Rural Construction, Faculty of Agricultural Engineering. It is engaged primarily in applied research on different nonconventional energies, and their use as a nonpolluting alternative, especially for the rural sector where other sources are not available.

- **Instituto Nacional de Investigación y Extensión Agraria (INIA).** Its mandate is to generate technologies for integrated management of important crops, in order to optimize product quality to market standards, while earning the greatest possible return. Its approach is based essentially on developing technologies focused on increasing productivity and reducing production costs. It seeks to make available to

producers appropriate varieties, and agronomic and post-harvest management techniques. It has given special emphasis to integrated pest and disease management.

h) Availability of other feedstocks for producing ethanol

Anhydrous ethanol could be produced in the country from sugarcane and sweet sorghum, given the favorable soil and chromatic conditions, both along the north coast and in the high *selva*. As well, hard yellow corn could be considered, because it grows well in Peru's coastal and jungle conditions, and it can be processed industrially and genetically engineered. It is one of the most variable crops: many hybrids have been developed, tailor-made to each region.

The following table presents key data on sugarcane production and conversion, comparing various aspects for the production of ethanol.

We also present a table on production, area and yield of hard corn, soft corn and sorghum.

i) Regulations governing the mix of ethanol in gasoline

On March 31, 2005, Regulations were approved to Law 28054, the Biofuels Act, establishing the percentage of alcohol to be blended in gasoline marketed in the country at 7.8%.

Those regulations also provide that ecological gasoline (blends of gasoline and fuel alcohol) will be produced and marketed in the coastal region from Piura to Lima; as of January 1, 2008 in the *selva*, and as of January 1, 2010 throughout the country.

The Biofuels Act also establishes the Biofuels Promotion Program (PROBIOCOM), comprising various public institutions, to establish guidelines and working groups.

j) Government and private programs for production and use of ethanol in fuels

The government is promoting the production of biofuels in Peru, and is discussing incentives that will be needed to develop production and supply the local market. It is currently working on the National Development Plan for the Sugar Industry, through a multisector commission. It has also issued equity protection rules for firms that do not have a strategic partner: they will have to present their recapitalization and investment plan. As well, standards on biofuel production and regulation have been issued.

For its part, the private sector has been expanding its agricultural frontier, and new investors are now acquiring lands for producing ethanol. In the Piura region, two companies have acquired approximately 13,000 ha. The Romero Group and Maple have each committed $100 million in investment. The Gerco group has already built a plant and is negotiating the purchase of lands.

Table 27.

Historic and actual data of sugarcane production in Perú

Indicadores	1995	2003	2004	2005	2006
Harvested area (ha)	59,594	77,720	70,851	61,547	66,162
Production of sugarcane (1000 t)	6,325	8,886	6,947	6,370	7,251
Yields of sugar cane (t/ha)	106	114	98	102	110
Sugar production (1000 tons)	641	955	747	694	805
Exports (1000 tons)	65	61	41	32	108
Exports (US$ FOB)	29,986	19,190	14,575	12,719	42,978
Imports (1000 tons)	239	11	181	213	212
Imports (US$ 1000 CIF)	90,600	2,962	50,055	63,998	93,384

Source: MINAG

Table 28.

Areas and yields of agricultural products with a potential for ethanol production (2000 - 2005)

Product	2000	2001	2002	2003	2004	2005
PRODUCTION						
Hard corn	959,7	1.062,5	1.036,9	1.098,6	962,7	998,8
Soft corn	281,1	253,3	252,8	259,7	218,1	243,8
Sorghum	0,5	0,0	0,0	0,2	0,1	0,1
AREA HARVESTED						
Hard corn	269,8	286,0	269,4	280,3	257,9	276,7
Soft corn	244,8	218,2	212,1	207,2	180,2	197,4
Sorghum	2,5	0,0	0,0	0,1	0,0	0,0
YIELD						
Hard corn	3,6	3,7	3,8	3,9	3,7	3,6
Soft corn	1,1	1,2	1,2	1,3	1,2	1,2
Sorghum	0,2	1,0	2,0	2,5	2,8	2,9

Source: Ministerio de Agricultura.

k) Annual consumption of gasoline

For 2006, gasoline consumption in Peru was 1.416 billion m³, of which 1.77% was imported.

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3.20 DOMINICAN REPUBLIC

The Dominican Republic's sugar industry holds great potential for producing ethanol and biodiesel to meet growing energy needs and eventually make inroads on the international market, and in this way improve the country's trade balance, in which rising fuel imports weigh heavily.

In terms of rural development, greater market opportunities that will boost the Dominican sugar industry can also improve living conditions in the countryside, especially for the Haitian workers who are part of the labor force available for future developments. To capitalize on these market opportunities, the public must be made aware of the benefits of using biofuels and the sugar industry must be modernized.

a) Area planted in sugar and current yields

The country has 350,000 ha in sugar, representing 22% of its agricultural land. The average yield of sugarcane during this decade has varied between 37 and 40 tons per hectare.

b) Area available for planting sugarcane

It is estimated that around 200,000 ha of traditional sugarcane land could be devoted to producing for biofuels, without diverting land from food crops.

c) Sugar production, yield and costs

The country produces around 464,000 tons, of which 40% is exported, with an average yield of 1.3 tons per hectare.

d) Ethanol production (per hectare and per ton of sugar) and costs

There is currently no production of ethanol.

e) Installed industrial capacity

The sugar mills currently in operation are shown in the following table 29, and have a total milling capacity of 43.795 tons.

Table 29.

Dominican Republic. Sugar Refining Capacity

Refinery	Capacity (tons/day)
Consuelo	4,537
Cristóbal Colón	10,889
CAEI	2,269
Boca Chica	3,630
Central Romana	15,426
Montellano	2,507
Barahona	4,537
Total	**43,795**

Source: Industria Azucarera Dominicana cited in IDB. A Blueprint for Green Energy in the Americas

Legislation on renewable fuels in the Dominican Republic dates from the 1940s, although it produced few results. In 2000 and 2001, Law 112-00 for Hydrocarbons and Law 175-01 for Electricity created incentives for renewable energy development. In 2002, Decree 557-02 regulated electricity generation in sugar mills. Decree 732, also issued in 2002, created specific incentives for ethanol production.

In 2005, a draft bill was submitted to parliament on the development of renewable energy sources and special regulations that provided further incentives: 100% tax exemption for imported machinery, equipment and accessories, permission to offset 50% of investments made in internal consumption of renewable energies against income tax, and a guaranteed market share for renewable energies.

f) Research and development institutes working on ways to improve cane, sugar and ethanol production

The Autonomous University of Santo Domingo has a number of research programs devoted to various aspects of renewable energy.

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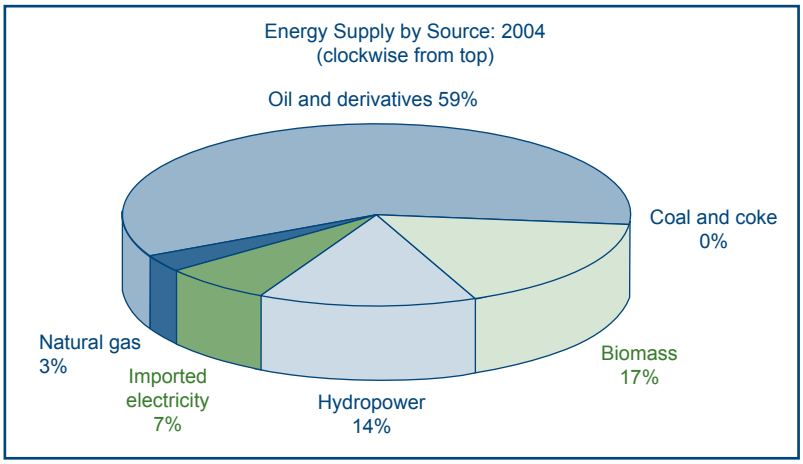
3.21 URUGUAY

In its "Energy Strategy Guidelines: Uruguay 2006" of August 18, 2006, the National Energy and Nuclear Technology Department identifies "significant progress in incorporating alternative sources of energy (in particular biofuels)" as an objective and line of action.

In 2005 the Interministerial Biofuels Commission was created, with representatives of government and ANCAP, to advise the authorities on a policy framework for the production and use of biofuels.

The two main factors that have brought agroenergy to the fore on the public agenda have been, on one hand, the trend in world prices for oil and its projected exhaustion, and on the other hand the country's high dependency on this fuel, given its share in the national energy mix.



Source: Dirección Nacional de Energía y Tecnología Nuclear, MIEM

The accompanying figure shows the structure of domestic energy supply for 2004, illustrating the importance of hydrocarbons (oil and derivatives at 59% and natural gas at 3%) and imported electricity (7%), and highlighting the country's dependency on fossil fuels.

Law 17,567 of 2002[16] declares it in the national interest to produce alternative, renewable fuels from domestic animal or plant feedstocks as substitutes for petroleum derivatives. As part of the new policy on fuels from renewable natural resources, a start was made at examining the feasibility of producing fuel alcohol from sugarcane.

There are currently three biodiesel plants with an installed capacity of

16 *http://www.dnetn.gub.uy/documentos/archivos/683_1.pdf*

more than 3,200,000 liters annually. One is located in Paysandú, producing 200,000 liters a year from sunflower oil, and the other two are located in Montevideo, one using recycled cooking grease and the other animal fat. The first of these two plants is small, and the second has a processing capacity of more than 3 million liters monthly.

A project is currently underway in the Bella Union zone, Department of Artigas, to process sugar and ethanol. An investment of US$7-8 million is planned to set up a distillery next to the refinery, to produce alcohol beginning with the 2007 harvest. The distillery will have an estimated capacity of 120 m³ of alcohol a day, which by 2010 could replace up to 5% of the gasoline consumed in the country.

Domestic vegetable oils, the basic feedstock for biodiesel, are in short supply. Between 40% and 60% of domestic demand for such oils is met through imports, which in 2004 amounted to 18,500 tons of crude and refined vegetable oils, versus domestic consumption of around 30,000 tons. This means that domestic prices are on a par with imported prices, and the product is expensive for use as a biodiesel feedstock.

Today's high prices for sugarcane, driven by the international market and reflecting the growing use of sugar in alcohol production, are such that the cost is probably at or above gasoline production costs, under equal conditions.

a) Area planted in sugarcane and current yields

According to the latest published data from FAO, the area planted in sugarcane in 2005 was 3,300 ha. The Ministry of Agriculture, Livestock and Fisheries (Magpie) reported a harvest area of 3,100 ha for that year.

The 2006 annual report of OPYRA[17] reports that the yield in 2005 was

Table 30.

Sugarcane Yield 1996-2005

Crop year [1]	Yield (kg/ha)
1996	51,281
1997	62,050
1998	53,945
1999	49,340
2000	54,360
2001	61,797
2002	60,563
2003	40,473
2004	48,311
2005	55,541

[1] *Harvesting is done between July and September of each year. The sugar crop year extends from May 1 to April 30 at the following year*

Source: Prepared by DIEA with data from ALUR (Alcoholes del Uruguay SA).

[17] *"Producción de azúcar" Ing. Agr. Eduardo Errea and Ec. Mayid Sáder Neffa. Anuario 2006 OPYPA/MGAP.*

55.541 kg/ha, 15% up from the previous year. The previous table shows the performance of yields over the last 10 years:

It is recognized that yields of up to 7000 kg per hectare can be achieved on a sustained basis with proper use of current management methods.[18]

b) Area available for planting and sugarcane

The best sugarcane growing conditions are in the north, in the Department of Artigas in the northern portion of Salto. One of the country's biggest processors (ALUR) is planning to expand sugarcane planting to 10,000 ha, a goal conditioned by the availability of irrigation and the distance to the mill (haulage costs).

c) Sugar production, yield and costs

According to the 2006 OPYPA annual report,[19] the 2005 harvest produced 19,820 tons of sugar, an increase of 18.6% over the previous harvest, and the second-highest in a decade, thanks to better agricultural yields and the high sugar content of the cane delivered to the mill, which averaged 11.5%.

Sugar output from crop year 2006/07 (the 2006 harvest) is estimated at 16,000 tons (down 15% from the previous year). This did not reflect any decline in sugarcane production, but rather the fact that some of that output was used as seed. ANCAP has established a seed nursery in Belen, planting 140 ha in seed cane under the supervision of ALUR, in order to improve local cane varieties.[20]

A feature of sugarcane is that it is planted not from actual seeds but from cane cuttings, i.e. from the same raw material as that used to produce sugar or alcohol. Consequently, the use of cane for planting has an effect on the availability of feedstocks. One hectare of crop devoted to seed will yield between 7 and 10 planted hectares.[21]

In any case, it may be said that the availability of "seed" cane is not a constraint to rapid expansion of the area planted. In the fall planting (which in fact runs from the end of January to March) some of the cane may be left standing for this purpose, and the date of sowing can be delayed slightly (for example until April) if the intent is to increase the area rather than achieve a high yield from the first harvest.

Since reserving part of the crop for seed means that the producer delivers less cane to the mill, an unusually high planting, or reserving specific areas as seed cane supply, implies the need to recognize and compensate for the commercial value to the producer. Recognizing the value of seed cane,

[18] *Information supplied by Ing. Agr. Darío Oxandabarat of ALUR SA.*

[19] *Information provided by Ing. Agr. Darío Oxandabarat de ALUR SA.*

[20] *"ALUR doubles its sugarcane output in one year". Article taken from the webpage of SEPREDI in Presidencia, February 2007.*

[21] *Information provided by Ing. Agr. Darío Oxandabarat de ALUR SA.*

both that left standing and that planted in summer and fall, is essential.

The 2007 harvest is expected to run for 150 days, double the length of the previous harvest.

On the cost side, it is estimated that it takes $1,640 to produce 60 tons of cane, i.e. $27.30 per ton on average.

d) Mechanization and irrigation

The cane harvest in Bella Union is semi-mechanized: cutting is done by hand, while most of the loading is mechanized. What distinguishes Uruguayan practice from that in other countries is that, because of the high soil humidity in winter, the cane is cut and piled manually at the parameter of the field for drying. In most other cane growing areas where harvesting is done manually, the cane is loaded on the wagon or truck directly within the cane field.[22]

Historically, different types of mechanized harvesting have been tested in the area, but they have not produced commercially viable results. In the case of simple cutters, the cane is left in the row and must be stripped manually. This is a difficult operation that producers avoid.

Chopper harvesters or combines are the most widely used means of mechanization. However, they are expensive, heavy, and require a well-organized transport system. They also raise issues with respect to the size of the field and of the cane plot, the length of the row, the distance between rows etc., all of which affect the efficiency of the harvesting system.

In any case, an increase in area such as that proposed would seem to offer a good opportunity to reconsider the entire issue of harvesting, with a view to reorganizing it.

In Uruguay, sugarcane growing requires much irrigation, equivalent to 1200 or 1300 mm of rain. There is no specific information on rainfall in producing zones. However, all sugarcane is irrigated.

There are three major systems of irrigation currently in use:

- CALAGUA currently irrigates 1100 ha of sugarcane, and could expand this to 2000 ha within the cooperative's initial area. It has planted more than 2000 irrigated hectares in the extension toward the east where it grows rice, and more than 1000 ha to the south of Route 30, which is currently planted in rice as well. Thus, considering the irrigated area that is not in rice, the potential could amount to some 5000 ha.

- CALPICA is currently irrigating 420 ha of sugarcane and could add another 1000 ha quickly. In previous years it irrigated up to 2100 ha.

- SOFORUCE has 500 ha in sugarcane, and a potential for 300 additional hectares.

[22] *Ibid.*

e) Ethanol production (per hectare and per ton of sugar) and costs

The ALUR project calls for construction of a distillery contiguous to the sugar refinery, which would come on stream in 2007[23] and would begin to produce as of the following harvest.[24] Distribution of the cane between the refinery and a distillery will be decided in light of technical considerations and relative prices for the final products.[25]

Generally speaking, the alcohol produced may be hydrated, a product that can be used as a fuel alternative to gasoline, or anhydrous, which can be blended with gasoline in a proportion of up to 25% and can also be used to make biodiesel via the ethylic route. The latter option, anhydrous alcohol, has been adopted for the project. In addition to these two main products, the process can also produce electric energy in a cogeneration system with molasses, stillage and bagasse as byproducts.

To estimate the costs and the quantitative significance of the ethanol produced by the project, an assumption was made that 25% of the feedstock would be used for making alcohol. On this basis, and with a target planted area of 10,000 ha, it is estimated that the ethanol produced could cover 4.5% of current gasoline production in Uruguay.

Yields. The following table shows estimated yields of ethanol in kilograms and liters, by type of crop:[26]

Table 31.

Estimated yields of ethanol per hectare for different crops

Crop	Yield per hectare in kilograms	Yield per hectare in liters
Sugarbeets	45,000	4,500
Sugarcane	55,000	3,600
New varieties of sweet sorghum 1/	90,000	5,400

1 *The yields of new varieties of sorghum were measured by technical staff of DNETN in a field sample and were found to be greater than those indicated in the table. They are not comparable to conventional yields from grain sorghum.*

Source: "Energías Alternativas" Chapter 6 of the publication "Sector energético en Uruguay, diagnóstico y perspectivas" of DNETN/MIEM, based on "Alcohol Fuels Options for Developing Countries", National Academy Press 1983 and interviews with producers, technologists, and field tests conducted by DNETN/MIEM.

23 *"Agroenergía: avanza el diseño de la política nacional de biocombustibles" Ing. Agr. Gonzalo Souto. Anuario 2006 OPYPA/MGAP*

24 *"Gobierno lanzó la zafra azucarera". Interview by Emiliano Cotelo of Radio El Espectador with the President of ALUR, Raúl Sendic, 29.06.2006*

25 *"Política sucroalcoholera" Ing. Agr. Eduardo Errea and Ec. Mayid Sáder Neffa. Article taken from Anuario 2006 OPYPA/MGAP.*

26 *"Energías Alternativas". Capítulo 6 de la publicación "Sector energético en Uruguay, diagnóstico y perspectivas" de la Dirección Nacional de Energía y Tecnología Nuclear/MIEM.*

Moreover, to evaluate alcohol production requires an understanding of the various annual crop cycles. The following table shows the possibility of complementarity between different crops.

The soil, sunshine and water requirements are different for each crop, and an agricultural system must recognize their specific features.

Table 32.

Annual crop cycles for producing ethanol

	Crop	Time of planting	Time of harvest
SUMMER CROPS	Sorghum	October-November	March-April
	Sugarcane	Perennial [1]	July-September
WINTER CROPS	Sugarbeets	May-April	November-December

[1] *Harvesting is done between July and September of each year. The sugar crop year runs from the beginning of May to the end of April at the next year.*

Source: "Energías Alternativas" Capítulo 6 de la publicación "Sector energético en Uruguay, diagnóstico y perspectivas" de la DNETN/MIEM

A distillery located along the western littoral could take advantage of the optimum conditions for producing the different crop options concentrated in that zone.

f) Installed industrial capacity

ALUR planned to produce 48,000 tons of sugar in 2006, a significant increase over what CALNU produced in 2005, because the objective was to get into the confectionery and beverages business.[27] For 2007 it plans to produce 55,000 tons of sugar, 17 million liters of alcohol and 15 MW of electricity, of which 12 would be sold to UTE, as Raúl Sendic reported to the local media.[28]

During 2006, ALUR invested $1 million in a thorough overhaul of the mill: boilers so that the harvest could

[27] *"Gobierno lanzó la zafra azucarera". Interview by Emiliano Cotelo of Radio El Espectador with the President of ALUR, Raúl Sendic, 29.06.2006*

[28] *"ANCAP financiará sorgo y girasol para biocombustibles". Article taken from Diario El País of 27/12/2006*

begin, and all the milling equipment and other items that showed major deterioration.

The proposed ALUR refinery would have a capacity of 120 m³ of ethanol a day[29], and would cost between $7 million and $8 million, since it would have a series of add-ons that would allow connection with the current refinery facilities. These works would be financed by ANCAP and the government of Venezuela (in exchange for alcohol).

With the resulting output, ALUR could replace up to 5% of gasoline consumption in the country by 2010. This would have a very favorable impact on ANCAP, giving it a greater volume for export, or reducing crude oil imports. To achieve this, the sugarcane area will have to be expended, if it is to continue to supply the sugar market as well. Initially, very small volumes would be blended with gasoline, and the blend would then be gradually increased.[30]

g) Research and development institutes working on ways to improve cane, sugar and ethanol production

The National Institute for Agricultural Research (INIA) is conducting experiments at the Palo a Pique unit of its "Treinta y Tres" Experimental Station, under the direction of Dr. José Terra, on the growing of sweet sorghum, one of the feedstocks that could be used to produce bioethanol.[31]
In 2006 work focused on a preliminary evaluation, examining the crop's response to different agronomic techniques that could be used for future production. The results have varied among the different materials tested. "The tests at Paysandú are already far advanced and are producing very encouraging results, but we are just starting down the road", he said.

Guillermo Siri, an agronomic engineer with the Faculty of Agronomy at the Mario Cassinoni Station, reported that the values they are obtaining in biomass generation are very competitive, but they have not yet experimented with yields in sugar or alcohol production.

h) Availability of other feedstocks for producing ethanol

Ethanol is being produced in Uruguay from other feedstocks such as grains, sweet sorghum, sugarbeets, corn, thistles, ligno-cellulosic products (forest wastes and field stubble) and hemp. The following table shows statistics for recent years on area,

[29] *"Agroenergía: avanza el diseño de la política nacional de biocombustibles". Anuario 2006 OPYPA/MGAP.*

[30] *"Gobierno lanzó la zafra azucarera". Entrevista realizada por Emiliano Cotelo de Radio El Espectador al presidente de ALUR, Raúl Sendic, del 29.06.2006.*

[31] *"Buscan obtener bioetanol a través del cultivo de sorgo azucarado". Article taken from Diario El País, 27/02/2006.*

Table 33.

Uruguay: Area, production and yield of potential feedstocks for producing ethanol (2003-2005)

Crop	2003	2004	2005
Planted area			
Corn	178.500	223.000	250.000
Sorghum	60.209	69.682	100.000
Production			
Corn	38.927	44.923	64.200
Sorghum	14.829	17.978	26.700
Yield			
Corn	4.59	4.96	3.89
Sorghum	4.06	3.88	3.75

Source: FAO

output and yield of sorghum and corn, the products with the greatest potential for producing ethanol in Uruguay.

i) Marco regulador para la mezcla de etanol y gasolina

A draft law on agrofuels[32] was sent to parliament on July 31, 2006, signed by the Council of Ministers, and is currently being considered in the Senate. It establishes the legal framework for production and commercialization of biofuels, as well as quality and safety standards.[33]

That draft also defines ethanol as "ethyl alcohol produced for use in internal combustion engines. It includes anhydrous ethyl alcohol and hydrated ethyl alcohol".

With respect to blending ethanol, article 4 of the draft instructs AMCAP to incorporate domestically produced alcohol into gasoline sold domestically for automotive use in a proportion of up to 5% by volume, by December 31, 2014, at which time this blend will become mandatory. It also empowers the government to set interim targets in the meantime.

As to the technical specifications for biofuel quality, those for alcohol will be determined in subsequent regulations, while those for biodiesel

[32] *See text at the DNETN/MIEM website http://www.dnetn.gub.uy/documentos/archivos/816_1.pdf*

[33] *Statements by Ing. Gerardo Triunfo, Director of DNETN/MIEM and the Minister of MIEM respectively, at the II Conferencia del Ciclo 2006: "el agro en los tiempos que vienen" organized by the IICA office in Uruguay, lSeragro Consultants and Diario El País in September 2006.*

are already set in UNIT Norma 1100:2005, approved in December 2005.[34] The draft law defines biodiesel as any product "designated as Biodiesel (B100) if it meets the specifications contained in UNIT Norma 1100 and future updates".

j) Government and private programs for production and use of ethanol in fuels

Prior to ALUR, political attention and activity relating to biofuels in Uruguay focused initially on biodiesel, reflecting the high consumption of diesel, the sharp growth in production and export of oil seeds, and favorable external price ratios.

The ethanol alternative was less attractive, essentially because it was a substitute for gasoline and it posed greater competitive problems for agriculture, because of the contrasting performance of oilseed crops (sunflower and soybean) vis-à-vis sugarcane (declining) and corn (scarce and expensive).

The picture changed significantly however during 2005, when the current government determined to promote greater sugarcane production, and this swiftly became associated with ethanol production (seeking to reduce the successful Brazilian "sugar-alcohol" model).[35]

As a result of recent visits to Uruguay by the presidents of Brazil and the United States, there is concrete evidence of the strategic importance that biofuels have for Uruguay. In the case of Brazil, a biofuels cooperation program was signed, as well as a protocol to create a permanent mixed commission on energy.

During his visit, President Bush stressed the desirability of intensifying scientific and technological exchange on alternative fuel production.

In light of these political signals, Uruguay could be interested in joining the Inter-American Ethanol Commission. In any case, the invitation should be addressed through the appropriate institutional channels.

k) Annual consumption of gasoline

Uruguay consumed about 287,134 m_ of gasoline in 2005, of which 45% was consumed in the Department of Montevideo, followed by Canelones (14%) and Maldonado (11%).

Uruguay has no fossil fuel reserves, and 100% of supply is important. Crude oil imports were the principal source of energy nationwide, accounting for 53% of final energy consumption in 2005.

[34] *"Jornada de difusión de la Norma UNIT 1100 de Biodiesel en Tacuarembó". Article taken from the "Novedades" section of the UNIT webpage.*

[35] *Agroenergía: avanza el diseño de la política nacional de biocombustibles". Ing. Agr. Gonzalo Souto. Article taken from Anuario 2006 OPYPA/MGAP.*

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3.22 VENEZUELA

High oil prices have again sparked debate over the development of "energy substitutes" for hydrocarbons. Although Venezuela is a major producer of hydrocarbons, it is government policy to work on alternative energy sources, recognizing that the agricultural sector needs to organize itself to supply demand that, in the not-too-distant future, will no longer be met by oil.

However, the explosion of costs in the energy matrix is a continuing issue. On one hand, it is creating tensions in different production chains, but it also represents an important opportunity for renewable fuels and for generating employment and income for small farmers. For this reason, the issue is on the agenda of the national authorities and of officials of national agencies involved in agricultural research and PDVSA.

Innovation in bioenergy technology is of particular interest for Venezuela, where one of the key thrusts of the country's development is to strengthen rural communities and food sovereignty, and generating energy from biomass could transform large rural areas that produce feedstock for biodiesel and ethanol.

The state oil company of Venezuela, PDVSA, is working to create a mixed enterprise devoted to ethanol production from sugarcane for use as a gasoline additive, in order to produce a less polluting blend. The country's daily requirements amount to 20,000 barrels, as fuel alcohol is being blended in all gasoline for the domestic market. In the preparatory stage, PDVSA financed feasibility studies of potential cane growing areas, with options of planting up to 276,000 ha. It currently imports ethanol from Brazil for blending with gasoline in a proportion of up to 8%.

A national agroenergy program is now being designed. As a first step, it calls for construction of an Agroenergy Technology Center (CTA) to serve as a technological showcase for generating and developing technologies for producing biofuels (ethanol and biodiesel) from plant feedstocks.

As part of INIA's activities a workshop was held on October 11, 2006 at the Santa Barbara Experimental Station in Monagas State to consider the outlook for creating the Santa Barbara Agroenergy Technological Center. The crops to be planted for producing ethanol are sugarcane, corn, rice, yucca, sorghum and potatoes. The CTA will engage in:

- Agricultural services (soil laboratories, quality laboratories, technical assistance).
- Genetic improvement (more efficient species for producing ethanol and biodiesel).
- Consolidation (research, development and technological innovation in crops for producing ethanol and biodiesel).
- Biotechnology (microbiology, more efficient microorganisms for fermentation).

a) Principal problems facing the development of agroenergy and biofuels

Tilling of the soil leads in the first place to the removal of the natural vegetation cover. In the best of cases, this implies stripping down the ecosystem as well as denuding the surface. There is also a trade-off between energy production and food production, in a country where the policy is to seek food sovereignty, but where a high proportion of agricultural products are imported.

The growing area and its productivity can be enhanced with irrigation, but this modifies the soil, directly and indirectly, and nearly always in an irreversible way.

Another important aspect is the pollution of water courses after they have been used for irrigation.

b) The main challenges in light of the trends observed

Venezuela has great capacities to produce ethanol because of its geographic and climatic conditions, and it also has excellent relations with the fuel market, a situation that is conducive to introducing this energy resource into industrial processes.

One of the challenges facing the country is to build its capacity to work with the new technological developments for producing biofuel as a component of agroindustry and to prepare pre-competitive project profiles to minimize the costs of producing biofuels using biomass as a source of feedstock and energy.

c) Outlook for agroenergy and biofuels

Complementary to the activities of INIA and PDVSA at the national level, Petroleos de Venezuela signed 12 energy agreements with China in 2006 in order to move ahead with significant expansion projects. Those agreements call for establishment of a binational technical team to conduct a feasibility study on the production of ethanol in Venezuela, taking advantage of broad Chinese experience in this area, in order to contribute to the development of biofuels.

The Venezuelan government has also signed agreements with Malaysia for developing biofuel technologies, recognizing that Malaysia has successful experience with biodiesel and ethanol production from palm oil.

Following are the strategies for establishing a program for agroenergy and national sovereignty:

- Establishment of an interministerial executive commission.
- Integration of official agencies (among others) into the Agroenergy Technology Center (CTA).
- Creating an agroenergy network with other Latin American countries.
- Challenge: to harmonize farming and oil activities.

d) Area planted in sugarcane and current yields

Venezuela has 130,000 ha planted in sugarcane and 21.6 million ha of agricultural land. The first zone, where the Ureña, Venezuela, Pastora, Tocuyo, Río Turbio and Carora sugar mills are located, covers slightly over a third of the harvested area, but accounts for nearly half of total production, because the harvesting season is 6.5 months. The second zone consists of the Majaguas, Portuguesa, Guanare and Tolimán refineries, accounting for another third of the planted area and a third of total output, with a harvesting season of four months. The El Palmar, Matilde, Santa Clara and Tacarigua sugar mills cover 20% of the available area, with a harvest of 2 1/2 months and 25% of output. Finally, the Cumanacoa, Ribero and Monagas refineries have a modest share, and a very short harvest season.

e) Sugar production, yield and costs

Total production is 67.69 metric tons per hectare of cane, and the sugar yield is 5.43 metric tons per hectare.

f) Ethanol production (per hectare and per ton of sugar) and costs

Demand for E10 ethanol is 1,270,100 m³ and production using molasses is only just getting off the ground.

g) Installed industrial capacity

The sugarcane industry currently produces no surplus for ethanol production.

h) Research and development institutes working on ways to improve cane, sugar and ethanol production

The ethanol research agreement signed with Brazil calls for cooperation among universities, research centers and companies.

i) Regulations currently the mix of ethanol in gasoline

To date there has been no action on legislation for bioenergy, but there are several laws relating to the area, including the following:

i. Organic Law on Hydrocarbons.

ii. Environmental Crimes Law.

iii. Oil Pollution Surveillance Law.

iv. Law Establishing the National Institute for Agricultural Research.

j) Government and private programs for production and use of ethanol and fuels

The project calls for construction of up to 17 plants for producing ethanol: the country's daily needs amount to 20,000 barrels, since fuel alcohol is being blended in all gasoline sold on

the domestic market. As part of its preparations, PDVSA has financed feasibility studies of potential sugarcane growing areas, with options of planting up to 276,000 hectares.

k) Annual consumption of gasoline

Current calculations for Venezuela show a daily requirement of 20,000 barrels of ethanol for blending, at a rate of between 7 and 8%, with gasoline for the domestic market. Other countries have managed to add more than 40%, but Venezuela has great capacities to produce ethanol because of its geographic and climatic conditions, and it also has excellent relations with the fuel market, a situation that should encourage the introduction of this energy source into industrial processes.

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ANNEX 1

Table 1.

Ethanol production potential and area required for blending 10% with gasoline. (E-10)

Country	Gasoline consumption		Sugarcane area		Arable area	E10 ethanol demand	Current ethanol output	Sugarcane area to meet E10 demand	
	M^3 000	%	Ha 000	%	Ha 000	M^3 000	M^3 000	Ha 000	%
Argentina	4.911,1	0,77	296,8	3,7	128.747,0	491,1	230,0	81,9	27,0
Barbados	124,4	0.01	8	0.01	19	12,4	-	2,1	26
Bolivia	763,4	0,12	105,0	1,3	37.087,0	76,3	33,8	12,7	12,0
Brazil	16.000,0	2,52	5.800,0	72,0	150.000,0	1.600,0	15.999,2	266,7	4,6
Colombia	4937,0	0,70	212,4	2,6	45.911,0	493,7	270,0	63,0	29,6
Costa Rica	855,1	0,13	52,0	0,6	2.865,0	85,5	30,5	14,3	29,0
Ecuador	1.944,6	0,31	78,0	1,0	8.705,0	194,4	47,1	24,5	33,0
El Salvador	560,0	0,09	63,0	0,8	1.704,0	56,0	42,3	10,0	18,0
Guatemala	1.160,1	0,18	197,0	2,4	4.652,0	116,0	144,0	17,9	10,0
Guyana	130,0	0,02	49,0	0,6	1.740,0	13,0	23,6	2,2	4,0
Haiti	288,0	0,05	18,0	0,2	1.590,0	28,8	2,0	4,8	27,0
Honduras	457,2	0,07	88,1	1,1	2.936,0	45,7	26,3	7,6	10,0
Jamaica	699,8	0,11	40,0	0,5	513,0	70,0	12,0	11,7	29,0
Mexico	39.455,3	6,21	680,0	8,4	107.300,0	3.945,5	445,2	657,6	96,7
Nicaragua	248,9	0,04	45,0	0,6	6.976,0	24,9	36,0	4,1	9,0
Panama	576,7	0,09	37,0	0,5	2.230,0	57,7	12,4	9,6	26,0
Paraguay	233,5	0,04	80,0	1,0	24.836,0	23,3	45,3	3,5	4,37
Peru	1.203.0	0,22	66,1	0,8	21.210,0	120,4	78,4	20,1	30,0
República Dominicana	1423,3	0,0	350	0,0	3696	142,3	0,0	23,71	6,7
Suriname	106,5	0,02	3,0	0,0	89,0	10,6	0,4	1,8	59,0
Trinidad & Tobago	493,1	0,08	13,0	0,2	133,0	49,3	5,3	8,2	63,0
Uruguay	281,1	0,04	3,0	0,0	14.955,0	28,1	0,7	4,8	147,0
USA	548.000,0	86,20	np	0,0	np	54.800,0	16.139,2	9.000,0	np
Venezuela	12.700,6	2,00	130,0	1,6	21.640,0	1.270,1	0	234,5	180,3
Total	637.428,30	100,01	8.406,40	99,90	589.515,00	63.742,70	33.623,70	10.487,3	

Source: IICA (2007) and CEPAL 2006
Source for gasoline consumption in USA and Brazil: Grain Feed Division Foreign Agricultural Service, USDA.

Table 2.

Sugar: Area, Production and Yield

Country	Current sugarcane area (Ha)	Available sugarcane area (Ha)	Recent agricultural yield of sugarcane (MT/Ha)	Sugar production	
				Total (tons)	Sugarcane (t/ha)
Argentina	296.760	435.000	66,05	2.030.653	6,84
Barbados	8.000	-	62	54.000	6,75
Belice	24.281	36.422	64	107.000	4,41
Bolivia	105.000	-	45,71	510.000	6,8
Brazil	5.800.000	12.000.000	77	29.500.000	5,09
Chile	0	0	0	0	0
Colombia	212.446	200.000	122,9	2.415.117	13,05
Costa Rica	52.000	45.000	75,3	382.824	8
Dominican Republic	350.000	200.000	40	464.000	1.3
Ecuador	78.000	675.932	78	510.000	6,80
El Salvador	62.934	20067	34.93	497.000	7,90
Guatemala	197.000	-	90,5	2.010.000	10,20
Honduras	88.120	-	73,12	381.018	4,32
Jamaica	40.000	513.000	47,5	167.000	4,18
Mexico	680.000	-	77,5	5.800.000	8,5
Nicaragua	46.500	150.000	101	426.907	9,18
Panama	37.000	11.000	56,8	165.000	4,46
Paraguay	80.000	450.000	50	131.198	5
Peru	66.162	-	102,4	694.599	11,98
United States	387.250	-	66,63	2.707.000	6,99
Uruguay	3.100	10.000	55,5	5.400	1,74
Venezuela	130.000	276.000	67,69	706.000	5,43
TOTAL	**8.736.553**	**15.022.421**		**49.745.082**	

Source: Situación y perspectivas de la producción de etanol en América Latina (IICA). FAO.
Cálculos IICA Office in Colombia
Note: This information is taken from the most up-to-date delivered by each country between 2005 and 2007

Table 3.

Sugarcane: Mechanization and Irrigation

Country	Mechanized portion of sugarcane area [1]	Potential for further mechanization	Rainfall characteristics
Argentina	91%	Mechanization feasible in all zones	In potential cane lands annual rainfall varies between 800 and 1300 mm
Belize	0%	Fields are too small for mechanization	Rainfall from January to December, totaling approximately 1050 mm
Brazil	35%	There is the potential	Variable. There are many different production zones.
Colombia	100%	Not applicable	In normal years rainfall varies between 800 and 2600 mm, with two rainy seasons (April-May and October-November), two dry seasons (January-February and July and August) and 4 transition months: March, June, September and December
Costa Rica	38.50%	Mechanization very feasible for new and traditional areas	Rainfall varies between 1300 and 4200 mm across the six producing regions
Ecuador	63%	Non-mechanized areas produce sugarcane for brown sugar and rum. Most such areas have irregular topography that impedes mechanization.	There are three growing regions: Litoral, Sierra and Amazonia. On the coast, rainy season runs from Dec/Jan to May with peak rainfall in March. Dry season begins in May and runs to September
El Salvador	100%	There is the potential	From 1600 to 1800 mm approximately.
Honduras	73%	Nearly 90%	Rainfall in sugar areas is 540- 1200 mm
Nicaragua	100%	Not applicable	6-month rainy season (May 15 to November 15) and dry season from July 15 to August 15

Country	Mechanized portion of sugarcane area [1]	Potential for further mechanization	Rainfall characteristics
Paraguay	35%		1500-1800 mm
Peru	100%	Nearly all fieldwork is mechanized, cutting his manual	In the Sierra, annual rainfall is 600 mm (December-March), supplementary irrigation during rest of year. In the selva, rainfall exceeds 3000 mm
Uruguay	Semi mechanized	There is the potential	

Source: Situación y perspectivas de la producción de etanol en América Latina (IICA) Borradores 1 y 2, Reportes Originales. Cálculos Oficina del IICA en Colombia
1,2/ The total is the proxy value of the percentage of area mechanized and irrigated in relation to the total area planted in Latin American countries, and includes only those countries reporting mechanization and irrigation percentages.

Table 4.

Ethanol production

Country	Ethanol production	Potential ethanol production from sugarcane [1]	Installed industrial capacity				Comments
	Ethanol (liters)/Ha		Number of refineries	Number of distilleries	Milling capacity (refineries and distilleries)		
					Tons of cane/ year	Liters/year	
Argentina	7500	400 million per year	23	19	20,500,000		Cane milling. 19 of 23 refineries have distilleries
Belize	0		1		1,300,000		Cane milling
Bolivia							Not reported
Brazil		72 billion		325		18 billion	Ethanol
Chile	0		0				No production
Colombia	9000		14		29,200,000		Combined capacity
Costa Rica	5600	4846	15		15,914,000		Cane milling
Ecuador						47,107,000	Ethanol
El Salvador				1		43,800,000	Ethanol
Guatemala	5570		15	4	17,800,000	178,850,000	Combined capacity
Honduras	0		7		9,642,570		Cane milling
Jamaica			7	2		196,820,000	Not reported
Mexico	4659		58		105,205,410		Cane milling
Nicaragua	6728	21,649	4		12,410,000		Cane milling
Panama	0		4		2,560,000		Cane milling
Paraguay	3750		10		10,693,250		Cane milling
Peru	0		10		13,614,500		Cane milling
United States			100			17,032,500,000	Combined capacity
Uruguay	3600						Not reported
Venezuela	0						Not reported

Source Situación y perspectivas de la producción de etanol en América Latina (IICA) Borradores 1 y 2, Reportes Originales. Cálculos Oficina del IICA en Colombia.

[1] Approximate value. Ethanol production according to area potentially available for sugarcane was calculated in relation to the cultivated area, agricultural yield in terms of ethanol output per hectare, and extrapolation to the potential area.

Table 5.

Regulatory framework for the use and management of ethanol

	Laws on ethanol in gasoline blending	Laws on ethanol production incentives	Laws and regulations on ethanol quality	Legal incentives
Argentina	✔	✔	✔	no
Belize	no	no	no	no
Bolivia	no	no	no	no
Brazil	✔	✔	✔	no
Chile	no	no	no	✔
Colombia	✔	✔	✔	no
Costa Rica	✔	no	✔	✔
Dom Rep	no	no	no	✔
Ecuador	no	no	no	✔
El Salvador	no	no	no	✔
Guatemala	✔	✔	✔	✔
Honduras	no	no	no	✔
Jamaica	no	no	✔	no
Mexico	no	no	no	✔
Nicaragua	no	no	no	✔
Panama	no	✔	no	no
Paraguay	✔	✔	no	✔
Peru	✔	no	no	no
Uruguay	no	no	no	✔
USA	✔	✔	✔	no
Venezuela	no	no	no	✔

Table 6.

R&D institutions active in the biofuels field

Country	Nº. of initiatives		Main research interest
	Public	Private	
Argentina	4	1	Improving crop management
Belize	0	0	
Bolivia	0	0	
Brazil	1	1	Improving management of sugarcane and other feedstock crops. Recycling agricultural wastes.
Chile	2	0	Ethanol production process
Colombia	0	2	Improving crop management Ethanol production process
Costa Rica	1	0	Improving crop management
Ecuador	3	1	Improving crop management Ethanol production process
El Salvador	0	0	
Guatemala	0	1	Improving crop management
Honduras	1	2	Improving crop management Ethanol performance in engines
Jamaica	1	1	Improving crop management Ethanol performance in engines
Mexico	2	1	Ethanol performance in engines
Nicaragua	0	0	
Panama	0	0	
Paraguay	1	0	Improving crop management
Peru	2	1	Small-scale biofuels production
United States	1	0	Improving crop management Ethanol performance in engines.
Uruguay	1	0	Improving crop management
Venezuela	2	1	Ethanol production process

Table 7.

Investment projects and government initiatives for ethanol production

Country	Projects, investments and distilleries			Government initiatives			
	Public	Private	Mixed	Laws	Programs	Projects	Technical support
Argentina	✔	✔		✔			✔
Belize		✔					
Bolivia	✔	✔		✔		✔	
Brazil	✔	✔		✔	✔		✔
Chile	✔	✔			✔		
Colombia	✔	✔	✔	✔		✔	
Costa Rica	✔	✔		✔			
Ecuador	✔	✔	✔		✔		
El Salvador	✔	✔			✔	✔	
Guatemala	✔	✔		✔	✔		
Honduras	✔	✔			✔		✔
Jamaica	✔	✔					✔
México	✔				✔		
Nicaragua	✔	✔			✔		
Panama	✔	✔		✔			
Paraguay	✔	✔		✔	✔		
Peru	✔	✔		✔			
United States	✔	✔		✔			
Uruguay	✔	✔			✔		
Venezuela	✔		✔				✔

ANNEX 2

Research and development institutions working on ways to improve sugarcane and ethanol production processes

Country	Institution	Nature	Lines to work from
Argentina	Instituto Nacional de tecnología Agropecuaria –INTA	Public	Improving competitiveness through: • new technologies • development of new varieties • integrated pest management • training and development of alternatives for SMEs
	Proyecto Integral NOA de caña	Public: INTA, provincial governments, S&T Ministry, universities, technical assistance agreements	• Developing new varieties (clones) • expanding the genetic base • integrated pest and disease management • disease-free genetic materials • dissemination of good management practices • training in planning and organizing work in different harvest systems • complementary and productive alternatives for SMEs • alternative uses of sugarcane
	Estación Experimental Agroindustrial Obispo Columbres (EEAOC)	Public	• Agronomic improvement • genetic improvement • sugarcane processing
	Chacra experimental agrícola de Colonia Santa Rosa (Salta)	Private	• Genetic improvement to obtain sugarcane varieties suitable to the ecological conditions of northern Argentina • pathology and biotechnology
	Secretaría de Ciencia y Tecnología	Public	• $35,468 recently approved for a feasibility study of extracting hydrogen from ethanol and its use as a fuel in automobiles.
Belize	Currently there is no institution doing research on sugarcane		
Bolivia	There is no institution doing research on sugarcane production		
Brazil	Empresa Brasileña de Investigación Agropecuaria (EMBRAPA)		• Alternative feedstocks for ethanol production • international market • agroenergy farming cooperatives • National Agroenergy Plan • technologies for using agricultural wastes

Country	Institution	Nature	Lines to work from
Brazil (cont.)	Centro de Tecnología Cañera de Brasil (CTC)	Private	• Technology transfer to the national sugar and alcohol industry • genome project to identify the 50,000 cane genes • production of biodegradable plastic • creation of VVHP-type sugar that requires less processing effort • technology for using cane processing residues in electricity cogeneration
Chile	Fondo de Innovación Tecnológica de la Región del Bio Bio (Innova Bio Bio)	Public	• Research project on producing bioethanol from forest biomass • production and marketing of bioethanol from wood (lingo-cellulose materials) and byproducts from processing
	Fundación Innovación en Agricultura (FIA)	Public	• Responsible for financing government projects and programs in agriculture. Studies are focused on the use of corn and sugarcane for ethanol to produce an initial 10% blend
Colombia	Centro de investigación de la Caña de Azúcar –CENICAÑA	Private	• Sugarcane varieties • biotechnology • efficient water use • reducing sucrose losses during harvest • clean technologies • process engineering • measurement standardization
	Corporación para el Desarrollo Industrial de la Biotecnología y la Producción Limpia (CORPODIB)	Private	• Studies to examine fermentation, energy consumption and disposal of solid and liquid wastes in ethanol plants.
Costa Rica	Liga Agrícola Industrial de la Caña de Azúcar (LAICA)	Public	• Intensive program of genetic improvement
Ecuador	Petroecuador - Instituto de investigación	Public	• Development of testing for the program to substitute a percentage of ethanol in gasoline
	Centro de Investigación de la Caña de Azúcar del Ecuador (CINCAE)	Private	• Development of sugarcane varieties and technologies • disease management • pest management • soil management

Country	Institution	Nature	Lines to work from
Ecuador (cont.)	Unión Nacional de Cañicultores del Ecuador (UNCE)	Public	• Provides advisory services to governments and other entities on sugarcane production problems • producers' registry • arranging import of inputs, agrochemical products, vehicles, farm machinery needed for sugarcane growing.
	Escuela Politécnica Nacional	Public	• Processing of sugarcane into ethanol and use of other feedstocks and innovative technologies
El Salvador	There is no institution involved in R&D on sugar		
Guatemala	Centro Guatemalteco de Investigación de la Caña de Azúcar (CENGICAÑA)	Private	• Development of sugarcane varieties • integrated pest management technologies • fertilizers • irrigation • training
Honduras	Universidad Nacional Autónoma de Honduras (UNAH)	Public	Preparation of thesis works on: • evaluating the use of ethanol in internal combustion engines • evaluating alternative methods of producing ethanol from yucca, cheese whey, sorghum, potatoes, sawdust and wood, cabbage, corn and its residues • evaluating agricultural yields of sugarcane as an economical agro-industrial crop
	Universidad de San Pedro Sula (USPS)	Private	• Agricultural production and potential production of ethanol from sugarcane
	Fundación Hondureña de Investigación Agrícola (FHIA)	Private	• Comparative studies on the adaptability of varieties
	Escuela Agrícola Panamericana (El Zamorano)	Private	• Research studies on sugarcane yields in different parts of the country

Country	Institution	Nature	Lines to work from
Jamaica	Corporación Petrolera de Jamaica (PCJ)	Public	• A pilot project was launched in May 2006 to research the most suitable ethanol-gasoline blend, using motor vehicles from the Petrojam group and the Ministry of Industry, Technology, Energy and Commerce.
	Instituto de Investigación de la Industria de Azúcar	Private	• Research on sugarcane and sugar processing
Mexico	Red Nacional de Investigación y Desarrollo de Bioenergéticos	Public	• Development and promotion of feedstocks for biofuel and bioenergy
	Instituto Tecnológico de Estudios Superiores de Monterrey (ITESM)	Private	• Study of fuel properties and optimizing the production process • operational tests of B100 in cars
	Red Nacional de Investigación y Desarrollo de Bioenergéticos	Public	• Development and promotion of feedstocks for biofuel and bioenergy
Nicaragua	There is no institute doing research on sugarcane production. The Instituto Nicaragüense de Tecnología Agropecuaria does no research on sugarcane or ethanol. There is no legislation assigning this responsibility.		
Panama	There is no institution doing research on sugarcane.		
Paraguay	Campo Experimental de Caña de Azúcar de Natalicio Talavera (CECA)	Public	• Sugarcane production and use for ethanol
Peru	Asociación Peruana de Productores de Azúcar y Biocombustibles (APPAB)	Private	• Production of sugarcane and biofuels • situation and outlook report from the 10 sugar mills
	Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica (CONCYTEC)	Public	• Assists in generating technologies and infrastructure for production, marketing and distribution of biofuels.
	Universidad Agraria La Molina (UNALM)	Public	• Production of biofuels in small-scale prototypes.

Country	Institution	Nature	Lines to work from
United States	National Resources Conservation Service USDA (NRCS)	Public	• Conservation Security Program (CSP) • Environmental Quality Incentives Program (EQIP) • Conservation Technical Assistance (CTA)
Uruguay	Programa Nacional de Bioetanol (Pronabio-E)	Public	• Has been working with the municipal governments of Montevideo, Canelones, Maldonado y Treinta y Tres, generating partnerships with the municipal governments of Bella Unión, Paysandú, Salto and Durazno. The program is focused primarily on process in sugarcane for ethanol production.
Venezuela	Etanol de Venezuela	Mixed	• Construction of 17 plants to produce 20,000 barrels a day
	Instituto Nacional de Investigaciones Agrícolas (INIA)	Public	
	Petróleos de Venezuela S.A. (PDVSA)	Public	• Important progress on expansion projects with signature of 12 energy agreements with China in 2006 • feasibility studies of future are sugarcane areas

ANNEX 3

Government and private sector interest in programs for production and use of ethanol fuel

Country	Public	Private
Argentina	• Captive demand through mandatory blending of gasoline with bioethanol • Law 26.093 establishes a promotion system • Expert technical support for developing the industry.	• Azucarera Los Balcanes inaugurated in 2006, in the Tucuman province, is the biggest refinery in Argentina, with a potential capacity of 350.000 liters per day. The industry intends to export ethanol to the Southeast Asia. Also it intends to invest in new technologies and equipment to obtain ethanol from other crops (corn, sweet sorghum, etc) extending its operations beyond the sugarcane harvesting season. • Adecoagro is currently developing a project of an agroenergetic model which integrates dairy and ethanol production from corn, with an investment of U S $392 million. This initiative in the province of Santa Fe intends to produce: 550 million liters of milk, 200 million liters of ethanol and 70 GWatt of electricity from biogas.
Belize		Identification of alternative fuel sources that could be cheaper than fossil fuels.
Bolivia	The national government promulgated Law 3546 of November 28, 2006, creating the agroindustrial complex known as "Complejo Agroindustrial de San Buenaventura", and declaring that company to be a national priority "for the production of sugar, biofuels based on ethanol, anhydrous alcohol and dehydrated alcohol, as well as the production of African palm for the production of oil and biodiesel, and sources of renewable and compatible energy within the context of ecologically sustainable production (…) defined by its characteristics (…) as a corporation of a public social nature."	The Guabira distillery produces refined sugar, alcohol and fertilizers. The company has around 28,000 ha in sugarcane and an ethanol production capacity of 300,000 liters a day. It recently announced the second phase of expansion, with an investment of $11 million.
Brazil	• The Brazilian AgroEnergy Plan (2006-2011), which has the full support of the government as a State policy, has eased the nerves of investors and seeks to minimize risks and maximize efficiency in agroenergy projects. • The government supported the Platform of Brazil, in which the countries of Latin America and the Caribbean pledged that, by 2010, at least 10% of the energy they use will be renewable.	• An example of the countries' interest in investing in the sector and drawing on Brazil's experience in ethanol production and use is the creation of the Inter-American Ethanol Commission. • Petrobras of Brazil and Mitsui of Japan announced plans to invest US$8 billion in the expansion of ethanol production capacity. • Firms such as Infinty Bio Energy, Cosan, Tereos, Dreyfus, Biagi and Cargill are investing in biofuels and listing their stock on the London Exchange.

Country	Public	Private
Brazil (cont.)	• At the International Conference on Biofuels, Brazil announced that it will begin to issue the Environmental Certificate, which will ensure the environmental, social and technical sustainability of Brazilian biofuels. • The North-South corridor is nearing conclusion, which will help consolidate the sugar-alcohol agroindustries in the States of Maranhao, Piaui and Tocontins.	• Mitsubishi Corp. signed a 30-year supply contract and has acquired shares in Usina Boa Vista. • Brenco (Brazil Renewable Energy Company) is building 10 industrial plants in the Central/West part of the country, with its partners investing approximately US$2.3 billion. • According to UNICA (União da Indústria de Cana de Açúcar), by 2012, 87 new industrial plants will be added to the 325 in operation presently.
Chile	• Creation of an interministerial commission comprising the ministries of agriculture, mining, energy and economy. • Creation of a public-private committee to prepare a technical, economic and legal proposal on biofuels.	Petrobrás has announced an interest in investing in an ethanol plant in Chile.
Colombia	Government interest in promoting biofuels production in the country is clear in the strategies adopted by the Ministry of Agriculture: • *Strategy for development of biofuels in Colombia.* • *Agricultural export strategy 2006-2020.* The strategic vision gives priority to 10 groups of promising export products, including sugarcane, caña panelera and yucca for ethanol and oil palm for biodiesel. • *Domestic energy agenda* represents a meeting of minds between the national government, territorial entities, the private sector, political players and civil society on the set of strategic actions that the country must take in the short, medium and long terms to improve the productivity and competitiveness of the economy.	• The National Federation of Cereals and Legumes Growers, FENALCE, has signed an agreement for germplasm and technical advice for research and development of hybrids and varieties of sweet sorghum developed essentially for regions of India, the Philippines and Africa. • Petrotesting in partnership with CIAT (Centro Internacional de Agricultura Tropical) has studied an optimal plant for producing ethanol from yucca. • CIAT has at yucca gene bank with 6000 varieties.
Costa Rica	Since the 1980s there has been both government and private sector interest in producing ethanol.	TABOGA's sugar mills have a current capacity to produce 200,000 liters a day, and the CAPSA mill has a daily capacity of 240,000 liters.

Country	Public	Private
Ecuador	• Interest in substituting renewable energy from various sources • Confirmed support for the Pilot Plan to Formulate and Use Gasoline with Anhydrous Ethanol in the City of Guayaquil	• The major Ecuadorian distilling companies CODANA, SODERAL and PRODUCARGO are interested in using their installed capacity to supply ethanol demand sparked by the biofuels plan. • The National Union of Sugarcane Producers (UNCE) has requested government approval to expand sugarcane production. • EPN has produced small quantities of ethanol from wood and paper residues.
El Salvador	• Program for production and use of ethanol • Country was selected from among 150 sugar producing countries for a US-Brazil pilot ethanol production plant.	• The La Cabana distillery in Agolares is operating 120 days a year, producing 60,000 liters of ethanol a day, and will double its capacity by 2007.
Guatemala	• The Fuel Alcohol Act (Decreto Ley No. 17-85, of 21/02/1985) and its regulations are in force. The act sets standards for the production, storage, management, use, transportation and marketing of fuel alcohol and blends. • The government signed the United Nations Convention on Climate Change in 1992, and it was ratified by Congress in 1995.	
Honduras	This interest is being addressed in three stages: • in the first stage, producers have undertaken to enhance productivity; • the second phase involves cogeneration of electricity with bagasse, and is already underway; and • the third stage calls for the experimental production of ethanol	• The president of the Independent Association of Banana Producers has announced that a group of Chinese investors will finance a $30 million, 20-year project to produce ethanol from yucca. • Grupo Pellas, an Nicaraguan agroindustrial concern, announced the investment of $150 million in Honduras, including development of 31,000 ha of sugarcane specifically for ethanol.
Jamaica	Jamaica has also been looking at the possible use of alternative fuels, particularly indigenous fuels such as ethanol from sugarcane, to provide a portion of the petroleum products used in the transport sector from renewable sources.	In partnership with Coimex of Brazil, Petrojam Ethanol Ltd in November 2005, invested US$10.5 million in a modernized plant, with a capacity to produce 50 million liters of ethanol per year from sugarcane feedstock.

Country	Public	Private
México	The government of the Federal District has declared its willingness to join forces with the federal government's energy authorities to design a pilot plan, with two purposes: • To support cane growers and the sugar industry. The plan would designate a large fleet of vehicles that would use gasoline blended with 10% anhydrous alcohol, and • To establish a program to monitor emissions and verify engine performance, and evaluate parts subject to wear (elastomers).	
Nicaragua	IntInterest in promoting programs to produce and use ethanol	The private sector is taking initiatives to produce ethanol. The San Antonio mill made the first export of 3 million liters of ethanol to Europe.
Panama	The national government, through the Ministry of Trade and Industry, has prepared a national policy on hydrocarbons and alternative energy (2005), in the context of Law No. 8 of June 16, 1987, which contains the elements necessary to identify and formulate guidelines, objectives, programs, projects, activities and measures in the energy sector to promote economic and social development, as well as parameters for instruments and measures over the short, medium and long term.	There is little in the way of biofuel development in Panama, but producers and investors see the country as a key distribution point for re-export of ethanol.
Paraguay	• Promulgation of the Biofuels Promotion Act • Decree No. 12.111 created a working group to study the technical and economic feasibility of biofuels	• Implementation of the Biofuels Promotion Act • Promotion of biofuels
Peru	• Discussion of incentives needed to promote production and supply for the local market. • Legal framework to promote biofuels has two instruments: the Biofuels Market Promotion Act (PMB) and Supreme Decree Law 03.	Major investments in ethanol: • Grupo Romero has committed $100 million. • Maple has committed $100 million • Grupo Gerco has built a plant and is negotiating the purchase of lands

Country	Public	Private
United States	USDA's Natural Resources Conservation Service (NRCS) has several programs that affect energy use on farms and ranches. • Conservation Security Program (CSP) • Environmental Quality Incentives Program (EQIP) • Conservation Technical Assistance (CTA),	• In August 2006 the alternative energy company Altra Inc., announced private investments of $120 million, with the expectation of attracting a further $250 million within the next six months. • The same company has begun construction on an ethanol plant in Ohio and recently acquired the largest ethanol plant, Goshen, expanding production capacity by 30% to around 132.5 million liters a year.
Uruguay	• The government is interested in promoting a biofuels program and has submitted a draft bill to parliament • The government has created the National Biofuels Commission, and interinstitutional authorities to advise on policies for production and use of biofuels.	• German and Canadian firms are planning to invest $45 million in an ethanol plant at Treinta y Tres, using rice husks that were formerly discarded as waste.
Venezuela	To date there has been no action on legislation for bioenergy, but there are several laws relating to the area, including the following: – Organic Law on Hydrocarbons. – Environmental Crimes Law. – Oil Pollution Surveillance Law. – Law Establishing the National Institute for Agricultural Research. • Plan 474 on sugarcane, for constructing ethanol distillers: the government intends to earmark $900 million over five years for ethanol production	