IV. BRAZIL

1. BRAZIL BIOFUELS 2020

A) INTRODUCTION

Brazil stands at a crossroads. Decades of public and private sector investment in agroenergy have positioned the country as the world leader in the efficient production of biofuels. There is no agriculturally-based fuel produced today that can compete with Brazilian sugarcane ethanol, which is competitive with gasoline at prices as low as $35 a barrel. The country has also gone farther than any other in successfully incorporating biofuels into its transportation fuel consumption. Mandatory blends of 20 - 25% +1% (today 23% +1%) ethanol and a target of 3% biodiesel in 2008 are impressive on their own, but current ethanol use far exceeds the consumption these requirements create. Brazilian-developed flex-fuel engine technology, already used in more than 70% of new cars sold, allows consumers to choose any combination of ethanol and gasoline based on their preferences and market price. Brazil is also a biofuels force beyond its borders. It leads the world in ethanol exports, accounting for 55% of ethanol traded internationally in 2005.

Brazil's leadership today is unquestionable, but it leads an industry that is very much in flux—and likely to be revolutionized by new technology soon. Ethanol, after all, is still traded on a limited scale (just 10% of global production in 2005). Brazil serves as a model for many countries seeking to establish vibrant biofuels industries as a tool for development, energy diversification, and emissions reductions. However, Brazil's path has not been linear, and the changing global environment requires even the industry leader to evolve. Understanding the rise, fall, and resurgence of biofuels in Brazil is critical to assessing the country's current competitive position and crafting a strategy for maintaining future leadership.

B) THE BRAZILIAN NATIONAL ALCOHOL PROGRAM – PROALCÓOL

The Brazilian National Alcohol Program, ProAlcóol, was launched in 1975 as a response to soaring oil prices and a crisis in the international sugar market. During the first oil crisis, the average price of a barrel of petroleum increased from $ 2.91 in September 1973 to $ 12.45 in March 1975.[1] Given low international sugar prices, the Brazilian government sought to utilize domestic sugar supplies to reduce its dependence on foreign oil, improve its balance of payments, reduce disparities in regional supply, expand production, and generate employment. The program was able to take off in part because of the significant capacity expansion that occurred in 1971/72 thanks to high international sugar prices.

Efforts to diffuse the impact of the oil crisis focused on the agroindustrial and technological development of sugarcane. The government embarked on a massive campaign to promote synergies along the supply chain from sugarcane farmers to ethanol producers and on to end users.[2] The government also sponsored efforts to produce anhydrous ethanol to be blended with gasoline through small initiatives that would expand and eventually create economies of scale.

During the first phase of the program, 1975-1979, government funds helped construct distilleries adjacent to existing sugarcane mills, enabling managers to switch between sugar and ethanol as market prices fluctuated. Such injections of capital helped the industry grow at a relatively rapid rate and allowed Brazil to reduce its dependency on foreign oil, insulate itself from the vagaries of the international sugar market, and ultimately form the robust and competitive industry that exists today.

The second oil crisis, in 1979, exposed Brazil's continuing vulnerability to international oil shocks and fortified the political will to enhance ProAlcóol. The government augmented the program by promoting the construction of independent distilleries capable of producing hydrated ethanol for fuel engines and negotiating with car manufacturers to develop 100% alcohol fueled vehicles.[3] The government designed a variety of incentives to entice agricultural producers, distillers, car manufacturers, distributors, and others to adjust their operations and help meet the anticipated demand increase.

The industry responded. Anhydrous and hydrated alcohol production levels increased from 500 million liters per year in the late 1970s to 15 billion liters per year in 1987. [4] Incentives provided to the auto industry led to the proliferation of alcohol-fueled vehicles, which reached 92% of new car sales between 1983-88 and comprised more than 50% of the total car fleet by 1992.[5]

Favorable macroeconomic and fiscal policies enabled the rapid expansion of the industry, but even strong government support could not completely insulate it from exogenous shocks. Declining oil prices in the mid-1980s eroded the economic case for ethanol. As oil prices leveled off, the production costs associated with ethanol rendered the product less competitive and highlighted the exorbitant costs of ProAlcóol subsidies. Disputes between the government and producers over price controls resulted in decreased subsidies and, consequently, decreased production[6] Domestic ethanol was not able to satisfy the demand generated by the spread of alcohol-fueled vehicles, making ethanol imports necessary. Brazil's economic priority shifted to combating inflation, and the government overvalued the country's currency, which inadvertently damaged ethanol's competitiveness.

ProAlcóol deteriorated further throughout the 1990s. The shortages of the late 1980s reduced consumer confidence in the program and decreased demand for alcohol-fueled vehicles, sales of which fell continuously throughout the 1990s. By 2000, only 10,000 such vehicles were sold.[7] At the same time, increased international sugar prices led sugarcane producers to divert their production away from ethanol and back to sugar.

While the outlook for ProAlcóol grew dim, the government continued to explore ways to sustain the program. In 1993, the government instituted a mandatory blend of ethanol and created another round of incentives to draw producers and consumers back into the sector. In the late 1990s, the government deregulated the sector and instituted a new tax (CIDE) that applied only to gasoline and diesel. In 2002, Development, Trade and Industry Minister Sergio Amaral declared the government's interest in reviving the program, but he sought assurances from the agroindustrial sector that the country would not suffer from cane ethanol shortages.[8] Indeed, fears that sugar producers would revert to sugar production prompted government officials to propose a sugar export tax in an effort to keep resources in the country. The government eventually relaxed fuel controls and allowed both gasoline and ethanol to be regulated by the market.[9]

In March 2003, the introduction of flex-fuel vehicles, which the Brazilian government taxed at a lower rate than regular cars, reinvigorated the ethanol market in Brazil. These engines allow consumers to choose any combination from 100% ethanol to 100% gasoline (although all gas in Brazil is blended with 23% ethanol today), based on their preferences and market price. Within 18 months, flex-fuel vehicles accounted for 73% of new car sales.[10] This new choice, combined with the sustained surge in the price of oil, revived the domestic ethanol market.

The demise of the original ProAlcóol program is often attributed to shortages in ethanol supplies toward the end of the 1980s that decreased consumer confidence in the program and precipitated the decline in alcohol-fueled cars. Sugar producers suggest that intense regulation by the government inhibited the sector from operating efficiently. While the development and proliferation of the Brazilian ethanol industry would not have been possible without substantial government involvement and investment, today ethanol production receives no direct subsidies and is competitive with gasoline to around $33 a barrel.

C) LOOKING FORWARD TO 2020

The development of the Brazilian ethanol industry through the ProAlcóol program has positioned Brazil as the global leader in the production of ethanol from sugarcane and the most efficient and cost-competitive of biofuels today. Countries around the world are looking to the Brazilian model as they establish their own industries. However, changed external circumstances demand a transformation in biofuels production. The resurgence of ethanol demand in Brazil, sparked in part by high oil prices, was also driven by the innovation of the flex-fuel engine, which made consumer choice possible. Continuing innovation along these lines will be essential. Moreover, the industry is going global, and Brazil is looking to export markets for growth. Countries around the world, many with deeper pockets than Brazil, are embracing biofuels and investing in both production and innovation China alone recently announced a planned $187.5 billion investment in renewable energy, including biofuels, through 2020. Brazil can remain the global leader, as both a commodity supplier and as a source of new technology, but doing so will require a cohesive strategy and significant investment. The challenge will be to establish the appropriate balance between supporting a growing industry and allowing it to freely and efficiently compete in the global market.

The next four chapters outline four pillars of such a strategy, each one addressing critical hurdles Brazil must overcome.

1. **Innovation**: Brazil is facing a newly competitive environment for biofuels innovation. There is a real danger that the country will become a large producer and exporter but fail to stay at the forefront of innovation. To prepare for future waves of activity, Brazil must focus on innovation now, pool resources for investment, address gaps in both R&D and education, and create a path to the next phase of innovation, leadership, and success. By focusing on improving existing technologies and creating new ones, Brazil can add value to its economy and push itself out of the category of under-developed commodity exporter. With the support of an innovative biofuels industry, Brazil can attract the investment flows needed to achieve the sector's sustainable development. Rather than just selling biofuels, Brazil can sell technology and expertise, by serving as a resource and collaborator on biofuels projects around the world. In the same way that the major oil companies stay on the technological cutting edge and partner with governments and smaller companies worldwide, Brazil should aim to develop a business platform that draws on its knowledge and expertise, not just its ethanol.

2. **Capacity Expansion**: Historically Brazil has easily outpaced the rest of the world in ethanol production. That has now changed. The United States overtook Brazil in 2005 as the world's largest producer of ethanol, and Brazil's productive capacity is increasing at a slower rate than the rest of the world. Production in Brazil grew nearly 6% in 2005, while the US and small producer countries both grew production by 21%. In 2006, US production is projected to grow to 18.2 billion liters, while Brazil will likely reach 16.7-17 billion liters. Still, Brazil remains one of the few countries with the available arable land for large-scale export production. The challenge is to expand production in an environmentally sustainable manner that does not infringe on needed grazing pastures or national reserves, while finding the capital to finance new projects.

3. **Infrastructure**: The Brazilian biofuels industry developed for domestic markets, and the infrastructure supporting it reflects that orientation. As Brazil develops a strategy to maintain its position as the global leader in biofuels and meet a projected surge in export demand, it must address the inadequacies in current infrastructure. Brazil must both facilitate the growth of the biofuels industry in underdeveloped regions of Brazil and look outward to how production reaches ports for export. The component parts of the biofuels infrastructure in Brazil are power, transport, storage and distribution, and communications. Together, they facilitate the production and distribution of ethanol and biodiesel products from factory to pump and from field to vehicle.

4. **Building Global Markets**: The global biofuels market is a key element to an overall economic growth strategy for Brazil and the Americas.n International trade in biofuels is still relatively undeveloped, and national policies usually focus on meeting domestic consumption needs. According to the IEA, in 2004 just 10% of world ethanol production was traded internationally, and only 20% of that was used in fuel. But current levels of consumption and growth rates suggest that energy-hungry countries such as the US, the EU, China, Japan, and India will not be able to meet

their growing demand exclusively with domestic production. Given their natural resource endowments, optimal climate conditions, and competitive labor and land costs, developing countries in Latin America, Asia and Africa may in the medium to long term be among the most efficient suppliers. Supporting the development of a market infrastructure in the short run will help to ensure adequate resource allocation and access to global supply. Brazil has taken a leading role in developing the ethanol industry and designing a futures market to enable international trade of the commodity. Timely efforts to harmonize biofuels commodity standards, reduce institutional and regulatory barriers, and standardize contract requirements will enable the international biofuels trade to achieve its potential.

Endnotes

[1] "Etanol combustivel: Balanco e Perspectivas," UNICAMP, 17 Nov. 2005.
[2] Jeverson Barbieri, "30 anos do Proálcool no centro do debate," Jornal da Unicamp, Edição 309 – 14, 17 Nov. 2005.
[3] Luis Cortez and Walter Arnaldo, "A Historical Overview of the Brazilian Bioethanol Program," Renewable Energy for Development, (Stockholm Environmental Institute, Vol. 11, No. 1. July 1999), 2.
[4] Jayme Buarque de Hollanda and Alan Dougais Poole, "Sugarcane as an Energy Source in Brazil," INEE Instituto Nacional de Eficiencia Energética, 2.
[5] Ibid, 2.
[6] N.a., "PróAlcool – Programa Brasileiro de Álcool", Oct 2006, <http://biodieselBR_com.htm>.
[7] Jayme Buarque de Hollanda and Alan Dougais Poole,
[8] Alastair Stewart, "Brazil Proposes Sugar Export Tax to Regulate Ethanol Production", Oster Dow Jones, 30 May 2002.
[9] Jayme Buarque de Hollanda and Alan Dougais Poole,
[10] "Ethanol in Brazil: A Successful Experience," MAPA, MDIC, MME, (Washington, Mar. 2006).

PILLAR I: INNOVATION

A) INTRODUCTION

Brazil has been a major innovator in the field of biofuels as well as a top producer and exporter of ethanol. Decades of investment in innovation have not only produced the most efficient agricultural and industrial processing in the world, but also yielded the flex-fuel engine, which sparked the resurgence of ethanol use in the domestic market and is now being introduced around the world. As the biofuels industry expands within Brazil and globally, the country is facing a new competitive environment. Countries around the world are investing significantly in this area, and Brazil will need to build on its strength with a cohesive national strategy if it is to retain its position. Without this, Brazil faces the real threat of becoming a large producer and exporter of biofuels without the technological competency to stay at the forefront of innovation for that industry.

R&D entails both scientific research and applied technology that can produce practical solutions. As a new and dynamic industry, the biofuels sector must constantly reassess its goals and seek to improve its systems; there is no room for complacency. Talented individuals are needed to innovate and conceptualize; skilled professionals to run tests and create new technologies; and specialized labor to support operations and drive growth as new technologies are introduced to help the sector expand.

The critical importance of trained personnel makes it logical to group R&D and education together within the innovation pillar. Innovation describes the process of creating or introducing something new as well as the successful implementation of that product or process; in the case of biofuels, new technologies must not only be developed, but applied in ways which add value to the sector and clear a path for future growth and achievement. R&D and education function together to drive innovation.

Brazil is on the cusp of a major evolution in its biofuels industry, and capacity expansion through technological and agricultural innovation will be critical. Launching significant R&D and education efforts will require preparation, funding, and commitments to change the educational, research, and business cultures within Brazil. The current university research system in Brazil lacks both a culture of entrepreneurship and practical links to industry. Similarly, the majority of private sector funding for R&D takes place through private research divisions within individual companies. This disconnect has resulted in the underutilization of Brazil's human resources in the R&D field and is a major barrier to the growth of innovative activity. The issue of financial support is particularly important. To achieve the government's projected goals for the sector, as well as the anticipated demand of the biofuels industry in the years to come, it is likely that billions of dollars will be necessary. Achieving advancements in biotechnology and industrial and agricultural processes will necessitate the expansion of research and test facilities as well as training and professional development of the sector's labor pool. Greater participation from and coordination with the private sector, universities, and research institutions can help ensure that research activities address the practical technological needs of the sector.

Examining the structures and policies in place for research and development, as well as for expansion of the biofuels sector, will provide a frame of reference by which to analyze current trends in both public and private participation in the innovation process. The Innovation Pillar of this report will assess the current state of R&D and education and identify new trends. It will also offer recommendations on steps to help move the biofuels sector forward.

Prepared by Garten Rothkopf

2.1 Research and Development

A) R&D Introduction

Brazil is currently the largest exporter and second-largest producer of ethanol in the world, but it must overcome research and development constraints within the field to maintain forward momentum, specifically cohesion among the various institutions and companies involved in the development of the ethanol and biodiesel industries. With respect to innovation within the value chain of the biofuels sector, R&D efforts have focused on efficiency of inputs and processes to optimize output per hectare of feedstock. These include the continued development of:

- Varietals that have a larger sugar or energy content as well as those which are resistant to disease, bacteria, and pests and have the capacity to respond to different environments;
- Cellulosic, or second-generation, production technology to allow the use of different feedstocks, as well as more components of those feedstocks, to produce biofuel; and
- Use alternatives, such as flex-fuel vehicle hybrids, gasification for biomass-to-liquids production, and electrical co-generation, among others.

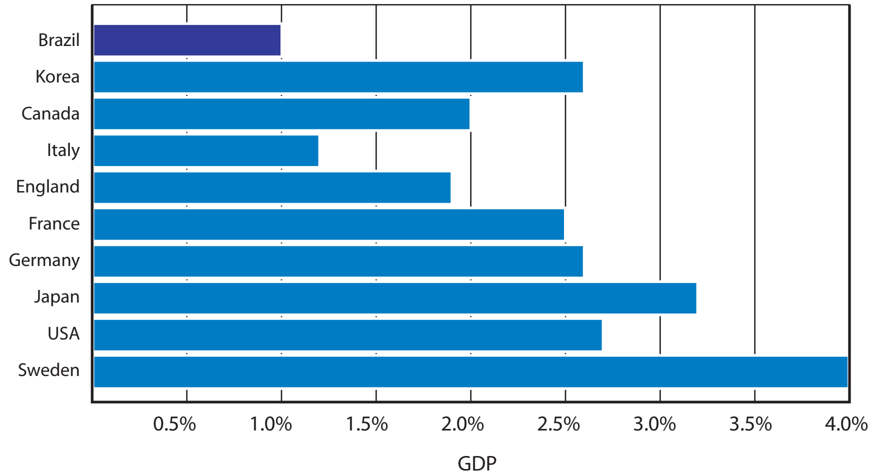
This type of advancement is important because, as demand for ethanol and biodiesel grows, so must supply. With limited space in which to plant feedstock for biofuels, maximizing output per hectare will be key in meeting the energy needs of the future. The development or optimization of co-generation and derivative-product manufacturing capabilities would also allow for comprehensive use of the greatest percentage of the feedstock as well as subsequent cost reductions and secondary business opportunities.

Innovation can help ensure that increased productivity and efficiency is achieved in a sustainable way, both environmentally and socio-economically. Deriving greater amounts of product from feedstock inputs is one way of promoting environmental sustainability, as is utilizing co-generation to power plants and discovering additional materials that can be used to produce biofuels such as biomass or waste. If Brazil can promote itself as a technological leader, as opposed to a simple commodity exporter, it will be in a position to build a more socially and economically beneficial and sustainable industry.

A-1) Funding for R&D

An understanding of the overall trends in Brazilian R&D provides necessary context for an examination of the specifics of biofuels-related R&D. Brazil spends less than 1% of its GDP on R&D, according to both the World Bank and Unesco, and funding has declined from 1% of GDP in 2002 to 0.97% in 2003 and 0.91% in 2004. With a GDP of $604 billion (market value) in 2004,[1] approximately $5.5 billion was spent on R&D for the year. Brazil leads Latin America, spending significantly more as a percentage of GDP than Chile and Argentina (0.61% and 0.41% respectively in 2003); however, developed countries like the US, Japan and Germany, as well as Korea, one of the "Asian Tigers", are spending more than 2.5% of GDP on investments in R&D. Sweden, the world leader, spent nearly 4% of GDP on R&D in 2003 [Chart 2.1a.].[2]

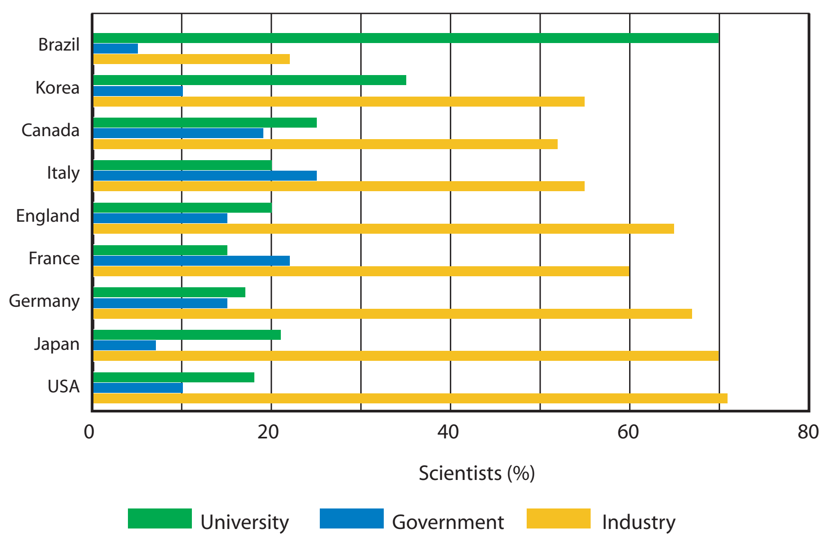
Chart 2.1a: R&D Spending as a Percentage of GDP (2003)



Source: UNESCO

Research and development in Brazil is heavily dependent on the public sector. Private sector investment accounted for just 42% of R&D spending in Brazil. In OECD countries, the percentage of investment from the private sector averaged 63% in 2001 (73% in Japan, 64% in the US, and 54% in the EU)[3] and nearly 62% in 2004. 64.4% of Chinese R&D came from industry.[4] [Chart 2.1b] The lack of private sector funding for R&D is illustrative of a lack of private sector participation in research and development overall in Brazil. Additionally, in OECD countries, the business sector performs 67.7% of total R&D activities;[5] in Brazil, only 11% of scientists operate in the business sector[6]. The exception to this rule of public-sector domination of Brazilian R&D is the biofuels industry, where private companies not only finance but also conduct the majority of ethanol and biodiesel research and development.

Chart 2.1b: Institutional Distribution of R&D Activity



Source: "Brazil and the Knowledge Economy", Brito/ FAPESP PP Presentation - 2005/06, 21.

Prepared by Garten Rothkopf

A-2) Patents and Scientific Production

A-2.1) Patents

One measure of the depth of the Brazilian R&D sector is patent registrations and grants, both domestically and internationally. According to the World Intellectual Property Organization (WIPO), the use of the patent system has become more internationalized, with residents and non-residents applying for patents across countries and increased utilization of the system by developing countries. Brazil is a signatory to the Paris Convention for the Protection of Industrial Property (the Paris Convention)[7] and adheres to the Patent Cooperation Treaty (PCT), which allows investors to file for the equivalent of an international patent, the rights of which would be honored in all member countries.[8]

Global Patent Comparisons

According to WIPO, use of the patent system has increased dramatically over the last decade. Non-resident patent filings have increased 7.4% since 1995, with more and more applications being filed in Brazil, India, China, Mexico, and Korea. Patent filings and grants, however, remain concentrated in the US, China, Japan, Korea and Europe, which together account for 75% of all applications and 74% of patents granted.[9]

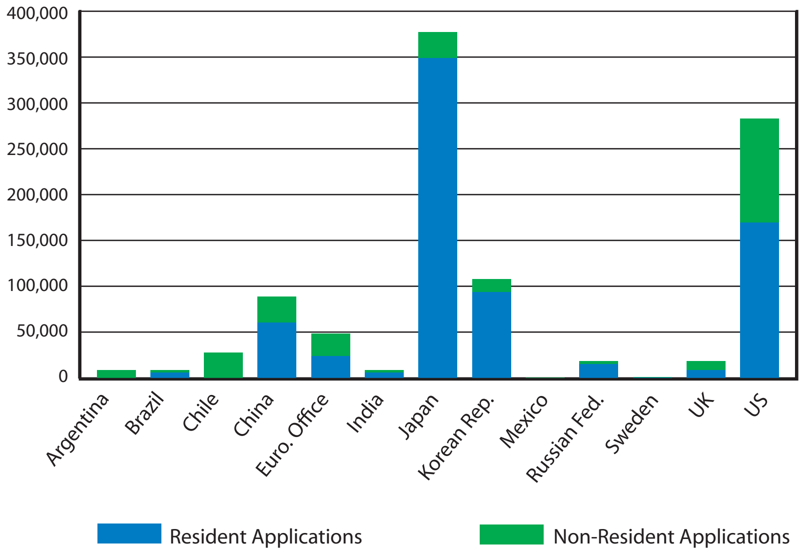
Brazil surpassed Argentina, Chile and Mexico in resident applications in 2004, but lagged behind Argentina, and far behind Chile, in non-resident filings. Brazil did, however, have the largest number of patents granted [Table 2.1a]. With respect to developed nations such as the US and Japan, Brazil, like many other emerging markets, is outmatched in all categories. It is notable that Korea boasts the third-largest number of resident patent applications and grants; further analysis of Korea's R&D might benefit Brazil's science and industry. To illustrate this point, take the case of each country's registry of patents in the US over a twenty-five-year period: in 1980, the US Patent and Trademark Office (USTPO) granted 24 patents to Brazilian inventors and 8 to Korean inventors; however Korea was able to increase its number of patents registered to 3,314 in 2000 and 4,352 in 2005, while Brazil reached only 98 registries in 2000 and 77 in 2005.[10] Possible explanations for this disparity include spending on R&D and output of scientists, issues which will be explored in greater detail in the second half of this chapter.

Table 2.1a: Resident and Non-resident Patent Applications and Grants (2004)

	Resident Applications	Non-Resident Applications	PCT National Phase	PCT International Applications*	Grants to Residents	Grants to Non-Residents
Argentina	1,090	6,900	-	21	230	-
Brazil	3,892	2,356	12,444	280	590	-
Chile	240	39,700	-	9	-	-
China	65,786	32,109	32,489	2,501	18,241	31,119
European Office	32,178	26,296	65,227	21,241	31,248	27,461
India	7,179	-	10,287	679	851	1,466
Japan	368,416	20,766	33,899	24,820	112,527	11,665
Korea, Rep.	105,250	13,428	21,437	4,686	35,284	13,784
Mexico	565	2,010	10,623	141	162	6,677
Russian Federation	22,985	1,958	5,247	656	19,123	4,068
Sweden	2,768	380	82	2,858	2,495	737
United Kingdom	19,178	9,407	1,369	5,102	3,780	6,761
United States	189,536	135,196	32,211	46,107	84,271	80,020

Source: WIPO 2006; * 2005

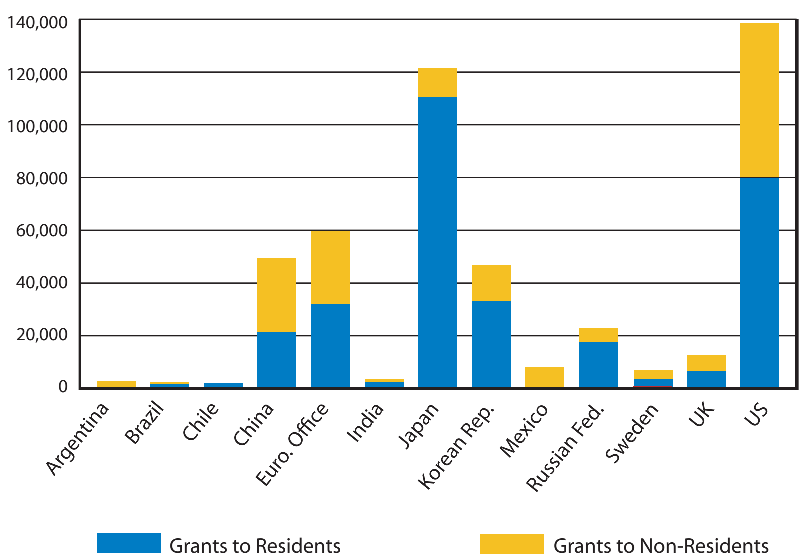
Chart 2.1c: Resident and Non-resident Patent Applications



Source: WIPO 2006

Japan's low level of non-resident applications is notable, as is the large number of non-resident applications for Chile (also detailed in Table 2.1a above). This indicates that not only are a large number of patent applications coming from Japan, but that a great deal of those are coming from the Japanese, making the prospect of partnerships with the Japan Bank for International Cooperation (JBIC), the Japanese government, or Japanese firms that much more interesting. Chile's values indicate that there is a market for new technology, but that domestic supply of technology is insufficient. This would indicate that there is a space within Chile for foreign innovation, and as Chile embarks on its quest to increase biofuels production and use, as part of its goal of energy self-sufficiency, technology transfer from Brazil could form an important part of this strategy.

Chart 2.1d: Resident and Non-resident Patent Grants



Source: WIPO 2006

The figures in Table 2.1b represent the number of patents filed by residents set against a number of variables, including R&D spending and GDP. Once again, Japan and Korea are at the forefront. Brazil's number of resident filings per million of R&D spending is above those identified as key players in the Latin America region, and its number of filings per billion of GDP is just below that of Argentina. India is an interesting point of comparison. Although it is a hot spot for foreign direct investment, particularly in IT and pharmaceuticals, which tend to be patent-intensive industries, India has proportionally fewer resident patent filings than Brazil.

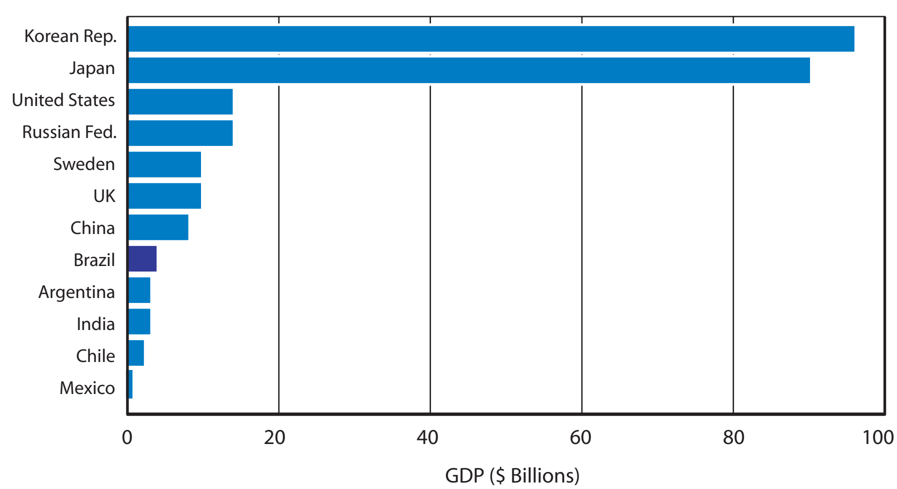
Table 2.1b: Resident Patent Filing by Population, GDP and R&D Expenditure (2004)

	Resident Patent Filings per Million Population	Resident Patent Filings per $Billion GDP	Patent Filings per $Million R&D Expenditures
Argentina	28.41	2.32	0.56
Brazil	21.16	2.81	0.29
Chile	14.88	1.49	0.25
China	50.75	9.37	0.71
European Patent Office	56.82	-	-
India	6.65	2.30	0.22
Japan	2883.56	107.26	3.41
Korea, Rep.	2188.96	116.19	4.40
Mexico	5.44	0.60	0.14
Russian Federation	159.78	17.56	1.37
Sweden	307.83	11.34	0.28
United Kingdom	320.34	11.31	0.60
United States	645.44	17.70	0.68

Source: WIPO 2006

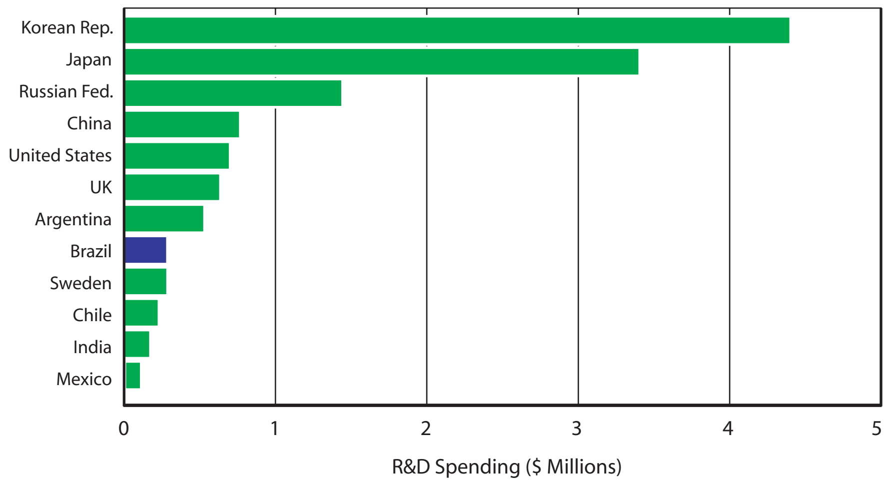
It is notable that Brazil is third among the BRIC countries in R&D spending, with only India trailing it.

Chart 2.1e: Resident Patent Filings per $Billion GDP 2004



Source: WIPO 2006

Chart 2.1f: Patent Filings per $Million R&D Expenditures 2004

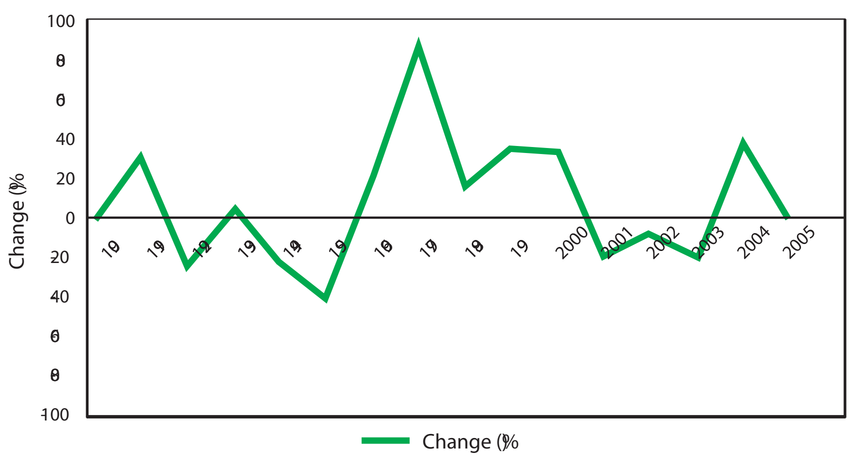


Source: WIPO 2006

Domestic Patent Activity

There is limited disaggregated data on the breakdown, by sector, of Brazilian patent requests. Chart 2.1g illustrates the peaks and valleys of public patent application filings in Brazil between 1990 and 2005, for which the total number of filings were 10,655 and 4,805 respectively (2005 data represent information gathered from January to May of that year; 2004 saw 22,071 filings).[11]

Chart 2.1g: Variability of Public Patent Filings in Brazil



Source: Banco de Dados do INPI. Updated in 2005.

Brazil's relatively low patent numbers are an indication of the under-performance of its R&D sector vis-à-vis more developed countries; this deficit has contributed to an annual trade deficit of $20 billion in R&D-intensive industries including chemical, microelectronics and pharmaceutical.[12]

A-2.2) Scientific Production

Another significant measure of scientific activity is the number of scientific articles published by a given country. As the tables below illustrate, Brazil has come a long way in its production of scientific material [Table 2.1c], but continues to lag behind more developed countries [Table 2.1d].

Table 2.1c: Increase of Published Articles, by Country, in Scientific Periodicals Indexed by the Institute for Scientific Information (ISI)

	1981	2004	% Change
Brazil	1,891	13,328	604.81
Japan	26,915	68,568	154.76
Sweden	6,872	14,901	116.84
UK	38,253	67,010	75.18
United States	172,132	256,374	48.94
India	13,498	19,852	47.07
Korea	229	19,217	8,291.70
China	1,651	46,022	2,687.52
USSR/ Russia	23,414	22,974	-1.88

Source: MCT[13]

Table 2.1d: Articles Published in the Scientific Periodicals Indexed by the Institute for Scientific Information (ISI) – World Participation 2004

Ranking	Country	2004	% of Global Participation
1	[illegible]	256,374	33.29
2	[illegible]	68,568	8.90
3	[illegible]	67,010	8.70
5	[illegible]	46,022	5.98
10	[illegible]	22,974	2.98
13	[illegible]	19,852	2.58
14	[illegible]	19,217	2.50
15	[illegible]	14,901	1.94
17	[illegible]	13,328	1.73

Source: MCT[14]

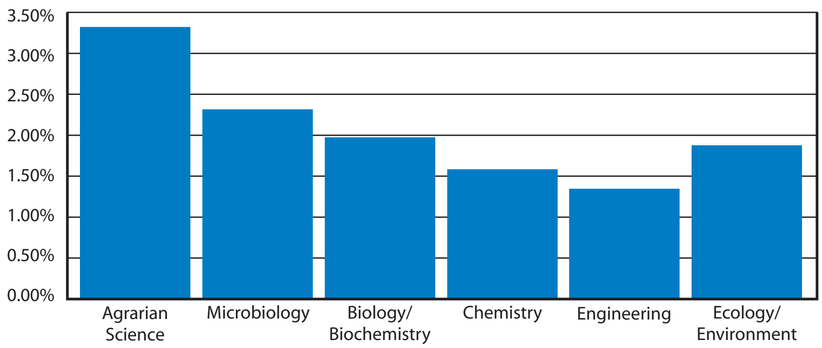
Table 2.1e: Number of Articles Published in Scientific Periodicals Indexed by the Institute for Scientific Information (ISI)

Year	Brazil	Latin America	World	% Brazil in Relation to Latin America	% Brazil in Relation to the World
1994	4,805	12,683	638,321	37.89	0.75
1995	5,432	14,265	668,581	38.08	0.81
1996	5,970	15,693	679,059	38.04	0.88
1997	6,662	17,458	683,800	38.16	0.97
1998	7,988	19,434	710,017	41.1	1.13
1999	9,034	21,664	724,323	41.7	1.25
2000	9,591	22,745	721,421	42.17	1.33
2001	10,631	24,642	740,248	43.14	1.44
2002	11,361	25,915	736,110	43.84	1.54
2003	12,679	28,673	800,624	44.22	1.58
2004	13,328	28,594	770,031	46.61	1.73

Source: MCT [15]

Chart 2.1h highlights Brazil's contribution to global publications in fields relevant to the biofuels sector. Its performance is in line with the country's overall share of global publications, which lag behind Korea, Indian, and China, and of course the US and the UK.

Chart 2.1h: World Share of Indexed Scientific Articles Published by Brazil (2004)



Source: MCT [16]

Taken together, the data indicates that Brazil is a leader within Latin America in terms of innovation and scientific achievement, but that it still requires improvement to compete at the international level. This information is not meant to suggest that Brazil is weak in its ability to conduct R&D or publish scientific research, only that resources, both human and monetary, might be better allocated to improve the country's standing. This picture of the Brazilian research, development and innovation field is important background in considering the state of the country's R&D sector for biofuels.

(For additional global comparisons, see Annex)

B) R&D and the Public Sector

Brazil's public R&D sector is very much embedded in the nation's public university system. It involves a variety of government agencies and funds that promote and support R&D as well as science and technology more broadly. A number of private companies are involved in the biofuels sector, though additional private participation is needed to help fund and communicate the needs of industry to the public research community.

Well-funded public universities, government institutions, and funding and networking agencies are the major players in the R&D field. Much of the country's wealth is concentrated in the southeast and south of the country, and the top universities with the best funding are located in these areas. The Brazilian government has conceived a number of biofuels initiatives, at both the federal and state level, and has a number of ministries, state bodies, and support institutions in place to promote these plans and facilitate growth of the sector.

B-1) Government Bodies

At the federal level, ministries involved in R&D funding and promotion relevant to biofuels are:

- Ministry of Science & Technology (MCT)
- Ministry of Agriculture, Livestock and Supply (MAPA)
- Ministry of Mines & Energy (MME)
- Ministry of Agrarian Development (MDA)
- Ministry of Development, Industry and External Trade (MDIC)

The MCT is at the forefront, providing research funding to a variety of institutions and organizations. MAPA is also an integral player, having been restructured in 2005 to include an agroenergy division, under which biofuels are considered an energy commodity. MAPA's National Agroenergy Plan (PNA), discussed in greater detail below, outlines the government's plan to develop the sector. The Agribusiness Council (CON SAGRO) also under MAPA, collaborates with organizations in the field on biofuels issues, among others, including the Brazilian Agribusiness Association and MAPA's research body, Embrapa.[17]

Also at the federal level, the National Institute of Industrial Property (INPI) regulates the use of industrial property, including the issuance of patents. The National Association of Petroleum, Natural Gas, and Biofuels (ANP), which falls under the jurisdiction of the MME, also regulates biofuels standards.

In addition to the federal ministries listed above, state governments participate in the promotion of R&D. As one would expect, the states with the greatest amount of funding and thus university research activity also have strong R&D promotion agencies. The São Paulo State Government's Biofuels Chamber promotes large-scale financing of biodiesel production ventures, including some R&D activity. The Paulista Agency of Agribusiness Technology (APTA) of the state of São Paulo facilitates the transfer of technology and information to promote agribusiness in an environmentally and socially conscious manner. It also works to develop new sugarcane technologies and varietals.

B-2) Government R&D Spending

B-2.1) Overall Spending

In 2005, MCT (science and technology) was by far the largest ministerial investor in R&D, investing $840 million, nearly half of the total federal investment in R&D of $1.85 billion. The Ministries of Agriculture and Education contributed $370 million and $280 million to R&D respectively.[18] From the MCT's resource pool in 2005, approximately $330 million was allocated to the National Council for Science and Technology Development (CNPq), and $325 million went to the National Fund for Science and Technology Development (FNDCT).[19] 27.3% of MCT's research funding goes to higher education institutions and 21% goes to agriculture, the largest percentages.

CNPq, which focuses on the development of human resources for research and technology in Brazil, offers grants and fellowships to researchers as well as masters, doctoral, and post-doctoral students in Brazil and abroad. CNPq also funds grants to institutions involved in research and innovation as well as those that provide post-graduate level courses in the various scientific fields. CNPq sets no limitations so long as research supports technological development beneficial to the country.[20]

In July 2006, the Brazilian government, as part of the Brazilian Forum of Biotechnology Competitiveness, launched a plan to put the country in a leadership position in the areas of human health, industry, and agriculture by 2020. The government anticipates investments of $3.25 billion, from both the public and private sector, over a period of 10 years. The focus of this effort is strengthening the link between research and production, to improve the business sector's productivity and innovation and boost Brazil's exports. The work will strengthen human and laboratory resources and will likely draw on MCT sectoral funds, outlined below, FINEP, BNDES, and the private sector.[21]

B-2.2) Biofuels Specific Spending

It is notable that 70-80% of biofuels funding has come from the private sector, according to the sugarcane-growers union of São Paulo, Unica. This is a departure from the national Brazilian trend and would indicate that there is room for increased government spending in this area.

The MCT has 16 sectoral funds, with the aim of funneling tax revenue collected from companies in particular industries back into R&D for that sector. Of these funds, 14 are sector specific and two are cross-sectoral. Financing decisions are made by the MCT's financing agency, FINEP (the Studies and Financing Entity), which not only provides academic grants, but serves as a lender to businesses interested in investing in innovation and research. To date, these funds have invested nearly $1.8 billion on more than 4,000 R&D projects.[22] MCT has no updated information on funding for bioenergy-specific R&D, but projects under the national biodiesel program received more than $4 million (R$12 million) in 2003-2004 from sectoral funds.[23] There are several sectoral funds which could potentially be tapped to fund R&D in biofuels, and they are summarized below.

Ministry of Science and Technology Sectoral Funds

CT-PETRO:
The PETRO fund was the first fund to be created, in 1999, with the objective of stimulating innovation in the production of oil and natural gas to improve production and the quality of the sector. It was also to bolster the qualifications of human resources and the development of partnerships between business and universities/ centers of research. The source of the fund is 25% of any excess of 5% oil & gas royalties.

CT-TRANSPORTE:
The TRANSPORT fund focuses on planning and development in civil engineering, transport engineering, materials, logistics, equipment and software for reducing costs and increasing the competitiveness of transport infrastructure. The fund receives 10% of receipts from the National Department of Streets and Roads in contracts with communications and other companies which use transport infrastructure.

CT-INFRA:
The INFRASTRUCTURE fund was created to modernize the country's infrastructure and education associated with the sector of civil engineering; and to build and renovate labs and buy equipment. The source of the fund is 20% of resources destined to each Sectoral Fund.

CT-ENERG:
The ENERGY fund aims to finance programs and projects in that sector, especially in the area of end-use energy efficiency. It looks to develop alternative sources of energy at reduced cost, and with better quality and fewer emissions; and to stimulate the competitiveness of national technology related to energy. The fund receives 0.75-1% of the liquid income of businesses which generate, transmit, and distribute electric energy.

CT-AGRO:
The AGRICULTURE fund focuses on scientific capacity and technology creation in the areas of agronomy, veterinary science, economics and social agriculture, among others, encouraging investment in biotechnology and the diffusion of new technologies. The funding comes from 17.5% of the CIDE (Contribution on Economic Activities) tax imposed on the production and trade of fuels in Brazil.

CT-BIOTEC
The BIOTECHNOLOGY fund targets the development of human resources for the biotech sector and the strengthening of the national research infrastructure and related support services. It also supports the expansion of the national knowledge base, the monitoring of advancements in the sector, and the stimulation of business development in the biotech field as well as the transfer of technologies to the business sector. Its funding comes from a 7.5% CIDE contribution.

GREEN-YELLOW
The GREEN-YELLOW fund is part of a program designed to stimulate university-business relationships for the support of innovation. Its objective is to intensify technological cooperation between universities and research centers and businesses, contributing to the elevation of activities in Science and Technology. The fund is derived from 50% of the associated CIDE tax.

Each of these funds relates to the biofuels industry in its own way. Stimulating innovation and improving quality in the oil sector involves ethanol and biodiesel, which make up 20% - 25% and 2% of gasoline and diesel fuel mixtures respectively. Transportation logistics and more competitive transport infrastructure are obstacles facing the biofuels industry, a concern underlined by Brazilian Chief of Staff Dilma Rousseff at the First National Biofuels Conference in late August.[24] For its part, the energy fund looks to develop alternative sources of energy, including biofuels, and to investigate the use of biomass and waste for fuel production. The promotion of scientific capacity in the agricultural sector, as well as the diffusion of biotechnology and the strengthening of national research infrastructure, are important to advancing the biofuels sector, as is the goal of the Green-Yellow fund to enhance linkages between the university and business sectors.

Alongside the MCT, the Brazilian National Development Bank (BNDES) has several lines of financing which are specific to bioenergy R&D. The Financial Support Program for Biodiesel Investments invests in all phases of biodiesel production, including R&D.[25] The Technology Fund (FUNTEC) was re-launched to support projects intended to stimulate technological development and innovation with respect to the strategic interest to the Brazil, as outlined by federal policies and programs. The two lines of financing under this fund cover investments in: 1) research, development and innovation, for which BNDES offers loans at a 6% interest rate plus a 1.8% credit risk rate over a period of up to 12 years; and 2) production, where financing is offered at the long-term interest rate (TJLP) plus a credit risk rate of 1.8%, a financial mediation rate of 0.8%, and financial institution fees of up to 3% over a period of up to 10 years.[26] FUNTEC will also finance up to 90% of the value of a project.[27] According to FUNTEC, it currently has 31 projects in the pipeline with nearly $180 million (R $383 million) invested and over $280 million (R $600 million) in investments.[28] These lines of financing are intended to enhance specifically the technological capacities of the Brazilian biofuels industry.

B-3) Government Biofuels Initiatives

The Brazilian federal government has developed and implemented two major biofuels plans. One focuses on biodiesel production and use, which is only beginning to develop in Brazil, while the other aims to expand ethanol use as well as that of biofuels in general. Consistent themes in these plans are diversification of feedstock and the enhancement of technological capability.

B-3.1) National Biodiesel Production and Utilization Plan

The Brazilian National Biodiesel Production and Utilization Plan (PNPB) involved biofuels in the Brazilian energy matrix by creating quota targets of 2% by 2008 and 5% by 2013 for biodiesel blending. The Plan also renamed the National Petroleum Agency (ANP) the National Petroleum, Natural Gas and Biofuel Agency (keeping the original acronym) and delegated to the agency the tasks of defining biodiesel and its value chain, and of authorizing specific producers. The development plan targets included:[29]

- The diversification of oil seed plants from which biodiesel can be produced and the expansion of castor bean, palm and soy use;
- The production of biodiesel using ethanol as a catalyst through transesterification; and
- The discovery of uses for biodiesel byproducts such as glycerin.

The plan was developed as an umbrella initiative to coordinate the individual work of several different involved ministries.

The Brazilian MCT plays an important role in the biodiesel sector, especially with respect to R&D, and promoted biodiesel initiatives even before the official national biodiesel plan came into effect. In 2002, it developed an initiative called the Brazilian Technical Biodiesel Development Program (Probiodiesel), in conjunction with the State of Paraná, to develop fuel from vegetable oil and to evaluate its economic, technical, and socio-environmental viability.[30] Under the national biodiesel plan, the government has created the Brazilian Biodiesel Technology Network, which involves 60 research groups throughout the country. The MCT will develop laboratory infrastructure to monitor production quality, help construct four new production units, and promote new research efforts from emerging groups and start-up companies.[31] The technological development of the program will be coordinated through the "state network" to avoid duplication of efforts; as of November 2006, 23 states had signed agreements and over 120 projects had been sponsored. [32]

There are additional initiatives taking place under the National Biodiesel Production and Utilization Plan, including several that address the social impact of biodiesel production. In 2004, to this end, the COPPE research institute at the University of Rio de Janeiro (UFRJ) tried to identify the best areas for castor bean production as well as for processing facilities in the northeast. Under the plan, the Ministry of Farming Development grants Social Fuel Seals to industrial producers who buy their raw materials from small family operations.

Biodiesel Funding
Within the biodiesel network of the national biodiesel program, there are 121 R&D projects with total funding of roughly $20 million (R $42.7 million).[33] Funding for the plan includes disbursements from the sectoral funds, and financing from Pronaf, or the National Program for the Strengthening of Familial Agriculture, which gave $ 43.3 million (R $100 million) in 2005 to the network. The interest rates for Pronaf loans were between 1% and 4%,[34] low considering that Brazil's Selic rate, or the benchmark rate charged by banks, was 13.75% in October 2006.[35] BNDES will also provide financial and investment support of up to 90% for projects under the Social Fuels Seal program and up to 80% for the remaining projects. Small-, medium- and micro-enterprises will be charged Brazil's long-term interest rate (TJLP) plus 1%, for Social Fuels Seal projects, or 2% per year. Large businesses will be charged TJLP plus 2%, or 3% per year.

B-3.2) National Agroenergy Plan

The National Agroenergy Plan (PNA), unveiled in 2005, was derived from the national biodiesel plan and created under the Ministry of Agriculture to organize and develop a proposal for research, development, innovation and technology transfer to ensure the sustainability and competitiveness of the agroenergy industry. It seeks to structure research efforts and supports the creation of an agroenergy consortium as well as an agroenergy unit through Embrapa.[36] The National Agroenergy Consortium would involve the Ministry of Agriculture and the private sector, and would organize and encourage the research, development and production of biofuels. The partners in the consortium are Embrapa, the Brazilian development bank BNDES, the Bank of Brazil and Itaipu Binacional, a hydroelectric complex owned jointly by Brazil and Paraguay. The Embrapa Agroenergy Unit is being formed out of Embrapa's existing decentralized research units, with the addition of implementation units in each region of the country to coordinate with municipal and state governments, and roughly 20 researchers to deal specifically with agroenergy.[37]

The plan's Research & Development and Innovation (RDI) Program contemplates short-, medium- and long-term goals for the industry, and will engage in four main areas derived from the main agroenergy production chains:[38]

- ethanol and energy cogeneration from sugarcane
- biodiesel from animal and vegetable sources
- forest biomass
- agroenergy and agroindustry residues and "dejects"

The RDI Program is designed to be multi-disciplinary, multi-institutional, and anchored in international cooperation.[39] Its strategic priorities will be genetic improvement through traditional methods, as well as through biotechnology, which will allow for the selection of optimal vegetable species for biofuels feedstock and a significant improvement in production.[40]

The ANP mandates several R&D objectives for the biofuels sector. With respect to ethanol, research will be devoted to a number of issues, including:

- The introduction of new characteristics via biotechnology (plague resistance, drought tolerance, and adaptability to land acidity and nutritional characteristics);
- The development of both agronomic and industrial production processes and management systems for sugarcane cultivation; and
- The improvement of sugarcane's industrial yield, the use of other parts of the cane for ethanol production, and co-generation processes.

For biodiesel production, the government will collaborate to:

- Maximize the energy yield from raw materials input, including the discovery of new oil-producing plant species and the use of organic residues;
- Create an aggregate value chain by developing processes not only for energy production from biomass, but also the production of co-products and residuals for the pharmaceutical and chemical sectors;
- Improve oil extraction processes as well as management systems for oil crop plants and harvesting and processing methods; and
- Conduct engine function and emissions studies to evaluate and promote the commercial use of biodiesel.

Both sectors aim to develop an agroecological zone in expansion regions and to integrate the different agroenergy chains (mentioned above).[41] Additionally, there is an emphasis on promoting efficiency in the development of biodiesel so as to reach the 2013 target of a 5% biodiesel blend as economically as possible.

B-3.3) Law of Innovation

The Innovation Law, approved by the Brazilian House of Representatives in July 2004, provides a legal framework to promote scientific and technological research and development, as well as other innovation-driven activities, by the private sector, particularly small and medium enterprises (SMEs).[42] This Law is driven by three main goals:[43]

1) To increase collaborative linkages between the public and private research communities, particularly universities, technological institutes and firms through the structuring of networks and international research projects; the promotion of technological entrepreneurism; and the creation of incubators[44] and technological parks. There is also a mechanism which allows science and technology institutes to share their facilities, including laboratories, with firms.

2) To increase the participation of science and technology institutes in the "innovative process", encouraging and facilitating the commercialization of technology developed by these institution-firm partnerships, including the patenting and licensing of generated intellectual property (IP), the protection of that property, and the remuneration of institutions and their associated researchers for services and expertise rendered.

3) To increase the participation of firms in the innovative process through the promotion of financing, economic subsidies or other incentives to be used for the payment of human resources, for materials purchases and for infrastructure needs associated with innovative activities. The Law also allows public agencies to transfer non-refundable funds to private firms for R&D, which was previously prohibited, provided that the firm contributes some of its funds towards the project.

The Law of Innovation intersects with the federal government's Technological, Industrial and Foreign Trade Policy (PITCE), an initiative announced by Foreign Minister Luiz Fernando Furlan in March 2004, which promotes, among other objectives, improvement of the productive sector's efficiency. The Policy's goal is to capacitate that sector technologically, allowing it to withstand external competition as well as to augment its exports through the competitive insertion of Brazilian goods and services with better quality, greater technological content, and higher value added, into the international market.[45] PITCE is also supported by BNDES funding.

B-3.4) State Programs

At the state level, a variety of biofuels promotion programs exist, particularly for the nascent biodiesel sector [Table 2.1f]. For example, the biodiesel program of Bahia, a state which leads the country in biodiesel production with a market share of 92%, has been working with universities and companies in the region to achieve commercial-scale production of biodiesel by 2006/2007.[46] The RioBiodiesel program has also been active in promoting biodiesel production and use, and in bringing together the work of the Federal University of Rio de Janeiro, municipal and state governments, and local industry (see University R&D Activities below for specific projects).

Table 2.1f: Biofuels Research & Development Projects by State

State	Program Title/Objective
Alagoas	Semi-arid Alagoano Oil crops: Technological Innovation, Sustainability and Social Inclusion
Amazonas	Insertion of the State of Amazonas into the National Program for the Production and Use of Biodiesel
Amapá	Research, development, and prospecting of native plants for the production of biodiesel in the State of Amapá
Bahia	Bahian Biofuels Network
Espírito Santo	Biodiesel in Espírito Santo
Goiás	Biodiesel Program of Goiás
Maranhão	Special Biodiesel Program of Maranhão
Minas Gerais	Mineiro Biodiesel Program
Mato Grosso do Sul	Biodiesel Program of the state of Mato Grosso do Sul
Mato Grosso	Biofuels Program of Mato Grosso (PROBIOMAT)
Pará	Biodiesel Production in the state of Pará
Paraíba	Technological Network of PB - Biodiesl
Pernambuco	Technical-Economic Studies to consolidate Industrial Production Processes for Castor-based biodiesel in Pernambuco
Piauí	Biofuels of Piauí: Energy from Castor
Paraná	Paranaense Bioenergy Program: Technical Development of Biodiesel
Rio de Janeiro	RioBiodiesel: Clean and Innovative Fuel
Rio Grande do Norte	Potiguar Biodiesel Program: Current Situation
Rio Grande do Sul	PROBIODIESEL-RS Project
Sergipe	Consolidate the Technological and Scientific Base for Processing and Output of Biodiesel
São Paulo	Biodiesel – SP Project

Source: Brazilian Network of Biodiesel Technology [47]

These programs are important in that they frame the objectives of the Brazilian government with respect to biofuels research. The next step is to match the structure and resources of the research sector in Brazil to the needs and expectations of these plans. Currently, the Brazilian R&D sector faces several important obstacles in achieving the goals laid out by the government, many of which have already been mentioned.

B-4) Areas of Focus for R&D

Brazil has been the leading innovator in traditional methods of growing, harvesting, and processing biofuels feedstock, particularly sugarcane for ethanol and vegetable oils for biodiesel. It is making enormous strides in genetic and genomic biotechnology, as well as agricultural and industrial processes related to biofuels production, but the real breakthrough in the industry will come with the mastery of cellulosic and second-generation production technology and processes, an important concept for future innovation in the biofuels industry. As land and water for feedstock cultivation become increasingly difficult to obtain, because of both environmental and food-security constraints within Brazil and globally, technological creativity and the ability to increase yield per hectare will be the competitive edge of countries hoping to expand their biofuels production and achieve the greatest cost efficiencies. The utilization of residues and parts of crops currently discarded or used for other purposes may make this possible. If Brazil can be at the forefront of this technology, it will be in position to export technical expertise, processes, and equipment, rather than just biofuels.

For ethanol production in Brazil, research is underway to increase sugarcane yield to meet growing demand, through both traditional usage of sucrose, and the future prospect of cellulose processing. Mapping the sugarcane genome, considered one of the most complex, has been a particular priority. Genetic researchers and engineers at several of the top public universities and research centers have been able to alter the crop's resistance to pests, bacteria and disease, as well as boost its sucrose production. These advancements have been cutting-edge and very important to the sector, but there is still more progress to be made. Sugarcane is comprised of 1/3 sucrose, 1/3 bagasse (fibrous material left after the juice has been extracted from the cane), and 1/3 waste, which includes the leaves and tops of the crop. Most production effort focuses on the sucrose rather than the remaining two-thirds of the plant. Future technologies will focus on producing ethanol from these parts of the cane and development of cellulosic production technology is a high priority for the R&D community. Additionally, biotechnology efforts are focused on boosting the fiber content of crops as cellulosic production techniques are perfected. Confidentiality makes it is difficult to ascertain all the institutions involved in developing these processes in Brazil, but two leaders in the field are the State University of Campinas (UNICAMP) and private companies such as the Sugarcane Technology Center (CTC), Dedini and Canavialis.

For biodiesel, there are several state and federal universities, such as the Federal University of Rio de Janeiro (UFRJ) and the State University of São Paulo (USP), which are engaged in the investigation and testing of various feedstocks for biodiesel production. These include castor beans, palm, jatropha, soy and other nuts as well as grasses and additional biomass materials such as residues, waste oils, and animal fats. The need to develop second generation technologies is also key for biodiesel production and is the focus of initiatives in this sector.

A number of other countries are engaged in similar R&D efforts. Honda and the Japanese research firm RITE (Research Institute of Innovative Technology for the Earth) announced in mid-September 2006 that they had developed a method to produce second-generation ethanol from biomass. Their specific process came about through RITE's creation of a microorganism that can convert sugar into ethanol while reducing interference from fermentation inhibitors, produced when the hemicellulose is separated from the cellulose.[48] This type of technology, similar to a rapid hydrolysis technique developed by Dedini and Copersucar (with support from Research & Support Foundation of the State of São Paulo, FAPESP) is needed to advance the potential of the sector, and countries such as the U.S. and EU are working to develop their own commercially-viable technologies. In the context of this activity, Brazil's best strategy to fully exploit its first mover advantage in biofuels to stay ahead of the curve, acting as a resource to those countries seeking to expand their capabilities in the sector.

B-5) Support from Civil Society

The scientific and business communities have created several civic organizations to promote the development and advancement of biotechnology in Brazil. Over the years, there has been an evolution from strictly science promotion through education, to business development and support for the state and national biofuels industry. Today, there is a strong network in Brazil for both the promotion of science and biotechnology as well as business incubation and promotion of the field as an economic endeavor; however, increased funding and better information sharing is required.

B-5.1) Science Focused

Founded in 1948 as a non-profit organization, the Brazilian Society for the Progress of Science (SBPC) has participation from over 70 groups and associations from various scientific disciplines, including teachers, students, professionals and other interested parties, and is one of the oldest promoters of science in the country. The Brazilian Society of Biotechnology (SBBiotech) was founded in 1988 as a non-profit whose goal was to promote progress om biotechnology. A decade later, a group of scientists created the National Biosafety Association (ANBio) to help biotech industry information and protect biological diversity. The Biotechnology Information Council (CIB) is also non-profit and aims to increase public awareness of the field through dissemination of technical as well as scientific information on biotechnology and its benefits to society. Finally there is the National Biofuels Reference Center in Piraciacaba, created in 2004 to support the expansion of production capacity, and direct public and private investments. It advises the government on public policies, including the National Biodiesel Production and Utilization Plan.

At the state level, the Research & Support Foundation of the State of São Paulo (FAPESP) and the Research & Support Foundation of the State of Rio de Janeiro (FAPERJ) are two important science-focused entities. Instituted in 1962, FAPESP offers research grants and assistance both within and outside the state of São Paulo and was a partner on the genome project. Programs such as the Small Business Innovation Research Program (PIPE) and Industry / Research Institution Partnerships for Research and Development (PITE) aim to address gaps in the R&D sector.[49] Similarly, FAPERJ supports scientific and technological advancement to assist socio-economic development in the state of Rio de Janeiro. Similar institutes include:

FAPEAL Alagoas	FAPEMIG Minas Gerais
FAPEAM Amazonas	FAPEPI Piauí
FAPESB Bahia	FAPERGS Rio Grande do Sul
FAPEMAT Mato Grosso	

B-5.2) Business Focused

The Brazilian Association of Biotechnology Companies (Abrabi) was created in 1986 with the aim of transforming biotechnology into economic activity and defending the use of genetic technology in agriculture and industry, among other activities. The group also created the Brazilian Market of Biotechnology to stimulate business development in the sector. It provides statistics on the sector's economic turnover, job market, and more. The Biominas Foundation was founded in 1990 as a private institute with the support of Fir Capital Partners to help transform scientific discoveries into business ventures. To date it has helped establish more than 30 companies in the biotech arena. The foundation provides seed capital and management advisory services to new business, helps with the incubation of start-up companies, and acts as a bridge between associated companies and strategic partners of the foundation. The Brazilian Agribusiness Association (ABAG) was created in 1993 and focuses on economic development and social and environmental sustainability. A strong supporter of research and development, ABAG is in the process of creating a National Committee for Biofuels. The National Association of Automobile Manufacturers (Anfavea), though not a direct advocate of biofuels or biotech companies, supports the automobile industry, including on issues having to do with biofuels and relevant technologies, including flex-fuel. Many states, including Rio Grande do Norte and São Paulo, have business forums, which promote investment and entrepreneurship.

RIPA (the Innovation and Prospecting Network of Agroenergy) aims to connect the science and innovation community with the public, private and civic sectors. The CT-Agribusiness fund helped start the network, which is managed by the National Fund of Science & Technology Development (FNDCT) and through the Studies and Projects Financing Entity (FINEP). RIPA is the product of an agreement between FINEP, the University of Sao Paulo (USP), Embrapa and others.[50]

Brazilian government and civil society groups focused on R&D, biotechnology promotion, and agroindustry development provide a support network for innovative endeavors, including for the biofuels sector. As the biofuels sector expands, these bodies will need to continue to evolve in their structure and organization. The number of moving parts in the biofuels research and development arena is immense, and there is a strong need for coordinating bodies like those examined in this section.

C) Public Sector R&D

As discussed, there are a variety of public and private research institutions involved in the biofuels sector, the majority of which are well-endowed universities in the south and southeast of Brazil, where ethanol production is concentrated. Biodiesel production has become more prevalent in the northeast - due to tax incentives for locating production facilities in that region, for cultivating plants used as biodiesel feedstock (such as castor bean or palm), and for supporting family-based agricultural producers—and research for this segment of the biofuels market is beginning to flourish at universities in this region. In addition to more public-private partnerships, the R&D sector needs greater involvement from institutes and universities in the northeast, as well as the mid-west where soy is prevalent, which could then interface with production firms and plants in that area.

C-1) Government R&D Bodies and Activities

Government initiatives aimed have helped spawn a variety institutions engaged in R&D for biofuels development. The discovery of new feedstock varietals and the improvement of industrial processes are priorities. For the federal government, the leading research bodies are Petróleo Brasileiro, or Petrobras, which is also involved in some biofuels production distribution; and the Brazilian Agricultural Research Corporation, or Embrapa, which has just begun its engagement in agroenergy.

C-1.1) Federal Level

Petrobras/ CENPES
Though 51% state-owned, Petrobras operates as an autonomous entity. Not yet a direct producer of biofuels, it is nonetheless heavily involved in the distribution and marketing of ethanol and biodiesel and participates in some joint-production ventures. Petrobras has its own research and development center, the Leopoldo Américo Miguez de Mello Center for Research and Development (CENPES), which coordinates important technologies, including renewables, through its laboratories at the Federal University of Rio de Janeiro (UFRJ).

CENPES Activities
CENPES coordinates several Petrobras initiatives to boost fuel efficiency and promote renewable energy. CENPES hopes to produce ethanol as well as to improve upon available technology by making it possible to produce biofuels from sugarcane residue and woodchips. The center is also set to update its facilities to include the latest technology in environmental conservation and efficiency.

CENPES' Fuel Innovation and Technology Program (INOVA) was created in November 2000 with the goal of creating new fuel market products by developing formulation and additive technologies; creating methodologies to assess performance, fuel emissions, and environmental impact; and adding value for petrochemical producers and customers.

The Technological Renewable Energy Program (PROGER) was created in early 2004 to develop, test, and transfer technologies in an effort to maximize renewable fuels use. The project's areas include biomass energy production, primarily from biogas derived from waste and waste treatment facilities; and biodiesel, including all phases of the product's life cycle. Through PROGER, Petrobras is building an experimental plant in Rio Grande do Norte to develop a system able to deliver biodiesel that meets international standards. The company has a minimum price guarantee with the state to buy castor beans, and it has developed a biodiesel technique that eliminates the crushing stage by employing ethanol and a catalyst. The plant is still under construction, but is expected to be operational soon, complete with a lab for quality control.[51] Another large unit is to be set up in São Mateus, Paraná by 2007 to study the best technology for large-scale production of diesel from soy, sunflower seeds, and turnips. The project will also try to identify new uses for glycerin, such as oil-well drilling; assess the potential of the Barbados nut for producing biodiesel; and investigate the use of methanol in production (methane is imported, but it is cheaper, simpler, and higher yielding).[52]

The Petrobras Refining Technology Program (PROTER) involves work with vegetable oils, such as soy and castor bean, and diesel. The H-BIO technology was developed by PROTER to help introduce renewable energy sources and support their expansion. The process involves catalytic hydro-conversion of a diesel and vegetable oil mix under hydrogen pressure and high temperatures controlled through a reactor unit. Petrobras aims to have the process in three refineries by 2007 and in an additional two refineries by 2008. Under this scheme, vegetable oil consumption is expected to reach 256 million and 425 million liters each year (corresponding to 10% and 16% of 2005 soybean oil exports respectively).[53] Petrobras estimates that this plan will require investments of $38 million for the 2007 goal, and $23 million for 2008.[54] It is projected that by 2008, if the plan is successful, Brazil will be able to replace 25% of its diesel imports, resulting in a savings of $240 million.[55]

Petrobras/ CENPES Funding

In partnership with Petrobras and the government of Bahia state, France signed a letter of intent on September 5, 2005 for research and development of a castor bean biodiesel plant. The agreement is the result of a program for incentives that has been developed by the Bahia government since 2003 and which has attracted total investments of $103 million from Petrobras, France's Dagris, Brasil Ecodiesel, and an undisclosed firm from São Paulo. The French secretariat is investing $8.2 million to support research on the feasibility of biodiesel.[56]

Petrobras' relationship to the ethanol and biodiesel industries is crucial, specifically with regard to the company's spending capacity; according to its annual report, Petrobras spent $386 million (R $934.6 million) on R&D across its various areas of operation in 2005. The company's installed transport and logistical systems, as well as its financial commitments to the development said infrastructure, are also of prime importance. As detailed in the Infrastructure section, the company has committed $660 million to the development of pipelines with the ultimate goal of linking Brasília to São Paulo and the ports of Santos and São Sebastião.[57] (The company recently announced that the investment of those funds in pipeline infrastructure would depend heavily on the strength of demand from Japan in the coming year.)[58] Petrobras has also mastered the process of transporting ethanol in multiuse pipelines. Petrobras is planning the creation of the Pipes Technology Center of Latin America (CTDUT), which will help foster advanced research, training, and certification of equipment. CTDUT will have laboratories and full-scale facilities and will occupy an area attached to the Campos Elíseos Terminal in Duque de Caxias, at Baixada Fluminense. The project is a partnership between Petrobras, via CENPES, TRANSPETRO and the Pontifícia Universidade Católica do Rio de Janeiro (PUCRJ), and may include other institutions, universities and non-governmental organizations.[59]

Embrapa

Embrapa falls under the umbrella of MAPA, the Ministry of Agriculture, and its mission is to provide viable solutions for sustainable development of Brazil's agribusiness sector through technological development and information sharing. The corporation has bilateral partnerships with 155 institutions and 55 countries and multilateral partnerships with 29 institutions and 34 countries. The corporation sponsors a project called PROETA whose mission is to promote the creation of new enterprises with agricultural, agro-industrial or forestry bases, utilizing the information developed at Embrapa labs.

Embrapa Activities

Embrapa participates in the development of Brazil's National Program for Biodiesel Production by preparing models and logistical studies, and analyzing the farming potential of different oil seed plants. Some of its technologies include biological nitrogen fixation in sugarcane, and soy and common bean inoculants. Embrapa aims to optimize oilseed cultivation for biodiesel, and works in conjunction with the University of Brasilia to build extraction equipment to this end. Under the PNA, an Embrapa Agroenergy Unit has been planned which would create a network of Embrapa research centers throughout Brazil dedicated to innovation in feedstocks, agroenergy products, and co-production of other outputs like glycerin, esters, and even animal feed. Significant funds and human resources have been dedicated to the initiative and its launch as soon as possible is very important to the plan's success.[60] An interesting component of the program is an agroenergy fund, initially financed by the public and private sectors, which would fund the development and diffusion of technology and then become self-sustaining through the royalties accrued.[61]

Embrapa Funding

In May 2006, the Ministry of Agriculture (MAPA) offered $5 million in financing for the development of the Embrapa Agroenergy Research Center; financing will run through the end of 2007.[62] Japan, via its development agency, JBIC (the Japan Bank for International Cooperation), has committed $568 million to Brazil's ethanol and biodiesel industries, and a portion of that funding will go to the Embrapa Agroenergia Unit and a Biofuels National Activity Center, which will be located in Piracicaba in the state of São Paulo. The financing seeks to encourage technological developments in the agroenergy field.[63] The initiative will also establish a fund to support local producers; the funds will be allocated through a special contract to be signed with the Ministry of Agriculture in October 2006.

The Support Project for the Development of New Enterprises based in Agribusiness Technology (PROETA) is being financed, in part, by the Multilateral Investment Fund (FOMIN) of the IDB; the total value of the 4-year project is $ 3.2 million, split between FOMIN and Brazilian players.[64] Embrapa's main responsibilities will be to structure and manage incubated firms, which will likely include firms in the biofuels sector.

Additional Federal Bodies

The National Institute of Technology (INT) falls under the Ministry of Science & Technology and aims to support Brazil's effort to remain a technological leader by supporting research, technological development, and human-resource training. INT conducts research on a variety of subjects including ethanol use in vehicles. Through INT, the state of Rio de Janeiro sponsors studies on the effects of biodiesel on fuel injection systems and storage tank corrosion. The Aerospace Technical Center (CTA), linked to the Ministry of Defense, is also involved in researching and testing ethanol use in vehicles.

C-1.2) State Level

Technological Research Institute of São Paulo

The Technological Research Institute of São Paulo (IPT) studies industrial processes as well as ethanol use in vehicles. It is supported by the State government, particularly by FAPESP, and its biotechnology group focuses specifically on biodegradable plastics made from sugarcane. It also participates in government programs such as the Program of Mobile Laboratory Units and the Program of Technological Support to Municipalities (PATEM), initiatives of particular interest since they support decentralized research and could potentially serve as a model for future programs.

The Technology Institute of Paraná

Located in Curitiba in the south, the Technology Institute of Paraná (Tepcar) is a public company connected to the Office of Science, Technology and Higher Education in Paraná. The institute performs research, development, and production, and is considered a national reference center because it is well integrated into the university and technology-center system and participates in a variety of joint studies and projects. Tecpar carries out laboratory tests analyzing biodiesel quality, which helped the National Petroleum Agency formulate its biodiesel specifications. The Center for Biofuels Reference (CENBIO) was created under Tepcar in 2002 to run Probiodiesel, a joint effort between the Ministry of Science & Technology and the State office for Science, Technology and Higher Education. The institute conducts research on the use of vegetable oil for biodiesel production and is deeply involved in the Paraná Bioenergy Program.

C-2) University R&D Activities

The Federal University of Rio de Janeiro (UFRJ) is mentioned most frequently among federal universities in the literature on biofuels R&D. Other federal universities identified as participating in the process include the Federal University of Ceará (UFC), which adapted a methane-based biodiesel processing technique to ethanol production that led to its first patent registration; the Federal University of Rio Grande do Sul (UFRGS), which boasts a biotechnology center with a research group focusing on molecular biology and plant technology, including genetic transformation of soy and sugarcane; and the Federal University of São Paolo (UFSCar), which has a biotechnology department (with a molecular genetics lab), a microbiology department, and a molecular agriculture department, through which it engages in activities such as the development of new varietals and agricultural and industrial processes. In the northeast, the Federal University of Bahia (UFBA) is working intently with the Bahian biodiesel program and FAPESB to move the industry forward in that region and has over $392,000 (R $847,600) in projects listed on the Bahian Biofuels Network.[65]

C-2.1) Federal Level

Federal University of Rio de Janeiro
The Federal University of Rio de Janeiro (UFRJ) is participating in several large-scale R&D biofuels activities. UFRJ has a Molecular Plant Genetics Laboratory (LGMV) as well as a post-graduate research and engineering institute, COPPE. Through COPPE, researchers have carried out a study to promote castor-bean diesel production in the semi-arid region of northeast Brazil. COPPE has become a reference center, and in association with Petrobras and the state government it conducts studies aimed at supplementing diesel with biodiesel. Other studies include ones on a methanol-based production process, the use of vegetable and animal oils, and industrial residues.

In 2001, as part of the RioBiodiesel Program, the International Virtual Institute for Global Changes (IVIG) of UFRJ began building a production plant with a capacity of 200,000 liters a day from soy and residual oil. The facility is the property of HIQ, a company by UFRJ. The biodiesel has been tested in vehicles belonging to the Municipal Urban Cleaning Company (COMLURB). The group has been expanded and is now developing fuel to provide power for the Gramacho landfill.[66]

The Gerar Company, also part of the program and incubated by UFRJ, developed a process of producing biodiesel using sewage. It obtained the patent for this process domestically in 2003 and internationally in 2004. Gerar has a project to produce fuel from waste at a 2,000-liter-per-hour pilot plant. Negotiations with State Water & Sewage Company (CEDAE) began in 2005 to implement this program at a treatment station. Under this process, the top layer of sewage is separated through a specialized vacuuming process, and the fat is extracted and turned into biodiesel through etherification, generating water as a sub-product. Project researchers believe that the evidence points to the cost being lower than that of diesel, depending on related taxes. The yield is lower than with vegetable oil (85% vs. 97%), but sewage- and residue-based biodiesel could substitute for almost 1% of the Brazilian diesel market and generate more carbon credits, since sewage generates methane, not CO_2.[67]

UFRJ has been involved in incubating biotechnology businesses, a process touted by industry insiders as essential to building connections between the private sector and public universities and helping ensure that research responds to industry needs.

RIDESA
The University Network for Sugar-Ethanol Development (RIDESA) connects seven federal universities and 12 experimental stations across eight states in Brazil in support of the sector. This network was created to incorporate and continue the activities of PLANALSUCAR, which closed in 1990, and has continued to promote R&D for sugarcane-derived ethanol, notably the development of new feedstock varietals under the RIDESA Program for the Genetic Improvement of Sugarcane. Sugarcane varieties developed under PLANALSUCAR and/ or RIDESA are cultivated in more than 50%

of the country's area, with some regions boasting a 70% share. Participating universties are:

- Universidade Federal de Alagoas
- Universidade Federal de Goiás
- Universidade Federal de São Carlos
- Universidade Federal de Viçosa
- Universidade Federal do Paraná
- Universidade Federal Rural de Pernambuco
- Universidade Federal Rural do Rio de Janeiro

C-2.2) State Level

The State universities of Brazil can be as high-powered as those supported by the federal institutions. The richer states of the Brazilian federation are the ones with the best-equipped universities, notably the State University of São Paulo and the State University of Campinas, listed in this sub-section. Additionally, the State University of Santa Clara (UESC) and the University of Salvador (UNIFACS) are active in biodiesel R&D efforts in the northeast, along with UFBA. UESC has over $578,400 (R $1.25 million) in projects listed on the Bahian Biofuels Network.[68]

State University of São Paulo

The State University of São Paulo (USP) is one of the largest and best-funded public universities in Brazil, and there are a variety of programs taking place through the school's different departments. Through USP's Superior School of Agriculture (Esalq) in Piracicaba, the Department of Agro-food Industry, Food & Nutrition has a program dedicated to sugar and ethanol technology, including a distillery and a field experimental area. This program's emphasis is on research support to the regional sugar and alcohol industries, including development of new varietals and agricultural and industrial processes, and on biodiesel studies. The Department of Chemical Engineering also participates in the development of new feedstocks and in the improvement of production processes.

Ladetel

USP's Clean Technology Development Laboratory (Ladetel), located in Ribeirão Preto, tests biodiesel use in engines in collaboration with several manufacturers. The tests yield information on power, emissions, and consumption in blends of up to 30% soy-based biodiesel. Working in conjunction with the Paulista State University of São Paulo (UNESP), tractor engines are also tested using mixtures ranging from 5-100% biodiesel. Additionally, the lab is testing 5% (B5) biodiesel (half of the sample is soy-based and the other half castor-bean-based) on a fleet of Coca-Cola distribution trucks with the goal of eventually testing B10. Anfavea, the national auto maker's association, is also monitoring engine performance so that when B5 becomes mandatory, they will be able to provide some assurance of engine safety. The results of these studies have been positive, showing a reduction in CO2 emissions and black smoke.

USP also engages in the study of biodiesel technologies; researchers at Ladetel developed a process involving the addition of ethanol or methane to vegetable oil and/or industrial residue. The reaction time was 30 minutes instead of the normal 6 hours, and the fuels separated spontaneously. The lab started a 400,000-liter per day, vegetable-based industrial plant in Piracicaba in 2005, which is now owned by Petroquímica Capital in conjunction with an Austrian firm. The plan is to evaluate the quality and feasibility of production on a large scale.[69]

Cenbio

Also located at USP, the Brazilian Reference Center on Biomass (Cenbio), founded in 1996, aims to efficiently implement energy generation from biomass materials through the dissemination of information through a variety of media. A joint creation of the Ministry of Science and Technology, the São Paulo State Secretariat of Energy, USP, and the Biomass Users Network, the center's goals are to foster cogeneration of sugarcane bagasse; to promote the use of vegetable oils as well as urban residues in power generation; to support legislation which promotes the use of biomass for power generation;

and to organize technical training on bioenergy.

***State University of Campinas*[70]**
UNICAMP, the State University of Campinas in São Paulo, is very forward thinking in its approach to the sector and is highly involved in many aspects of agricultural engineering as it relates to biofuels. Their activities include:

- Developing new varietals;
- Studying sugarcane genomics;
- Modernizing sugarcane harvest technology;
- Testing hydrolysis, fermentation, and gasification processes;
- Perfecting bagasse and trash utilization as well as electricity generation;
- Developing fuel cells;
- Testing fuel quality; and
- Studying the sector's socio-economic impact, including employment, infrastructure, investment requirements, the environment, and public policy.

In addition to its wide-ranging R&D activity, UNICAMP engages the business community through its innovation company, Inova, which helps emerging companies on issues including intellectual property rights and patents and acts as a liaison between the companies and key energy sectors. In 2004 and 2005, Inova incubated 22 companies and licensed 40 patents, a testament to the company's and the university's commitment to innovation and scientific achievement.[71]

There are additional state universities participating in smaller scale biofuels R&D activities, too many to list in this report. The range of biofuels projects in the university system, as well as the examples of development partnerships with the private sector, illustrate the ability of these institutions to conduct important research and further the practical application of technologies. There is still more that can be done, however, in terms of creating linkages between the public and private sectors.

D) Private Sector

Brazil's private sector research activities occur primarily in small firms or through private production and technology companies. There is collaboration and integration between firms, including joint ventures between feedstock suppliers and equipment producers, with several notable initiatives and projects underway; however, there could be even greater collaboration among private, as well as public and private, firms given that the next wave of biofuels technology will require large-scale research and development of next generation technologies and processes.

D-1) Private Research Institutes

Private participation in R&D in the biofuels sector, outside of institutions connected to production, is less common; however, such firms exist and are gaining momentum as the "biotech start-up" business model takes hold in Brazil.[72]

Two private institutes doing biofuels research are Alellyx and Canavialis SA, both biotech start-ups financed initially by Votorantim New Business Ventures. Located in Campinas, Canavialis specializes in the development of new sugarcane varietals, including disease-resistant strains. The firm also manages varietal development for customers from the planting to the milling phase. Canavialis is also a partner of Alellyx, which specializes in plant genomics, including increasing the sucrose content of sugarcane and creating plants resistant to drought and pests. The company was founded in 2002 by a group of molecular biologists and biotechnologists and is 100% Brazilian-owned. Researchers have developed 22 varietals of sugar cane, which now represent 60% of the sugar cane grown in south-central Brazil.

Financing
Votorantim is a Brazilian, family-owned, industrial conglomerate founded in 1918. In 2005, its net income was $1.07 billion, with investments of $2.27 billion.[73] Votorantim

New Business Ventures, a venture capital fund, was created in 2000 to make investments in life sciences, IT and communications. The Votorantim Group has allocated $300 million to this end, typically investing $1-15 million for a period of 3-7 years in a given project. Alellyx started in 2001 with $11 million from Votorantim New Business Ventures; Canavialis received $7 million in start-up funding.[74]

Fir Capital Partners of Belo Horizonte is also a venture capital firm that invests in technology-driven companies with growth potential. Because of the nature of the Brazilian venture capital market, it plays a more hands-on role in developing ideas, capital, and staff than a typical venture capital firm. It invests as little as $100,000 and as much as $3 million with the expectation of investing $1-2 million over the life of a given project.[75] By 2003, it had invested $5 billion in five biotechnology companies in Brazil; one of its projects is the Biominas Foundation,[76] which in turn invested $1.7 million in seven companies between 1999 and 2003[77].

D-2) Fuel Producers

Biofuels and related equipment producers, as well as auto manufacturers, participate in projects ranging from genetic enhancement to the study of the effects of biofuels on car engines. These projects involve both ethanol and biodiesel, though the latter is done on a much smaller scale.

D-2.1) Ethanol

The two main sugarcane and ethanol producing companies, as well as one large producers' union, in Brazil command the attention of the nation's top leaders. In late August 2006, Unica, the Agroindustrial Sugarcane Union of São Paulo, met with the president to discuss an increase in the nation's required blend percentage to 25% from 20%.[45] (It was eventually raised to 23% after the Brazilian presidential election in October 2006.) It is likely that these companies, along with Petrobras, will continue at the forefront of the sector.

Copersucar
The Cooperative of Sugarcane, Sugar and Ethanol Producers of the State of São Paulo (Copersucar) is one of the largest ethanol producers. In 2005-06, its income was $2.15 billion, 58% of which came from ethanol. It produced 56.8 million tons of sugar and 2.7 billion liters of ethanol.[79] Its Genetic Improvement of Sugar Cane Project has resulted in new varietals, the sale of which has generated rights and royalties. The cooperative's R&D activities are largely accomplished through the Sugarcane Technology Center (CTC), formerly known as the Copersucar Technology Center.

Copersucar Sugarcane Technology Center (CTC)
The Sugarcane Technology Center (CTC), located in Piracicaba, is a private institution the objectives of which include researching and developing new technologies for application in agricultural activities, logistics, and industry, as well as creating new varietals of sugarcane. The original center worked on producing varietals, as well as biological ways of controlling pests, and biodegradable plastic (PHB), and creating a VVHP-type sugar that requires less energy to be processed, and co-generation technology to create electricity from sugarcane waste. Today, using modern equipment, the center can track and monitor varietals to help predict harvest time, manage pests, and diagnose and control disease and bacteria. It has also developed a high-tech mechanism for extraction, the Hydrodynamic Extraction System, and a dry cleaning process which, when coupled with mechanical collection, cuts down on impurities and improves efficiency both in the milling process and for energy generation. CTC works with yeast DNA to analyze the potential for increased ethanol production efficiency and added value. It is also developing solutions for the transport of sugarcane for its 123 cooperative members, including 32 from Copersucar. Since the center separated from Copersucar it has reportedly struggled to maintain its funding and it remains to be seen whether CTC can sustain its position as a leader in the R&D field.

Financing
CTC, financed completely by cooperative members, has an annual budget of roughly $13.4 million (R $30 million) to concentrate on developing new sugarcane and ethanol production solutions. It also has $10 million in resources from the international Global Environment Facility (GEF).[80] In August 2005, it was determined that fixed contributions from association members would include $6.09 (R $13.17) per hectare of land and a minimum contribution of $4,627 (R $10,000) annually per associate member. Additional contributions include 2.7 cents (R$ 0.058) per ton of milled cane per factory, 3.4 cents (R$ 0.0737) per ton for delivered cane for supplier associations, and a one-time fee of 50% of estimated annual contribution. There is also an entry fee for any sugarcane processor wishing to join the sugarcane association and receive the benefits of R&D from CTC.[81]

CTC helps not only to oversee R&D projects but also finances them. One such project was the sugarcane genome mapping project, initiated in 1988 as a partnership between Copersucar and FAPESP, an $8 million project which was also supported by CTC.[82]

Cosan
Located in Piracicaba, Cosan is one of the largest producers of sugarcane and one of the largest sellers of sugar and ethanol in the world. In fiscal year 2006, it produced more than 1 billion liters of ethanol. Cosan has fashioned itself into a major player in the sugarcane industry. After a series of mergers and acquisitions and an IPO, the firm has signed a technology deal with Canavialis. The collaboration is intended to improve the genetic structure of sugarcane with the potential of enhancing the productivity of Cosan's units. Canavialis will install an experimental plantation within one of Cosan's units, and they will test diverse varietals.[83]

UNICA
Unica is also a major institutional player for sugar, ethanol and related derivatives production. It was created in 1997, incorporating the Association of Sugar and Ethanol Industries of the State of São Paulo (AIAA), previously created by producers, to help spread the production and use of ethanol and to strengthen the dialogue between government and society. Unica's network of more than 100 associates, mostly from the state of São Paulo, makes up more than 60% of Brazil's production, and the union has plans to add 70 additional units to its roster over the next 4 years, increasing its representation of sugarcane production by more than 200 million tons. The union also acts as a national reference center, maintaining data on the scientific and industrial progress of the sugarcane, sugar, and ethanol industries. It lobbies for more open sugar and ethanol markets abroad and the increased use of biomass in Brazil's energy matrix.

Similar to São Paulo's union, each state has its own syndicate team which represents producers at the institutional level. Additionally, the Union of Bioenergy Producers (UDOP), representing the producers from Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná and São Paulo is another group which works in political representation and capacity building for producers.

D-2.2) Biodiesel

The major biodiesel producers in Brazil are not yet as large as the ethanol producers, but their capacity is growing. Cooperation between these companies and universities appears to be developing.

Agropalma
The Agropalma Group, with production facilities concentrated in the Amazon region, is the largest producer of palm oil in Brazil and sells most of its production to Petrobras. It recently opened a plant in Belém in the state of Pará to produce biodiesel from palm oil refining residues, a process developed in conjunction with UFRJ. 95% of the oily acids extracted from palm oil in the refining process can be used to make a cheaper, glycerin-free biodiesel. The plant should have a production capacity of nearly 8 million liters per year, 3 million of which will be used to substitute for diesel used by the company's vehicle fleet.[84]

Biobras

The Biobras Group has four plants in different states with a total capacity of 65 million liters. According to the group's VP, José Luiz Cerboni de Toledo, the plants await the National Petroleum Agency's authorization to begin production of biodiesel. Another 4 plants were under construction and were to be ready by the end of 2005.[85] To guarantee production, the group has been involved with planting smallholdings in Mato Grosso for the past 3 years, under the supervision of the Ministry of Agrarian Development. The seeds are provided to farmers, and the purchase of plant production is guaranteed at a minimum price. The group has also signed a technical cooperation agreement with the University of Uberaba to improve seed quality and identify more optimal regions in which to plant, both aimed at increasing the sector's productivity. Soyminas is also a member of the group.[86]

Brasil Ecodiesel

Brasil Ecodiesel employs a socially inclusive, cooperative-style cultivation model for the provision of feedstock for biodiesel production. It is involved in one project with the State of Piauí and Tecbio to produce biodiesel. In 2004, the project planted 58,000 hectares of castor beans using a production system belonging to Tecbio.[87] The first harvest took place in 2005, as did the inauguration of a processing plant with an annual capacity of 27,000 tons of biodiesel, capable of processing any type of vegetable oil.[88] It is also involved in project to study castor beans and set up a production plant in Bahia with Petrobras and the French energy firm Dagris (see Biodiesel Funding for more information).

Monsanto

Monsanto, a global company offering products and solutions for agricultural producers, invested roughly $500 million worldwide and $7.5 million in Brazil for research and development in 2003.[89] A subsidiary, Monsoy, commercialized and produced genetically enhanced soy under its RoundUp Ready Technology brand, for which it will receive $100 million per year for the intellectual rights to the RoundUp Ready brand.[90] The company also conducts R&D to increase both the crop and oil yields of soy, other seed crops, and corn.

Additional Companies

Ecomat, or Mato Grosso Ecological Industry and Trade, is a production company with a plant boasting a capacity of 14.6 million liters of soy-based diesel.[91] Hidroveg Indústrias Químicas (HIQ), supported by UFRJ, produces biofuels from vegetable oils and animal fats with partners UFRJ, FINEP, Petrobras, McDonalds, and the city of Rio de Janeiro. Under the Rio Biodiesel Plan, the state anticipates a requirement of 8 million liters of biodiesel a month. The state of Rio de Janeiro already has access to 6-million-liters worth of capacity through HIQ.

Biodiesel Funding

In additional to the Financial Support Program for Biodiesel Investments, funded by BNDES, FINEP announced in July 2006 a $2.8 million fund to support the production of biodiesel. This initiative also includes incentives for universities and Brazilian businesses to collaborate on R&D projects aimed at increasing the competitiveness of the industry.[92] Additionally, the Ministry of Agrarian Development allocated $24.8 million to the cultivation of 150,000 hectares of castor beans, enough to supply 10% of estimated 2008 demand.[93]

Roberto Fortuna Carneiro, head of technological and business development at the Science, Technology and Innovation Secretariat of Bahia, said that by 2006 five biodiesel plants would be opened in the state with a capacity of more than 380 million liters per year, most from cottonseed. Furthermore, the Secretariat plans to invest $8.2 million to support research on the feasibility of biodiesel.[94]

The State of Bahia implemented an incentive program to promote biodiesel production in 2003, which has attracted approximately $103 million in total private investment. This program was the impetus for an investment made by Petrobras, Dagris, and Brasil Ecodiesel to form a venture for the study and production of biodiesel in Bahia state.

D-3) Technology/ Equipment Producers

D-3.1) Production Equipment

Several firms engage in the development of technology and equipment, and they often collaborate with other firms to develop new processes of production.

Tecbio

Bioenergetic Tecnologies Ltd (Tecbio) supplies full industrial plants and smaller plants for remote areas. Based in Fortaleza, it also has a biofuels production project in conjunction with the state of Piauí and Brasil Ecodiesel for the production of biodiesel from any type of vegetable oil, employing ethanol or methane as a processing agent. In late August 2006, Tecbio joined forces with NASA and US aerospace firm Boeing to produce biokerosene for aviation use, a process it began testing more than 25 years ago.[95]

Dedini Indústrias de Base

Dedini is a global leader in turn-key manufacturing of sugar mills and ethanol and biodiesel production plants. It builds cogeneration and steam equipment, as well as other integrated systems. It has installed more than 800 fuel ethanol plants in Brazil (accounting for 80% of Brazilian ethanol production) and 17 overseas. It also had 10 new fuel ethanol plants in operation by 2004, producing over 4 million liters per day. Dedini has developed the "Continuous Production Process by Dedini Ethylic Route", which is described as being well-suited to the Brazilian National Biodiesel Program because of its lower cost and energy-consumption efficiency. It has also developed the Rapid Hydrolysis Process (RHP) in conjunction with Copersucar. In conjunction with the Italian firm Ballestra S.P.A., Dedini has produced exclusive technology for biodiesel plants producing 10 – 100 thousand tons annually. There is also a plan under negotiation between the governments of Brazil and the UK to establish a biofuels program in Africa, including the construction of a sugar and ethanol plant in South Africa to be supplied with technology from Cosan and equipment from Dedini.[96]

In 2003, Dedini opened a process demonstration unit capable of turning bagasse into ethanol. After decades of research and development, in collaboration with Copersucar and with funding from FAPESP, researchers at Dedini and CTC were able to develop a hydrolysis process to convert the cellulose in bagasse to ethanol. With its discovery, the company projected that it would be able to increase the production of ethanol in Brazil by 30%, adding an additional 5.4 billion liters to the country's output. The advantage of this new technology, named Dedini Rapid Hydrolysis (DHR), is its speed and simplicity. Traditionally, processes required the use of acids and took 5 hours to complete; the DHR process requires less than 10 minutes and the use of an organic hydrosolvent (ethanol, for example) and sulfuric acid. According to the company, an industrial plant with capacity of 60,000 liters a day[97] is to be completed by the latter half of 2007.

Financing

Dedini also has its own R&D unit, which has been commissioned by Granol to design and construct the first biodiesel plant to be integrated into a sugar and ethanol plant.[98] In July 2006, Dedini announced the launch of a new business, Dedini Automation Processes, and an inaugural joint venture with a German software development firm, Proleit, to automate industrial processes and equipment used for ethanol production. Financing information for the project has not yet been released.[99]

D-3.2) Auto Manufacturers

A number of automotive producers, including parts and systems suppliers, are involved in the biofuels market by performing tests and research on biofuels use in vehicles. These include montadoras, or car assemblers, most of which are foreign companies (GM, Ford, Volkswagen, etc.) with Brazilian subsidiaries. Bosch, a German automotive group that produces gasoline systems for flex-fuel cars, and Delphi, described below, have been singled out by industry leaders as potential participants in public-private partnerships and joint research efforts.

Magneti Marelli
Magneti Marelli, an Italian automotive company specializing in the production of components and system solutions, supplies many of the world's major auto producers. With the assistance of Brazilian engineers, the company launched the Software Flexfuel Sensor (SFS) technology, which allows people to drive on any blend of ethanol or gas. Developing the SFS technology required four years and $3 million. The company is the leader in the flex-vehicle market with a 58% share of Brazil's domestic market, and holds the top spot in Brazil for electronic injection systems with a 40% market share.[100]

Delphi
A US company and world leader in automotive solutions and systems technology, Delphi's South American regional headquarters is in São Paolo. The company's Brazilian products include fuel and diesel systems and engine management systems. Delphi's technical centers in Brazil focus on research for engine management systems, including ethanol use in vehicles.

There is ample private-sector activity aimed at biofuels development. Yet there is a distinct lack of public-private partnerships, particularly with Brazilian public universities. Nevertheless, the private sector plays a significant role in conducting R&D for ethanol and biodiesel development, and will likely continue to do so as the sector moves forward.

E) International Funding

International bodies, and particularly subsidiaries of foreign firms, have been active in the Brazilian biofuels sector. The two major investors that have dedicated financing to Brazilian bioenergy R&D are Japan and France, discussed in previous sections. Other international investors with proven interest in Brazilian bioenergy R&D include Belgium, which is teaming with Dedini, Germany, England, and Peru, whose sugar and ethanol company, Empresa Agraria Azucarera Andahuasi, is to invest $5 million in new Brazilian bioethanol production technology.[101]

With regard to multilateral organizations, the Inter-American Development Bank has invested more than $35 million in various broad-based projects including the following: AGROFUTURO, the Clean Tech Fund, Agricultural Biotechnology in Latin America and the Caribbean (LAC), Renewable Energy, Energy Efficiency, Carbon Finance in LAC, Renewable Energy and Energy Efficiency in LAC. However, no fund has been specifically designated for either R&D or education and human capacity strengthening in Brazil's ethanol or biodiesel sectors. Meanwhile, the World Bank and UN Development Program have funds that invest in the development of cogeneration, but again, none specific to ethanol or biodiesel development.

Continued foreign investment in the Brazilian biofuels sector will provide added support to initiatives aimed at the sector's expansion, and will likely be instrumental in ramping up the R&D and production capacities of the ethanol and biodiesel industries. In addition to financing, increased participation between private, foreign firms would add value to the industry's R&D activities, as would collaboration between Brazilian and foreign universities and research institutions.

F) Conclusions

F-1) Funding and Financing

One of the main challenges of the Brazilian R&D sector is overall funding. Brazil must increase its spending on R&D to compete with some of the more developed countries interested in developing their own ethanol capabilities and breakthrough technology. To do this, the public sector will need to promote greater efficiency in, and coordination of, fund dispersal and the private sector will need to contribute more in terms of supporting complementary public and academic sector initiatives in biofuels promotion and development.

One of the main challenges of the Brazilian R&D sector is overall funding. Brazil must increase its spending on R&D to compete with some of the more developed countries interested in developing their own ethanol capabilities and breakthrough technology. To do this, the public sector will need to promote greater efficiency in, and coordination of, fund dispersal and the private sector will need to contribute more in terms of supporting complementary public and academic sector initiatives in biofuels promotion and development.

Public Sector
Addressing the bureaucracy surrounding R&D funding will be a significant challenge. There is also some question regarding contingency versus non-contingency funds where monies are, at times, too openly allocated; there is a need to be more specific in identifying the targeted ends of the dispersed amount. Additionally, the sectoral fund mechanism only partially covers investment in R&D for the biofuels industry. Recommendations for addressing this issue include more focused allocation of funds from existing sectoral funds, and potentially the creation of a bioenergy fund along the lines of the other cross-sectoral funds. The development of greater linkages between the R&D sector and regulating mechanisms has also been suggested to facilitate easier utilization of the sectoral funds.

Private Sector
The private sector has contributed 70-80% of the funding that has gone into biofuels R&D, but needs to engage in more collaborative research activities; enterprises must be more involved in the dialogue regarding R&D focus areas for a given industry, and in investing in education and skills training for the future benefit of their respective business sectors. This ties in to the concern that there is not enough investment in human capacity building, including the development of a larger pool of strong, academic researchers and scientists with advanced degrees.

F-2) Competitiveness

If the needed breakthrough in biofuels production is to be a universal one, Brazil will need to organize, consolidate and modernize its R&D and education systems. Countries such as the US and China, as well as the EU and others, are all interested in developing their own indigenous capabilities and are putting forth large investments and making deals to that end. Brazil cannot rest on its laurels, lest the country risk losing its position as a front-runner in biofuels innovation and technology.

Sector Orientation[102]
The current orientation of the biofuels sector is towards the food and agricultural industries; however, there is a school of thought that believes that the sector will need to be refocused on the energy sector to truly develop into a high-volume, high-profit industry. Incorporating oil companies into the discussion on planning for expansion of the biofuels sector would have a dramatic effect on the scope and direction of the field's growth, and is one option which is under discussion.

Scholars at UNICAMP, for example, have indicated that this re-orientation has begun to take place in small steps, through the restructuring of the Ministry of Agriculture and the creation of an agroenergy unit, for example; however, some advocate that this be taken a step further, involving the major oil companies in fundamental discussions about which direction the industry should head. In this scenario, the problems of the biofuels sector would be re-defined in terms of how biofuels could provide a base for transport fuel consumption on a global scale. In thinking about the breakthroughs needed to push the bioenergy sector forward, this camp believes that if the sector remains rooted in the food industry, the breakthroughs would likely be feedstock-specific; however, if they are realigned with the energy industry, breakthroughs could be more universal.

There is also the belief that a great deal of funding will be necessary to achieve the technological breakthroughs necessary to keep Brazil at the forefront, breakthroughs which should be based on the oil industry's needs and which can be funded only through the deep pockets of the oil majors. Some examples that illustrate the spending power of large oil companies are investments by US petroleum companies ExxonMobil and Chevron of $100 million and $37 million respectively for US university-based research on alternative transport fuels and greenhouse-gas emission reductions. The UK's BP is also investing $725 million for alternative fuels research in conjunction with both US and British universities (see the next section, *Education and Labor*).

Coordination

A great number of biofuels projects and programs are underway in Brazil. Various funds and agencies are in place to support the development of the sector and of new industrial technology; all of these moving parts need greater coordination and synthesis to increase their impact. There is always a need for additional financing for projects, but the funds available should also reach the agribusiness and research communities in the quickest, most efficient and effective way possible. Coordination of funding activities, away from the heavy bureaucracy of government, could help to ease any bottlenecks in funding supply. For better coordination within the government, public-sector insiders have suggested the creation an inter-ministerial committee to organize all of the federal activities of the various ministries acting in the biofuels space, along with their funds and promotion agencies.

The disconnect between Brazil's business and research sectors, and the lack of a coordinated and cohesive national strategy, are significant obstacles in the country's quest to remain the foremost authority in biofuels technology and expertise. As outlined in the beginning of this chapter, if Brazil were to fall into the trap posed by the boom in ethanol, it would repeat the old pattern of major emerging-market nations becoming commodity producers and exporters rather than creating the kind of high value-added economies that produce better jobs and sustainable investment flows, and which leave the country less vulnerable to inevitable commodity-market price fluctuations. While Brazil has been a scientific and technological innovator in the past, and is today by far the most efficient producer of sugar cane and ethanol in the world, the enormous flows of capital that are likely to be directed into these areas worldwide suggest that an even more intensive focus on innovation drivers and related coordination is required now.

F-3) A Center of Excellence

A Brazilian Biofuels Research Center would create a major focus point and symbol for the development and growth of a more unified, coordinated and innovation-driven biofuels sector. This type of center is in line with the current global trend of large-scale collaboration for biofuels R&D:

- The US Department of Energy has earmarked $250 million over five years for the creation of two Bioenergy Research Centers by 2009,[103] based in US universities, with a focus on achieving the goals of the nation's Energy Policy Act of 2005.
- BP is in talks with universities in the US and the UK to create the BP Energy Biosciences Institute, with an investment of $500 million, by the end of 2007.[104]
- The Energy Technologies Institute of the UK, dedicated to accelerating the development of low-carbon energy technologies, is expected to begin operating in 2008; in addition to initial funding for the institute, the Department of Trade and Industry is to provide $95 million (£50 million) each year over a period of 10 years starting in 2008-09.
- A separate Energy Research Partnership in the UK will raise a total of $1.89 billion (£1 billion) over the next ten years, including matching funding from the private sector; as of September 2006, EDF Energy, Shell, BP and E.ON UK have committed to providing funds.[105]

If Brazil does not catch up with this global movement, it could fall behind, a reality that Embrapa has already recognized by proposing the creation of its own central coordinating unit for R&D related to biofuels, with greater private participation and a less bureaucratic mechanism for funding projects and initiatives. A Brazilian Biofuels Research Center would create a major focus point and symbol for the development and growth of a more unified, coordinated, and innovation-driven biofuels sector.

Funding for this emblematic center could include:

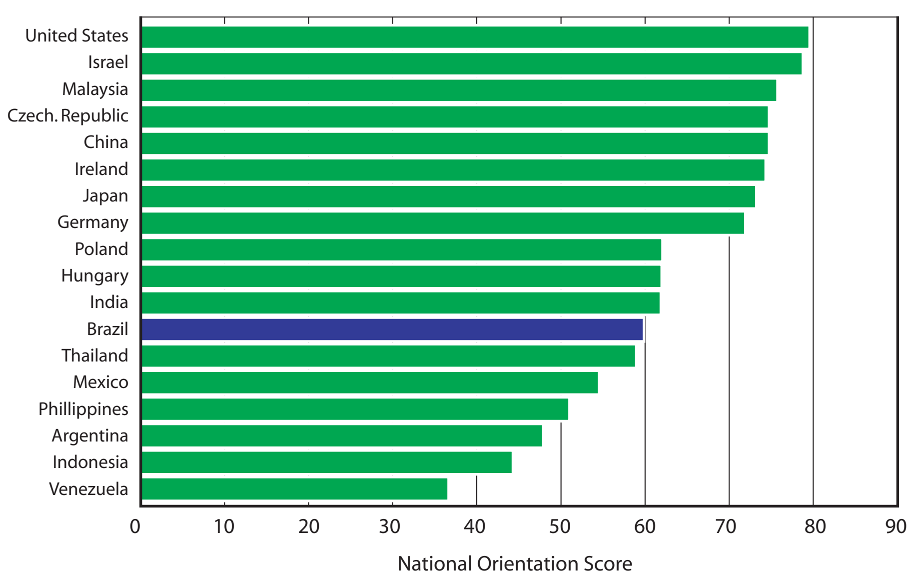
- A Global Renewable Resources Institute as a platform from which Brazilian know-how would be exported to other developing countries through various means, including academia, policy expertise and private sector investment;
- A Biofuels Human Capital Fund to support scholarships at international universities and attract global academic luminaries to work in Brazil; and
- A competitive fund to distribute grants for research and development in the private and public sectors, promoting firm-university collaboration in biofuels;
- A facility to finance new ventures by technology-based firms in biofuels, possibly including an incubator;
- A fund to support the development of new feedstock varietals and production processes, including second-generation technology, to facilitate capacity expansion;
- A policy-based loan to support regulations already in place to promote greater private participation in R&D, including tax incentives for equipment purchased for use in biofuel R&D by firms and universities, economic subsidies, and government procurement of technology generated through R&D activities.

There are already instances of Brazilian universities such as UFRJ incubating new companies, and research institutes like CTC are acknowledged worldwide for expertise in the sector and for attracting foreign investors. Embrapa has conceptualized its own fund, which would have contributions from both the public and private sector, and which would become self-sustainable once the technologies developed were commercialized. The Brazilian Law of Innovation also promotes policy which invigorates innovation through incentives. The individual points of this outline are already in existence in Brazil. What this center would offer is a central coordinating unit to streamline and maximize industry activities, as well as provide a ramp up in funding, to achieve the collectively desired outcome of sustainable, value-added growth of the Brazilian biofuels sector.

Annex: Global Comparisons

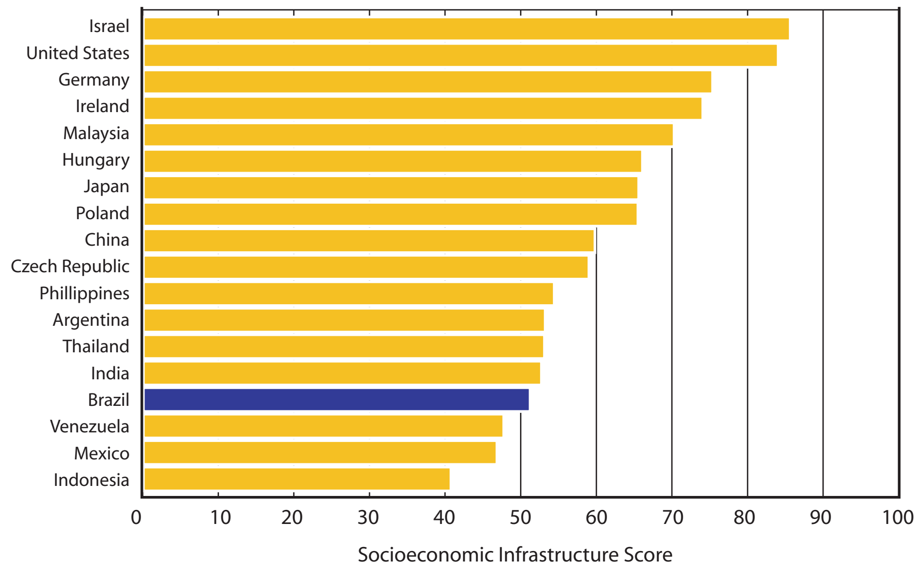
The National Science Board of the United States has produced a series of indicators to rate the technological competitiveness of 15 countries across different regions with respect to technology exports. While consistently ranking above Mexico and Argentina, Brazil also consistently ranks below fellow BRIC countries, India and China, as well as other OECD countries. The following charts suggest that greater coordination and promotion of innovation and technological advancement are needed in Brazil. The four ratings are:[106]

Chart 2a: National Orientation



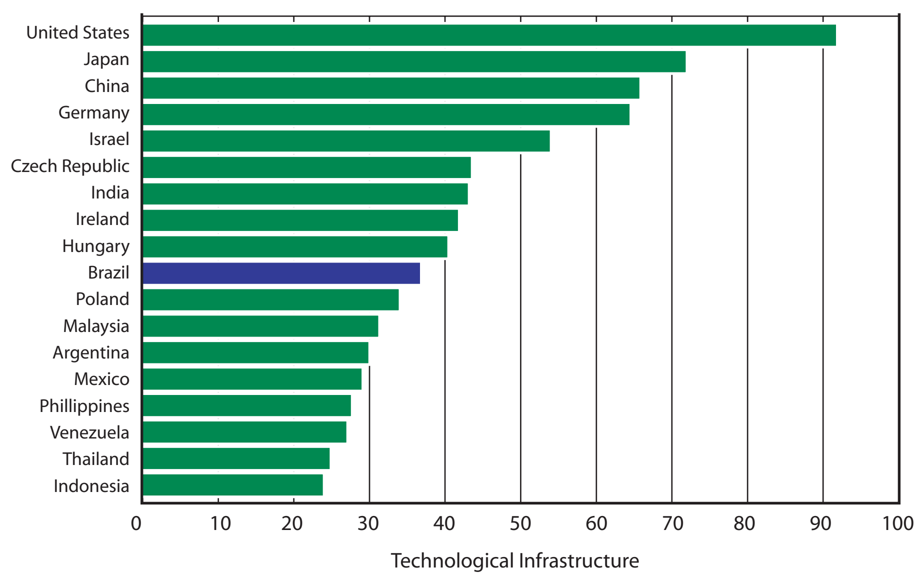
National Orientation measures the extent to which governments, businesses, and the culture at large support and promote high-tech development. Ratings include expert opinions on national strategies aimed at promoting high-tech development, entrepreneurial spirit, and social weight attached to technological change.

Chart 2b: Socioeconomic Infrastructure



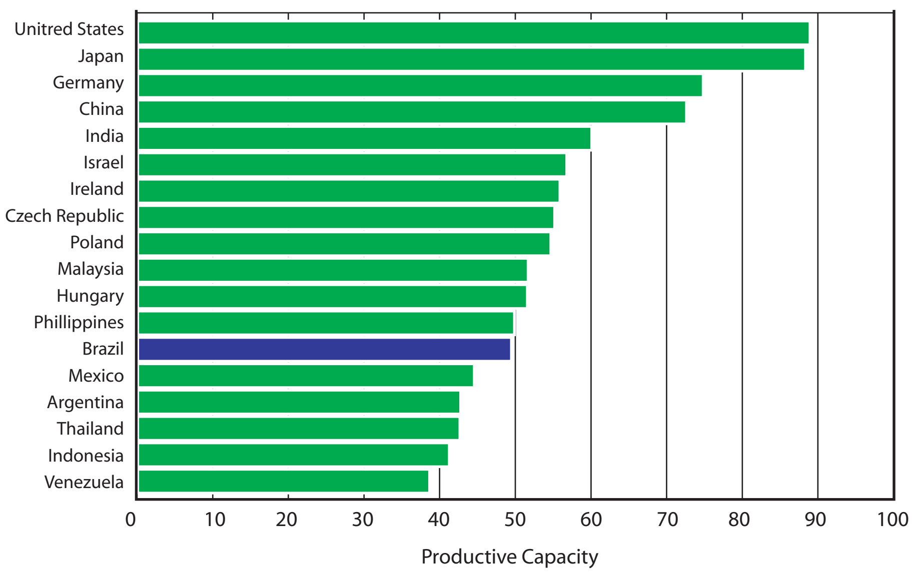
Socioeconomic Infrastructure measures the underlying financial and human resources, as well as physical infrastructure, needed to support a technology-based nation. The ratings are based on percentages of the population in secondary and tertiary education; capital mobility; and the encouragement of foreign investment and business activity.

Chart 2c: Technological Infrastructure



Technological Infrastructure measures the institutions and resources necessary for the development, production, and commercialization of new technology. The rating is based on the number of scientists active in R&D; national purchases of electronic data-processing equipment; and expert ratings of domestic capacity to train in the Science and Engineering fields, to effectively use technical knowledge, and to link R&D to industry.

Chart 2d: Productive Capacity



Productive Capacity measures the strength of a nation's manufacturing infrastructure, using that data as a benchmark for evaluating that country's capacity for future growth in the high-tech sector. The rating considers the availability of skilled labor; the number of domestic high-tech companies; the level of management ability; and the current electronics production of a given country.

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2.2 Education and Labor

A) Introduction

Education is the cornerstone of any productive society. In the developed world, education and the strength of human resources drive innovation, prosperity, and continued growth. This too should be the case with the developing world to help emerging nations break the cycle of poverty and achieve sustainable growth. Brazil's biofuels sector presents an additional vehicle for the nation to address the issues of poverty and inequality and promote civil and financial stability. It also provides the opportunity to avoid the trap of commodity exportation with minimal value added to the economy or society. If R&D is to be the path down which Brazil travels to secure its position of dominance in the biofuels sector, education will provide the necessary stepping stones.

This section of the report will examine:

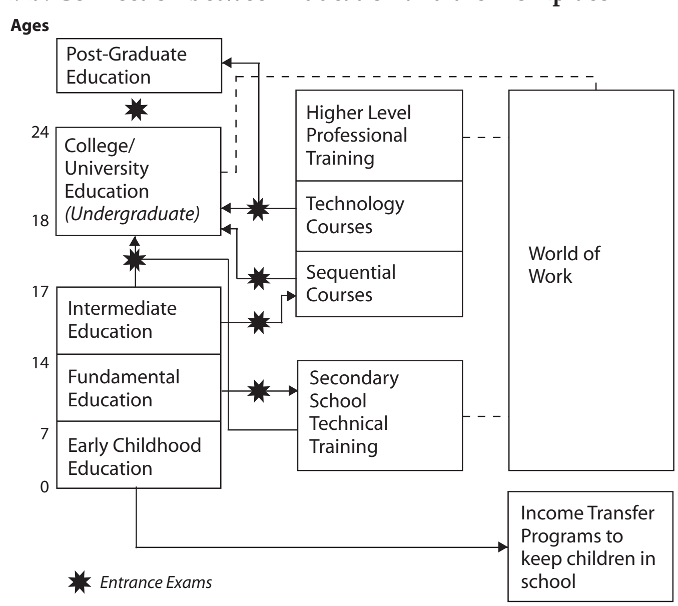
- Linkages between education and the labor force;
- The current make-up of the biofuels labor sector and the labor requirements of the biofuels sector including any gaps which need to be filled;
- The structure of Brazil's education system and weaknesses in its coverage; and
- International comparisons as a frame of reference.

As the biofuels sector expands, there will be a general need for additional labor, including skilled labor to meet the specific R&D and technical needs of the industry. Augmenting the country's output of scientists, researchers and engineers, particularly those with post-graduate education and specific training in biofuels issues, will be essential. As important is addressing the gaps in Brazil's basic education system in order to improve rural agroindustry and augment the number and diversity of students reaching the technical training and university levels.

B) Linkages between Education and the Labor Force

Examining the structure of the Brazilian education system is important in analyzing the obstacles facing the biofuels sector as its labor needs grow.

Diagram 2.2a: Connection between Education and the Workplace



Source: Consultores[1]

Prepared by Garten Rothkopf

There are a number of government proposals and programs in place to address systemic needs, but they must be placed in the context of the system as a whole as well as that system's linkages to the labor force. [Diagram 2.2a]

B-1) Structure of the Labor Market

The industry and service sectors dominate the Brazilian economy. In 2003-2004, services contributed 50% to Brazil's GDP and accounted for 66% of the labor force. Industry contributed 40% of GDP and 14% of employment. The agricultural sector employed 20% of the labor force but only accounted for 10.4% of GDP. [Table 2.2a]. Between 1994 and 2004, Brazil's labor force grew by 1.5%,[2] and in 2004, the country's unemployment rate was 9%.[3]

Table 2.2a: Structure of the Brazilian Economy (2004)

	% of GDP *(2004)*	**Ave. Annual Growth %** *(2004)*	**Employment Breakdown %** *(2003)**
Agriculture	10.4	5.3	20
Industry	40.0	6.2	14
Services	49.6	-5.5	66

Source: World Bank; * World Factbook [4]

As the agricultural sector employs the second largest percentage of workers, but yields only 10% of GDP, value added to the agrarian sector through biofuels production will play an important role in the country's socio-economic development.

B-2) Biofuels Labor Requirements

The types of jobs required by the biofuels sector vary, although they do not differ a great deal between the ethanol and biodiesel markets. Some basic education is required for every area, and there are ascending educational requirements for the more demanding and innovative job posts.

The biofuels industry requires four main categories of workers: 1) scientists and researchers; 2) managers; 3) laboratory technicians and support staff; and 4) biofuel cultivators and producers. The first two categories require the highest levels of educational qualification and expert knowledge, usually provided by universities and advanced centers of learning. Centers of research require well-trained support staff and laboratory technicians who have completed basic education as well as received specialized scientific training. There is more variation in the educational requirements for cultivators and producers, but there is a positive correlation between level of education and the productivity of small farmers.[5]

Agriculture

Sugarcane cultivation and ethanol production have a long history in Brazil. Processes are well developed and in some cases very advanced. For example, there are mechanized harvesting and cleaning techniques for cane. The requirements for this type of work include farmers with basic skills as well as personnel capable of operating the machinery and managing quality control. A practical knowledge of farming is needed as well as some training in agribusiness or exposure to mechanical technology.

Due to government initiatives to promote social inclusion through the Social Fuel Seal program, the biodiesel segment is more reliant on family cooperatives and thus requires labor with more basic educational attainment to grow and harvest smaller plots of castor bean, palm, soy and other feedstocks. Because biodiesel production is concentrated in the northeast, where educational attendance and attainment is lower, basic education and the development of basic functional skills are important barriers to biodiesel production.

Industrial Processing
For the processing and refinement of materials for biofuels production, the differences between the ethanol and biodiesel segments are minute. According to industry experts, a typical processing plant would need no more than twelve employees in three categories: operators, lab scientists, and supervisors. A plant operator would be required to operate heavy machinery and computerized systems and would most likely need technical training, though not a university degree. Lab scientists run daily tests to guarantee the quality of the fuel produced and would normally have at minimum a degree in chemical engineering. A plant supervisor would also need at least a chemical engineering degree to oversee the operation from the moment the crop arrives to when it leaves as fuel.[6]

Research & Development[7]
The innovation pillar of this report has placed a strong emphasis on the need for continued research and development within the biofuels sector. To accomplish this, the industry will require researchers and research assistants, as well as laboratory technicians, to monitor quality control and processes within research institutions. The types of technology used for second-generation cellulosic production of ethanol and biodiesel differ from those used to produce traditional ethanol and biodiesel, which are also different from each other. In addition to standard degrees in biochemistry, researchers need training in different scientific specializations:

- Traditional ethanol is produced through fermentation often utilizing yeast as a catalyst; this type of work would normally require a PhD in microbiology, biochemistry, or biochemical engineering.
- Traditional biodiesel production calls for the introduction of an acid or a base as a catalyst; a researcher in this field would likely have a PhD in biochemistry or biochemical engineering as well as organic chemistry.
- Cellulose production of either biodiesel or ethanol is moving away from acidic conversion, due to high costs, towards enzymatic processing of cellulose materials; a PhD biochemist or biochemical engineer would likely execute the introduction of enzymes to induce the conversion process. A microbiologist would support this process by identifying enzymes. A biochemical specialist in "proteomics", analogous to genomics but focused on the study of proteins, would look at the structure of an enzyme to see how it might be improved. A bioinformatics professional complements their work by using computer technology to build models and optimize the enzymatic process.
- PhD molecular biologists and geneticists would study plant structure through DNA and genomic analysis in an effort to improve feedstock. An advanced biotechnology degree would also be relevant to R&D work in the biofuels sector in terms of developing processes of fermentation or catalytic conversion.

Within the hierarchy of a research facility, researchers and research assistants would likely have advanced PhD degrees within their area of specialty. Production technicians, who oversee quality control and who might also liaise with feedstock producers, would likely also have some superior training in engineering or microbiology, although advanced technical training might suffice. Personnel who have training or a degree in computer technology or informatics would also be an asset in this role, as many R&D processes are now computerized.

Flex-fuel Technology
Much of the automotive industry is now computerized; as with research labs, there is a need for employees who are comfortable working with computers and who have some training in informatics.[8] A portion of the Flex fuel segment continues to conduct R&D to improve the technology. Degrees in chemistry or chemical engineering would be important in monitoring fuel mixtures and their effect on engine systems, and an engineering background would be essential for those monitoring engine function.

Global Strategy
Outside of these core vocations, there is a need for professionals with expertise in other fields. Professionals with a solid understanding of agribusiness management will be

important. Persons with more specific energy specialties might participate in co-generation projects. Depending on how the sector develops and what linkages are created to industry, professionals with a knowledge base in oil & gas markets would likely be useful. As the biofuels sector becomes more global, there may be a need for expertise in political and economic risk as well as geo-strategic analysis with respect to global energy markets, although individuals with this expertise are already prominent in Brazil's education and private sectors.

B-3) Biofuels-related Labor Market Indicators

Scientists
Brazil's science and technology sector is robust; according to Brazil's Ministry of Science & Technology (MCT), in 2004, 1.5% of the Brazilian population (roughly 2.76 million people) had a science or technology occupation.[9] There were 77,649 researchers and 47,973 doctoral researchers in Brazil, who, combined, made up 4.5% of total laborers with science and technology jobs.[10] There were also 335 research institutions and 19,470 research groups.

In the technology sector, more than two-thirds of professionals have advanced degrees; however, nearly 3 times the number of managers and 6.5 times the number of technicians are without superior education training [Table 2.2b].

Table 2.2b: Breakdown of Labor Force with Technical Jobs (2004)

	Total	w/o Superior Education	with Superior Education
Total	15,002	9,809	5,193
Managers	3,165	2,351	815
Professionals	5,089	1,608	3,481
Technicians	6,748	5,851	898

Source: MCT[11]

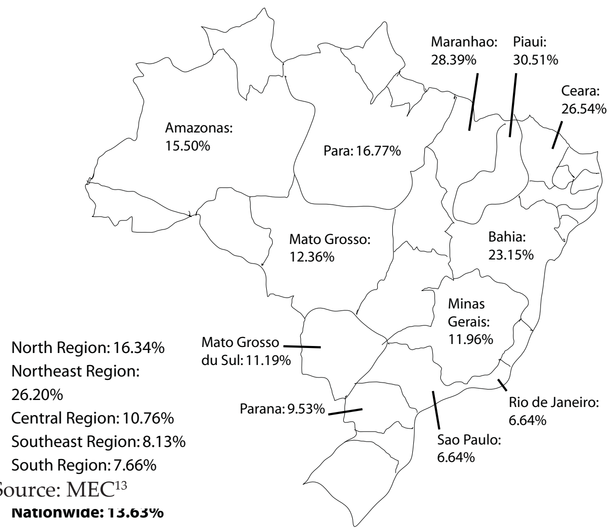
Whether or not this is significant for the expansion of the biofuels sector is debatable. These numbers include all technology jobs, not solely the biofuels sector (no breakdown is currently available). Second, there is no evidence to suggest that workers without advanced degrees are less productive than those with advanced degrees, particularly at the technician level. The sector has been quite successful with its current structure, yet augmenting the numbers of workers with superior educational attainment would very likely increase its potential for achievement and growth. However, increasing the education level of employees would likely increase salaries and thus operating costs, and perhaps hurt the industry's competitiveness. Further study should address whether the sector would benefit from more advanced-degree holders in existing positions. It is clear that as the sector expands and new positions are created, more technically-oriented personnel will be required to fill those vacancies.

The ethanol sector can help illustrate projected future labor needs in the industry. There are 340 ethanol refineries in Brazil employing a total of 4080.[12] According to Unica, 89 new ethanol plants will come on line over the next four years, which will require an estimated 1,068 new workers, an increase of 26%. Considering the many other industries that require trained biochemists, agricultural specialists and the like, it is apparent that the skilled labor pool must expand.

Agricultural Growers
The following section of this report will look at the structure of the Brazilian education system nationally. One of the issues that will be highlighted is the disparity between rural and urban, as well as regional, educational access and achievement. To contribute in agroindustrial endeavors such as biofuels, agricultural growers must possess basic education. Industry producers have identified the need for improved basic education in the more rural and underprivileged areas where biodiesel feedstock is being produced. Companies participating in the Social Fuel Seal Program, which

aims to involve family agricultural producers, face literacy and functionality issues when working with local farmers lacking basic education. Map 2.2a. highlights the disparities in illiteracy rates between the north and northeast, the main target areas of the Social Fuel Seal program, and the other regions of the country. This impediment reduces efficiency and increases operating costs in these regions, increasing the burden on companies investing in production.

Map 2.2a: Illiteracy in Brazil by Region/ State (Based on 2000 Census)



Source: MEC[13]

Source: MEC

C) Education in Brazil

C-1) Structure of Educational System

The education system in Brazil is divided into basic and higher education, with four main categories: early childhood education, primary education, secondary education, and higher education. [Table 2.2c].

Table 2.2c: Structure of the Brazilian Educational System

General Title	Specific Title	Nomenclature/ International Education Classification	Duration/ Grades	Cohort/ Ideal Age	Authority
Basic Education	Early Childhood Education	Nursery School	4 years	0-3	Municipalities & Federal District
		Pre-School	3 years	4-6	
	Primary Education (Compulsory)	Primary Education	1st Grade	7	Municipalities, States & Federal District
			2nd Grade	8	
			3rd Grade	9	
			4th Grade	10	
		Lower Secondary School	5th Grade	11	
			6th Grade	12	
			7th Grade	13	
			8th Grade	14	
	Secondary Education	Upper Secondary Education	1st Grade (or 9th Grade)	15	States & Federal District
			2nd Grade (or 10th Grade)	16	
			3rdt Grade (or 11th Grade)	17	
Higher Education	Undergraduate	1st and 2nd cycles	Variable	18-24	Federal Government
	Post-Graduate Master's Doctorate	3rd cycle	Variable	Variable	

Source: MEC, 2004

The system also includes technical and vocational schools at the secondary and higher education levels, not shown in the diagram above.

In theory, the entire public education system is free and mandatory. In practice, large numbers of poor children are unable to complete even the first four years of primary education because of the hidden costs of attending school, including school uniforms, textbooks, and transportation as well as opportunity costs.

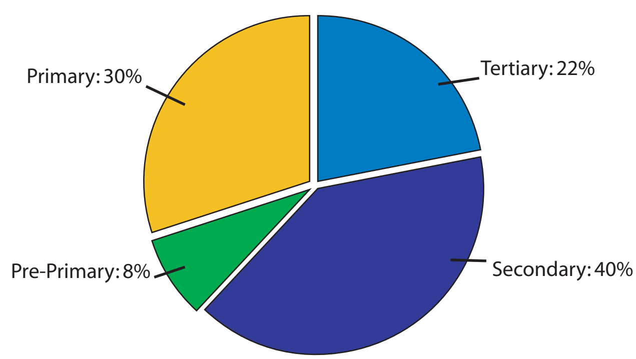
The Federal government is responsible for post-secondary education (universities), municipalities for primary (or fundamental) education, and state governments for secondary education. The education system is highly centralized because resources are distributed through federal agencies. There is little flexibility in terms of administration and curriculum generally, and schools in poor municipalities in particular have very little autonomy.

C-2) Government Education Policy & Funding

In 2002, investment in education was 4.4% of GDP[14] and 10.9% of total government spending.[15] In 2003, total public spending on education was roughly $25.2 billion.[16] The Ministry of Education (MEC) oversees the financing and management of the Brazilian educational system with the support of the National Education Council (CNE) and the National Commission for the Advancement of Superior Education (CONAES). Neither total spending nor the nature of its distribution between the different levels of education (primary, secondary and higher) and different administrative levels (municipal, state, and federal) is sufficient to address the structural problems embedded in the system.

In recent years, primary education and public universities have been the priority [Chart 2.2a]. Current initiatives in these sectors include feeding children in school, providing stipends for poor parents, distributing free textbooks to primary school children, and making more financial aid available to university students. The current Lula administration has also made literacy a priority through the Brazil Literacy program, with a budget of more than $100 million (2006).[17] It aims to promote literacy among those 15 and older.

Chart 2.2a. Breakdown of Public Spending on Education (2001)



Source: Unesco[18]

Historically, municipalities, and to a lesser extent states, have had a limited ability to spend on public education (public primary schools are maintained by municipalities and public secondary schools are maintained by the states). Generally speaking, richer municipalities, states, and cities have better public schools with relatively well-paid teachers and adequate physical infrastructure. Two relatively recent reforms, however, demonstrate that reforms aimed at redistribution in educational finance can have an immediate and far-reaching impact on the system.

The Federal Constitution of 1988 gave the municipalities greater autonomy in organizing their education systems. It also changed the system of educational expenditure to ensure that the division of tax revenues corresponded to the division of education responsibilities between municipalities and states. The Constitution mandated that 25% of state and municipal revenues and 18% of federal government revenue were to be allocated to education, 60% of which was to go towards primary education. Non-compliance with this mandate, however, has become the norm.[19]

The second important reform came through a 1996 Constitutional Amendment which created the Fund for the Development of Elementary Schooling and Valuing of Teachers (FUNDEF) under the Ministry of Education. In each state, the Fund receives 15% of all tax revenues, which is then redistributed among state and municipal governments. A minimum per pupil value is calculated and the money is allocated to state and municipal education systems according to student enrollment. When states cannot meet this minimum expenditure, the Federal government is required to make up the difference. Although the Federal government has not yet paid this amount in full, FUNDEF has nonetheless had a significant redistributive effect on primary education in the poorest north and northeast regions.

D) Primary and Secondary Education

As discussed, primary and secondary educational attainment has been identified as a missing link in the biofuels production chain, particularly in the north and northeast.

D-1) Specific Issues

According to Former Education Minister Cristovan Buarque, Brazil suffers from three major systemic problems: teachers' salaries, absence from school, and educational equipment and infrastructure.[20] The following statistics demonstrate the ways in which inadequate educational funding shape the educational environment:[21]

- Ninety percent of students in grades 1- 4 study in a school without a library and more than 99% do not have a science laboratory. 65% of students in grades 5 - 8 do not have access to a library and 95% do not have a science laboratory.
- Urban schools tend to have slightly better infrastructure than rural schools. Only 58.3 % of rural primary schools (grades 1 - 4) have electricity as compared to 99.8% of urban schools.
- A greater number of rural secondary schools and primary schools (grades 5 - 8) have electricity, 99.4% and 89.6% respectively, while only 5% of rural primary schools have a library and fewer than 1% have a laboratory or access to the Internet.

Urban schools tend to have teachers with higher qualifications because they are able to pay higher salaries. For the same reason, more teachers with higher qualifications are found in secondary schools (which are administered by the state government) than in primary schools. The combination of a lack of infrastructure and support and lower salaries contribute to very high turnover, particularly for rural school teachers.

D-2) Indicators

In 2003, the net enrollment ratio for primary education was close to 100% and the net enrollment ratio for secondary education was close to 75%.[22] However, failure and drop-out rates are very high. A very small section of the population has access to tertiary education, and the gross enrollment ratio in 2003 was 20.1%.[23] At least one-fourth of children beginning primary school do not pass grade 4.

Greater disparities in terms of access and school completion become apparent when the numbers are disaggregated by region, family income, rural-urban differences, and race/ethnicity. In general, children and youth from the poorest rural regions (north and northeast) and poorest urban regions (southeast), from the lowest per capita income quintile, and black and indigenous children have the lowest number of years of schooling (4 - 5 years).[24]

Other significant rural-urban, public-private, and regional disparities in duration and quality of schooling include:[25]

- In 2001, less than 75% of children starting primary school completed the fifth grade. The age-grade distortion rate was 25% in first grade, 39% in fourth, 46% in eighth, and 51% in eleventh.
- The illiteracy rate was 3% among youth aged 15 -19 years and 12% within the whole population aged 15 or more.
- In 2000, in the richest state, Sao Paulo, 94% of the population over 10 years could read and write while in the state of Alagoas in the northeast only 68% were literate.
- In 1999, a little over 25% of workers in the northeast region had more than 8 years of schooling as compared to 49% of workers in the southeast region.

The difference in quality of education is underlined by the regional disparities in SAEB[26] test scores for Mathematics and Portuguese. Students in the north/northeast consistently score lower on these tests than students in the South/Southeast at all levels of education. Factors that contribute to high test performance are: teachers with higher education; number of hours of instruction, availability of libraries as well as teacher salaries, and per-pupil public expenditure.

D-3) Key Policies and Programs

The stated objective of the National Education Plan is to make primary education universally available, to improve the quality of teaching at all levels, to reduce social and regional inequalities with respect to access and repetition, and to increase public participation in the governance of schools and the management of the education system. More specifically, the government has committed to:

- Provide mandatory education to all children ages 7-14 (primary education);
- Eradicate illiteracy for youth and adults;
- Increase the numbers of students in other levels of education including early childhood, secondary and superior education;
- Improve the status of the teaching profession and provide teachers with more training and support through continuing education, improved work conditions and adequate pay; and
- Develop information systems to support all levels of learning.

To this end, the government has set up a variety of educational support and funding programs.

<u>FUNDESCOLA</u> (The Fund for Strengthening Schools) has focused on improving the professional development of teachers and the quality of schools in specific urban and rural areas. In some cases, the Fund also supports the acquisition of equipment and furniture for schools in rural areas including agrarian reform settlements, quilombolas, and indigenous communities. Between 1998 and 2001, FUNDESCOLA supported the improvement of school buildings in 162 rural schools: 94 in agrarian reform settlements, 63 in indigenous schools, and 5 quilombola schools.[27] It was implemented by MEC in three phases in partnership with states and municipalities with money borrowed from the World Bank:

1) Fundescola I ($125 million), approved in April 1998. The goal of the first phase was to create a preliminary set of tools and support systems to improve school equity and effectiveness[28] and to increase public participation in school governance.
2) Fundescola II ($400 million), approved in June 1999. The second phase focused on improving and expanding the changes initiated in phase one, extending the program to additional schools, and launching a more aggressive campaign to engage the public sector.
3) Fundescola III, divided into two phases - Fundescola IIIA ($320 million), approved on June 2002, and Fundescola IIIB ($450 million), which was scheduled to begin in July 2006.

The underlying belief of the project was that greater parental and public participation in, and ownership of, the school system, coupled with well-aligned school policies and a reduction in infrastructural disparities, would enhance the system.[29]

Escola Ativa focused on the development of a pedagogy for rural schools, creating multi-grade schools while resisting traditional, rigid pedagogies. It was modeled on the Escuela Nueva project in Colombia and funded through the North-East Project of the World Bank. Beginning with 69 schools in 1997, the Project reached some 3609 schools, 4300 teachers, and 96,122 students in 558 municipalities by 2003. The majority of schools were in the northern region followed by the regions in the central east and the north. According to the 2002 School Census, the program has reached approximately 13.5% of multi-grade schools. An evaluation study by the United Nations Development Program in Brazil (PNUD) found that both teachers and students became more actively engaged in learning activities; that there were improved relationships between parents and schools; that the rotation of teachers declined; and that autonomy for the persons and institutions involved in school administration increased.[30]

Proformação (In-Service Training Program for Teachers) is a secondary education-level, distance-learning course for teachers in state and municipal schools in the north, northeastern and central-eastern states. It is implemented by state and municipal secretariats of education in partnership with the federal Secretariat for Distance Education (SEED) and has reached some 27,372 teachers in 1107 municipalities in 15 states, mainly in the north, northeast and central-east regions of the country.[31] An external evaluation study found that more than 80% of teachers reported an improvement in their teaching practices as a result of the program.

Additional programs such as the Money Direct School Program (PDDE), created in 1995 to support basic education, and the High School Maintenance Project (PMEM) of 2004, support the basic education system with budgets of nearly $161.6 million and $2.8 million respectively.[32] The High School Improvement and Expansion Program (Promed) is financed with 50% contributions from both the Inter-American Development Bank (IDB) and the Brazilian Ministry of Education. With a total budget of $220 million, $39.3 million in funding comes from the Brazilian Treasury and $70.7 million from the states (this arrangement expires in January 2007).[33] These programs also focus on improvement of the system of basic education.

The Brazilian government has also recognized the social constraints affecting the education of Brazil's youth, and has created programs to address them. The National School Nutrition Program seeks to provide children with adequate nutrition to augment their performance and capacity, as well as teach them healthy eating habits. It has a budget of $692.6 million for 2006.[34] Bolsa Escola, carried out with cooperation from UNESCO, grants a stipend to under-privileged parents who keep their kids in school and in good health.

The reform initiatives for math and science education[35] are of direct relevance to the biofuels discussion. Existing initiatives geared towards improving the quality of math and science education at the primary and secondary levels include:

- Pre-service and in-service training and support for mathematics and science teachers such as the program called Gestar, or Management of School Learning, and the university-based Proformação (participating universities for mathematics and science education include UFPA, UFRJ, UFES, UNESCP, and UNISINOS).
- Environmental education in public schools sponsored by the National Policy on Environmental Education.
- The School Textbook Evaluation Program (PNLD) which targets five components of the curriculum (first - eighth grade) including mathematics, science, history, geography and Portuguese language.

Education technology such as TV Escola, a satellite television channel, and Radio Escola, a radio project dedicated to education, also enrich the teaching-learning process and bring public schools into the digital world.

E) Professional Education: Technical and Vocational Schools

The professional education system in Brazil focuses on providing training and continuing education to persons currently employed, including technical training and graduate and post-graduate learning.[36] Technical and vocational schools can also serve as an alternative to secondary school. Recent reforms divided this kind of education into three levels: basic, technical, and technological. The first two categories require advancement through the first two levels of basic education. These schools provide technical training and also cover the regular secondary education curricula. The third category of technological education provides career-training opportunities.

Historically, urban, government-sponsored technical schools maintained by SESI (Industrial Social Service) and SENAI (National Service for Industrial Learning) have received funds from industries to run courses tailored to the market. SENAC (the National Service of Commercial Learning) is another professional training institution, present in all states and offering training in a variety of sectors.[37] These schools offer an alternative to a full degree program, and are usually attended by underprivileged students.

Outside of these learning centers, the Federal government maintains a network of technical schools considered the best in Brazil. Reforms have transferred responsibility for technical and vocational education, but public administration continues to be involved through partnerships that fund private institutions.[38]

E-1) Specific Issues

The agriculture sector, though employing 24.2% of the population, has much lower levels of educational enrollment. Although a vocational education system (SENAI and SENAC) was founded for the secondary and tertiary sections in the 1940s, the federal government only established an agency devoted to the rural sector in 1991. The stated mission for SENAR (National Service for Rural Apprenticeship) was to develop rural occupational training and social promotion activities for men and women who work in rural areas. Specific goals included:[39]

- To organize and manage rural occupational training and social promotion of rural workers in the national territory;
- To support employers' entities in organizing and developing training programs at the workplace;
- To establish and spread rural vocational training and social promotion methodologies;
- To coordinate, supervise and control rural occupational training programs and projects; and
- To support the federal government in issues regarding rural occupational training and social promotion.

SENAR recognizes that vocational training in rural areas needs to take into account the realities of the rural sector, including the fact that workers tend to have lower levels of general education and can seldom leave their workplace. The population is also highly scattered and employers often do not realize that education can increase productivity.[40] All courses and projects are offered to rural workers rather than employers. The majority of workers reached by SENAR to date work in cattle raising, extractive exploitation of animal and vegetable resources, agro-industry and agriculture. In many instances, SENAR combines literacy education with occupational training. Another focus is the preparation of workers, particularly medium and small producers, to improve productivity and expand output. In this context, SENAR has formed an effective partnership with SEBRAE (Brazilian Micro and Small Business Support Service) a public, non-governmental organization that supports small, medium, and individual businesses.

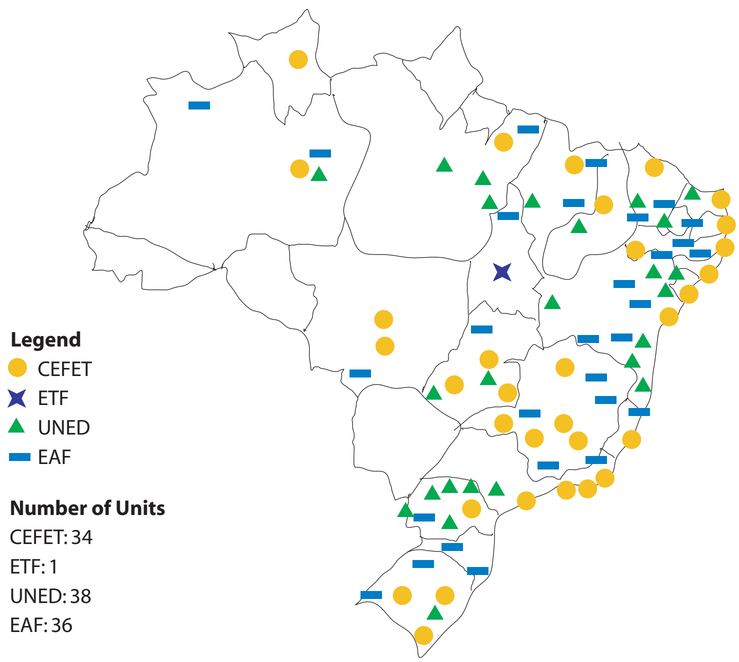
E-2) Indicators

The Federal Institutions of Educational Technology comprise a network of 139 schools, including:

- 36 Federal Agricultural Schools (EAF), which provide vocational education in the area of agriculture;
- 34 Federal Educational Technology Centers (CEFET), which administer undergraduate and postgraduate courses that train technicians and specialists in technology as well as teachers and specialists in vocational and technical education;
- 30 Vocational Schools linked to federal universities that offer courses in both agriculture and service industries; and
- 38 Decentralized Education Units (UNED), which are schools that have their own premises but have administrative, pedagogic, and financial ties to CEFETs.

As shown in Map 2.2b., these institutions tend to be concentrated in the industrialized regions of south, southeast and central-east Brazil.

Map 2.2b: National Network of Professional Education



Source: MEC

There are also a large number of private providers of technical courses, especially directed at training for mid-level workers in production industries. According to the 2003 School Census, a total of 589,383 students are enrolled in vocational education. Of this number, 25% attend health-related courses. Other areas with large numbers of students include industry, management, computing and agriculture.

Table 2.2d: School Census – Enrollment in Technical Courses by Administrative Authority, by Area of Employment

Federal Unit	Technical Area	Courses by Administrative Authority Total	Federal	State	Municipal	Private
Brazil	Total	589,383	79,484	165,266	19,648	324,985
	Agriculture	39,135	20,477	12,655	958	5,045
	Art	5,782	241	1,528	332	3,681
	Communications	4,063	0	738	284	3,041
	Commerce	6,676	389	1,574	205	4,508
	Civil Engineering	13,767	6,357	5,145	381	1,884
	Social Development/Leisure	6,733	234	1,663	214	4,622
	Design	5,997	644	2,029	9	3,315
	Geomatics	1,403	985	378	-	40
	Management	87,407	3,013	15,421	8,309	30,664
	Personal Appearance	963	187	0	-	776
	Industry	109,559	20,814	35,714	2,436	50,595
	Computing	82,969	8,066	18,230	2,358	54,315
	Environmental Studies	6,618	2,388	1,420	98	2,712
	Mining	1,318	753	210	-	355
	Chemistry	18,068	3,633	5,977	1,570	6,888
	Fishery	358	329	29	-	-
	Health	174,073	5,165	25,104	1,965	141,839
	Telecommunications	12,536	2,317	2,757	112	7,350
	Transport	1,378	435	455	-	488
	Tourism and Hospitality	10,580	3,057	4,239	417	2,867

Source: MEC/ INEP/ DEEB

It is notable that the number of courses providing technology training increased 74.7% between 2000 and 2002 according to MEC/INEP. Enrollments in technology courses increased 29% during the same period. The number of students completing these courses has also increased by almost 20% since 1999. The top three technology courses in terms of student enrollment are Data Processing, Technology in Computing, and Technology in Mechanics (see Table C in the Appendix).

E-3) Key Policies and Programs

Recognizing the importance of professional education and technical training, the Brazilian government has for several decades implemented a series of skills-development programs. In 1990, Brazil set up its first National Secretariat for Educational Technology, now known as the Secretariat for Professional and Technological Education (SETEC). Five years later, the federal government established the National Plan for the Further Training of Workers (PLANFOR), which works with unions, private organizations, and state and municipal governments to offer a variety of relatively short and inexpensive training courses to urban and some rural workers.

Currently, SETEC is working to define government responsibility for the sector, encourage the provision of places and courses according to local and regional needs, and implement the National System of Vocational Qualifications. It also administers Escola de Fábrica (Factory School) jointly with the Ministry of Education (MEC), with the objective of including youths from low-income families in the labor force. Private-sector entities are encouraged to participate by forming partnerships with public agencies or nonprofit organizations recognized by MEC.

Other programs include the Professional Education Expansion Program (Proep), which aims to provide greater autonomy, flexibility and resources to students. The Ministries of Education and Labor participate in a 50/50 initiative with the IDB on this program as well, giving the program a budget of nearly $185 million this year. There is also a human-resources development component to the program.[41]

In collaboration with UNESCO, there is also an initiative underway to explore whether the Federal Centers for Technology can be transformed into technological universities.

The four UNEVOC (International Center for Vocational and Technical Education and Training) Centers in Brazil, the Federal Centers for Technology Education of Minas Gerais, Rio de Janeiro, Paraná, and Bahia, are key partners with the Brazilian Ministry of Education in this effort to improve the quality of technical and vocational education and training in the country.

Much more remains to be done, and one major criticism of the technical training sector is that the vocational system is too small and the process for obtaining accreditation for new institutions is too bureaucratic.[42] Reforms in vocational education will need to avoid the pitfalls of traditional "shortcut methods" such as offering one-off, short-term courses, investing too little in training technical teachers, and neglecting institutional support for training centers. A strong focus on short-term employability adversely affects quality and the long-term capacity of providers.[43]

F) Higher Education

Most students leaving secondary school do not have any technical training and must attend a university to obtain a diploma. Acceptance to public universities is based on merit; students must take an entrance exam, which can vary by university, called a "vestibular". Students who can afford to do so attend expensive private study courses, dubbed "Cursinhos", to prepare for this exam. The majority of students in the elite public universities are graduates of the private school system.[44] There are several other types of higher education institutions.

Types of Higher Education Institutes

Universities: Standard, multi-disciplinary public or private institutions that train high-level personnel and conduct regular teaching, research and extension activities.

Specialized Universities: Public or private institutions offering high-level teaching in a focused area of knowledge or professional training. They provide opportunities for teaching faculty to obtain additional qualifications.

University Centers: Multi-curricular, public or private higher education institutions offering high-quality teaching as well as qualification-enhancement opportunities for teaching faculty.

Federal/Technical Education Centers: Public or private multi-curricular superior education institutions, the Federal Technological Education Centers (CEFET) and Technological Education Centers (CET) offer technological education at different levels and through different methodologies. Their aim is to provide higher-level technological education to prepare workers for various sectors of the economy where they will participate in the research and development of new processes, products and services closely linked to the manufacturing sector.

Integrated faculties: Public or private superior education institutions with multi-curricular interests housed under a unified program. They offer courses at various levels, including undergraduate, and specialized courses and postgraduate programs (master's and doctorate).

Isolated faculties: Public or private educational institutions, with curricula linked to a variety of knowledge areas, which enjoy independent administration and direction. They also offer undergraduate, and specialized post-graduate courses and programs.

Source: Consultores, 27

F-1) Specific Issues

NGOs have begun to offer special preparatory programs called Pre-Vestibular for Blacks and Indigent Populations (PVNCs), at low or no cost to disadvantaged students. These students face tremendous obstacles to learning, even after they gain entrance to elite public universities. Public universities do not charge fees but there is little support available for buying textbooks and defraying the cost of living. In addition, some students require tutoring and other forms of academic support in order to perform well in the university environment. A few universities have introduced affirmative action-type elements into their admissions system but these mechanisms focus on admissions and provide few services to help disadvantaged students complete their course of study successfully.

Current trends in university enrollment do not bode well for the biofuels industry. There are more students enrolled in the "soft sciences" such as business, the humanities, and education than in fields relating to science and technology. Graduates of science, mathematics, and computing fields only constitute 9% of the total number of graduates from public institutions and 7% of those from private institutions. There are two main explanations for this phenomenon. First, there are a limited number of slots in science programs due in part to the high costs of laboratories and other equipment. In private institutions, non-science courses are cheaper.[45] Cost and funding are therefore integrally related to the demand for and supply of educational instruction, particularly the kind and quality that will be needed for the expansion of the biofuels sector.

F-2) Indicators

Some other key indicators for higher education are:[46]

- In 2004, there were 2,013 superior education institutes (universities, faculties, and institutes) in Brazil. 719 were located in the capital, and 1,294 in the interior. Of those, 224 were public and 1,789 were private.
- Within those institutions, there were 2.32 million vacancies in 2004, up nearly 15.8% from the year before. More than 5 million students applied for those positions, representing a demand increase of 3.1%. In total, 1.3 million new students joined those already matriculated, bringing the total to roughly 4.164 million.
- Of students enrolled in 2004, more than 680,000 (16%) were in the programs most relevant to biofuels (Science, Mathematics & Computation and Engineering, Production & Construction).
- There are very low numbers of blacks and indigenous students in higher educational institutions.

F-3) Key Policies and Programs

Brazilian higher education is undergoing some far-reaching reforms under the umbrella of PROUNI--the University for All program. These reforms have been prompted by the fact that universities currently offer places to less than 10% of eligible students each year. There are also serious concerns about quality, particularly from the private sector. Federal and state universities have historically offered students an excellent education, but a 24% cut in annual funding and a 70% cut in infrastructure investment between 1995 and 2002 have led to deterioration in quality.[47] Research in science and technology has suffered from the reduction of public spending and outsourcing to the private sector, as well as from a reorientation towards commercial goals.

The challenge facing the system is to increase access to higher education, specifically among students from disadvantaged backgrounds. The MEC has a comprehensive reform plan for the higher education system that includes more than 48 expansion programs planned through 2007.[48] Initiatives that are underway have focused on making financial aid available to students who wish to pursue higher education. Some of them include:

- Superior Education Student Financing Program (FIES). Since September 2005, the government has financed 50% of the costs for students in need with the student paying the additional 50% directly to the school.[49]
- ProUni (the University for All Program). Provides students with grants for coursework undertaken in private higher learning institutes. In its first round, 112,000 grants were offered to students in 1,142 institutions, and the program aims to offer 400,000 more over the next four years.
- SINAES (the National System of Higher Education Evaluation). Seeks to improve quality across higher education through external evaluations carried out by a committee of specialists as well as guided self-evaluations by the institutions themselves.

The program has opened up more spaces in the educational system, primarily in private higher education institutions. The government hopes that this will move the country closer to the national education plan's goal of enrolling 30% of the 18-24 population by 2010[50] (only 9% are enrolled now[51]).

Other initiatives include increasing the federal budget for public higher education, hiring more professors, providing professional development training, improving current infrastructure and equipment, building new facilities, and increasing access for black and indigenous students (in part through UNIAFRO and PROLIND).

The initiatives of the Ministry of Science & Technology (MCT) are particularly relevant to education and professional development as it relates to the biofuels sector. According to the Brazilian Embassy in the United States, the National Council of Science & Technology Development (CNPq) has traditionally supported roughly 50,000 fellowships and scholarships in Brazil, including 20,500 grants for undergraduates; 3,500 for specialized and advanced training; 11,000 graduate scholarships; 5,000 doctoral and post-doctoral fellowships; and 10,000 research grants. Additionally, the Ministry of S&T and CNPq support approximately 2,100 fellowships outside of Brazil, including 1,800 doctoral fellowships and 300 post-doctoral fellowships.[52]
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G) Partnerships for Educational Development

There are several initiatives sponsored by both the government of Brazil and various private and non-profit organizations to promote greater educational achievement throughout the country that are relevant to the biofuels industry.

G-1) Advanced Education

CAPES (the Coordination for Superior Level Development) serves as a tool for the university community, seeking to develop standards of academic excellence, which go beyond masters and even doctoral-level study, through observation and examination of the superior education system. The organization helps to formulate policy based on the results of its evaluations and provides scholarships, stipends, and support programs to that community.[53]

Instituto Ayrton Senna designs, implements and evaluates "social technologies", which are used to improve educational methodologies and management strategies and implement educational programs at the public policy level. The institute's programs have reached 25 states and invested more than $68 million (R$146 million). The Ayrton Senna Advanced Center of Social Technologies has trained nearly 25,000 educational professionals.

G-2) Agrarian/Rural Education

ABEAS (The Brazilian Association of Superior Agricultural Education), a non-profit organization based in Brasília, conducts advanced courses in the agrarian sciences and is recognized by the National Council of Education (CNE). Its objective is to promote the development of advanced agriculture education and distance learning, and it has been one of the main instruments in this effort.[54]

EMBRAPA is engaged in numerous technology transfer and education programs throughout the country. Examples include the Embrapa and School Programs, which aim to promote the importance of science & technology in daily life by exposing students to research and allowing them to visit Embrapa.[55] In just two years, Embrapa professionals trained 304 technicians from the Bank of Brazil to work on agricultural finance with farmers. Additional programs are executed in conjunction with the Brazilian Service for the Support of Small and Medium Enterprises (SEBRAE), and in partnership with foundations in the states of Maranhão, Bahia, Mato Grosso, Mato Grosso do Sul, Goiás, Paraná, Rio Grande do Sul, Minas Gerais and Distrito Federal. These partnerships have helped increase soy and corn cultivation.[56]

NEAD (the Agrarian Studies and Rural Development Nucleus) is a technical cooperation project between the Ministry of Agrarian Development (MDA) and the Inter-American Institute for Agriculture Cooperation. It seeks to evaluate, develop, and improve rural development policies geared towards agrarian reform, family agriculture, and sustainable rural development.[57]

SABERES DA TERRA, or "Land Knowledge", is a program which involves the Ministries of Education, Labor & Employment, and Agrarian Development, and works to widen the scope of professional development in rural areas, focusing on education and training for farms. There are approximately 32 million Brazilians working in rural areas, and this program seeks to provide a portion of them with technical training that is enriching and relevant to their surroundings. Like several of the government biodiesel initiatives, the pillars of the project are family agriculture and sustainability.

G-3) Biofuels Specific

RIDESA (The Inter-university Network for Sugar-Ethanol Development) comprises seven federal universities (Parana, São Carlos, Viçosa, Rural/ Rio de Janeiro, Goiás, Alagoas, and Rural/ Pernambuco) which have signed an agreement to develop research for biofuels sector improvements. There are twelve "experimental stations" strategically located in states where sugar cane production is significant. Most studies are done at the graduate or PhD level with an emphasis placed on research related to the Sugarcane Genetic Improvement Program (PMGCA).[58]

G-4) Private Sector

Overall, a number of educational and professional development programs exist to help improve the effectiveness of Brazil's education system. Private sector participation, however, is only beginning to gain momentum. This section has demonstrated that there have been efforts to link education and training to industry needs but that significant room for improvement exists.

The biofuels industry already enjoys close links with the current Lula administration and, as discussed in the R&D section, public-private collaboration on biofuels development is increasing, though primarily at the university level. The industry now needs to develop close ties with federal and local education agencies as well.

H) International Comparisons

An international perspective supports the case for further investment in education and training. Brazil lags behind OECD countries and also the "East Asian Tigers" which emerged in the 1990s as development success stories. The economic achievements of South Korea, Singapore, Hong Kong, and Taiwan were based on export-driven growth plans with an emphasis on universal access to education and open market access. There are also comparisons to be made within Latin America and the Caribbean (LAC), specifically with Chile, the region's own development "tiger", and Mexico, which derives economic benefits from its close relationship to the United State but still suffers high poverty and inequality rates.

H-1) Educational Attainment

30% of Brazilians between the ages of 25 and 64 have achieved some level of secondary education. The average for OECD countries is 67% (Korea is at 74%), and Brazil falls between Mexico and Chile in this category, which scored 23% and 50% respectively.[59] Brazil's shortcomings in this respect have not gone unnoticed, as recent government programs to expand secondary education indicate.

H-2) Spending

Brazil's basic (through secondary) education system suffers from a lack of financial and teaching resources, as well as from the external effects of poverty. More efficient spending on educational infrastructure, equipment and teacher qualification, as well as incentives aimed at keeping underprivileged children in the educational system are of vital importance. Brazil actually spends a slightly higher percentage of GDP on education than Korea and Chile, investing 4.7% to Korea's 4.6% and Chile's 3.7%. Yet Brazil's spending per student is far below that for Chile and Korea, not to mention the OECD average, for primary, secondary and overall spending. The only exception is Brazil's spending on tertiary education, including advanced research, which surpassed that of Chile and Korea and almost reached the OECD average [Table 2.2e].[60]

Table 2.2e: Annual Expenditure on Educational Institutions per Student – 2003*

	Primary	Secondary	Tertiary	Primary –Tertiary
Korea	3,642	5,697	6,302	5,095
Chile*	2,163	2,249	7,090	2,908
Brazil*	879	1,134	10,167	1,256
OECD Average	5,511	7,040	11,422	6,916

Source: OECD[61], *Values are for 2003 or closest available; for Chile they are 2004 and for Brazil, 2002.

Total expenditures on education, as well as the ways in which resources are allocated within the system, must be considered a vital part of the expansion puzzle.

H-3) Output of Scientists

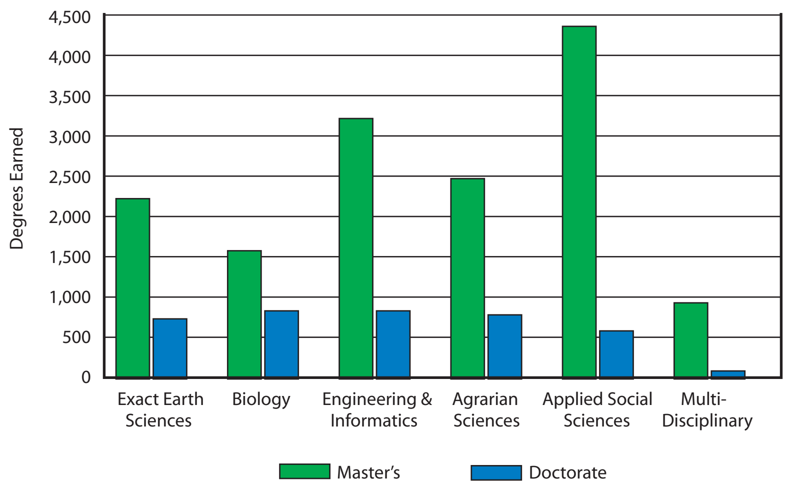
Brazil faces a deficit in the its output of graduates in the science and engineering fields. Table 2.2f and Charts 2.2b and 2.2c show that the social sciences attract more students in Brazil than any other discipline, which is not the case for North America, Europe, or Asia.

Table 2.2f: Degrees Earned in the Science Fields in Brazil (2002 and 2003)

	2002 Masters	2002 Doctorate	2003 Masters	2003 Doctorate
Exact Earth Sciences	2,270	746	2,408	913
Biology	1,763	894	1,927	1,028
Engineering & Informatics	3,227	818	3,798	1,023
Agrarian Sciences	2,324	785	2,577	1,026
Applied Social Sciences	4,426	614	5,154	736
Multi-Disciplinary	1,011	79	1,423	121
Total	15,021	3,936	17,287	4,847

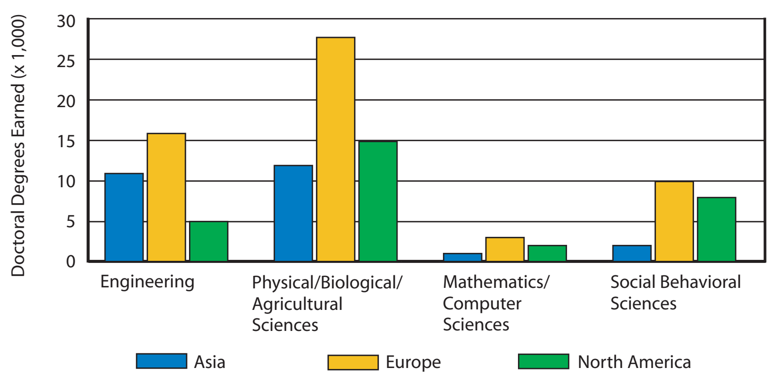
Source: MCT[62]

Chart 2.2b: Degrees Earned in the Science Fields (2002)



Source: MCT

Chart 2.2c: Doctoral Degrees in Asia, Europe, and North America, by Field (2002)



Source: MCT

Brazil also lags behind several OECD countries in the graduation of engineers.

Table 2.2g: Graduation of Engineers as a Percentage of the Population

Country	Per 1000 Inhabitants
South Korea	0.802
US	0.22
France	0.33
Germany	0.33
Brazil	0.08

Source: Com Ciência[63]

These figures suggest that greater support and promotion of the biological and chemical sciences, as well as engineering, is needed in Brazil if it is to compete with other regions for technological dominance in the biofuels sector.

H-4) Collaboration between Universities and the Private Sector

Linkages between the biofuels industry and education are gradually increasing, but there are still strides to be made. If the country is to keep pace with the US, Europe and

Asia it will need to match those countries' efforts in collaboration with academia and the private sector. There are several examples around the globe of such collaboration, including large investments by private companies for biofuels research and development at universities. Some representative examples include:

- The collaboration between Novozymes, a leading biotechnology company in Europe, and the Technical University of Denmark (DTU) on a new pilot plant for the production of second-generation ethanol; and
- The partnership between the Tsinghua University (China) and the China National Cereals, Oils and Foodstuffs Import & Export Corporation (COFCO) to serve as joint organizers of the World Biofuels Symposium 2006 in conjunction the Department of Agriculture of the University of Minnesota (US).

Some larger-scale efforts include:

- Investments of $225 million from BP and $100 million from ExxonMobil made to Stanford University in June 2006 for an energy research program aimed at reducing greenhouse gas emissions.[64]
- An investment of up to $25 million by the Chevron Corp. made to researchers at the University of California, Davis to develop, over the next five years, renewable transportation fuels from cellulosic material such as farm and forest residues, urban wastes, and energy crops.[65]
- An investment of up to $12 million, also by Chevron, to the Georgia Institute of Technology, for research into alternative fuels over the next five years.[66]

These projects represent two of the latest trends in biofuels development: large-scale partnerships between universities and private companies and increased participation by major oil companies in the biofuels sector. This kind of collaboration between the Brazilian private sector and university system does not yet exist. Petrobras is involved in the Brazilian biodiesel and ethanol industries, including through its own research unit CENPES, but large-scale collaboration with a Brazilian university has yet to be seen.

I) Conclusion

The most pressing issues facing the Brazilian biofuels sector with respect to education are:

1) Deficiencies in basic education in Brazil's north and northeast, due in large part to regional disparities in income and educational spending, the repercussions of which impact biodiesel producers in these areas;
2) The availability of a labor force with technical training to operate in various capacities within the expanding biofuels value-chain; and
3) The output of scientists and engineers in the disciplines relevant to biofuels feedstock development and production processes.

These issues affect all levels of the Brazilian education system, and policies aimed at bridging these gaps will be a key element of an overall development strategy for the sector. In particular, the education and biofuels sectors need to work together to address the following challenges:

Cultivation and production - The provision of basic education and literacy as well as agricultural training to farmers and machine operators, particularly in the northeast, where literacy rates are the lowest in the country.

Industrial processing - The provision of basic education and advanced technical training for plant operators in ethanol and biodiesel processing plants, including pre-service and in-service training to ensure that workers are current with the latest technologies and innovations in the field. Plant supervisors and lab scientists require at minimum a degree in chemical engineering and/or agribusiness management.

Research and development - Training to produce highly qualified support staff and management-level workers with minimum degrees in engineering, computer technology or agribusiness management; and researchers with advanced doctoral degrees in fields including including microbiology, biochemistry, biochemical engineering, bioinformatics, and organic chemistry.

Flex-fuel Technology - Training to produce technologically adept support staff as well as scientists for the laboratories of the automotive industry.

Collaboration
As discussed, there is inadequate collaboration between the private sector and educational institutions. A continued failure to develop this cooperation may hamper Brazil's ability to realize its potential not only as a producing powerhouse, but also as a technological leader in biofuels.

Increased participation by oil companies in the biofuels sector has been discussed elsewhere in this report (and particularly in the R&D section) and must be reiterated here with respect to education. The international collaborations discussed in this chapter should be a model for and a challenge to Brazilian industry.

I-1) Recommendations

In presenting these recommendations, it is necessary to emphasize that educational development is not linear in nature. Some kinds of education, and particularly scientific training, require a long lead time. One cannot hope to change one set of educational institutions and practices without making inputs into related institutions and practices. With these caveats in mind, the following recommendations are presented to assist with systematic planning and cost discussions, keeping in mind both short-term and long-term goals listed below.

I-1.1) Centralization and Coordination

One of the most effective educational models identified by a roundtable discussion at the World Economic Forum[67] was the engagement of domestic corporations, industry associations, and foreign investors in basic education through coalitions working in partnership with government ot enhance regulatory reform, policies, and incentives. Collaborations of this type can be effective in basic education as well as technical training and higher educational programs.

This finding is in line with the proposal of this report for an emblematic biofuels center, which would include:

- A policy-based loan to support reforms such as the education and training framework to create a sufficient supply of skilled labor for the sector;
- Competitive grants for teaching institutions in biofuels-producing regions to set up new programs in biofuels, responding to clearly identified local human resource demands in the sector;
- A human capital fund to support scholarships in international universities and attract global academic luminaries to work in Brazil; and
- A competitive fund to distribute grants for research and development in the private and public sectors, promoting firm-university collaboration in biofuels.

This type of cohesive, collaborative effort would be instrumental in helping Brazil achieve its expansion goals and achieve the status of biofuels technology expert and exporter.

In addition to funding for a Brazilian Biofuels Research Center, the IDB should consider providing $20 million for technical training, as well as literacy and basic skills programs, for rural laborers in the biodiesel sector in the northeast. Additional funding could be matched by the Brazil government and incorporated into its national biodiesel program. This estimate is based on the $90 million+ the IDB has put towards the Brazilian professional education program, Proep, which is broader in scope. An additional $50 million should be considered for scholarships in higher education institutions, to be augmented by private donations, in the science and engineering fields relevant to biofuels production. The IDB could also provide technical assistance in promoting the sciences more universally and in attracting greater private sector investment to universities.

I-1.2) Short-term goals

1) Build human capacity: world-class engineers, scientists, technicians, and managers will be needed to strengthen and expand ongoing R&D initiatives
2) Retain current science graduates as well as scientists and researchers already in the field
3) Attract world-class researchers
4) Create more research centers in the north and northeast of Brazil
5) Encourage scientific entrepreneurship
6) Provide technical training for labs and processing plants, and agricultural training for small sugarcane producers
7) Develop greater linkages between the business community and university

The current administration has prioritized reforms in both higher education and vocational and technical education; the success of these reforms will help determine whether Brazilian workers are able to rapidly learn new technologies and become innovators in their own right. Achieving this will require flexible systems that enable trainees to move beyond the conventional curriculum, the lecture room and the workshop, and into the laboratories and workplaces of the businesses that are practicing those technologies. Education, human resource development programs, and adequate provision of infrastructural support are all vital components of a healthy scientific and technological culture.

Technical/ Vocational, Agricultural, and Professional Training
- Support practical training in the technical fields
- Provide basic skills and literacy training for agricultural workers
- Supply agricultural inputs to small farmers and train them in their use

Higher Education
- Strengthen faculty research positions and research centers in universities in the northeast
- Offer paid internships to university students
- Create "Young Scientists" program along the lines of the World Bank
- Support pre-vestibular programs and provide scholarships in the sciences for disadvantaged students
- Encourage universities to provide more remedial support for university-level science programs

Industry
- Promote collaborative R&D activity and investments in universities

I-1.3) Long-term goals

1) Create a new culture of research
2) Popularize science so that more students choose to study science in secondary school and university

Long-term goals should focus on the system as a whole, addressing each of its segments. A particular focus should be continuing the technical and higher education programs listed above.

There is an urgent need to popularize science and technology in Brazilian society at large. Specifically, in the context of math and science education, Brazil (along with other industrialized and industrializing countries) is facing a decline of student interest in science. This is something of a paradox given the tremendous scientific advances and technological innovations announced on an almost daily basis. Young people are eager to use new technology but are less interested in studying science. Brazilian students do not score well on international tests (such as PISA, administered by the OECD) in mathematical ability.

Access to information technology for the average child is also very limited in Brazil. Most public schools do not have computers or laboratories, and teachers are often not trained to teach science using practical, rather than abstract, methodologies. These limitations are important elements of student performance in math and science related subjects and in their attitudes towards a career in the sciences. Educational institutions can play a key role in changing attitudes and behaviors among the population at large, and the biofuels industry must work closely with government agencies at all levels to support change in this direction.

I-1.4) Costs

The costs of these measures would include training and salaries for teachers, facilities, high-quality teaching materials, laboratory equipment, salaries for scientists and technicians, and stipends for student researchers.[68] Multi-disciplinary, multi-institutional working groups with representatives closely linked to all relevant sectors will be needed to develop more strategic initiatives in the area of education. For the biofuels sector and in general, one important risk to investing in technical and scientific education is that the private sector will not be equipped to absorb the ensuing surge in scientists and technicians. Investment in education and training must therefore be matched by an expansion of infrastructure such as labs and test facilities.

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PILLAR II: CAPACITY EXPANSION

3. Pillar II: Capacity Expansion

A) Introduction

The global demand for biofuels is only expected to increase in the coming years. While countries around the world are implementing domestic agroenergy programs, many will not be able to meet local demand with local production. To give just a few representative examples, both the US and EU would have to dedicate approximately 20% of their arable land to biofuels to meet the demand generated by a 5% blend of biodiesel and ethanol. In Asia, Japan is considering increasing its ethanol blend to 10%, which would create a 6 billion-liter-a-year market, and in China, an effort to reduce car pollution is expected to produce an 11 billion liter shortfall in biofuels by 2020, despite significant increases in domestic production.

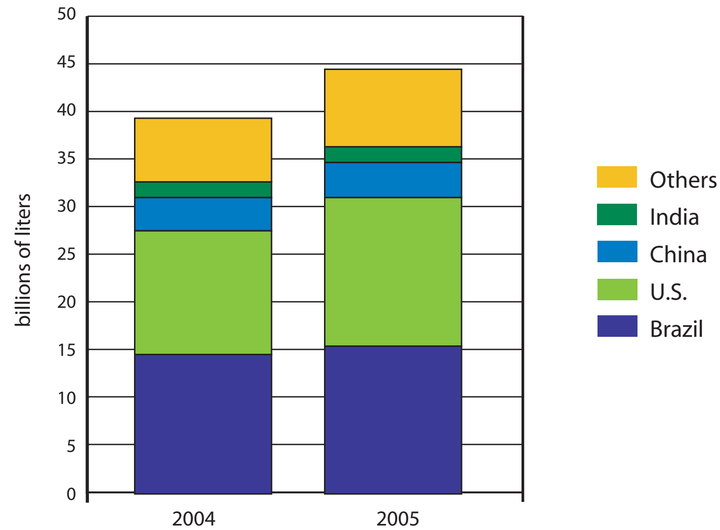
This creates a huge opportunity for a nation like Brazil, which has both abundant land and an appropriate climate, not to mention decades of experience and a strong political commitment. Through its ProAlcóol program, from 1975-1984 Brazil increased ethanol production from 3.7 billion liters to just over 11.2 billion liters (2006 production is expected to be almost 17 billion liters). Today the government is putting its energy behind biodiesel, through the National Program for the Production and Use of Biodiesel.

Ethanol expansion will cater primarily to the export market, while biodiesel will initially expand to meet aggressive domestic blend targets. The industries share three key challenges for growth: the impact of efficiency gains, the availability of suitable land (including environmental constraints), and access to financing and investment. In addition, the biodiesel industry has social development goals that will shape its growth. The current state of the industries, their potential for growth, and the impact of these issues on that growth will be assessed in the following chapter.

B) Ethanol

Brazil is the global leader in the efficient production of ethanol and the world's top exporter, thanks to years of investment in the sector. Sugarcane-based ethanol in Brazil can compete with oil at prices above $35 a barrel, and in 2005 exports totaled 2.6 billion liters, 65% of total global ethanol trade. The country is now gearing up for a significant expansion in production to meet a surge in demand on global markets. Though historically Brazil has far outpaced the rest of the world in the production of ethanol, it has been joined in recent years by one major competitor, the United States, which overtook Brazil in 2005 as the world's largest producer of ethanol. It is also worth noting that Brazil's productive capacity is increasing at a slower rate than the rest of the world. While production in Brazil grew nearly 6% in 2005, production in the US and small producer countries grew by 21%. In 2006, US production is projected to grow to 18.2 billion liters, while Brazil is only projected to hit between 16.7 billion and 17 billion liters.[1] Brazil will remain the leading exporter, however, and the US will be its biggest export market this year. For Brazil to maintain its leadership position, it will have to develop a cohesive strategy of capacity expansion supported by the necessary infrastructure and innovation. The challenge is to do so in an environmentally sustainable manner that does not infringe on needed grazing pasture or national reserves, while finding the capital to finance new projects.

Chart 3a: Global Ethanol Production 2004/2005



Source: F.O. Licht

B-1) Key Issues Surrounding Capacity Expansion for Ethanol

It is agreed industry-wide that by 2020, Brazil will likely need to triple its fuel ethanol production capacity to accommodate internal demand, currently at 14 billion liters a year, and position itself as a global market leader in ethanol. Analysts project that Brazil will have the capacity to produce 26.4 billion liters by 2015 – 20 billion liters to supply domestic demand with the remainder devoted to exports.[2] Experts argue that Brazil could feasibly double its output through the expansion of crop area and further investment in ethanol production facilities.[3]

Three major factors must be taken into account in assessing ethanol capacity expansion:

a) Efficiency gains;
b) Increases in sugarcane cultivation; and
c) Augmentation of processing capacity.

Efficiency gains allow production to increase without increasing inputs. This has been achieved through the optimization of productive processes and systems, training of labor, and feedstock improvements. Improvements in capacity and cost-competitiveness to date are a result of these three areas, and they are expected to have a positive impact on the next stage of expansion, particularly with the advent of next-generation technologies.

The current Brazilian land area devoted to sugarcane is no more than 6 million hectares, which represents less than 1% of available arable land. Some estimates of available arable land suitable for cane cultivation range from 90-100 million hectares, including 10 million in São Paulo state alone. The parameters of this expansion will be defined by suitability of the land, avoidance of monoculture, and environmental concerns.

Finally, with regard to processing capacity, Brazil already has 340 mills and a total of 89 greenfield projects under construction or in planning, comprising a total investment of approximately $10 billion. One study projects that this alone will increase productive capacity by 7 billion liters by 2010.[4] Still, the pace of investment is slower than in the US and other new producers.

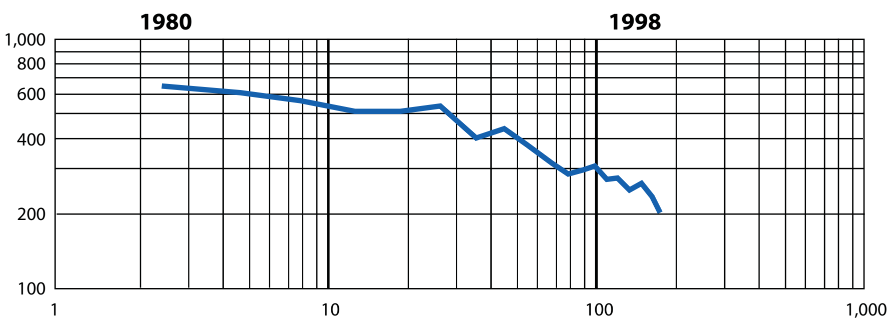
An aggressive increase in ethanol production capacity also raises questions about economies of scale. Do increases in ethanol production by factories enhance profitability or does a breaking point exist where costs begin to exceed the price of sale? While not necessarily true in the case of Brazilian biodiesel, it has been demonstrated that larger ethanol plants produce economies of scale through the lower capital and labor costs that automation yields.[5] In the United States, a 400-million-liter-per-year ethanol plant has an economic impact slightly less than twice that of a 200-million-liter-per-year plant, suggesting a fall-off in profitability somewhere within that range.[6]

In its aim to significantly expand ethanol production capacity, Brazil will face several important challenges. In particular, it will be critical for the country to access a much wider expanse of arable land for sugarcane and to do so in an environmentally sustainable fashion. Furthermore, financing these new production projects will require access to capital and investment for private-sector firms involved in the capacity expansion process.

B-2) Ethanol Efficiency Gains

Brazil's ethanol industry has achieved the highest productivity through the optimization of each stage of the productive process, from planting and harvest to refining. This has been achieved through significant investments in research and development, and the innovation of practicing technicians and farmers. The chart below illustrates the changing cost of production over time.

Chart 3b : Ethanol Cost "Learning Curve"
Ethanol Cumulative Consumption (million cubic meters)



Source: Professor J. Goldemberg

Gains in efficiency have been made by measures such as the mechanization of harvest techniques and the genetic improvement of the sugarcane itself. Over the past decade, scientists working in Brazil's ethanol sector have worked to map the complex sugarcane genome in an effort to make the plant more resistant to disease, bacteria and pests while yielding a greater amount of sucrose. This trend is expected to continue and boost the capacity of existing and new facilities and farms. As demand for biofuels increases and the availability of arable land decreases, gains in efficiency and yield will be what allow the sector to continue to grow.

Table 3a: Possible Gains in Productivity

	2005		2015		2025	
Technology	l/tc	l/ha	l/tc	l/ha	l/tc	l/ha
Conventional	85	6,000	100	8,200	109	10,400
Hydrolysis	--	--	14	1,100	37	3,500
Total	85	6,000	114	9,300	146	13,900

Source: CANAPLAN

Studies conducted by leading Brazilian consultancy Canaplan created the previous table from a number of sources[7] to determine the impact of a strong growth in ethanol supply on the land use. It concluded that efficiency gains and the introduction of hydrolysis technology from 2015 on could minimize the amount of additional land needed.

Recent gains were not the product of a single major breakthrough, but rather the optimization of each step in the productive process from field to plant. This will likely not be the case in the next stage of innovation. Second-generation technology will allow the sector to produce more ethanol by using more of the plant in the extraction and fermentation process. Today, only 1/3 of the energy content of the sugarcane plant is used to produce ethanol, with the remaining bagasse and stalk used for co-generation, or simply discarded. Second-generation technology will allow ethanol producers to use the cellulosic material found in the cell walls of this and other plants as the feedstock for ethanol. Breakthroughs in these processes are not far off; indeed the Brazilian production and equipment firm Dedini is planning to build a test facility for the cellulosic process it created in 2003. The challenge to this process is technical. Scientists are still searching for ways to simultaneously remove the protective covering of the cellulose, called hemicellulose, and break the materials down for processing (achieved through treatment by enzymes). Efficiency gains in this area will result in the discovery of more suitable pre-treatment and enzymes solutions. While cellulosic production is possible today, it is not yet commercially viable (see discussion in Innovation chapter).

B-3) Ethanol Land Availability & Environmental Constraints

As of the end of 2005, six million hectares of arable Brazilian land were dedicated to sugarcane cultivation, representing approximately 0.6% of the arable land available in Brazil. Of that area, approximately 70% is owned and operated by 340 mills, with the remaining 30% of the land run by 60,000 small-and medium-sized production enterprises. Large operations, on average, command 30,000 hectares, while the small-and medium-scale producers control an average of 27.5 hectares of cane-land. The processing capacity of the 340 mills is anywhere from 600,000 to 7 million tons of cane per year. In comparison, the SME processors are capable of an average of about 2,050 tons of cane annually.[8]

According to UNICA, an average of 55% of Brazilian sugarcane is turned into alcohol and 45% into sugar.[9] Current expansion of land for cane planting has proceeded primarily in areas formerly used as pasture for cattle rather than land planted with other crops. Brazil has 300 million hectares of livestock pasture and experts claim that with more sustainable grazing methods, this could be condensed substantially.[10]

B-3.1) Available Land for Future Production

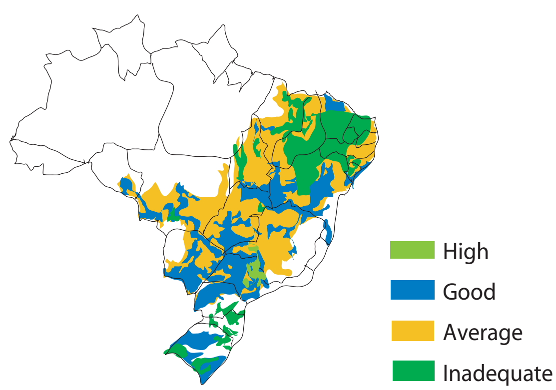
The discussion of available arable land for ethanol production is too often framed in general and rather grand terms, stressing Brazil's impressive land mass and fertility. While the country is indeed abundantly endowed in both areas, a study commissioned by the Brazilian Government has produced a more rigorous analysis. Eliminating areas protected by environmental regulations and those with a slope greater than 12% (which precludes mechanized farming), the rest of Brazil's arable land was then evaluated for its suitability for cane. The most accommodating climate for sugarcane occurs in zones where temperatures fluctuate between 20 and 24 degrees Celsius with a yearly rainfall of some 1,200 millimeters. The mid-west and southeast regions have a plethora of zones that fit this description. The appropriate soil will have medium acidity, medium to high fertility, and adequate drainage.[11] Land was evaluated for its quality both with and without irrigation.

Table 3b: Available Land for Sugarcane Expansion

	Expected	Potential Area				Potential Production - 2005			
Potential	*Productivity*	*Without Irrigation*		*With Irrigation*		*Without Irrigation*		*With Irrigation*	
	(t/ha)	(1,000ha)	(%)	(1,000ha)	(%)	(1,000 t)	(%)	(1,000 t)	(%)
High	81.4	7,897.1	2.2	37,919.8	10.5	642,493.7	3.4	3,085,075.5	14.6
Good	73.1	113,895.0	31.5	98,018.5	27.1	8,324,183.3	44.7	7,163,831.6	33.9
Average	64.8	149,216. 6	41.3	167,645.1	46.4	9,671,027.3	51.9	10,865,412.1	51.5
Inadequate	0.0	90,579.4	25.1	58,004.8	16.0	0.0	0.0	0.0	0.0
Total		361,588.1	100.0	361,588.1	100.0	18,637,704.3	100.0	21,114,319.1	100.0

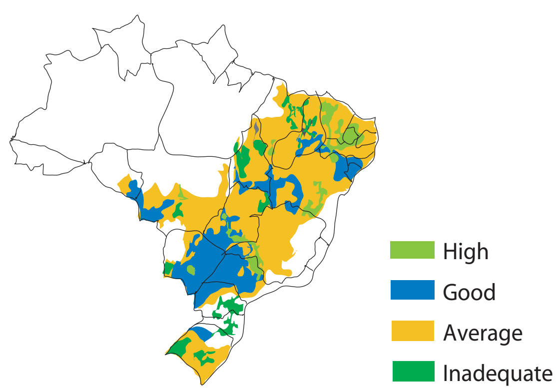
Source: CGEE, Unicamp, NIPE, ABDI study

Map 3a: Land without Irrigation



Source: Unicamp

Map 3b: Land with Irrigation



Source: Unicamp

With 2.6 million hectares cultivated for ethanol production, tripling production without the benefit of any gains in productivity (which is as conservative an estimate as can be made) would only require an additional 5.2 million hectares. According to the government study, there are 7.89 million hectares ideally suited to sugarcane farming without the benefit of irrigation (more productive than the current industry average), and an additional 113.9 million hectares of good quality (about equal in productivity to the current average).

Prepared by Garten Rothkopf

It is important to understand the cane-planting harvest cycles indigenous to those regions which currently harvest cane and those which aim to expand into the sugarcane sector such as Bahia, Maranhão, Piauí, and Tocantins.[12] As a rule of thumb, sugarcane is cultivated over a year and a half period, and land can usually yield 5 to 6 separate crops before exhaustion. However, it is also possible to cultivate and harvest a cane crop within a calendar year. In the southeast, with yearlong cane, the planting takes place in two periods: May/June (winter cane) and September/October, with harvests occurring April to November. Year and half-long cane is planted from February to April and harvested from April to November. By contrast, in the northeast, the planting cycle for yearlong cane runs from June to September (normal cane) and September to December (special areas), with harvest occurring September to March.[13]

EMBRAPA estimates that at least 20 million hectares of that land could come online with the implementation of "technological advances in cattle handling".[14] The estimate bodes well for the expansion of ethanol production given that less than half of that land area would be necessary to triple capacity by 2020. As the report will stress in the infrastructure pillar, connecting that land to markets and ports may require a large-scale investment in transportation and distribution infrastructure.

Crop diversification serves as another key issue in the discussion of land availability for future ethanol production. The tendency towards monocultures that may occur by virtue of the economic advantage of clustering production and locating plants near the feedstock is concerning. Monoculture can only serve to heighten the environmental risks (described below) that are attached to its cultivation. In addition, an unbalanced monoculture renders local economies vulnerable to crashes in crop prices.[15]

Given that São Paulo State dedicates nearly 65% of its cropland to sugarcane, there is some concern over the state's commitment to a single crop. São Paulo has transformed itself in the cane-growing center of Brazil, and the state is arguably best equipped from an infrastructural, legislative, research, and regional market standpoint to continue advancing production, but the price of land there is becoming prohibitive. More cost effective greenfield investment could occur in states tangential to São Paulo such as Minas Gerais, Goiás, Paraná, and Mato Grosso do Sul.[16] A more detailed discussion of the proposed factories will follow below.

B-3.2) Environment

There are several environmental risks associated with the intensification of sugarcane farming for the purpose of ethanol production expansion. They include:

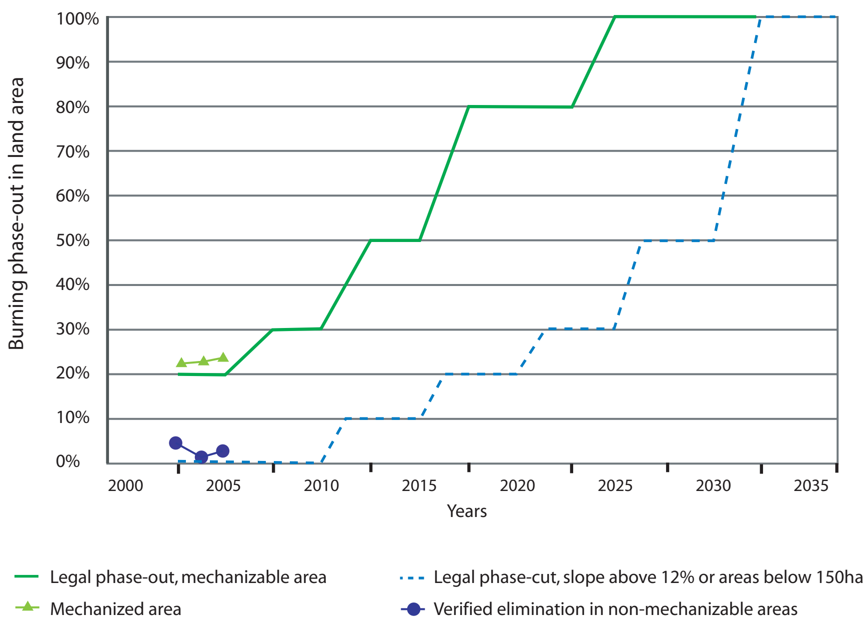
1) soil depletion;
2) the increase of fertilizers and chemicals;
3) the destruction of natural vegetation in protected areas; and
4) the pollution of the atmosphere with noxious carcinogens.[17]

Over time, there has been significant soil erosion in the State of São Paulo, largely due to cattle and grain production. In fact, the expansion of the sugar cane reduced the erosion thanks to its deep root system and the protection it offers against the impact of rain. That said, monoculture cultivation conditions are negative. This phenomenon limits cane's productive potential and increases the costs to producers. The erosive run-off can also itself pollute the groundwater and sicken the crop.[18] The possibility of having 15 to 20% every year of sugarcane in rotation with soy, peanut and other crops, not only corrects the problem, but also creates new synergies in ethanol and biodiesel production.

In addition, the burning of excess foliage is a common practice applied by over 80% of cane-growers used to facilitate the harvest. As crop rows are often narrow and choked out by superfluous leaves, burning can speed up access to the actual cane itself. It is also used to ward off crop disease and insects that flock to the plants. There is a state law that limits the prohibition of the burning of the sugar cane year by year and requires that one-third of trash is brought to the factory for processing.

Today, farmers must apply for a specific authorization from the Brazilian government to burn excess foliage. This authorization takes into consideration two conditions: the current climatic conditions and the landscape of the region in question, which cannot have a slope higher than 12%. In addition, the authorizations are distributed so that burning does not occur on multiple properties in the same region at the same time. In São Paulo state, the use of burning is prohibited in mechanized areas and will be in non-mechanized areas by 2012. The chart below shows the projected phase-out of this practice.

Chart 3c: Elimination of sugarcane harvest burning in Sao Paulo



Source: CENBIO[19]

Another concern is related to the use of fertilizers and chemicals to eradicate various insect pests as well as bacterial crop diseases that appear to contaminate the plants. Runoff from these fertilizers can jeopardize groundwater and the land. Over time, soil can become so contaminated that it is no longer suitable to raise cane.[20]

Research suggests that land availability is not a major obstacle to the expansion of ethanol production through 2020 as long as steps are taken to ensure that the expansion is undertaken in an environmentally stable and sustainable fashion and in compliance with regulations.

In Brazil, the Ministry of Environment (MMA) has sole oversight powers over environmental regulations pertaining to the ethanol industry, as well as the impact of sugarcane farming expansion on significant domestic ecosystems. The MMA's main responsibility is to design and enforce political and administrative national guidelines for wildlife preservation and environmental conservation. In addition, the MMA also works closely with its main agency, the Brazilian Institute for Environment and Renewable Sources (IBAMA), to ensure continuous oversight on all industrial, commercial, and tourist activities that may impact the environment.[21]

However, the MMA is consistently under-budgeted and understaffed, despite being widely recognized for its efforts on environmental preservation and its responsibility for such extensive tracts of land. This lack of funds makes it difficult for the MMA to enlarge its inspection personnel, as well as ensure an even distribution of physical infrastructure, such as inspection posts, which are essential to the fulfillment of its mandate.

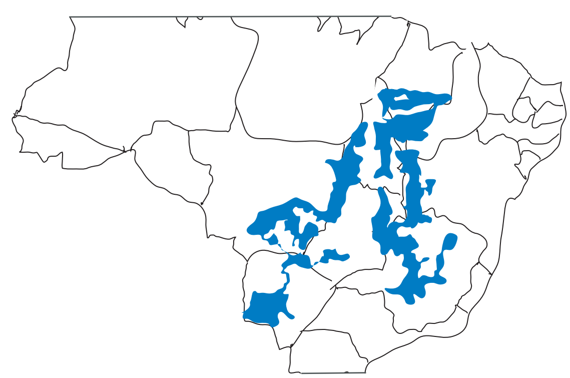
While not yet enacted, a bill is under consideration that could have a significant impact on the availability of land for sugarcane expansion.[22] The "Cerrado Amendment", which is being debated in Congress, seeks to preserve the Cerrado region via the creation of a National Forest Reserve. If approved, it would considerably restrict further agricultural expansion. A similar restriction already applies to the Amazon Region, which covers 5,217,423 kilometers square or 61% of Brazil's territory.[23]

The Cerrado is a vast tropical savannah eco-region of Brazil that includes 1,916,900 kilometers square or 22% of the country (almost the size of Alaska). It is characterized by an enormous range of plant and animal biodiversity and includes:[24]

- the state of Goiás and the Federal District, most of Mato Grosso, Mato Grosso do Sul, and Tocantins;
- the western portions of Minas Gerais and Bahia, the southern portion of Maranhão and Piauí (also large producers of edible oils for biodiesel); and
- small portions of São Paulo and Paraná

The proposed amendment would directly impact the expansion of the ethanol industry. Outside of São Paulo and Paraná, which are unlikely to be affected, Goiás, Mato Grosso, Mato Grosso do Sul, and Minas Gerais are the states attracting the most new ethanol projects thanks to their relatively cheap land, existing infrastructure, and suitability for cane cultivation. Maranhão and Tocantins have also been identified as having potential, but they are unlikely to attract significant investment in the short term due to a lack of infrastructure, adapted feedstock, and support industries. If one compares the map below to Maps 3a and 3b, the significance of the Cerrado Amendment to the expansion of production becomes clear. Possible restrictions that could be imposed by the MMA include prohibiting the cultivation of certain agriculture crops, such as GMO crops, as well as granting tax incentives for environmentally-responsible practices. The proposal is still in the early stages of debate, but has already garnered support from several political parties.

Map 3c: Cerrado Area in Brazil (2002)



Source: IBAMA

B-4) Ethanol: Private Sector Investment and Access to Capital

Given the pace of industry investment over the past two years and projections for future ethanol production, the role of the private sector becomes integral to any discussion of capacity expansion. Will small and medium enterprises (SMEs) make greater inroads into the ethanol production landscape in the coming years or will a few large-scale players continue to dominate the market? Will advances in technology or the overall supply chain encourage a new set of market entrants? And, importantly, how will old and new market participants find access to capital and lines of financing to support a sustained and aggressive expansion of production capacity? Certainly, there is sufficient land to support a doubling or tripling of sugarcane cultivation, but investment and private sector producers will ultimately drive the industry forward.

B-4.1) Current State

The process of Brazilian ethanol production has been refined over three decades of research and experience in the country beginning with the ProAlcóol program in the late 1970s. Today, Brazil's ethanol industry derives its product from a sugarcane culture that is concentrated in the mid-west and south regions, predominantly the states of São Paulo, Paraná, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro, and Espirito Santo. São Paulo alone is responsible for 62% of the sugarcane production in Brazil. 13% of production comes from the northeast, largely in Algoas, Pernambuco, Paraíba, Sergipe, Rio Grande do Norte, and Bahia.[25] São Paulo's sugarcane industry, the most concentrated and developed in the country, provides a clear example of the ethanol value chain and the role of different private sector actors.

B-4.2) Mapping of the Value Chain: Participation of SMEs and Large Enterprise

The sugarcane industry, by its nature, lends itself to large-scale enterprises that possess the resources and capital to own large tracts of land, purchase high-powered processing equipment, and train workers to manage production. Nearly 85% of the area of cultivated sugarcane is held by large-scale producers –those who possess more than 100 hectares of land. This is especially true in the mid-west and south, predominantly in São Paulo state.

340 mills for the production of ethanol were in operation in Brazil as of June 2006, 170 of which are located in the state of São Paulo with Paraná's 30 plants a distant second.[26] Several large enterprises own a number of mills for which annual ethanol output tops 400 million liters. These include the Cosan Group, the São Martinho Group, the Farias Group, Copersucar, Coinbra, and in the northeast, Carlos Lyra. These mills combined to put out approximately 16.1 billion liters of ethanol in 2005 and are on pace to reach 16.7 billion liters by the end of 2006, the largest volume ever produced in Brazil.

The Brazilian ethanol industry is comprised of a variety of private sector stakeholders that operate in separate capacities along the overall supply chain and distribution network. Key tangential sectors alongside ethanol production include construction, equipment and services, process technology, research and development, transport, storage, and distribution. In addition, there exist several private sector associations with oversight responsibilities in the industry.

B-4.3) Large Enterprises

As the ethanol industry stands today, the value chain is dominated by large enterprises; nevertheless, there is potential for small and medium enterprises to enter the market. Key names in the sector include the aforementioned ethanol producers as well as São Paulo's Sugarcane Agro-Industry Union (UNICA), an association that represents more than 2/3 of the ethanol producers in the state. The state is also home to the Union of Sugar and Alcohol Producers from Western São Paulo (UDOP), an association that represents nearly 40 sugarcane processing companies.

In construction and equipment services, one key player dominates: Dedini Indústrias de Base. The company claims to have built plants accounting for approximately 80% of ethanol production in Brazil. Dedini has also moved into other industries, including biodiesel production and cogeneration facilities construction. The company is a good example of Brazil's potential to remain a center of high-value added exports related to biofuels; Dedini's in-house research has developed sophisticated turnkey refinery systems that are in demand around the world. Representatives say the company is moving aggressively to meet international demand.

In the areas of transport, distribution and storage, Petrobras and its various subsidiaries continue to dominate the field. Petrobras, or Petróleo Brasileiro, the quasi state-owned oil company, formerly played a leading role in the ethanol production industry as it used to buy quantities of ethanol as a gasoline additive at a regulated price. This regulation is no longer intact, but Petrobras maintains a substantial role in the market by maintaining ethanol transport and distribution networks as well as the end-use storage facilities and station pumps for the product. Transpetro, Petrobras' transport infrastructure subsidiary bears the responsibility for much of the distribution of ethanol, especially that from the state of São Paulo. Although Petrobras is 51% government owned, it operates as a private sector entity and as such, will be considered under the umbrella of the private sector discussion for the purposes of this report. As part of Brazil's Growth and Acceleration Plan (PAC), Petrobras is negotiating with partners to invest R$12.1 billion in the construction of ethanol factories in the next four years. By entering into the supply of ethanol, Petrobras will resolve the difficulty of signing long term export contracts. The company anticipates that the total investment will create 50 additional ethanol and biodiesel plants.[27]

Finally, the export of ethanol has opened space for trading companies. This segment is composed of a variety of actors. The larger sugar and ethanol producers have divisions within their companies to handle trade. Additionally, global trading companies like Louis Dreyfus are active in the ethanol market, and have even acquired some productive assets rather than operating solely as a middle man between producers and consumers. There are also small-and medium-sized enterprises engaged in ethanol trading.

B-4.4) Small and Medium Enterprises

As discussed, small and medium enterprises abound, but do not dominate the ethanol production industry. At this stage, most experts agree that small and medium enterprises (SMEs) face significant challenges entering the ethanol industry on the production side. Their limited capital, machinery, and human resources and the notoriously challenging climate for new businesses in Brazil conspire to deter many firms. However, SMEs may have more success providing support services to the industry such as tanker truck rental, equipment dealing and servicing, and trading services. The expansion of production clusters in new regions is not solely a matter of investment in cultivation, a processing plant, and the associated infrastructure. To achieve efficiency, support services will be necessary.

Despite the dearth of SMEs in the ethanol production sector, there exist a number of programs, including financial and other types of support, which encourage the strengthening of SME resources and capacity. National, regional, and state-level development banks offer a variety of low-cost credit lines tailored to SMEs. In addition, the Agency of Support to Small Business and Entrepreneurs (SEBRAE), a privately-held association that operates on the national, state, and municipal levels, provides programs to build capacity and train human resources. SEBRAE is an important resource for SMEs. The financing lines available to SMEs are detailed below, while the programs that SEBRAE offers to SMEs will be discussed in the biodiesel section of this chapter.

B-4.5) Pace of Investment in Capacity Expansion

Since January 2005, the pace of investment in Brazilian ethanol capacity expansion has quickened considerably. In 2005, approximately $700 million worth of investment was devoted to constructing 19 new ethanol facilities.[28] In 2006, investment has accelerated further, amounting to nearly $1.2 billion in projected investments through the middle of the year. Total investment for 2006 may reach $2 billion as the number of ethanol facilities under construction continues to grow.

Demand has been driven in part by a new mandate for a 20-25% ethanol blend to be applied to all automobile transport fuel. The current blend level is 23%. Consumer demand also increased markedly as gasoline prices remained high. Running in parallel with these factors was the rising trend of Brazilian consumers purchasing flex-fuel vehicles – automobiles that are capable of running on any blend ratio of ethanol to gasoline. 2005 witnessed a significant jump in sales of flex-fuel vehicles, from approximately 35% to nearly 75% of overall new car sales. This rise has continued and is expected to plateau at about 80% of overall car sales through 2006.[29]

One early sign of the 2006 expansion was the initial public offering of Cosan, a large-scale producer of ethanol, in November 2005. The company was able to raise nearly $350 million on the open market, thus providing it with capital with which to pursue acquisitions and expansion of its ethanol production facilities. Cosan further advanced its expansion strategy by issuing $300 million in perpetual bonds.[30] Apart from making two key sugarcane mill acquisitions (the Corona Group and Bom Retiro) in early 2006, Cosan has also invested heavily in genetic research related to sugarcane in collaboration with CTC and Canavialis, the research subsidiary of Votortantim. Private sector investment into genetically modified sugarcane to enhance the hardiness and productive capacity of the crop has been a priority since 1999, the year that marked the beginning of a sugarcane genome project, which has since been successfully completed.

Other companies that have chosen to invest heavily in Brazilian ethanol production plants in 2006 include Companhia Energética de Açucar e Álcool ($279 million), Maity Bioenergia ($300 million), Grupo Itamarati ($320 million), and Alto Alegre ($135 million).[31] Investment has also arrived at the ethanol sector in the form of logistical services; Petrobras announced a $600 million investment in both ethanol and biodiesel. Dedini Indústrias de Base has also been part of several separate major contracts this year for the provision of construction and equipment for ethanol production facilities. It announced at the annual International Symposium and Tradeshow of Sugar-Alcohol Agro-Industry (SIMTEC) that it had begun work to spin off a joint-venture subsidiary specializing in industrial automation, a potential boon to ethanol production.

Alongside these investments have been the announcements of two major funds that they will focus their equity stakes on Brazilian bioenergy, specifically the development of ethanol. The first, the Fund of Investments in Bioenergy will be managed jointly by PTZ Bioenergy of Brazil and Holland's BTG Biomass Technology; it is expected to reach over $640 million in three years and will devote its investments to cogeneration ethanol mills, which use their bagasse byproduct to produce electricity.[32] This fund will also make investments in biodiesel production. The second, the Bioenergy Development Fund, launched in August 2006, is managed by the French bank Société Générale and seeks to purchase 20-25% equity stakes in "sugar and ethanol firms located in strategic regions of Brazil."[33]

Investment in the private sector for ethanol production has also been boosted by international sources. Japan's International Bank of Cooperation (JBIC) has pledged over $550 million to Brazilian ethanol and biodiesel projects. In particular, the states of Tocantins, Maranhão, and Piaui are to receive $300 million from JBIC for the expansion of their ethanol production, the output of which will be primarily devoted to the export market in trade with Japan.[34] Japan has remained a loyal advocate of Brazil's ethanol production and overall bioenergy program since 2005, having installed a national distribution and marketing facility, Brazil-Japan Ethanol, which is jointly owned by Petrobras and Nippon Alcohol Hanbai.[35] International players considering investment in Brazil's ethanol production sector include France, Germany, Sweden and India, all of which have either signed MOUs or verbally expressed a desire to enter the sector. Most recently, Noble Group Ltd., a Hong-Kong based commodities supplier bought Usina Petribu Paulista Ltda., a sugar mill in Sao Paulo state with a 2 million metric ton capacity for $70 million. Noble will spend up to $200 million to further expand the plant to a crushing capacity of 10 million tons of cane in the coming years.[36]

B-4.6) Financing Lines Available

Ramping up ethanol processing capability represents a major obstacle to capacity expansion, and Brazil must locate capital for its domestic private sector. Already, $10 billion worth of investment is planned by 2014 in 89 greenfield production facilities. Interest rates in Brazil, though falling, remain high and act as a disincentive to credit-based financing. Guaranteed lines of financing will be necessary to support this expansion, as will other sustainable and medium-rate forms of financing for maintenance and continued operation of facilities currently in operation. Brazil's long experience with ethanol has brought awareness concerning the need for financing lines, and a number of options are available. Nonetheless, it will be critical for Brazil and its private sector to have access to guaranteed large-scale funding and capital markets wherever possible.

Private sector representatives such as UNICA report that there is an abundance of financing available for new projects. Financing comes from several sources, most notably national development entities and ministries, state and local governments, multilateral organizations, and finally, private sector institutions themselves, including banks and large-scale conglomerates with the ability to issue corporate bonds and other derivative financial products. Financial markets such as the Brazilian Mercantile and Futures Exchange (BM&F) and Bolsa de Valores do Estado de São Paulo (BOVESPA) are additional sources of capital for the industry. Furthermore, the burgeoning international carbon credit market, which will be discussed more in later sections, may serve as an important source of sustainable financing for ethanol capacity expansion.

From the public sector, several development banks at the federal, regional, and state levels are involved in financing both ethanol and biodiesel. While the National Biodiesel Program gains more attention and offers specific financing lines from a rural economic development perspective, the ethanol industry's concerted push to enhance production is, in terms of profitability, equally creditworthy. The players here include, most prominently, the National Development Bank of Brazil (BNDES), Banco do Brasil SA, Banco do Nordeste do Brasil SA, Banco da Amazônia SA, the Regional Development Bank of the Extreme South, the Development Bank of Minas Gerais (BDMG), and the Development Bank of Rio Grande do Sul. However, it should be noted that in some cases, these smaller banks actually serve as local financing agents for BNDES rather than as separate sources of credit.

BNDES, as the development financing arm of the Brazilian government via the Ministry of Development, Industry and Foreign Trade, is concerned primarily with local-level economic development and infrastructure-related projects that fulfill that mandate. BNDES "seeks to strengthen the capital structure of private companies and the development of the capital markets, the trade of machines and equipment and the financing of exports."[37] BNDES devotes an entire set of funding programs and financing lines to agriculture. The most relevant financing lines to the ethanol industry are BNDES Automatic Financing to Endeavors (FINEM), the Special Agency for Industrial Financing (FINAME) and Agricultural FINAME. Programs which can fund ethanol production include the Program for the Modernization of the Agricultural Tractor Fleet and Related Accessories and Harvesters (MODERFROTA), the Irrigation and Storage Incentive Program (MODERINFRA), and the Technology Fund (FUNTEC). The specifics of each financing line and program are detailed in Table 3d.

Table 3d: BNDES Financing Lines and Funding Programs Relevant to Ethanol Production

Financing Line	Focus (Including, but limited to)
BNDES Automatic	Biomass-derived renewable energy , particularly those focusing on technological developments with long-term potential.
FINEM	Financing for amounts over $4.6 million to carry out implementation, expansion and modernization projects, including the acquisition of new machinery and equipment domestically manufactured, accredited with BNDES, as well as imports of machinery and associated working capital, carried out directly with BNDES or through accredited financial institutions.
FINAME	Financing, without limit in value, for single acquisition of new domestically manufactured machinery and equipment accredited with BNDES, and associated working capital for micro, small and medium enterprises, through accredited financial institutions.
Agricultural FINAME	Financing, without limit of value, for the acquisition of new domestically manufactured machinery and equipment accredited with BNDES, and destined to the farming sector, accredited with BNDES.
MODERINFRA	To support the development of irrigated agriculture, economically and environmentally sustainable, in order to minimize the risk in production and increase the offer of food for domestic and foreign markets; and to expand the storage capacity of rural properties.
FUNTEC	The Technology Fund [FUNTEC] provides financial support to stimulate the technological development and the innovation of strategic interest for Brazil, in accordance with the public policies and programs of the Federal Government.

Source: BNDES

BNDES also has a number of financing lines that target SMEs specifically and provide financing that could assist SMEs attempting to enter the market for ethanol production. In addition to the financing lines listed above, which possess components directed toward SMEs, BNDES also offers the following lines of financing, which could, theoretically, be devoted to large enterprises, but are more likely reserved for their small and medium-sized counterparts. They are the Export Support program and the Leasing FINAME program and are detailed in Table 3e.

Table 3e: BNDES Funding Programs for SMEs Seeking Entry into Ethanol Production

Export Support	Financing for the export of goods and services through accredited financial institutions, in the following categories: -Pre-shipment: finances the production of goods and services to be exported in specific shipments -Pre-shipment Agile: finances the production of goods associated to an Export Commitment for a period from six to twelve months -Special Pre-shipment: finances the national production of exported goods, without connection to specific shipments, but with a pre-determined period for their execution -Pre-shipment Anchor Company: finances the commercialization of goods produced by micro, small and medium enterprises through the exporting companies (anchor company) -Post-shipment: finances the trade of goods and services abroad, through the refinancing of the exporter, or through the buyer's credit category.
Leasing FINAME	Financing to lesser enterprises, without limit in value, for the acquisition of new domestically manufactured machinery and equipment, accredited with BNDES, for merchant leasing operations. The financing is granted to the lesser enterprise for the acquisition of goods, which will be simultaneously leased to the user enterprise, the lessee.

Source: BNDES

As noted in its literature, BNDES disbursements to "micro, small and medium enterprises reached $5.4 billion. Of this total, $2.6 billion corresponds to disbursements to the FINAME program, $974 million to Agricultural FINAME and $1.3 billion to the line BNDES-Automatic." Banco Bradesco served as the leading financial agent with $1.1 billion to micro, small and medium enterprises. The other four leading financiers were: Banco do Brasil, with $602 million; DaimlerChrysler, with $378 million; Unibanco, with $157 million; and Votorantim, with $32 million.[38]

Apart from BNDES, several regional banks including Banco do Brasil SA, Banco do Nordeste do Brasil SA, Banco da Amazônia SA, and the Regional Development Bank of the Extreme South have separate credit lines devoted to the biofuels and agriculture sectors related to renewable energy. These regional development banks oversee funds directed toward their respective regions, that is, the center-west, northeast, north and southeast regions respectively. The interest rates on these credit lines fall anywhere between 6% and 14% annually, below the benchmark rate of 14.25%. These funds give priority to MSMEs.

The state-level development banks such as the Development Bank of Minas Gerais (BDMG), the State Bank of Rio Grande do Sul (BANRISUL), and the State Bank of São Paulo (BANESPA) focus on funding programs specific to their state territories. As Minas Gerais, Rio Grande do Sul, and São Paulo are major players in the biofuels sector, their respective development banks represent important financing vehicles for ethanol production. BDMG is engaged in the PRONAF funding program aimed at family agriculture. In addition, the bank provides agriculture financing including the acquisition of machines and farming tools as well as expenses related to environmental licensing and technical assistance.[39] Rio Grande do Sul's state bank also offers several financing lines including one within the PRONAF program, as well as lines to finance machines and equipment related to agribusiness.[40]

Coupled with the national, regional, and state-level development banks, one federal ministry in particular has several lines of funding that could be available for ethanol production expansion in the future. The Brazilian Ministry of Science and Technology (MCT) houses the Financial Agent of Studies and Projects (FINEP), its primary funding organ, which is responsible for a set of sectoral funds devoted to research and development. Several of these funds are relevant to biofuels and are discussed more fully in the Innovation section.

At the international level, a number of multilateral organizations and development banks have become involved in Brazil's bioenergy program and, more specifically, ethanol production. These actors include the Inter-American Development Bank (IDB), the World Bank, the United Nations, the United Nations Environment Program (UNEP), and the United Nations Development Program (UNDP). Also included in this group are the development agencies attached to countries such as Germany, Japan, and the United States; they are GTZ, JBIC and the US Agency for International Development (USAID) respectively.

The IDB has created and implemented a number of programs related to ethanol expansion in Brazil. They include:

Support to the Development of the Ethanol Market (Brazil) - $1 million
- To develop a model for a receivables markets for the Agroenergy Program that adapts current operational models in the industrial sector to the needs of ethanol and biodiesel markets.

Financing of MSMES-BNDES (Brazil) - $1 billion
- To support development and modernization of MSMEs in Brazil by providing medium and long term financing to projects making these firms more competitive.

AGROFUTURO (Brazil) - $33 million
- To strengthen capacity of agricultural innovation systems in strategic areas critical to agro and rural development.

Clean Tech Fund (Regional) $995,000
- To improve resources available to renewable energy project developers and sponsors in LAC. Mobilizes more than $20 million in capital commitments from partners including national, bilateral and multilateral banks.

Agricultural Biotechnology in LAC (Regional) - $130,000
- To prepare an issues paper and guidelines for investment and technical guidance for bank lending to agro-biotech research and development.

Renewable Energy, Energy Efficiency, Carbon Finance in LAC (Regional) - $890,000
- To promote renewable energy, energy efficiency, and carbon finance projects in LAC.

Renewable Energy and Energy Efficiency in LAC (Regional) - $1.2 million
- To support increased investment in renewable energy and energy efficiency projects.

While the IDB programs are tailored to Brazil's ethanol industry, the funds from the World Bank and the United Nations entities are not. These funds cover the renewable energy sector more generally or are focused on cogeneration using the sugarcane bagasse.

Key private sector entities involved in the financing of biofuels have been surveyed above, but that discussion did not cover the financing mechanisms available through capital markets and derivative products, most notably the Brazilian securities and futures markets as well as the international carbon credit market. The exchanges available to the private sector domestically include the BOVESPA, an important source of financing for those private sector entities able to stage an initial public offering. A BOVESPA listing allows for the involvement of major domestic and international financial service institutions, which can in turn create the opportunity for creative repackaging and the securitization of collateralized derivative products.

B.5) Gaps and Impediments for Ethanol Capacity Expansion

There are a number of gaps and impediments facing ethanol capacity expansion:

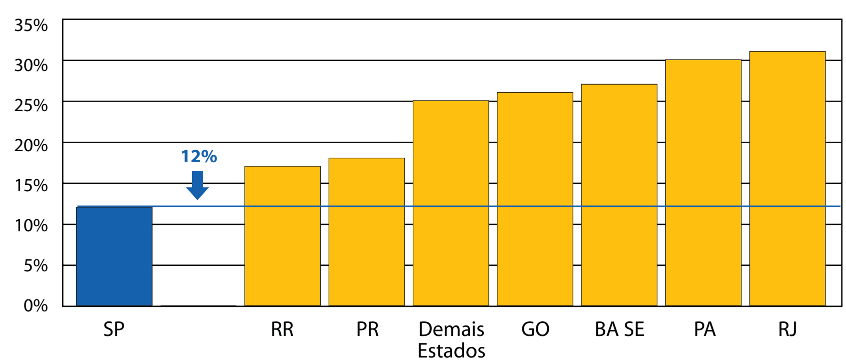
1. New strategies and methods of design for cane expansion and ethanol production are limited.
2. Financing lines to production lack focus, with no national financing lines specifically dedicated to ethanol capacity.
3. Technological innovation is a major bottleneck. Genetic engineering, innovative breeding of cane, process technology, and human-capacity building, particularly in the area of cane processing, all need increased attention (see the Innovation chapter).
4. Infrastructure is lacking both for the export of ethanol and to service new regions (see the Infrastructure chapter).
5. Tax Policies

There is no overall design for private sector expansion of cane cultivation and ethanol production. While the federal government has sponsored a study to define such a blueprint, today's initiatives are generally small-scale at a regional level.

The sugarcane industry is highly concentrated in São Paulo state, specifically the Piracicaba and Ribeirão Preto regions, making it vulnerable to extreme drought or overabundant rainfall. Further, the price of land has been driven up in São Paulo State, changing the economics of greenfield investments there and encouraging expansion into new regions. However, regions suitable for expansion lack the necessary infrastructure and support clusters and may soon be limited by environmental regulations, such as the proposed Cerrado Amendment.

Financing for the industry remains constrained by high interest rates and a lack of dedicated financing lines at BNDES and other financing institutions. Sugar and ethanol producers note that the structure of returns requires credit lines tailored to the industry. At the moment, the principal source of financing for the many new additions – over 50 new projects are expected to come on line shortly – is the private sector. International investment in Brazil's ethanol sector is fairly limited, particularly when compared to the flood of capital entering the relatively inefficient US ethanol industry. Investors interviewed for this report cited a lack of attractive projects and local partners in Brazil, and some called for the industry to incorporate international standards of governance to attract equity capital.

Chart 3d: Brazil: State Level of Tax (ICMS) for Hydrated Ethanol



Source: Sindicom

One of the problems with the expansion of ethanol demand in Brazil is the disequilibrium caused by the federal and state taxes on the product. The federal tax (PIS/COFINS) has discouraged the participation of oil distributors and brokers in the futures market of ethanol. The ICMS state tax creates more significant problems as taxes vary by state, with São Paulo the lowest at 12%. The high level of the ICMS discourages the purchase of flex-fuel vehicles in states where hydrated ethanol is not competitive with gasoline.

C) Biodiesel Capacity Expansion

In contrast to the established ethanol industry, the country's biodiesel program is young. The National Program for the Production and Use of Biodiesel, begun in 2003, is seen not only as a means of contributing to Brazil's energy independence and security, but also as a tool to encourage rural development and family agriculture in the north and northeast.

C-1) Key Issues Surrounding Capacity Expansion for Biodiesel

For the foreseeable future, the capacity expansion of the biodiesel industry will be driven by the ambitious domestic blend targets established by the National Program for the Production and Use of Biodiesel. By 2013, when all diesel fuel in Brazil will be required to have a 5% blend of biodiesel, the country is projected to need 2.4 billion liters, almost double current production. As with ethanol, a number of key issues surround its growth:

a) Social Development Goals;
b) Efficiency gains;
c) Increase in cultivated land; and
d) Augmentation of processing capacity.

The pillars of the program include "social inclusion", "regional development", and "enhanced business opportunities".[41] To this end, the government has implemented a Social Fuel Seal program through which only companies with this approved designation are granted advantages when supplying biodiesel. It may be true that Brazil has yet to fully build out the economic, political, and social parameters that accompany the biodiesel value chain; nonetheless, it has developed two ambitious fuel blend mandates that will drive the industry forward and require considerable capacity expansion.

Social Fuel Seal

Created in 2004, the Social Fuel Seal is given to eligible biodiesel producers that have complied with a series of requirements defined by the Ministry of Agrarian Development, including:

1) buying a minimum amount of their raw materials from family-based farmers; and
2) promoting their social and local inclusion

Only producers awarded the social fuel seal are allowed to participate in periodic purchase auctions organized by the National Agency for Petroleum. In addition, specific producers of palm or castor, with activities in the north and northeast regions of the country, are entitled to extra tax incentives.

The Social Seal Fuel mechanism has made social development a major driver of this industry, and more than 150,000 families, mostly in the north and northeast, have profited from this emerging industry. However, some have argued that even these incentives are insufficient to alleviate the pressure created by other types of taxation.

Brazil has set a target of 2008 for all diesel fuel to be blended at the B2 level (2% biodiesel) and 2013 for a nationwide B5 (5% biodiesel) blend.[42] Based on projected diesel consumption, it is estimated that at least 800 million liters of vegetable oil fuel will be necessary for the B2 mandate, while a total of 2.4 billion liters will be required to meet the B5 target five years later.[43] These fuel blend mandates represent a challenge to the nascent industry, and the public sector has attempted to attract the private sector through various subsidy and investment schemes. In particular, a set of biodiesel auctions, overseen by the National Petroleum Association (ANP), have fostered competition between Social Seal accredited biodiesel producers (small, medium, and large) to provide product, primarily to Petrobras.

The high price offered in the auctions has produced sufficient biodiesel to reach the B2 blend target, but production capacity for the B5 target remains a challenge, especially at the level of quality necessary for the average consumer and at a cost that will convince producers of the commodity's commercial viability. Interviews with biodiesel industry representatives suggest some reluctance to commit further investment to a sector, the profitability of which depends on political commitment, rather than market forces.

Like ethanol, the biodiesel industry can be expected to achieve significant efficiency gains as practical knowledge develops, best practices form, and innovations emerge. Today, for example, there has not been a final determination of the best feedstock for each particular area of the country. The industry has also yet to agree on whether to employ a methyl or ethyl esterification process. Furthermore, the recent development of Petrobras' own-patented H-Bio technology could well revolutionize production in the industry, even at this early stage. Petrobras plans to buy vegetable oil from producers and produce H-Bio at its four refineries.

To maintain the pace of production and ensure that the facilities that have been recently planned come on-stream over the next several years, investments will be necessary not only directly to production, but also to infrastructure and research. Brazil will have to clearly decide which feedstock it intends to rely upon to achieve the 2008 and 2013 targets, and devote investments to the foundational agriculture structures in the northeast.

C-2) Biodiesel Efficiency Gains

As with any new industry, efficiency gains will appear as knowledge accrues and best practices develop both at the plant level and industry wide. As demand for biodiesel climbs, plant capacities will undoubtedly increase, as will cultivation of biodiesel feedstock. The resulting economies of scale will also drive efficiency gains. It is reasonable to expect the Brazilian biodiesel market to follow a trajectory similar to the ethanol market, experiencing declines in production costs over time and as the scale of production increases.

Of the many vegetable oils that may be processed into biodiesel, the top Brazilian choices are soy, which the country grows in abundance, castor and palm oil. While soy is the most obvious choice due to an already well-developed food oil industry, it has a low oil content compared to castor and palm, both of which are cultivable in the northeast and therefore fit well into the family agriculture component of the program.[44] Unfortunately, the human resources and production infrastructure in the northeast are not yet in place for this region alone to produce at a level necessary to reach the 2013 target.[45] On the labor front, basic education for family agricultural producers is lacking, a reality that increases production costs and saps efficiency. Training family producers to operate more proficiently and autonomously will translate to gains for the sector, as is detailed in the education section of the Innovation pillar.

Second-generation technology will also be vital for increasing the yield of biodiesel per hectare. There are initiatives to produce biofuels from residues and different types of vegetable oils as well as waste and other biogases. As knowledge and experience are accumulated, the development and use of this type of technology will expand the sector's growth potential.

C-3) Biodiesel Land Expansion

Any discussion of land availability for biodiesel production must revolve around a decision of what feedstock will be used to produce the fuel. By some counts, there are over 90 species of plants that may serve as raw material feedstock for biodiesel; however, the Ministry of Agriculture, Livestock, and Supply (MAPA), in concert with the Brazil Institute for Agricultural Research (EMBRAPA), has designated 5 species that they consider best qualified: soy, palm, castor, sunflower, and colza. The first four are discussed at length here.

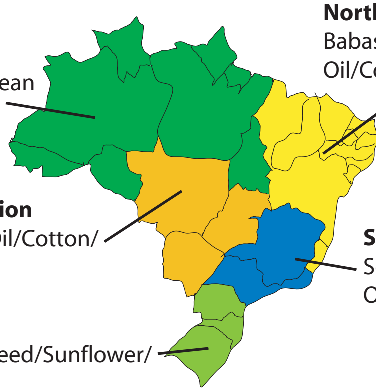
Table 3h: Productivity by Crop (2004)

	Productivity (t/ha)	Oil Content	Cost of Production $/T	Under Cultivation (ha)	Potential Expansion (ha)
Palm	2.2	22%	286	60,000	7,000,000
Soy	2.7	20%	85	23,000,000	20,000,000
Castor	1.2	48%	720	148,000	4,000,000

Source: Created from estimates by Embrapa and Biodiesel Brasil

These species have been chosen because they represent the most oleaginous, most abundant, and best understood from a cultivation standpoint.[46] Each of these species has its own oil-producing characteristics and regional specificities, and their potential will be discussed separately.

Map 3d: Vegetable Oil in Brazil



Source: ABIOVE

C-3.1) Palm

Brazilian palm oil production reached 132,000 tons in the 2004 crop cycle, and expansion of this sector is continuing.[47] Not only is palm oil – dendê, in Portuguese –a multipurpose product, it also may serve as a generator of employment in the Amazon region of Brazil. It is estimated that for every 10 hectares of palm planted, one direct job is created. Palm, like castor, is a hardy plant and requires little in the way of soil fertility or tending – in fact, it tends to adapt to the environment of most rainforest plants quite easily as evidenced not only in the Amazonian rainforests, but also those of Indonesia and Malaysia.[48]

The palm oil industry in Brazil is dominated by Agropalma, which accounted for approximately 72% of production in 2004.[49] The industry is centered in Pará state, in the north, where nearly 52,000 hectares were planted with palm in 2004 and over 120,000 tons of palm oil produced – more than 90% of the industry total. Other palm-growing states include Bahia and Amazonas, which cultivated 5,800 and 1,610 hectares to produce 11,300 and 400 tons of oil, respectively.[50] To incorporate small farmers into the industry, two models are recommended by the GTZ (German international cooperation enterprise) among others: a 10 hectare plantation model for small producers and a 5-6,000 hectare model for large-scale extractors.

Although palm oil represents an ideal driver of the economy in the remote north and a strongly positive energy balance crop that is well suited to biodiesel production, the Brazilian industry lags behind those of Colombia and the Central American states, not to mention world leader Malaysia, which produces approximately 13.8 million tons annually. Palm requires a minimum annual and monthly rainfall of 1,500 milimeters and 120 milimeters, respectively, as well as an average annual temperature between 25 and 28°C.[51] The potential for Brazil to expand its land area for palm plantation is substantial. While by some estimates there are up to 65 million hectares available, when environmental constraints are taken into consideration, the number drops to 7 million. In Amapá, Amazonas, and Pará alone, nearly 3 million hectares of land that have already been deforested were suitable for immediate plantation at the end of 2005.[52]

Despite these benefits and the great potential for land expansion, palm does have some drawbacks. The cultivation cycle is three years and there is no return until year seven. Financing lines would have to be designed specifically for this industry, particularly for small farmers. Agropalma, in collaboration with the state government and the Bank of Amazonas, has an innovative program for 150 families that could serve as a model. The company provides training, seedlings, and infrastructure; the state government provides land; and the Bank of Amazonas finances the participating families with fertilizer and a minimum wage for the first three years. Agropalma is legally obligated to buy 100% of production at 10% of the price of crude palm oil in the EU. Payment goes through the Bank of Amazonas, which takes a 20% cut until the start-up financing is repaid.[53] This cooperative relationship with farmers is especially important because palm oil requires an immediate extraction process within 24 hours of harvesting, requiring extensive collaboration between farmers and refiners.

Palm may represent the strongest biodiesel feedstock in Brazil given its positive energy balance and high oil content. Malaysia and Indonesia have begun to invest heavily in palm as the feedstock of the future, and Brazil may wish to follow this example. Close oversight and extreme care would be necessary, of course, to avoid deforestation of the Amazon.

C-3.2) Soy

Of Brazil's primary oil crops, soy is the leader by a significant margin, and as such, it is believed by some that soy plantations are the only ones large enough to sustain a national biodiesel industry.[54] Approximately 23 million hectares are planted with soy, the production from which is nearly 60 million tons.[55] The primary drawback of biodiesel production from soy is that oil content is just 20%, with soy meal making up the remainder. Because of this, the production of oil is inherently tied to the international protein market.[56] Also, due to external factors, including the international price of soy and the strength of Brazil's exchange rate, investment in the soy industry in Brazil has lagged recently and may limit an expansion in cultivation.

Soy is planted predominantly on plains where large-scale farm machinery has easy access and where there is less than a 20% probability of drought. Soy is harvested in the mid-west, south, southeast, and northeast of Brazil. Five states – Paraná, Mato Grosso, Rio Grande do Sul, Goiás, and São Paulo – drive approximately 80% of the processing capacity. Cultivation of soy has risen steadily in those regions over the past five years, particularly in the mid-west, where soy farming has more than doubled.[57] According to Embrapa, soy cultivation could expand by 20 million hectares. Other estimates claim that available area for soy is just under 100 million hectares.[58]

Soy-based biodiesel is already an important part of the country's biodiesel production and will remain so given its relative abundance, but there are a number of factors that argue against relying exclusively on this feedstock. For one, the increased production of the plant for fuel, given its low oil content, could result in a negative energy balance. There are also environmental risks associated with monoculture. Furthermore, the soybean industry is concentrated in the relatively affluent south and mid-west and is consolidated under large agribusiness, which would not serve the social development goals of the National Biodiesel program.

C-3.3) Castor

According to the Ministry of Mines and Energy, half of future biodiesel production will come from castor.[59] In keeping with the general tenets of the Social Fuel Seal initiative and the push for biodiesel as a driver of social development in rural areas, castor can be grown by small-and large-scale producers alike. Unlike sunflower, palm and soy, demand for castor oil for human consumption is minimal. Castor, known as mamona in Portuguese, is a hardy plant indigenous to the northeast that can be harvested in year-long cycles and requires little tending. In addition, as its cost of production is low, castor is viewed as an ideal feedstock to promote the National Biodiesel Program in the impoverished northeast, with family farmers each cultivating 3 to 4 hectares.

At present, the state of Bahia far outpaces its closest rivals, Mato Grosso and Ceará, with approximately 125,500 hectares of castor, compared to 3,600 hectares and 1,900 hectares, respectively in 2003.[60] According to GTZ, this grew to more than 165,000 hectares by 2005, primarily due to expansion in Bahia.[61] In terms of production per hectare, farmers will generate anywhere between 0.3 and 2 tons per hectare, depending upon the cultivation and harvest process. In terms of available land, the state of Bahia offers an abundance of unfarmed territory for castor plantation, but it does not come without risks. The northeast is subject to great variability in the amount of rainfall, and as a result, large-scale investment in castor cultivation is perceived as higher risk.[62]

The feedstock itself also suffers several drawbacks. For one, the oil produced from castor is highly viscous and cannot be mixed well with other vegetable oils in the production of biodiesel. All parts of the plant are toxic if ingested.[63] Furthermore, the production and cultivation infrastructure is poor, and the price for castor oil is low if not subsidized by the federal government. Finally, there is still some doubt about castor's relative energy balance.[64] These drawbacks notwithstanding, rural development is a central aim of the government biodiesel initiative and with appropriate subsidies and technological developments castor may still emerge as a sustainable and even profitable feedstock.

C-3.4) Summary

Each of these crops has strengths and weaknesses with respect to the twin goals of producing sufficient feedstock for a B5 blend by 2013 and encouraging rural development through the incorporation of family farmers into the value chain. The logical strategy is not to pick a single feedstock, but to develop distinct strategies for different regions of the country. Further study to assess the feasibility of these and alternative feedstock is needed, as is investment in the development of new technologies and best practices. Embrapa has proposed the matrix below for the progressive growth of domestically produced biodiesel.

Table 3g: Proposed Geographic Distribution of Biodiesel Production

Region	Feedstock	Hectares for B5	Hectares for B10
South	Soy	600 thousand	1.2 million
South East	Soy	1.3 million	2.6 million
North East	Castor	600 thousand	1.2 million
North	Palm	36 thousand	72 thousand
Mid West	Soy	360 thousand	720 thousand
Brazil		2.9 million	5.8 million

Source: Embrapa

C-3.5) Environment

As with ethanol, there are environmental constraints and risks associated with the large-scale expansion of biodiesel production. Most of the regulatory limitations pertaining to ethanol may also apply to biodiesel production expansion, with exceptions made for the different growth regions. The Ministry of Environment (MMA) is the main government body overseeing environmental regulations and will play a considerable role in the expansion of the biodiesel industry.

The MMA is expected to become increasingly involved in the issues surrounding GMO crops for biodiesel production, such as research and development into the improvement of yield per hectare. The MMA has appeared repeatedly before Congress to present perspectives on GMO studies in relation to other crops. In fact, private sector demand for a clear regulatory framework on this issue has been so strong that the government has approved a new regulation stipulating federal guidelines and procedures for genetic experiments on non-GMO crops. So far, research on GMO soy has been approved. However, if the industry is seriously committed to increasing the current yield per hectare through the planting of GMO crops, it will be important to follow any future regulatory developments closely.

The MMA is also tasked with making policy for environmental protection areas, of which Brazil possesses extensive tracts. In early 2006, the government launched the National Plan for a Sustainable Amazon (PAS), a set of guidelines and public policies aimed at developing the Amazon Region while abiding by strong environmental standards, as part of a larger program to promote environmentally responsible growth throughout the country. For its part, the Cerrado Amendment would cover much of the land suitable for the growth of biodiesel feedstock, particularly soy in the mid-west and castor in Mato Grosso.

Other risks in the expansion of biodiesel production vary by feedstock. For soy, there are concerns that São Paulo State may become overly farmed and its soil exhausted. A significant expansion of palm, without close oversight, could increase the deforestation of protected Amazonian reserves. However, at this stage, there are at least 3 million hectares of already deforested lands that could accommodate a palm oil expansion. Finally, castor seed cultivation, especially in Bahia State, appears to carry no major environmental risks. The land itself is already arid and dry, and protected land is a non-issue in this region. Because mechanization of castor production is so limited, soil erosion and exhaustion are also not considered issues.

C-4) Ethanol: Private Sector Investment and Access to Capital

The National Program for the Production and Utilization of Biodiesel offers financial incentives and tax incentives to attract private sector participation. In particular, the federal government has attempted to create an auction mechanism whereby a given volume of biodiesel is placed on offer, and private sector producers compete to supply their product, generally to Petrobras or REFAP (a joint venture between Petrobras and REPSOL of Spain). As with the ethanol industry, but on a much smaller scale, the success of the national biodiesel initiative will hinge on the willingness and capital resources of private sector producers.

C-4.1) Current Situation

At present, private sector involvement in the biodiesel auctions depends upon the company's achievement of the Social Fuel Seal from the Ministry of Agrarian Development (MDA). This requires that producers purchase a percentage of their oil from family farmers, with specific requirements and subsidies varying by region and feedstock. At the end of 2005, 10 of 20 private producers had achieved the Social Fuel Seal from the MDA, but only 5 gained permission from the National Petroleum Association to sell the fuel in its periodic biodiesel auctions.[65] That number has since increased to 8 firms listed below in order of their authorized capacity to supply:

Table 3i: Biodiesel Producer Capacity

Firm	Authorized Capacity *(L/day)*	Annual Capacity *(103 L/yr)*
Granol	333	100,000
Brasil Biodiesel	92	27,600
Agropalma	80	24,000
Soyminas	40	12,000
Bolix	30	9,000
Fertibom	20	6,000
Renobras	20	6,000
NUTEC	2.4	720

Source: ANP[66]

Of this group, only Brazil Biodiesel refines castor oil from rural farmers in the northeast, site of the largest government incentives.

Table 3j: Federal Tax Incentives

Tax Incentive	Biodiesel				Regular Diesel
	Subsistence Agriculture: North, Northeast regions w/castor or palm	Subsistence Agriculture	Medium-Large Farmers: North, Northeast regions w/ castor or palm	All Others	
IPI	full exemption	full exemption	full exemption	full exemption	full exemption
CIDE	full exemption	full exemption	full exemption	full exemption	0.07
PIS/COFINS	100% reduction (R$ 0.000)	68% reduction (R$ 0.070)	32% reduction (R$ 0.151)	0.218	0.148
Federal Tax sum	100% reduction (R$ 0.000)	68% reduction (R$ 0.070)	32% reduction (R$ 0.151)	0.218	0.148

Source: Government of Brazil, Executive Orders # 5,297/04, 5,298/04 and 5,457/05.[67]

The most recent ANP auctions allowed producers awaiting their Social Fuel Seal to participate, including smaller-scale producers such as Agrosoja, Barrálcool, Biominas, BsBios, Caramuru, Fiagril, and Oleoplan.

The current supply chain of biodiesel from field-to-vehicle contains a limited number of private-sector participants. Biodiesel producers with the Social Fuel Seal purchase a contracted amount of feedstock – either castor, soy, palm, canola, or sunflower – from farmers, though there is often a middle man who facilitates the sale of feedstock between local farmers and the oil refiner. Those producers who have been given the Social Fuel Seal and authorized by ANP to participate in biodiesel auctions may then submit their product to be bid upon by distributors of the fuel. In the first four auctions, the only two distributors bidding were Petrobras (the national oil company) and REFAP. These distributors then transport and store the biodiesel product via the national distributor. Transpetro brings the product to the pump, where Petrobras and REFAP branded stations supply the fuel to vehicles.

It has recently been announced that fuel distributors Ipiranga and AleSat have joined the biodiesel supply chain, thereby increasing the involvement of the private sector and enhancing competition.[68] In addition, entities such as Usina Cassia, USP-Ribeirão, and Agropalma perform some distributing of their own. Recent entrants into production have been large-scale operators such as Bunge, ADM, and Cargill who either intend to build plants or have already done so. Opportunities for other firms, especially

SMEs, to enter the direct production chain are limited at this stage to the refining and processing stage. The third and fourth auctions for biodiesel witnessed smaller-scale firms competing alongside their large-scale counterparts and successfully selling their product.

It is worth discussing the role of Petrobras further to fully explain its presence in the biodiesel sector. Petrobras was the sole large-scale distributor until the July 2006 entries by Ipiranga and AleSat.[69] In addition, Petrobras' role in creating biodiesel-ready transport, storage, and supply stations is central to the sector. In an interesting twist, Petrobras announced in May 2006 the development of a new type of diesel, H-Bio, in a further effort to steer away from fossil fuel imports. It has yet to be seen whether H-Bio, a combination process with hydrogen, vegetable and mineral oils, will adversely affect the current biodiesel program by crowding out producers or limiting the production process itself. According to Petrobras, H-Bio will not disrupt the biodiesel production chain.[70]

Other large enterprises with participation in the sector include commodities-related associations such as the Brazilian Association of the Vegetable Oil Industry (ABIOVE), which lobbies for benefits on behalf of its members, and Abiodiesel.[71] As the industry grows, these private associations will likely play an increasing role.

C-4.2) Small and Medium Enterprises

The participation of small and medium enterprises (SMEs) in the biodiesel production chain is limited to direct production. However, as the pace of investment quickens within the sector, more space will emerge for SMEs to participate, and a number of support programs exist to encourage their involvement. These programs support SME financially as well as logistically and are managed by the Brazilian Agency of Support for Entrepreneurs and Small Businesses (SEBRAE), certain banks, and state governments.

SEBRAE has resources both on the state and federal level for SMEs, especially those seeking start-up financing and human resource training. At the national level, programs exist in affiliation with agencies of the national government such as the FINEP in the MCT to finance small-business start-up and technological innovation. Other programs facilitate SMEs that function with a socially responsible model and are energy efficient in their operations, ideal for an SME in the northeast looking to enter into biodiesel production. The national programs of SEBRAE also provide educational tools for SMEs such as online libraries, curricula, and business development models.[72] At the state level, SEBRAE has programs which operate in states crucial to the biodiesel supply chain such as São Paulo, Goiás, Mato Grosso, Minas Gerais, Bahia, Amazonas and Pará.

The Brazilian government has several other policies and programs to support SMEs. The Statute of Micro and Small Enterprises seeks to establish a legal framework for small businesses, while two legislative policies, FACÍL and O SIMPLES, provide ways to speed the entry of SMEs into particular sectors. FACÍL attempts to increase the speed with which a small business is registered in the country. SIMPLES, a single tax for small companies, attempts to reduce the tax on small businesses and simplify bureaucratic processes. National and private sector bank programs that provide financing for SMEs will be discussed in the following section.

C-4.3) Pace of Investment Expansion

Since the initiation of the National Program for the Production and Use of Biodiesel, investment in biodiesel capacity expansion has been strong. In 2005, four new biodiesel plants were inaugurated. Early entrants include Soyminas, Agropalma, Biolix, and Brasil Biodiesel. However, these firms have been joined more recently by a larger group of producers, both large and medium, which have begun to generate some industry competition.

While exact investment dollar amounts are not readily available for 2006, it is known that over $130 million in investment has gone into biodiesel production facilities in Brazil. An even stronger indicator of expanding investment in the biodiesel industry over the past year is the auction statistics from ANP. The first ANP auction, held in November 2005, generated a purchase of 70 million liters of biodiesel fuel. Eight producers participated in the auction, of whom four were selected; 92.5 million liters were put on offer. Just eight months later, 11 additional firms were able to compete in the third and fourth auctions, with 1.27 billion liters offered and 600 million liters purchased. This suggests that the pace of expansion has been intense in the last 18 months and that a 2013 target of 2.4 billion liters is within reach.

Furthermore, some of the larger multinational firms with the capacity to process and refine vegetable oil into biodiesel have factories coming on-stream and will likely enter the market soon. Examples of these multinationals include Archer Daniels Midland (ADM), Bunge and Cargill. Of the trio, ADM announced its first biodiesel plant in Rondonopolis, Mato Grosso, which will open with an annual capacity of 180,000 tons in 2007. Bunge and Cargill will likely follow if the market potential stays strong.

Table 3j: Summary of Biodiesel Projects

Region	State	Municipality	Company	Capacity *(Liters/Year)*	Raw Material	Status
N	PA	Belém	AGROPALMA	8,000,000	Palm	Complete
	RN	Guamare	PETROBRAS	520,000	Castor	Complete
NE	CE	Fortaleza	TECBIO	650,000	Castor	Complete
	PI	Teresina	Brasil Ecodiesel	730,000	Castor	Complete
		Floriano	Brasil Ecodiesel	25,000,000		
	BA	Ilhéus	Univ. Sta. Cruz	460,000	Castor	Complete
		Luís E . Magalhães	DA GRIS	13,000,000	Cotton, Sunflower, Castor	Complete
CO	MT	Cuiabá	ECOMAT	8,000,000	Soy, Sunflower	No Forecast
		Dom Aquino	ADEQUIN - BIOBRAS	6,000,000	Soy, Sunflower, Turnip	Complete
SE	PR	Rolándia	Biolix -BIOBRAS	6,000,000	Soy, Sunflower, Turnip	Complete
	MG	Iguatama	AGRODIESEL	3,000,000	Soy, Sunflower, Turnip	Complete
		Barbacena	FUSERMANN	3,000,000		Complete
		Cassua	SOYMINAS	12,000,000		Complete
		Itatiaiucu, Itauna e Pitangui	BIOMINAS	20,000,000	Sunflower	Complete
	RJ	Rio de Janeiro	COPPE/UFRJ	620,000	Used Oil	Complete
	SP	Ribeirão Preio	USP	n/c	N/A	Complete
		Charqueadas	PETROCAP	25,000,000	Residues from metal, Soy Oil, and other animal and vegetable oil industries	Complete
		Catanduva	FERTIBOM	7,000,000	Various	No Forecast
		Campinas	Ceralit-BI OBRÁS	3,000,000	Soy, Sunflower, Turnip	Complete

Source: COPPE

The international excitement surrounding ethanol in Brazil has, to some degree, bled over into the biodiesel market. In particular, the $640 million Fund of Investments in Bioenergy, developed jointly by PTZ Bioenergy of Brazil and Holland's BTG Biomass Technology, will also invest in biodiesel production throughout Brazil.[73] Furthermore, a portion of the $550 million investment by Japan's Bank of International Cooperation (JBIC) will be directed to biodiesel production.[74]

C-4.4) Financing Lines Available

Because biodiesel production is a national initiative, a variety of financing lines and capital sources exist, especially for rural farmers seeking to plant feedstock such as castor and sell it to production companies with a Social Fuel Seal. As is discussed below, the National Development Bank of Brazil (BNDES) offers several funds and financing programs. Several other banks including Banco do Brasil, Banco da Amazônia, and Banco do Nordeste do Brasil also support biodiesel production via the national program.

Alongside the national and state-level programs which are listed below, are a number of programs established by multilateral institutions. Most of these cater to bioenergy generally and are discussed in the ethanol section of this chapter. Similarly, private initiatives for biodiesel tend to overlap with those described for ethanol. As of yet, there are no biodiesel-specific investment funds in Brazil. As with ethanol, financial exchanges and capital markets could finance the capacity expansion of Brazil's biodiesel industry. The BOVESPA and the developing international carbon credit market are all potential sources of finance for private sector firms.

Specific to biodiesel, the Brazilian government announced the initiation of the National Farming Program, designed to provide $42 million in loans to finance approximately 17,000 families engaged in the cultivation of biodiesel feedstock. Alongside this federal program are a number of BNDES programs that are biodiesel specific.

BNDES also has financing lines that target SMEs specifically and provide capital access to those businesses seeking to enter the production space. In addition to the financing lines listed above, which possess components directed towards SMEs, BNDES also offers the following financing lines, which could in theory support large enterprises, but are more likely reserved for their small and medium counterparts:

Table 3k: BNDES Funding Programs for SMEs Seeking Entry into Biodiesel Production[75]

BExport Support	Financing for the export of goods and services through accredited financial institutions, in the following categories: -Pre-shipment: finances the production of goods and services to be exported in specific shipments -Pre-shipment Agile: finances the production of goods associated to an Export Commitment for a period from six to twelve months -Special Pre-shipment: finances the national production of exported goods, without connection to specific shipments, but with a pre-determined period for their execution -Pre-shipment Anchor Company: finances the commercialization of goods produced by micro, small and medium enterprises through the exporting companies (anchor company) -Post-shipment: finances the trade of goods and services abroad, through the refinancing of the exporter, or through the buyer's credit category.
Leasing FINAME	Financing to lessor enterprises, without limit in value, for the acquisition of new domestically manufactured machinery and equipment, accredited with BNDES, for merchant leasing operations. The financing is granted to the lessor enterprise for the acquisition of goods, which will be simultaneously leased to the user enterprise, the lessee.

Source: BNDES

Table 3l: BNDES Financing Lines Specific to Biodiesel Production

BNDES Automatic	Biomass-derived renewable energy, particularly those focusing on technological developments with long-term potential
FINEM	Financing for amounts over $4.6 million to carry out implementation, expansion and modernization projects, including the acquisition of new machinery and equipment domestically manufactured, accredited with BNDES, as well as imports of machinery and associated working capital, carried out directly with BNDES or through accredited financial institutions.
FINAME	Financing, without limit in value, for single acquisition of new domestically manufactured machinery and equipment accredited with BNDES, and associated working capital for micro, small and medium enterprises, through accredited financial institutions.
Agricultural FINAME	Financing, without limit of value, for the acquisition of new domestically manufactured machinery and equipment accredited with BNDES, and destined to the farming sector, accredited with BNDES.
Financial Support Program for Biodiesel Investments (Probiodiesel)	Invests in all phases of biodiesel production (agricultural phase, crude oil production, biodiesel production, warehousing, logistics and equipment for biodiesel production), future destination of biodiesel product must be revealed; Supports acquisition of registered machines and equipment for the biodiesel or crude vegetable oil use; Supports investments that will benefit biodiesel co-products and sub-products. Financing lines come from FINAME, Agricultural FINAME and Leasing FINAME, through the Ministry of Mines and Energy. The programs will offer loans for up to 80.0% of the total project cost. Payments will begin six months after the loan has been issued, and the loan will mature in 12 years. There are currently seven projects approved for Probiodiesel.
Program for the Refinancing of Agricultural Inputs	To finance the acquisition of Rural Product Financial Bonds [CPRF] and/or refinance other representative bonds of producers or their cooperatives, with suppliers of farming inputs, related to the cotton, rice, apple, manioc, corn, sorghum, soy and wheat cultures, referring to the 2004/2005 and/or 2005/2006 crops.
Special Agricultural Financing Program	Financing for the acquisition of irrigation systems; mechanic milking machines, milk refrigeration and homogenization tanks; machines and equipment; seed processing units; processing or industrialization of other farming products that are not included in this item; aircrafts of agricultural use accredited by BNDES.
Social Fund	Constituted with part of BNDES's annual profits, it supports social nature projects on the areas of: job and income generation, urban services, health, education and sports, justice, nutrition, dwelling, environment, rural development and other connected to regional and social development, and of cultural nature.
MODERAGRO	The Program has the objective of stimulating soil correction, restoring degraded cultivated pasture areas and systematizing low lands, aiming at increasing the production of grains. In the South Region States it is also accepted the restoration of native pasture areas. acquisition, transport, application and incorporation of correctives (limestone, plaster and others);
MODERINFRA	Supports the development of irrigated agriculture, economically and environmentally sustainable, in order to minimize the risk in production and increase the offer of food for domestic and foreign markets; and expands the storage capacity of rural properties.
FUNTEC	The Technology Fund [FUNTEC] provides financial support to stimulate the technological development and the innovation of strategic interest for Brazil, in accordance with the public policies and programs of the Federal Government.

Source: BNDES

As part of the national biodiesel program, several regional banks also have programs designed to encourage biodiesel production directly. They are listed below:

⚜ **Banco do Brasil**
⚜ **BB Biodiesel**

- This program supports the production, commercialization and use of biodiesel with the source of renewable energy. The assistance to the production sector will be made by the disbursement of financing lines for cost, investment and commercialization, collaborating for the expansion of processing of biodiesel in the country, to support feedstock development, plant installation and commercialization.
- Benefits agricultural production, with funding credit rural agricultural producers and business. In industrialization, BNDES Biodiesel, PRONAF, PRODECOOP, Credito Agroindustrial, are lines for the industrial sector. Principal criteria to be considered is a guarantee of production of farming for biodiesel.

⚜ **Garantia de Preços Agropecuários – GPA**

- Program of support for commerical farming wiht a use of machines and tools of the protection from prices of commodities and national and international futures markets. The Futures market can be joined with BB CPR and Credito Rural to make additional gains and protect prices for the farmers.

⚜ **Banco da Amazonia**
⚜ FNO-AgroIndustria

- Finances all goods and services necessary for planting, modernization, environment or relocation of agroindustrial business in the North region. Finances agroindustries which turn raw materials into products used in industry.
- Finances investments in products and services necessary to obtain reduction in electrical energy in business. Finances investments that guarantee self-sufficient energy generation.

⚜ **Banco do Nordeste do Brasil FNE VERDE:**
⚜ **Financiamento à Conservação e Controle do Meio Ambiente**

- Supports actions to protect environment and productive activities which limit environmental damage. Fixed investments and semi-fixed related to environmental protection such as recomposition of degraded areas, pollution control, and recomposition of forests. Elaboration of studies and reports of environmental impact.
- Generation of alternative energy. Rural producers, cooperatives and businesses are eligible. Funds come from Fundo Constitucional de Financiamento do Nordeste (FNE).
- Investments fixed and mixed up to 12 years.

C-5) Gaps and Impediments to Biodiesel Expansion

Brazil has the natural resources and political commitment to meet its goal of expanding biodiesel production to meet the 2013 target of a B5 blend, but to accomplish this, key hurdles will need to be overcome, including:

1. Limitations in existing technology;
2. Unstable supply of feedstock;
3. Lack of guarantees;
4. Insufficient financing, especially for family agriculture.

The first two challenges are closely related. As with any new industry, the efficiency and expansion of biodiesel production is constrained by a lack of know-how. While soy and palm are established industries in Brazil, castor has never before been widely cultivated, and optimized techniques for care and harvesting have not been developed. This is evidenced by the wide range of yields already found in the northeast (between 0.3 and 2 tons per hectare), depending on the process used. Further, additional feedstock crops like Jatropha are under study and if selected, will require the development of optimal techniques of production and training for farmers. The process of developing know-how is one that occurs naturally over time, but the combined efforts of the government, private sector, and research institutions could accelerate the process dramatically.

The related second challenge is the instability of supply, which has prompted biodiesel producers Granol and Soyminas to speak out.[76] While there is new technology that can produce biodiesel from any feedstock, it is not yet widespread. Conventional technology employed by most firms requires that the plant and processes be structured around one feedstock. This reliance leaves producers vulnerable and discourages investment. Technological innovation in plants, as well as improved productive techniques in agriculture, could greatly reduce this vulnerability.

The third challenge, a lack of guarantees, derives from the structure of the biodiesel program. Biodiesel production around the world is dependent on government support to be commercially viable, but the choice that Brazil has made to include a rural development component in its strategy further decreases the competitiveness of the industry. Auctions, which offer above-market prices, are a short-term solution to this problem, but they do not provide the private sector with any long term guarantees. This heavy dependence on the political will of the Brazilian government to maintain the auctions and their pricing structure is a disincentive to further investment. This is not to argue against the family farming component of the program, but rather to point out that its inclusion requires long-term government commitments to offset the efficiency lost in this model.

Finally, there is insufficient financing available for the expansion of the industry, particularly to local farmers in the north and northeast. While programs and financing lines exist, they are still functioning on a small scale. As detailed earlier, palm production is a special case because of the seven-year time horizon before returns are captured. While this case is extreme, all family production will require start-up financing, not just to acquire the necessary land and materials, but to ensure an income to families until the project becomes profitable. An added but by no means insurmountable challenge is the support that must also be given to help new producers integrate into the formal banking system.

In addition to these challenges, there are two principal risks to the biodiesel program associated with the market price of oil and vegetable oil. Biodiesel is not nearly as equipped as ethanol to weather a significant drop in oil prices. There could be political pressure on the Brazilian government to decrease the mandated blend, which would leave producers with no guaranteed demand in a market in which they cannot hope to compete. Supply is also vulnerable to changing global commodity prices. If the price of soy or palm oil rose dramatically, it would impact the availability and cost of these feedstocks and the supply of biodiesel in the Brazilian market. This scenario is not unlike what occurred in the ethanol market in the late 1980s, and it merits planning.

D) Conclusion

Brazil's potential for capacity expansion makes it unique among biofuels producers. Technology and land availability are the primary constraints to significant integration of biofuels into global transport fuels consumption. Both factors restrict the supply of biofuels and negatively impact their price competitiveness with fossil fuels. Technological innovation, particularly the advent of next-generation biofuels like cellulosic ethanol could dramatically reduce the cost of production, increase yield per hectare, and allow for the use of marginal land. However, the scientific breakthroughs necessary to make cellulosic technology commercially viable may be 10 to 20 years away. Land availability, the demand for which could be reduced through technological innovation, is and will remain the critical factor for agriculturally derived fuels.

There is a mismatch between those nations suited to produce biofuels and those expected to drive consumption. Countries around the world are implementing domestic agroenergy programs, but many, particularly those that are highly industrialized or have limited arable land, will not be able to meet local demand with local production.

For example, both the US and the EU would have to dedicate approximately 20% of their arable land to biofuels to meet a 5% blend target in biodiesel and ethanol. In Asia, Japan is considering increasing its ethanol blend to 10%, which would create a 6 billion liter a year market. In China, an effort to reduce car pollution is expected to produce an 11 billion liter shortfall in biofuels by 2020, despite significant increases in domestic production. Brazil stands at the forefront of potential biofuels exporters, with vast expanses of available, arable low-cost land and cutting edge technology and production practices. The challenge is to build on these competitive advantages and maximize the contribution biofuels production can make to the national economy.

Brazil is already the world's leading exporter of ethanol, accounting for just over 50% of total trade in 2005 and is expanding capacity to meet global demand. In contrast, the relatively young biodiesel industry is focused on expanding to meet ambitious domestic blend targets of B3 in 2008 and B5 in 2013. The two industries share three key variables affecting their growth: the impact of efficiency gains, the availability of suitable land (including environmental constraints), and access to financing, particularly private capital. In addition, the biodiesel industry has social development aspects that will shape its growth. While the challenges are conceptually similar, the current position of the two industries argues for addressing them separately.

D-1) Ethanol

There is consensus in Brazil that the country will need to triple current capacity of 16 billion liters a year by 2020 to accommodate internal demand and position itself as the global market leader. This would mean a total capacity of 48 billion liters, to be achieved through a combination of efficiency gains and greenfield projects. To date, expansion in sugarcane production has been almost entirely driven by efficiency gains through intensive research into the sugarcane genome, the development of varietals resistant to disease and pests and with a high sugar content, and the optimization of agricultural and processing techniques. If this trend continues as expected, yield per hectare could increase approximately 50% by 2020, even without cellulosic technology, which could become commercially viable in this timeframe.

By the end of 2005, 6 million hectares were under cane cultivation. This is just 0.6% of arable land in Brazil and only about half of this is dedicated to ethanol production, with the remainder going to sugar. According to a study commissioned by the Brazilian government, there are an estimated 7.9 million hectares of land available that would produce well above the national average. An additional 113 million hectares would produce at the national average. The primary constraints on expanding production are environmental issues, infrastructure, and supporting industries. Today, sugarcane production is concentrated in Sao Paulo state and a cluster in the north of the country. High land prices in Sao Paulo have pushed greenfield projects further afield. Much of the land identified as ideal for sugarcane plantation is located in Brazil's vast grassland, the Cerrado. A bill under consideration in the legislature would restrict agriculture in this region and will be an important variable. Further, as expansion occurs in new regions, the supporting infrastructure and related industries will need to accompany it, suggesting that expansion should be strategic, supported by the government through financing and infrastructure projects to facilitate export.

Investment in capacity expansion is also an issue. $10.5 billion has reportedly been committed to greenfield projects through 2010 and industry leaders report that there is no lack of investment funds for the industry. Yet the pace of investment in Brazil is slower than in the US, and international investors consulted for this report cited a lack of good investment opportunities and partners in an industry that has historically been dominated by traditional family businesses. Market leader Cosan's IPO this year is an excellent example of how the industry could modernize and tap into international capital markets, rather than depend on loans in Brazil's high interest rate environment. There is also a strong argument in favor of a new approach to ethanol production that is divorced from the sugar industry – a true agroenergy business that would integrate biodiesel and ethanol to create entirely self-sufficient productive environments geared exclusively to biofuels export. There is already a trend in Brazil among new mills to focus solely on ethanol, rather than employ turnkey technology that allows the refinery to switch between sugar and ethanol production depending on the market price, a practice that has put supplies in jeopardy in the past.

The optimal strategy for capacity expansion in ethanol is one that is seamlessly integrated with investment in infrastructure and innovation and the development of global markets. For ethanol, it is the global market that is driving the expansion, and as such, global demand and global capital should be engaged whenever possible. The biggest incentive to increased capacity utilization would be solid assurances of markets abroad. Ideally, existing research could be employed by the government, in coordination with the private sector, to zone the country, identify the ideal areas for capacity expansion, and encourage the development of production clusters, with supporting infrastructure, education and research centers. The whole industry is a potentially high-payoff development initiative, with important second generation effects on human capital development, new business, and broader use of new infrastructure. A modern agroenergy cluster, with integrated biodiesel/ethanol facilities and supporting small businesses, infrastructure, and training would be an anchor and driver of development, with tremendous knock on effects down the road. The IDB could provide:

1. Technical support and financing for this zoning effort, including involvement of the MMA so that environmental constraints can be considered from the start.
2. Dedicated competitively-priced financing lines and guarantees for the acquisition of land and equipment.
3. Specialized financing lines and investment strategies for SMEs to establish support enterprises.
4. A program to develop private sector transparency to encourage foreign participation, taking the Cosan IPO as a model.

D-2) Biodiesel

Biodiesel is still finding its feet in Brazil. In addition to being a relatively new priority (the National Program for the Production and Use of Biodiesel was only created in 2003), the industry has characteristics and objectives quite distinct from ethanol.

First, it is oriented to the domestic market and is not conceived of as a significant export industry in the medium term. Domestic fuel blending targets, mandated by the National Program, constitute the essential demand base for the product. Major expansion of feedstock crop production and refining capacity will be necessary simply to meet the National Program's 2013 target of a B5 blend, which translates to an annual production of 2.4 billion liters of biodiesel.

Second, biodiesel does not have an obvious feedstock source in Brazil, such as sugarcane provides for ethanol. Several crops are suitable for biodiesel production and are being evaluated by the government based on their yields, cost of production, availability of suitable land, and contribution to the government's rural development goals. Each has its pluses and minuses. Soy is a highly developed industry in Brazil and is suitable for large-scale production. It is the cheapest source of oil for biodiesel, but only because soy meal, which represents nearly 80% of production, is also a marketable commodity. The expansion of soy is thus tied to the international protein market. This parallel demand structure imposes a constraint that must be considered in expanding soy production.

Palm is considered an ideal feedstock for biodiesel, given its strongly positive energy balance, high oil content, hardiness, and suitability for large-scale production. Its major drawback is the length of the production cycle (three years to the first harvest), which means high start-up costs and the need for specially targeted financing, especially for family farmers. Finally, castor is being seriously considered for production in the northeast, where it is an indigenous crop. The Ministry of Mines and Energy estimates that half of future biodiesel production will come from castor. Like palm, it is a hardy plant with potential to employ family farmers. Unlike with palm, however, there is no parallel demand for human consumption, so price instability due to competitive uses is not a factor. However, castor also has numerous drawbacks. Current yields are low and highly variable, production and cultivation technology is poor, and castor does not mix well with other vegetable oils in the production of biofuels.

Given these variables, Brazil has wisely chosen to avoid dependence on any one feedstock. However, it has yet to fully zone the country for biodiesel production or implement a coherent strategy for the industry's expansion. A decisive determination of the feedstock it intends to foster, and where, will be essential to meeting the blending targets.

Third, biodiesel is a critical element in achieving the country's rural development goals. The government in 2004 instituted the Social Fuel Seal to encourage biodiesel producers to support agrarian development by buying a minimum amount of their raw materials from family-based farmers and promoting their social and local inclusion. The Social Fuel Seal has been a requirement for participating in biodiesel auctions (the main marketing vehicle) overseen by the National Petroleum Association. The high subsidized prices offered at the auctions have been enabled the government to reach its B2 blending target for 2008. However, there is no long term guarantee that these above-market prices will be maintained, a clear disincentive to any major expansion of private sector investment.

Finally, there are environmental considerations. These include the possibility of overfarming in the south, invasion of Amazon lands for production of palm oil, and the possibility that the Cerrado Amendment could drastically restrict feedstock production in a large area of the country.

Despite these uncertainties, the number of firms participating in the biodiesel sector is growing. Private fuel distributors Ipiranga and AleSat have joined the biodiesel distribution chain and large-scale operators such as Bunge, Cargill and ADM are entering the market. Smaller scale firms have also begun participating in the auctions. More robust growth will stimulate efficiency gains as practical experience develops, best practices form, and innovations emerge.

A number of steps could be taken by the Brazilian Government and the IDB that would speed the process of innovation and capital investment needed to put the industry on a sound footing. As with ethanol, a strategy for capacity expansion will be most successful if integrated into an overarching strategy that includes infrastructure and innovation projects to facilitate production and distribution and develop improved varietals and production methods. What is needed is a macro-level blueprint which would:

1. Identify appropriate zones for the production of each feedstock, with an eye to closely coordinating environmental and development objectives, particularly in regions like the Cerrado where expansion may be constrained by restrictions on GMO use, and identify resource requirements.
2. In coordination with a well financed research program to improve yields and farming practices, develop a program for the identification and creation of vertically integrated production centers, particularly in the northeast, that would address the interrelated needs for small farmer financing, extension services in best agricultural practices, small- scale infrastructure development and investment financing for refineries.
3. Institute a marketing system that will give biodiesel producers more stable long-term price assurances to limit downside risks.
4. Provide incentives to joint ventures, such as concessionary loan financing, that will leverage equity investment and stimulate technology transfer from countries with more experience in biodiesel production.
5. Greater coordination among lending agencies at the various levels of government to maximize the impact of available resources and establishment of a specific credit lines to finance biodiesel production, including resources targeted to SMEs.

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PILLAR III: INFRASTRUCTURE & LOGISTICS

4. PILLAR III: INFRASTRUCTURE & LOGISTICS

A) Introduction

The importance of infrastructure and logistics in the large-scale development of the Brazilian biofuels industry cannot be overstated. The "Brazil cost" of moving goods within the country is a well-known and long-lamented barrier to effective business operations. As Brazil develops a strategy to maintain its position as the global leader in biofuels and meet a projected surge in export demand, addressing both the inadequacies in current infrastructure and the need for infrastructure expansion is essential.

The high costs imposed by insufficient and poorly maintained infrastructure could handicap Brazil's competitiveness on global markets, and getting to market at all is by no means guaranteed. The Brazilian biofuels industry developed for domestic markets, and the infrastructure supporting it reflects that orientation.

What is now required is a dual focus: looking into Brazil to facilitate the growth of the biofuels industry in underdeveloped regions and looking outward to develop the capacity and agility of export infrastructure so that production reaches ports for export.

The three component parts of the biofuels infrastructure in Brazil are:

A) Power
B) Transport, Storage and Distribution Logistics; and
C) Communications

Taken together, these components facilitate the production and distribution of ethanol and biodiesel products from factory to pump and from field to vehicle.

The first, *power* is needed at all stages of the infrastructure chain, and especially at the production stage (where cogeneration can create a self-sufficient production environment). Power is also needed for storage tanks, holding facilities and containers during transportation, and at stations with automated pumps dedicated to ethanol and biodiesel. There is some concern that Brazil will perhaps within as few as three or four years lack the power generation capacity required to maintain its growth. Biofuels plants are not only self-sustaining thanks to cogeneration technology, but they also have the potential to contribute to the diversification and security of Brazil's power matrix.

Second, *transport, storage, and distribution logistics* are undoubtedly the most critical requirement for the success of the biofuels industry as it expands. In a country of continental proportions, these variables cannot be overlooked. Specifically, the search for better ways to connect supply and demand must be continuous and energetic. If Brazil truly intends to lead the global industry, transport logistics must be prioritized in order to facilitate trade, improve cost competitiveness, and expedite delivery from crop to tank.

One of the main concerns of the biofuels sector is the high cost of transporting goods in Brazil, including port operations that must refurbished. It is fair to say that *transport, storage, and distribution logistics* are the most serious obstacles to the expansion of biofuels, and these elements are prioritized in the following discussion.

Finally, *communications* infrastructure plays a twofold role. It serves as a guarantee that all players in each node of the supply chain have a clear channel of contact with each other and access to the most recent information. As will be detailed later in this chapter, basic communication between players makes a tremendous difference in the industry's chances of success. In addition, and especially in the case of an agribusiness, uninterrupted flows of information regarding weather conditions, the latest technologies, best practices, etc., can enhance the efficiency and competitiveness of the industry.

Some projects are underway in Brazil to bolster existing infrastructure and enhance logistics countrywide; however, in looking forward to 2020, a national strategy to boost the present transport, power, and communications networks for biofuels must be set in motion and the capital to finance it must be identified and secured. Brazil must find ways to capture existing lines of domestic financing and streamline them to focus on infrastructure expansion that serves not only a burgeoning biofuels industry, but also broader economic and social goals. Given the scope of needed investment, a variety of investment sources will be needed, from government and local private sector to international financial institutions and international capital markets.

A revised regulatory framework would help create the political space in which a dramatic infrastructure and logistics upgrade can occur. A reworking of policies related to pipelines, roads, rail, and shipping could increase competition and facilitate cogeneration, an additional source of revenue in ethanol production. Understanding the current policy landscape is essential to analyzing how it might be altered.

The Infrastructure and Logistics section will examine existing assets, assess their limitations, and identify how they might be remedied. It will begin with a discussion of all infrastructure and logistical networks relevant to biofuels, including power, transportation, and communication. Though in most cases these networks will be applicable to both types of biofuels discussed, specific issues pertinent to ethanol and biodiesel infrastructure will be highlighted accordingly. A discussion and analysis of Brazil's existing infrastructure landscape will follow, including a description of the projects underway and the financial and regulatory incentives to support them. Finally, the section will close with a brief analysis of the risks Brazil faces related to infrastructure.

B) Current State of Infrastructure: Existing Assets and Projects Underway

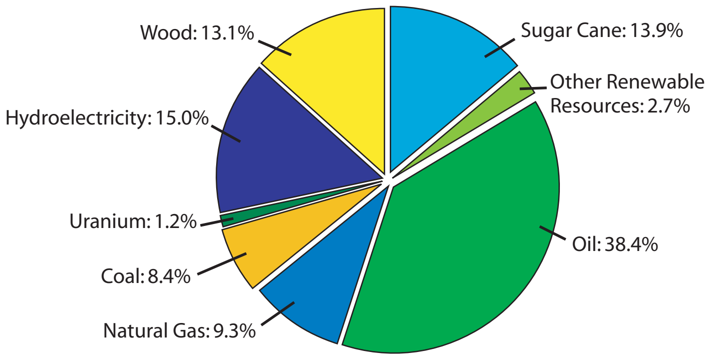
The current infrastructure is insufficient to accommodate a large-scale capacity expansion of ethanol and biodiesel, not only because it lacks the range to link various production and distribution sites, but also because existing assets are often underdeveloped or in disrepair. Even though projects are underway to address these limitations, a much stronger national strategy is needed.

B-1) Power

Power supply is an essential element of the minimum infrastructure needed for the biofuels industry, both in production and distribution. Electricity is needed at the plant, as well as throughout the supply chain. However, unlike other industries, biofuels production not only has the potential to be self-sufficient, it can actually contribute to the power sector by feeding into the national grid or providing electricity to isolated communities through cogeneration.

Today, Brazil has a diversified energy matrix [Chart 4a]with a relatively high use of renewables. 44% of the matrix is composed of various renewable sources of energy, compared to the world average of just 14%. In addition, Brazil has recently reached oil self-sufficiency, bringing even more security to the country's energy supply.[1] However, the reference scenario for GDP growth through 2015 projects that the country will need to increase electricity generating capacity by 5% each year, or an average of 3,200 MW, requiring $6 billion in annual investment.

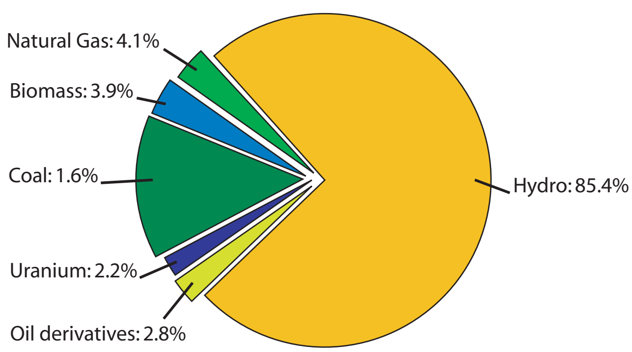
Chart 4a: Brazilian Energy Matrix (2005)



Source: Ministério de Minas e Energia do Brasil

This same diversity is not present in the country's power matrix. With current installed capacity of 93.969 MW, generated by both private (15%) and state-owned (85%) companies, the system represents almost 60% of South America's electric consumption. At its peak load, the Brazilian power system is the equivalent of systems in Italy or the UK (61.800 MW).[2] The vast majority of Brazil's electricity (85%) comes from hydroelectric power generation.

Chart 4b: Brazilian Electric Energy Matrix



Source: Ministério de Minas e Energia do Brasil

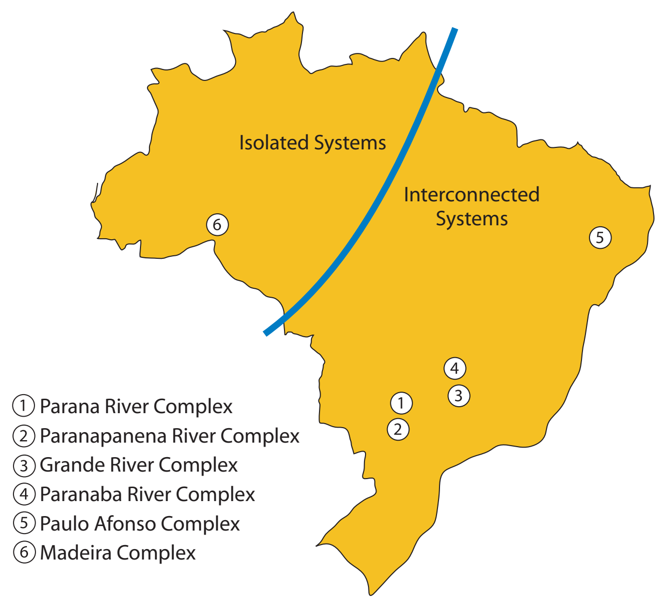
Brazil's heavy dependence on hydroelectric power is understandable given its massive system of rivers. However, there are three challenges for the expansion of hydroelectric power that suggest that diversifying might be advisable in the long term: environmental constraints, seasonal capacity variation, and regional concentration.

The argument in favor of hydroelectric power expansion is obvious for a country with Brazil's resources, but the politics of this expansion have been complicated by a substantial and growing environmental protection movement. While a relatively clean power source, hydro projects are not without their environmental and social costs, namely the flooding of communities and ecosystems. In recent years, environmental groups have stepped up their protests of these projects with increasing effectiveness, successfully delaying the approval of the 11,000MW Belo Monte Dam Project for four years.[3] The delay or potential blocking of projects is a concern given projections that Brazil will need to increase its power supply by 5% annually to keep pace with economic growth.

A second issue is the seasonal variability of hydroelectric power generation, which is weakest during the dry season. A power shortage in 2001 was in part due to this vulnerability. The third issue is the regional concentration of hydro-generating capacity. Most of Brazil's dams are in the southern part of the country, including Itaipú Dam, on the border with Paraguay, with 12,600 MW of capacity.

There is a clear disparity between the north and the coastal regions of Brazil. The north accounts for less than 2% of the energy market and is mainly sustained by thermal plants. The coastal regions, by contrast, are highly developed and heavily dependent on hydroelectricity produced primarily in the south.[4] Energy is lost in the process of transportation and distribution at a rate of 16%, twice that of the US.[5]

Map 4a: National Power Grid (2005)



Source: Ministério de Minas e Energia do Brasil and Operador Nacional do Sistema (ONS)

Despite these constraints, it is likely that Brazil will remain, for many years to come, primarily dependent on hydroelectric power generation. Nevertheless, the country is seeking to increase the share of alternative power sources, and the biofuels industry has potential to address the limitations of hydro through cogeneration.[6] Currently, there are 2,800MW of installed cogeneration capacity in Brazil's sugarcane refineries, 600MW of which is being commercialized through distribution companies.[7] This number could be dramatically increased were ethanol mills to invest in high-pressure boilers. Peak production of ethanol, and thus peak generating capacity, occurs in the dry season, the weakest period for hydroelectric power. As the industry expands, biofuels production will be dispersed throughout the country and could contribute to the decentralization of supply. The capacity for cogeneration should also improve with technological advances, which would allow plants to generate power more efficiently, increasing output by between 4 and 12 times current capacity.[8] A study commissioned by the Brazilian government estimates that a new production cluster of just 15 mills could generate 1,200 GWh per year, more than 0.3% of national electricity consumption in 2004.[9]

Today, the vast majority of current cogeneration capacity is in Sao Paulo State, which is also the center of power consumption in Brazil. The state has no new sources of hydroelectric power to supply its continued growth,[10] but it does boast the country's most extensive power transmission infrastructure. For areas of new expansion, the situation is varied. Plants that choose to cogenerate bear the cost of connecting to the grid, an expense which can be formidable when the grid is distant. The state of Goias has been identified as an ideal candidate for new biofuels production and cogeneration projects because of the suitability of its land and well developed infrastructure. On the opposite end of the spectrum, Maranhao has extremely limited grid coverage.[11]

Another potential benefit of cogeneration is locally generated electricity in rural areas; in essence, electrification "off the grid". Brazil's power grid coverage of rural areas is limited and is considered a significant constraint on development. Rural electrification has been a focus of both the Brazilian government and multilateral lending institutions, but much remains to be done; there is 73% coverage in rural areas, compared to around 85% coverage in Argentina, Chile and Mexico.[12] The regions with the greatest shortfalls are the north and northeast, which are also the areas in which the biofuels industry is projected to expand.

Table 4a: Permanent Private Households without Electricity (2002)

	Urban	%	Rural	%	Total	%
North	56,195	2.4	447,124	59.7	503,319	16.1
Northeast	201,642	2.2	1,110,339	34.4	1,311,981	10.7
South	49,011	0.8	125,235	10.3	174,246	2.3
Southeast	166,565	0.8	206,214	11.9	372,779	1.7
Mid-West	31,610	1.0	90,336	21.5	121,946	3.5
Brazil	505,023	1.2	1,979,249	27.0	2,484,271	5.2

Source: World Bank ESMAP, 2005

Updated numbers available from the ANEEL, which do not disaggregate into rural and urban, do not show a significant change in total electricity coverage. While coverage has increased slightly in the south and southeast, it has actually declined in the rest of the country.

Table 4b: Permanent Private Households with Electricity (2006)

Region	% of Households
North	81.55%
North East	87.70%
Mid West	95.78%
South East	98.77%
South	98.01%
Total	94.54%

Source: ANEEL

Brazil is addressing the issue of rural electrification primarily through the Luz para Todos program, which intends to extend coverage to 2.5 million households by 2008. Ethanol and biodiesel plants could contribute to the provision of power to isolated communities as well, playing a role similar to a small-scale hydro plant. This option is being explored in developing countries around the world. Biodiesel, in particular, could serve as valuable energy source for isolated Amazon communities that rely on diesel power.

Cogeneration has other significant benefits. The sale of associated carbon credits through the Kyoto Protocol's Clean Development Mechanism (CDM) could also become a sustainable source of revenues. Indeed, biomass cogeneration has much greater potential for carbon credits than the production and sale of biofuels. Of the bioenergy CDM projects in the global pipeline, 54% of bioenergy projects are based on cogeneration, and of these, more than half are specifically sugarcane bagasse projects. By contrast, there is only one biofuels production project in the pipeline.[13]

Proinfa

The Brazilian Government is acting to address its dependency on hydro power, the growing environmental constraints on its expansion, and the capacity of the power grid. Eletrobras, the Brazilian National Energy Company, launched a new "Program of Incentives for Electric Energy from Alternative Sources" (PROINFA), which pledges to buy electricity produced from different renewable resources.[14] The initial goal of the program is to reach 3,300 MW in wind, biomass and small hydropower and to have these renewable sources account for 10% of Brazil's electricity consumption in 20 years.[15]

In order to properly acquire such a high volume of energy, the government established a series of auctions within the PROINFA framework. In December 2005, an auction contracted 200MW of biomass cogeneration from various producers, with 25-year contracts beginning in 2008.[16] In preparation for 2006 auctions, sugarcane producers, cogeneration associations, and equipment manufacturers together promoted increased biomass cogeneration in the energy matrix through private investment and fair competition with other energy sources. The scheduled 2006 auctions are for energy delivery for 2009 and 2011, and the biomass initiative plans to offer between 1,000 and 3,000MW.[17] Projects linked to the PROINFA are eligible to receive up to 80% of their financing from BNDES, to be used for the acquisition of high-pressure boilers, for instance.

B-1.1) Gaps and Limitations

Despite the potential of electric cogeneration, most mills in Brazil are not investing in the high-pressure boilers needed to produce excess energy. For instance, of industry leader COSAN's 30 sugar and ethanol mills (with electricity production potential of 700MW), only one is engaged in government auctions and will produce 60-70MW beginning in 2009. The high cost of replacing boilers is cited as the primary reason behind industry reticence in this area.

PROINFA has been heavily criticized for its reliance on subsidies and for its weak market orientation. While ethanol refinery cogeneration was envisioned as one of the main sources of energy for rural electrification under the program, only projects connected to the grid are eligible to participate in the PROINFA, which automatically excludes a good percentage of isolated plants, especially those located in the northern region of Brazil. Those close enough to connect to the grid still face financial and bureaucratic obstacles; the plants must cover the costs of connecting and must apply for authorization from the National Agency of Electric Energy (ANEEL).

Its faults notwithstanding, PROINFA is a well conceived plan that opens a strategic path to electricity matrix diversification. Energy auctions need to continually seek higher quotas for renewable sources. In addition, the bureaucratic process to join the program and register for the energy auctions should be revised. Red tape, including environmental licensing, is a barrier to investment. According to industry expert Plinio Nastari, from DATAGRO, each individual mill must apply for authorization from ANEEL. He suggests a new methodology, similar to one used in the United States, where a "blanket authorization" to sell to the grid acts as a catalyst to actors throughout the industry.[18]

B-2) Transport, Storage and Distribution Logistics

Transport, Storage and Distribution Logistics (the transportation system) are arguably the most significant infrastructure constraint to the expansion of the biofuels industry in the country. A premise of this study is that Brazil's transportation system must be capable of facilitating the expansion of the biofuels industry into new productive regions and guaranteeing access to ports for export. Absent determined action, transport will become a significant bottleneck to the expansion of the biofuels sector.

Brazil's complex multi-modal transportation system is administered by several different government bodies. In addition to the Ministry of Transportation (responsible for transportation policies, including Merchant Marine affairs and air transport), the country has three different structures: the National Department for Infrastructure for Transportation (DNIT), the National Agency for Terrestrial Transportation (ANTT), and the National Agency of Waterways Transportation (ANTAQ).[19]

The need for government involvement in the provision of a public good such as transportation infrastructure is clear. However, bureaucratic red tape, questionable funds administration, and the lack of proper coordination have obstructed development. In an effort to upgrade this system, the Brazilian government has chosen a gradual privatization of transport infrastructure. Waterway and railway systems have been entirely privatized since 1996 and 1997 respectively, while the highway system is still in the process of privatization.[20]

B-2.1) Biofuels Transport and Distribution

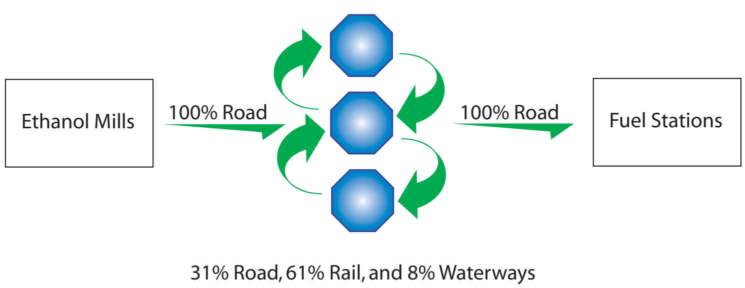
The transport and distribution of biodiesel is relatively simple, because the industry is entirely domestic and is still small in scale. The bulk of Brazilian biodiesel production, approximately 1.1 billion liters, is managed under ANP's public tender auction. Petrobras has been buying almost 97% of total production, which is distributed to the refineries by the producers themselves.

The case of ethanol is much more complex, and the supply chains for domestic and foreign distribution must be analyzed separately. Ethanol is produced at sugarcane mills, of which 60% are located in the state of São Paulo and the rest distributed through the northeast coast, as well as the south and the mid-west regions.

For domestic distribution, ethanol producers are usually responsible for the "first leg" of the distribution chain: the transport of ethanol from the mills to the fuel distribution companies such as Exxon, Shell and Petrobras, which then blend it with gasoline.

Ethanol producers may vary their distribution strategy depending on the region in which they are located and the destination in question. For instance, São Paulo producers normally use road distribution to supply their own state, but Petrobras has a pipeline that runs from São Paulo to Rio de Janeiro and the company has plans to extend its pipeline network through to Goiânia – Goiás. Waterways are an option for producers from the states of Minas Gerais, Goiás, and São Paulo, with railroads a longer-term possibility.

Diagram 4a: Distribution Hubs for Domestic Markets



Source: ANEEL

Transportation from the production point to distribution points is done 100% by highway with an average distance of 200 kilometers. Transfers between fuel distribution points are carried out 61% by rail, 31% by highway, and 8% by waterway. Average distances are 717 kilometers, 597 kilometers, and 1000 kilometers respectively.[21] Transfer to the final consumer is done 100% by highway with distances covered as follows:

Table 4c: Distribution Distances

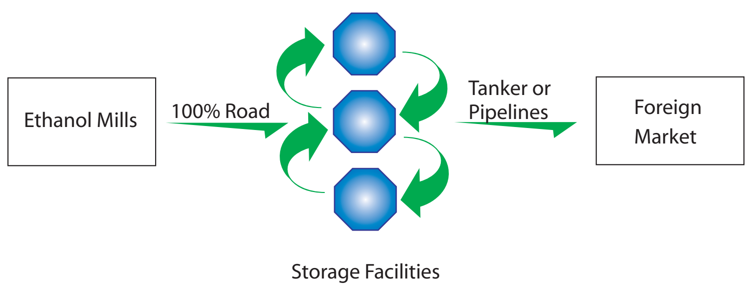
69%	0-100 km
15%	100-200 km
7%	200-300 km
9%	300-600 km

Source: Ministry of Transportation

The biofuels transportation system was established for domestic consumption of fuels, and is only now beginning to adjust to growing international demand. The logistics of ethanol distribution for export involve two new players: the trading company and the foreign buyer. In the Brazilian export market for ethanol, trading companies are usually present to mediate the trade between local producers and foreign markets. After acquiring purchase options (with fixed prices and established volumes), trading companies search for Brazilian producers willing to meet the volume and price desired by the foreign buyer.[22]

Once the deal is established, the producers themselves are in charge of delivering the product to the trading companies, who are then responsible for exporting it. Normally, producers contract private trucking companies to deliver the ethanol (very few producers have their own fleets). Depending on the contract, the ethanol could be delivered at a storage facility near a port, railway, pipeline or even directly into tankers. Most of the time, the product is delivered to ports, where it is then stored for later transfer to tankers.[23]

Diagram 4b: Distribution Hubs for Export



Despite the many efforts by both the Brazilian public and private sectors to improve infrastructure, several obstacles remain. A 2006 poll conducted by Volkswagen found that transport infrastructure is seen as a major impediment to exports:[24]

Table 4d: Infrastructure Opinion Poll

[illegible]%	Cite infrastructure as creating the most difficulties in exports
[illegible]%	Feel the current system either does not meet or barely meets needs associated with exporting.
[illegible]%	Feel the federal government is responsible for all the bottlenecks
[illegible]%	Feel the situation may worsen
[illegible]%	Feel the railway system does not meet their needs.

Approval ratings: Railways: 11% Highways: 21% Waterways: 22%

Source: Volkswagen 2006

It is important to note that infrastructure improvements made to boost ethanol exports will soon benefit biodiesel. As the biodiesel industry evolves, it will take advantage of the infrastructure established for ethanol distribution, much as this has profited from the infrastructure already established for oil distribution. The same storage facilities, port terminals and tanker compartments are used for both oil and for ethanol, and they will gradually serve biodiesel as well.

B-2.2) Road and Highways

Roads now provide more than 70% of biofuels transportation needs and they will likely remain important, particularly for domestic distribution. However, the country will need to gradually decrease its dependence on highway transportation in favor of other modes of transportation.

In 2000, according to the Brazilian Statistical Bureau of Transport, highways experienced a transport volume of 451,270 million tons per kilometer, and had increased every year to that point.[25] Highways have reached maximum operating capacity, resulting in less than desirable conditions.

Roads in Brazil are administered by federal, state, and local authorities.[26] The Ministry of Transportation has classified 28.3% of roadways as being in "Good" condition, while 30.9% are in "Normal" condition, and 40.8% in "Bad" condition.[27] Overall, Brazil's roadways are in a precarious state.[28]

Table 4e: Highway Pavement Conditions

	Paved Highways	Non-paved Highways	Total
Federal	55,905.3 Km	34.352,4 Km	90,257.7 Km
State	91,348.4 Km	116,538.1 Km	207,886.5 Km
Local	16,993.0 Km	1,429,295.9 Km	1,446,289.2 Km
Total	164,247.7 Km	1,580,186.4 Km	1,744.433.4 Km

Source: ANTT 2005

Municipal and state roadways are the key links, particularly between ports and the highly productive regions like São Paulo state or the more remote interior of the Mid-West. Several federal programs are trying to improve the conditions of existing roads and highways. The Integrated Revitalization Program (PIR IV) is dedicated to the recovery, maintenance and conservation of 7,700 kilometers of highways at a projected cost of R$710 million ($330 million). Another program, the Exploration Highway Program/ Exploration Bridge Program (PER/PEP) oversees the investments and activities of the private companies that manage certain roadways. These "concessions" must manage construction and services for the highway segments they were assigned.[29] In all, 36 private concessions operate in 165 markets covering 9,547 kilometers. Six are federal concessions, 29 are state, and one is local.[30]

In an attempt to address bottlenecks, the states of Minas Gerais, Goiás, and Espírito Santo, announced in June 2006 the creation of a logistics transportation corridor linking the three states at an estimated cost of $6.5 billion. The project will rehabilitate existing roadways and lay down new railways to improve linkages between agricultural regions in landlocked Goiás and Mato Grosso states and ports in Espírito Santo. For this particular project, the three states involved and the federal government will partially fund the program, and the private sector will contribute additional funds via Public-Private Partnerships (PPP). No timeline for the project has been identified, but Companhia Vale do Rio Doce (CVRD) has been collaborating with various technical teams within the government.[31] The initiative should significantly improve the exporting capabilities of mid-west producers.

Multilateral organizations have also become involved in the maintenance and improvement of Brazilian roadway infrastructure. The IADB is supporting the São Paulo State government in its roads infrastructure rehabilitation (IADB São Paulo State Highways Phase II). The project will finance the rehabilitation of critical sections of the state road network.[32] In addition, the World Bank Federal Highway Decentralization Project has worked to speed the privatization of highways throughout the country and place more responsibility for maintenance in the hands of the private sector.[33]

B-2.2.1) Gaps and Limitations

The most pressing issue in roadway transport of biofuels is highway maintenance. This fundamental requirement has often been overshadowed by the construction and expansion of new highways, which tend to garner more attention and support than basic maintenance. The majority of the highway network is not paved.[34] Privatized roads have received an 84% approval rating whereas most state and federal roads are deemed "bad or "terrible".[35] Lack of funding is compounded by inadequate weight control of trucks. The damage caused by excessive loads is exponential, not proportional. Sophisticated weigh stations do exist but trucks usually do not stop for inspections. In addition, transit authority inspection is necessary.

The dire state of roads has a direct effect on consumers, and on demand for ethanol. Transpetro has developed a pipeline distribution network, which services the major consumer centers: São Paulo, Rio de Janeiro, Belo Horizonte and Brasília.[36] To access those pipelines, however, it is necessary to use a series of roadways. In regions far from São Paulo, the current state of roads and highways is poor, and the high cost of transport is reflected at the pump. The average price of ethanol in the southeast is $0.69 per liter, whereas the price per liter in the north is $0.89.[37]
The transport situation will become even more serious as capacity expands in regions with minimal transport infrastructure. This report will detail a number of projects for employing railroads and waterways, but it should be clear that connecting to a railroad, waterway, or major highway will always require a system of access roads. The availability of this minimal infrastructure will be a critical part of investment calculations in the sector.

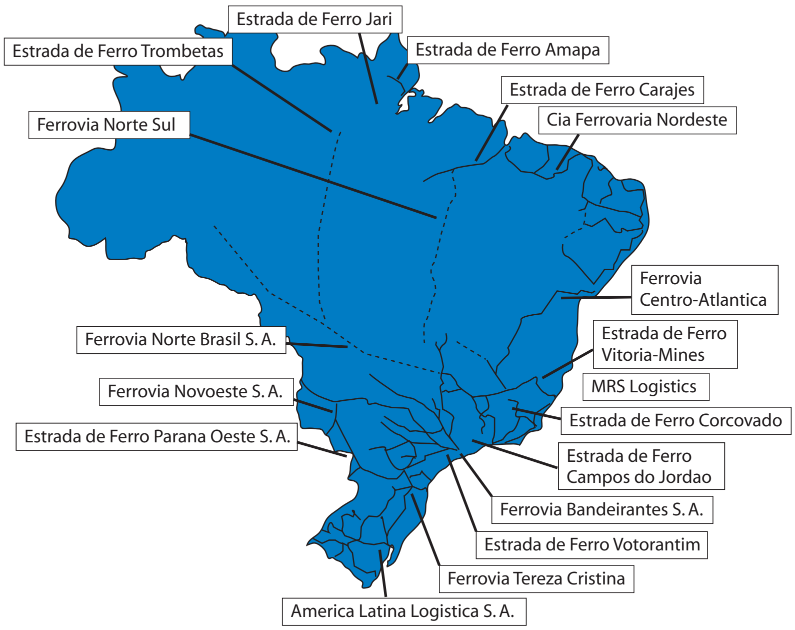
At a more general level, however, Brazil must move away from a reliance on road transport. Even conservative estimates project 6 billion liters of ethanol exports by 2012. According to estimates by Crystalsev, 600 million liters a year of ethanol, just 10% of this projection, will require 20,000 tanker trucks. Increased use of railways, waterways, and pipelines will be essential.

B-2.3) Railways

Brazil's growing biofuels industry relies significantly upon rail transport (17%) as a means to link distribution hubs and storage and export centers. Total railway coverage is 28,000 kilometers, mostly along the coastal regions of the south, southeast, and northeast. Railway networks represent only 20% of the Brazilian transport matrix and are responsible for 21% of cargo transport in Brazil, principally for minerals, agricultural products, and iron ore, which are transported to the various ports in the country. In 2003, nearly 325 million tons were transported and minerals, agricultural products, and iron comprised 80% of that load.[38]

An extremely sparse network of rail runs through the interior regions of the north and mid-west, both critical regions for biofuels expansion.[39]

Map 4b: Brazilian Railway Network



Source: Ministério dos Transportes do Brasil; ANTAQ

To improve services, the federal government created the National Privatization Program (PND) to privatize most of national transportation systems, including the Federal Railway Network (RFFSA). The institutional structure is comprised of the National Council for Privatization (CND) and BNDES with the following objectives:

1) unburden the federal government;
2) improve resource allocation;
3) increase operational efficiency;
4) promote the development of a transportation market; and
5) improve service quality.[40]

Today, three entities own the rails that run throughout Brazil: RFFSA, Companhia Paulista, and CVRD. Brazilian railroads are operated, through concessions, by various private firms. Several construction projects are underway to augment the system, many of which could help link current and future productive regions and export sites.

Principally, the rail expansion projects include:

1) North-South railroad
2) Ferro Norte railroad
3) TransNordestina railroad

These projects, described below, are at various stages of planning, financing, and construction.[41]

The North-South railroad project will link Goiás state to Brasília and then proceed north to pass through Tocantins state and enter the coastal Maranhão state. Overall, the additional rail will run 1,638 kilometers and allow linkages between the ports of Itaqui, in Maranhão, and the mid-west, thereby reducing the cost of transport from that region north. In addition, the North-South railroad will connect to two other important railroads. In the north, it will link up with the Carajas railroad, which is owned by CVRD and covers 892 kilometers in the state of Maranhão; in the south, it connects with the Ferro Norte railroad, described below.[42]

The North-South railroad project is being conducted via a Private Public Partnership with financing from the Companhia de Desenvolvimento dos Andes and the Inter-American Development Bank. At present, construction is underway on the rail south of Estreito, in the Maranhão State.[43]

The entire region through which this railway passes has great potential for ethanol expansion and is already attracting significant investments. Anticipating the infrastructure expansion, the State of Maranhão has offered incentives for 20 new ethanol plants.[44]

The expansion of Ferro Norte has four segments connecting several cities, including Santarém, in the state of Paraná; Cuiabá, in Mato Grosso; Porto Velho, the capital of Rondônia; and the region of Alto Araguaia, in the state of São Paulo. Construction is set to begin in 2007 and is awaiting environmental licensing. This expansion would reduce the cost of transport from Mato Grosso, cut fuel consumption, and generate jobs. The project would have a particularly positive impact on the biofuels industry as it crosses a region that is a center for soy-based biodiesel production and the site of new ethanol distilleries.[45]

Finally, the TransNordestina project represents a potential boon for the rural and impoverished northeast region, especially in relation to castor bean programs in place there through the National Program for the Production and Use of Biodiesel (PNPB). This railway would link points in Maranhão to those in Bahia, potentially easing the logistics of both ethanol and biodiesel transport to northern export sites. The links are to run from Petrolina (PE) to Salgueiro (PE) and from Salgueiro to Ingazeira (CE). The TransNordestina Railroad linking the ports of Suapé (BA) and Pecém (CE) to regions such as southeast Piauí, south Maranhão, and west Bahia will be 2000 kilometers long. Construction began in June 2006 and is expected to last 3 years. The Transnordestina project will be implemented by Companhia Ferroviária do Nordeste (CFN).[46]

B-2.3.1) Gaps and Limitations

A key obstacle to improving the Brazilian railway infrastructure is the lack of investment in the sector. Even though the railway system is operated by various private enterprises, including CVRD, the network extends only 30,000 kilometers and is in poor condition. Investment has been limited to the purchase of equipment and wagons. Brazil's government recognizes the need to support the agricultural sector by expanding the railway system, a project it sees as the shared responsibility of the public and private sectors.[47]

According to experts, the current system suffers severe limitations in terms of logistics and flexibility that lead to underutilization. For instance, although the western region of Minas Gerais (a major producer of ethanol) has reasonable access to railroads, the rail network is not linked to major ports for export, which leaves highways as the only means of reaching ports.

B-2.4) Waterways

Waterways, including the terminals and ports that they service, allow for the transport of biofuels. Approximately 22 million tons per year of cargo are transported via waterways. The Amazon Basin represents the bulk of waterway use, at approximately 18 million tons.[48]

In cases where production sites and plantation areas lack access to roads or the rail system, waterways can often be a viable alternative.[49] However, the waterway system in Brazil has not been made a high priority for modernization.

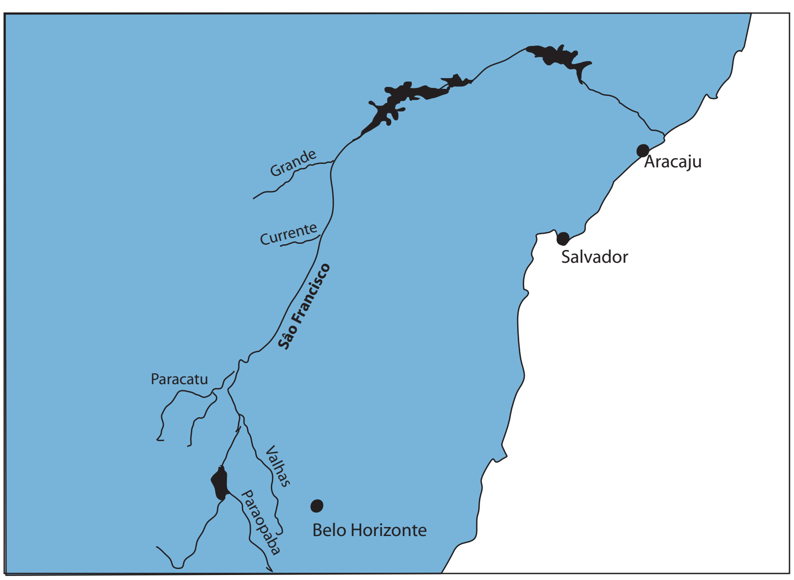
Map 4c: Brazil's Main Waterways

Source: Ministério dos Transportes do Brasil; ANTAQ

In their current state, extant waterways cannot support a significant expansion of the biofuels industry or any other major sector for that matter. The government has undertaken three initiatives to improve the waterway system, including the São Francisco River, the Paraguay to Paraná waterway complex,[50] and the Paraná to Tietê Basin.

The São Francisco waterway, which is navigable, runs for 1,370 kilometers from the southeast to the northeast, from Pirapora (in the state of Minas Gerais) to Juazeiro (in the State of Bahia). The Sao Francisco river project is one of the most ambitious infrastructure projects yet undertaken by the Brazilian Government. The route offers opportunities for many industries, and especially agribusiness. The biofuels industry in the northeast, in particular, could benefit from the access that this route offers to consumer markets in the south.[51]

Map 4d: The São Francisco Basin



Source: Ministério dos Transportes do Brasil; ANTAQ

When completed, this proejct would not just expand waterway routes but also reroute the river to better distribute water throughout the dry and poor northeast. As discussed elsewhere in this report, addressing the needs of the north and northeast is a critical step towards a sustainable expansion of the biofuels industry. The São Francisco River project is a step in that direction. The build-up of sediment in the river basin, caused by indiscrimiante logging, needs to be removed for it to be navigable by larger ships.

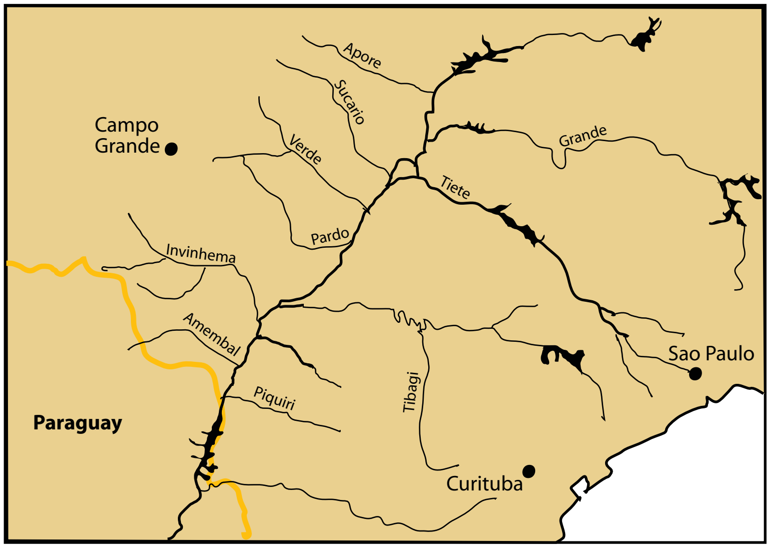
The Paraguay to Paraná waterway complex runs for over 3,400 kilometers from Nueva Palmira in Uruguay to Cáceres in Brazil (state of Mato Grosso). This waterway is regulated by a 1969 treaty between Argentina, Bolivia, Brazil, Paraguay, and Uruguay.[52] The benefit for the biofuels industry, especially for soy-based biodiesel production, is the access it could provide for production through the mid-west of Brazil to neighboring export markets.

Map 4e: The Paraguay Basin

Source: Ministério dos Transportes do Brasil; ANTAQ

The Paraná to Tietê Basin link is also under construction and will connect the Piracicaba River, in São Paulo, to the Tietê River.[53] It is believed that the Tietê – Paraná waterway could provide ethanol transportation, given the presence along the waterway of at least four ethanol mills. In addition, this particular project offers the possibility of connecting waterway transportation with pipeline networks that already connect to the southeast, especially between Rio de Janeiro and São Paulo.

Map 4f: The Paraná to Tietê Basin



Source: Ministério dos Transportes do Brasil; ANTAQ

B-2.4.1) Gaps and Limitations

All the waterway projects described above have the potential of linking autonomous productive regions with major consumer markets, but waterways in Brazil are likely to remain underutilized unless certain constraints are addressed.

A number of problems plague these river routes. The system of signals and buoys is poorly structured, making for dangerous passages. Like the rail system, the national fleet is aging. Issues of environmental regulation also remain a concern in the expansion of waterways since they limit the amount of inflammable products that may be transported at one time. As with the São Francisco River, the depth of most rivers is a constraint on capacity expansion, as they currently do not allow passage by larger vessels. Additionally, not much attention has been given to the fact that bridges and dams often obstruct passage to and from the interior of the country.[54]

B-2.5) Pipelines

Many experts consider pipelines to be the best mode of transport for both domestic and international markets. The main advantage is cost. While railroad construction costs around $1 million per kilometer in Brazil, pipelines cost $40,000 per inch, per kilometer (with a speed of 2m/s), a significant difference.

Today, Brazilian pipelines for petroleum, derivatives, ethanol and gas are almost entirely controlled by Petrobras via one of its subsidiaries, Transpetro S.A. Created in June 1998, Transpetro is responsible for the transport and storage of petroleum (and its byproducts), transport of natural gas through pipelines and ships, and operation of terminals. Transpetro is Latin America's largest shipbuilder and Brazil's main logistics and transportation company, with the capacity to export one billion liters of ethanol per year.[55] Petrobras has years of experience transporting ethanol in multiuse pipelines, a practice not common in other markets.[56] According to Transpetro, the company still has no role in the biodiesel industry, due to its low volume.[57]

Key pipelines operated by Transpetro include the Mid-West/SP/Southeast line; the South Region line; and the North-to-Northeast Line. Together these lines account for a total distance of about 9,875 kilometers, about 7,000 kilometers of which are oil lines, while the remainder are gas lines.[58] Transpetro has been transporting ethanol in multiuse pipelines for many years, but the pricing structure in place has discouraged use by the private sector.

The Mid-West/SP/Southeast line conveys products to the major centers of consumption including São Paulo, Rio de Janeiro, Belo Horizonte, Brasília, and Goiânia. This line passes through the strategic epicenters of cane production, Ribeirão Preto and Piracicaba, and connects to the ports of Alemoa, São Sebastião, Ilhas D'Água, Ilha Redonda, and Cabuiúnas (southeast region). The South Line is divided into two parts, the first links the states of Paraná and Santa Catarina, and the second carries products to the state Rio Grande do Sul. The North-to-Northeast uses a hub-and-spokes model connecting to ports, which are Madre de Deus, Aracajú, Maceió, Suape, Cabedelo, Dunas, Guamaré, São Luis, Miramar, and Solimoões.[59]

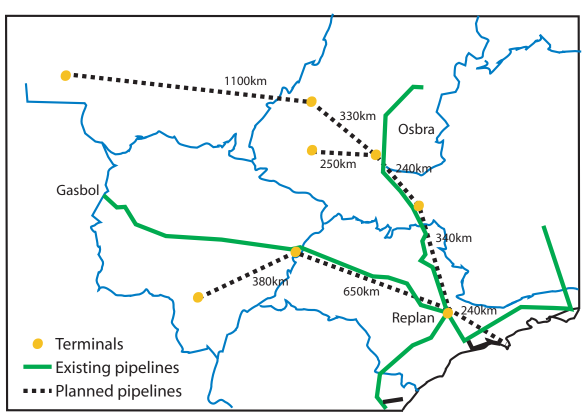
Table 4f: Ethanol Dedicated Pipelines

	Sao Paulo/Rio de Janeiro System
Receiving Points	Petrobras Distributora in Paulinia, SP - highway Railway Terminal in Paulinia, SP - rail Guarhulos Terminal - highway
Delivery Points	Barueri Terminal - pipeline Guarulhos Terminal - highway Duque de Caxias Refinery - pipeline
	Parana/Santa Catarina System
Receiving Points	Araucaria Refinery
Delivery Points	Guajamirim Terminal - highway Itajal Terminal - highway or pipeline Biguacu Terminal - highway Paranagua Terminal - maritime
	Jequie and Itabuna Terminals (Bahia)
Receiving Points	Jequie Terminal - highway Itabuna Terminal - highway
Delivery Points	Jequie Terminal - highway Itabuna Terminal - highway
	Uberaba and Uberlandia Terminals
Receiving Points	Uberaba Terminal - highway Uberlandia Terminal - highway
Delivery Points	Uberlandia Terminal - highway Uberaba Terminal - highway and rail

Source: Transpetro

Dedicated ethanol pipelines that service ports directly are limited in number. Petrobras has developed a plan to significantly upgrade these systems, including through an expansion of distribution ducts connecting the Refinaria de Paulínia (REPLAN) in São Paulo to Rio de Janeiro's Ilha D'Água Terminal.[60] At present, this line can only carry about 480 million liters per year, but with Petrobras' current investment plans, it can be upgraded to transport 2.8 billion liters per year by the end of the decade.[61]

Map 4g: South Central Brazil Ethanol Pipeline Network



Source: Unicamp

Prepared by Garten Rothkopf

The next phase of Petrobras construction will link REPLAN to the Guararema terminal, also in São Paulo State, which currently has storage tanks devoted to ethanol. The third stage of the Petrobrás project seeks to link the terminals of Uberaba (MG), Ribeirão Preto (SP), and Paulínia (SP) in advance of constructing new terminals and transport boats for the Tietê-Paraná waterway, as well as a new system of pipelines connecting Tietê to Paulínia. The final two phases seek to connect Brasília to São Paulo. One pipeline will bring the production from Northern São Paulo, Triângulo Mineiro, and the south of Goiás to Paulínia, while another will connect Guararema to São Sebastião, both of which are in São Paulo. Petrobras had said that the construction of these pipelines depends on the signing of sizeable long-term contracts with export markets, particularly Japan, which is considering making its 3% blend option mandatory.[62] There are indications that Japan's Mitsui and Petrobras have reached a joint venture agreement to move forward with construction, but this has not been confirmed.

Table 4g: Petrobras Ethanol Pipeline Development to 2011[63]

Phase I	Upgrade link between Refinaria de Paulínia (REPLAN) (São Paulo) and Ilha D'Agua Terminal (Rio de Janeiro).
Phase II	Link REPLAN to Guararema, São Paulo terminal.
Phase III	Link the terminals of Uberaba, Minas Gerais; Ribeirão Preto, São Paulo; and Paulínia, São Paulo. Construct new terminals and transport boats for the Tietê-Paraná waterway. Build new system of pipelines connecting Tietê to Paulínia.
Phase IV	Link Northern São Paulo, Triângulo Mineiro and the south of Goiás to Paulínia.
Phase V	Connect Guararema, São Paulo to São Sebastião, São Paulo.

In addition to the Petrobras plans, UNICA, the São Paulo Sugar Cane Agro-industry Union, in conjunction with the government of São Paulo state, is considering building pipelines in the government land-zones that run parallel to São Paulo State highways. These pipelines would also connect the interior to major ports, in this case Santos and São Sebastião. A Letter of Intention between the Ministry of Transportation of São Paulo and UNICA was signed in July 2006 for this new study.[64]

B-2.5.1) Gaps and Limitations

While pipelines offer a relatively low-cost method of transport, there is concern that the existing system is aging (it is older than 20 years) and that the residues left in ethanol from multiuse pipelines create barriers to trade as quality standards vary around the world. As ethanol travels through pipelines, it acts as a solvent for residue and absorbs condensation, which must then be removed from the product to meet quality standards.

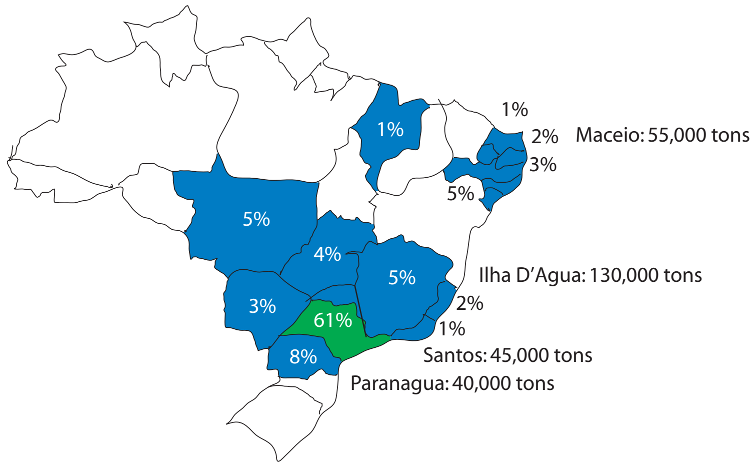
Specialists emphasize the need for an integrated system of pipelines, rail and ports. Plans for the creation of a dedicated ethanol pipeline network are well developed, but have not been implemented.

B-2.6) Ports and Terminals

Considering the upcoming ethanol capacity expansion, and Brazil's desire to position itself as a major global exporter of ethanol, ports and terminals will play a critical role.

The Brazilian port system is comprised of 31 maritime ports and 14 interior waterway ports, all of which are operated by the private sector.[65] Generally, these ports are complemented by a system of terminals that function as weigh-stations and transfer nodes. The maritime ports serve as import-export hubs as well as distribution points for all manner of cargo. The main exporting ports in Brazil are Santos (São Paulo), Paranaguá (Paraná), Ilha D'Água (Rio de Janeiro), São Sebastião (São Paulo), Maceió (Alagoas), Cabedelo (Paraiba), and Vitória (Espírito Santo).

Map 4h: Brazil's Main Ethanol Ports



Source: ABDI

A study commissioned by the Brazilian government identified Santos, Paranaguá, Ilha D'Água, and Maceió as the primary export ports [Map 4h], with a total capacity of 270,000 tons of ethanol each month. Trading companies contacted for this study estimated total capacity to be between 400,000 and 500,000 tons a month and included São Sebastião as a primary export hub, and Vitória as having some additional traffic, limited by storage capacity and proximity to production.

Ethanol arrives at ports and is either delivered to storage tanks or directly onto tankers. Storage areas are owned and operated both by trading companies directly, or in many cases, independent companies. The vessels that transport the ethanol to foreign markets are large multiuse petrochemical tankers, which require only cleaning to be fit for transporting ethanol. The benefit for the industry is that a shipment does not have to achieve considerable scale to make shipping economical, as any given vessel could be transporting a number of different petrochemical products. It is expected that as capacity expands, dedicated shipments of ethanol will leave Brazil's ports for high-demand markets like Japan. Already, major private-sector players are exploring investments in dedicated ethanol terminals at secondary ports.

B-2.6.1) Gaps and Limitations

To date, Brazil's ports have had sufficient capacity to handle ethanol exports, though they face access issues that are common across export industries. However, the pace of exports has grown dramatically in recent years and expanding port capacity is a top priority of producers. According to UNICA, existing infrastructure in ports is at capacity, with a projected 3.1 – 3.2 billion liters of exports in 2006. Primary constraints are crowding due to a lack of shipping berths and terminals, storage capacity in ports, and depth.

Traffic into ports by road has reportedly faced up to a 50 kilometer backlog of trucks awaiting entry to Santos.[66] Additionally, to arrive at the Santos port, trucks must pass through the metropolitan center of São Paulo. The average delay for transportation and port logistics is 39 days in Brazil compared to an average of five days in other countries.[67] The increased use of alternatives like railways and pipelines will be imperative as exports grow.

Once ethanol reaches ports, storage facilities present an additional constraint. Investment is needed to expand storage facilities at ports already exporting ethanol in significant quantities and ports closer to potential productive regions, such as Itaqui in Maranhão. Vitória port (Espírito Santo), which is very well connected to railways and could serve Minas Gerais' ethanol producers, has minimal storage capacity. Producers are forced to choose road transportation to Santos, Ilha d'Água, or Paranaguá ports. Transpetro estimates that the cost of investment in new storage capacity is $360 per 1000 liters.[68]

Another constraint is port crowding due to a lack of shipping berths, which limits the number of ships able to dock at any one time. At the Vitória Port, for instance, only two ships can dock simultaneously close to the ethanol storage facilities, greatly slowing transfers. Additionally, restrictions on ship access where depths are not sufficient for major tankers is a problem in many locations, including the Santos port, the largest in the southeast region. The São Sebastião port could serve producers from the interior states, but is already crowded by Petrobras oil exports. Logistics expert Fernando Fleury, a professor at the Federal University of Rio de Janeiro, has predicted that Brazil's ports will need $320 million in additional investments to export 10 billion liters of ethanol per year, which is at the higher end of export projections for 2012.[69]

B-2.7) Storage and Distribution

Storage capacity for biofuels, especially for ethanol, is a critical link in both domestic and international supply chains. Even with considerable improvement of its transportation systems (roads, railroads, pipelines, etc.), Brazil will not be able to meet growing demand if the issue of storage capacity is not addressed.

Petrobras Distribuidora is the largest storage provider in Brazil. The company is currently responsible for:

- 51 private distribution hubs
- 9 pooled distribution hubs
- 11 storage bases
- 8 ethanol collection sites
- 1 rail terminal in Paulínia
- More than 7,200 service stations

These distribution hubs are used by firms affiliated with the National Syndicate of Distributing Firms for Fuels and Lubricants, which represents about 75% of the market.[70] At the end of 2005, Brazil had 428 fuel bases with an approximate storage capacity of 670 million liters of ethanol. More than 50% of this storage capacity is located in the south, while another 20% is located in the northeast. At the beginning of 2006, 29,650 of the 32,000 total fuel stations had ethanol-dedicated pumps. (This is in addition to the 23% mandatory blend in all gasoline sold in Brazil.[71])

It is noteworthy that Petrobras Distributidora has handled most of the transport and distribution needed for the biodiesel industry with no involvement by Transpetro.[72] With production volumes increasing to the 2013 target of 2.4 billion, it is likely that both subsidiaries will become involved.

B-2.7.1) Gaps and Limitations

The primary gap in Brazil's storage infrastructure is the inadequacy of storage tankers in Brazil's ports to meet projected export demand. For more information, please refer to the ports section.

B-3) Communications

In a modern and efficient export-oriented industry, changes in demand schedules must be immediately dispatched from state to state and region to region. If Brazil is to position itself as a global distributor of ethanol, it must be able to communicate minute-by-minute changes and reroute supply to various transport hubs and ports accordingly. Further, access to telecommunications networks can greatly enhance the efficiency of production, as evidenced by practices employed already in the sugarcane industry, which uses satellite imaging to determine the exact moment to harvest for maximum sucrose.

When it comes to infrastructure for telecommunications, especially in rural areas, Brazil is moving rapidly. After the first phase of privatization in the late 1990s, most of the country's telecommunications systems were transferred to the private sector, which promoted technology convergence such as broadband internet connections and the expansion of mobile phone systems.

Additionally, the Brazilian internet business-to-business segment (B2B), just a $5.4 billion market in 2001, is today a $32.5 billion market that accounts for more than half of Latin America's total. This growth is not confined to major cities and has already had a positive impact in rural areas, where telecommunications improvements are expected to bring efficiency to the agribusiness sector.

Today, 14% of the Brazilian population has access to the internet. Even though Brazilians account for almost half of South America's internet usage, penetration is low compared to regional leaders like Chile (27%). Fast, quality internet connections are available to all rural properties and agro-industrial facilities in Brazil through dial-up, radio, or cable connections, in urban areas, and via satellite communications nationwide.[73]

TV and internet are expected to penetrate even further in rural areas, as cable and wireless network capacities spread throughout the country. A technology that combines mobile phones and satellite internet has also been expanded.

Contributing to this effort, EMBRAPA has implemented the AgroLivre network. Launched in 2004, this project is dedicated to promoting the use of "freeware" computer programs for agribusiness and assists in the acquisition of equipment and software.[74] It is scheduled to be completed by late 2006.[75]

B-3.1) Gaps and Limitations for Communications

Telecommunications networks have already proven to be an extremely valuable tool in the modernization and competitiveness of Brazilian agribusiness. The remaining challenge is to increase access to telecommunications, through either new systems or improved cost effectiveness of current systems. Internet communication is still expensive for most small farmers, on whom the National Program for Biodiesel depends. In addition, for most of the regions in which the biofuels industry wishes to expand, such as the north and mid-west, the need for basic communications infrastructure affects the viability of new projects.

C) Financing

The availability of financing for infrastructure investments remains a troubling barrier in Brazil. Government investments in infrastructure have suffered severe cutbacks in recent years. Investments in infrastructure have dipped from nearly 2% of GDP in the 1970s, to 1.2% in the late 1980s, and to below 0.2% in 2004.[76] This level of investment will not be sufficient to meet growing needs.

Public-sector funding sources include the Ministry of Transportation, through the National Infrastructure Fund, BNDES, and the Ministry of Science and Technology (MCT), whose sectoral infrastructure fund goes into research and development, rather than directly into maintenance and construction. There is ample room for additional players, including international investors from export markets.

According to the Brazilian Ministry of Planning, Budget & Management, $1.2 billion was designated in 2004 for the Ministry of Transportation to upgrade its biofuels transport mechanisms with a subsequent revision to $1.6 billion. However, only $1 billion was authorized as part of the spending budget. In addition, according to TRANSPETRO, $1.8 billion is being devoted to the construction of 42 ships and a program of transport for ethanol exports.[77]

BNDES has several financing lines from which biofuels infrastructure investments may be made. The bank's projects are the following:

- The expansion and modernization of the power sector and the diversification of the national energy matrix;
- The resolution of urban transport bottlenecks with contoured transportation systems; and
- The enlargement of telecommunications systems.[78]

The bank also lists the following priorities in supporting infrastructure:

- Railway modal projects in the north and northeast regions;
- Roadway, aviation modals, ports and terminals; and
- Roadway concession projects.[79]

These projects are financed via BNDES lines including FINAME, FINEM, and Automatic BNDES, all of which are described in the Capacity Expansion section.

On the private-sector side, or, in this case, quasi-private sector, Petrobras, in an August 2006 announcement, increased its investment in ethanol pipelines, committing $660 million to ethanol duct maintenance and construction through 2011. Originally, the state-owned oil company had committed $330 million, primarily devoted to projects in the southeast. With this new funding, the project will expand into the mid-west as well.

Petrobras believes that this expansion will triple Brazil's ethanol export capacity – especially to Japan, where the company has established a joint venture with Nippon Alcohol for marketing and distribution.[80] As mentioned earlier, this project has been put on hold until long-term contracts are established with key export markets, a clear demonstration of the role global markets play in all aspects of this expansion.

Specific to biodiesel infrastructure, there is the "Financial Support Program for Biodiesel Investments", which invests in all phases of biodiesel production (agricultural phase, crude oil production, biodiesel production, warehousing, and logistics and equipment for biodiesel production). Its financing lines run via FINAME, Agricultural FINAME and Leasing FINAME under the auspices of the Ministry of Mines and Energy.[81]

There is also international financing already committed. The Japanese Bank for International Cooperation (JBIC) has made a large-scale investment in the biofuels industry. It is believed that part of JBIC's $565 million will be devoted to biodiesel and ethanol transport and logistics infrastructure.[82] Furthermore, Belgium, Germany, France, India, and China have begun to express interest in this sector of the biofuels supply chain.[83] From a multilateral standpoint, the IDB, World Bank, and USAID have broad-ranging initiatives that may include some infrastructure investments for biofuels.

The private sector, while concentrating its strategic investments in production facilities for capacity expansion, is also engaging in infrastructure investments, particularly export infrastructure. Ethanol manufacturers and related industries are also pressuring the government to move forward with infrastructure investments and are exploring joint projects, such as the proposed Unica/State of Sao Paulo pipeline.

In the global context, while most countries invest 2% - 2.5% of GDP in infrastructure, Brazil has invested only an average of 0.5% since 1990. Across industries, infrastructure is considered a stumbling block for growth, which is steady at less than 4%. Specifically for biofuels, the $10 billion in capacity expansion investments already underway creates an immediate need for investment to connect these projects to markets or risk significant losses in revenue, energy and time. In addition, the government must give serious attention to how important logistical and inter-modal infrastructure will be for the biofuels sector. For an industry with a rapidly growing number of participants, distribution has become extremely fragmented. National projects involving logistics and transportation must be considered in order to reduce costs and sustain the industry's competitiveness. Cumulative logistical costs throughout the entire supply chain are considered much higher than in other countries.

D) Risks for the Sector

The risks to not investing in infrastructure in support of biofuels capacity expansion include an over-reliance on one mode of transport, which is currently roads, and thus elevated costs, accidents, and backlogs in moving fuel. A further concern is the inability to compete on the international market as a result of delays in ethanol from the interior reaching Brazil's ports. An often-cited example is that ethanol produced in Piracicaba and Riberão Preto must be trucked through the city of São Paulo before reaching its coastal port destinations.[84] Brazil's ability to provide quickly and on a deadline when oil prices skyrocket and an international importer requires supply could be severely complicated. The lack of transport diversity could also exacerbate the country's storage shortfalls. If production continues and backlogs occur, adequate storage space will be critical.

Actors in this sector are keenly aware of the risk associated with making major infrastructure investments for a market that can still only be called "potential". This hesitance was most recently evidenced by the announcement that Petrobras will not begin construction of the touted ethanol pipeline network without long-term contracts from export markets. Brazil is wisely seeking foreign partners, ideally from the export markets with an interest in its biofuels production, to jointly invest in infrastructure ventures, sharing both the risk and reward. Industry leaders complain that infrastructure is following production, not leading it.

The lack of attention to infrastructure for the much smaller biodiesel industry is not as worrisome. That said, if Brazil is to scale up production to 3 billion liters and beyond, Petrobras Distribuidora will not be able to handle that quantity via a single mode of transport. This is particularly the case because much of biodiesel production is likely to come from palm and castor, feedstock cultivated in less developed regions of the north and northeast. Because biodiesel expansion is a government-sponsored social development program, additional consideration will need to be given to providing sufficient logistics to enable access to production by small-scale, family farmers.

Inattention to infrastructure could also limit the number of pumps available for biodiesel in the country and thereby prevent access to the blended fuel, making it difficult to reach the 2013 target of universal B5 usage. Still, focusing too heavily on biodiesel, which carries a social development component, might take attention away from ethanol, which by virtue of its scale is clearly the priority commodity from a business perspective and in terms of promoting Brazil's global leadership.

E) Conclusion

Infrastructure, particularly transport infrastructure for export, is the leading concern of virtually every expert and industry representative consulted for this report. Cogeneration represents an opportunity for diversifying Brazil's electricity generation capacity both geographically and by source. Communications networks, while not universal, are expanding rapidly and offer a platform, rather than a constraint for capacity expansion. The real challenge lies in reorienting Brazil's biofuels transport infrastructure to face out to export markets, expanding its overall capacity, and pushing into new regions of production.

There are fundamental problems in the existing transport infrastructure, which depends largely on Brazil's roadways, that are universally acknowledged and not sector specific. The poor conditions of the highway system and the congestion in port access affects export industries across the board. There is no short-term, easy solution. However, looking forward, the growth of the biofuels export industry should bring a graduation of sorts. If the conservative estimate referenced in this report of 6 billion liters of ethanol exported in 2012 is accurate, a shift into rail, waterway, and most importantly, pipeline transport will be critical. While roads will likely remain the primary means of domestic distribution, their relevance to export will lie in providing access to collection points for conveyance via these other forms of transport. Various studies of ethanol expansion have concluded that a major investment in infrastructure is needed, ranging from $1 billion a year for the next 20 years for production of just over 100 billion liters to $1 billion a year for production of 31 billion liters by 2020.

The other significant bottleneck to export growth is port capacity. The primary constraints are crowding due to a lack of shipping berths and terminals, storage capacity in ports, and depth of shipping channels. Determining where and how an estimated $320 million in short-term (to increase export capacity by 7 billion liters) investment is distributed is under active discussion today in Brazil, requiring an assessment of ports as an intermediate step in a supply chain from farm to foreign market. Given Brazil's ambitious capacity expansion goals and the average costs of port projects underway (terminals cost $70 million each, shipping berths cost $30 million each, etc.) investment needs in the medium term are likely to be closer to $1 billion.

The interdependence of capacity expansion and infrastructure demands that both be integrated into a common strategy. What is now required is a dual focus – looking into Brazil to facilitate the growth of the biofuels industry in underdeveloped regions and looking outward to how production reaches ports for exports. Industry leaders complain that to date, infrastructure has followed, rather than led production. With the current pace of investment, and with some $10 billion in new projects underway, the time to move forward is now.

Actions that could be taken to improve the infrastructure to support biofuels capacity expansion include:

1. Develop an Agroenergy Infrastructure Fund that, with the Brazilian government and private sector, would structure and finance integrated infrastructure projects already identified or underway to service existing production as well as develop new integrated infrastructure projects for areas of potential production. The Fund would anticipate and create the market, rather than follow it:
   a. Existing production projects: A number of projects are planned or underway to facilitate export from areas of concentrated existing production. Notable examples are the construction of a pipeline to connect the Sao Paulo State REPLAN refinery with the Ilha D'Agua port in Rio de Janeiro and the planned $600 million Petrobras pipeline expansion project through Sao Paulo Goiânia - Goiás and eventually into Mato Grosso. In these cases, the Fund would provide financing for complementary infrastructure projects, as needed, such as the construction of storage facilities, the expansion of terminals and berths, and access roads to the pipelines.
   b. Identified/Proposed Projects: There are also a number of projects that have been proposed and which reflect a clear need, but for reasons of financing, regulatory restrictions, or insufficient buy-in from key actors, have not moved forward. Notable examples are a possible rail connection between Minas Gerais and the Vitoria port in Espirito Santo and the development of an ethanol-dedicated terminal in Sao Paulo state, but not attached to the ports of Santos and Sao Sebastiao. In these cases, the Agroenergy Infrastructure Fund would collaborate with relevant public and private sector actors to develop an integrated infrastructure project, analyzing the entire supply chain to identify the most cost-effective means of transport at each stage. A set of financing packages would be made available to the appropriate actor or actors for each component of the project.
   c. New Projects/New Regions: In regions like Tocantins and Maranhao, integrated infrastructure projects could serve as the impetus for the expansion of production itself. In these places, pipelines or rail would help create a transport infrastructure system designed specifically for export. Today, the lack of infrastructure in these regions is the primary disincentive to productive expansion. Studies done for the Brazilian government predict that productive capacity could increase more than six-fold if investment is made in new projects and the research necessary to adapt cane production to these areas is successful. Infrastructure can lead this investment, if projects are undertaken as part of a cohesive strategy, as advocated by this report.
2. Conduct an in-depth study of the economic impact of current regulations, that have created a near monopoly in pipeline transport, and suggest policy alternatives.

Cogeneration:
Cogeneration offers Brazil a substantial opportunity to increase generation capacity, diversify its electricity system, improve the geographic distribution of generation, address the specific vulnerabilities of hydroelectric power, and meet the government's rural electrification goals. 85.4% of electricity comes from just one source, hydro, with current supplies concentrated in the country's south and with an average loss of 16% in distribution. Further, while industrial growth and urban populations are concentrated in this same region, there is limited potential for new projects there. Additionally, hydroelectric power is seasonally variable, and a drought in 2001 contributed to a shortage that year. There is also a great disparity in Brazil between rural and urban electrification, with nearly 60% of rural households in the country's north still without electricity according to the most recent data. The government has recognized these issues and is actively engaged in their resolution through new hydro, nuclear, and renewable power projects, the ProInfa program, and an ambitious rural electrification program, Luz para Todos. Cogeneration is not an alternative to these efforts; it is an additional source of power that could make a much greater contribution than it does today to addressing the specific vulnerabilities of the system. According to Brazilian government estimates, if existing mills upgraded to high-pressure boilers, they could provide more than 6% of the country's power consumption in 2004, and that does not consider further technological advances or the construction of new mills. To best exploit this opportunity, the following actions could be taken:

1. Identify appropriate policy reforms to encourage cogeneration by streamlining the bureaucratic process or, possibly, providing a blanket authorization allowing producers to connect to the grid.
2. Conduct an in-depth study of the potential of biofuels as a source of "off-grid" electrification, either through biodiesel-fueled systems or through mill-generated electricity used locally.
3. Provide financing lines for investment in high-pressure boilers and infrastructure to connect to the grid.

Communications:
Access to the internet in Brazil is still far from universal, but is growing rapidly and offers a platform for increased efficiency in the biofuels industry and an increased connectedness with global markets. Unlike fossil fuels, biofuels can be produced on a relatively small scale, which fits into the Brazilian government's additional goal of using the industry as a tool for rural development. These smaller producers could gain efficiency by using the internet to establish virtual economies of scale. This could be through simple knowledge and information sharing, or though a more sophisticated system of collective purchasing and marketing.

Further, as global markets develop, electronic trades in liquid global markets should allow producers and consumers with access to the system to have direct links to one another, or to a common global futures exchange on which to trade their products, rather than rely on a trading company. In effect, the middle men will disappear. Possible actions to support these developments include:

1. Developing an "Agroenergy Internet Project" which would:
    a. Serve as an initial platform for knowledge and information sharing between producers;
    b. Develop into a means of establishing "virtual economies of scale" through collective purchasing and marketing; and
    c. Connect producers to Brazil's Innovation Center of Excellence network to fa cilitate the dissemination of new technologies and improved agricultural or processing methods.
2. Provide training to farmers and small-scale producers to ensure that they can reap the benefits of such a system.
3. Create a "micro-financing" line that would enable small-scale producers to acquire the necessary technology to access these systems.

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PILLAR IV: BUILDING GLOBAL MARKETS

5. PILLAR IV: BUILDING GLOBAL MARKETS

A) INTRODUCTION

A key prerequisite to an overall economic growth strategy for Brazil and the Americas must be an understanding of the global market for biofuels. Worldwide, governments have responded to energy shortages by investing heavily in biofuels, channeling resources into research and development, designing producer and consumer incentives, and, in some cases, imposing biofuels blending requirements. Currently, Brazil and the United States lead the world in biofuels, producing 16.04 billion liters and 16.19 billion liters respectively in 2005,[1] totals that are expected to grow to meet swelling global demand.

For all its potential, the global biofuels trade is relatively undeveloped, and national policies are still primarily directed toward domestic consumption. According to the IEA, just 10% of world ethanol production in 2004 was traded internationally, and only 20% of that was used in fuel. However, the need for an international trade in biofuels is becoming clear. Both ethanol and biodiesel production require robust agricultural sectors, and only countries with advanced agroindustrial capacity have been able, thus far, to create a solid foundation for the industry. Production capacity for ethanol is concentrated largely in Brazil and the United States, while biodiesel is concentrated in the EU. Even these relatively developed biofuels industries, however, rely heavily on government subsidies and support, particularly in the US and Europe.

Given current levels of consumption and present growth rates, countries with high energy demand such as the US, EU, China, Japan, and India will not be able to satisfy their growing demand through domestic production alone. Given their natural resource endowments, optimal climate, and competitive labor and land costs, developing countries in Latin America, Asia and Africa may be among the most efficient suppliers in the future. Supporting the development of a market infrastructure in the short run will help to ensure adequate resource allocation and access to global supply.

While the desire for energy security drives a significant amount of biofuels investment, relying solely on augmented domestic capacity would, in fact, reduce countries' overall energy security. Feedstock production depends on consistently good agricultural conditions, and adverse weather or pestilence can easily disrupt domestic production (as happened recently in India) and force countries to tap the international market. An established global trade in biofuels can ensure supplementary supplies, allow for the build up of stocks, ease price fluctuations, and reduce subsidies.

A functioning international biofuels market does not yet exist, but Brazil has taken a leading role in developing the ethanol industry and designing a futures market to enable international trade of the commodity. Recognizing the global potential for trade and development, Brazil has already signed multiple technical cooperation agreements with countries around the world and has called for an international conference to establish consensus on global standards. Additionally, countries including the US, EU, India, Singapore and Brazil are also beginning to develop commodity indices and risk management tools to support biofuels exchange. International exchanges are launching new futures contracts for biofuels feedstocks and the global demand for biofuels is slowing putting pressure on financial markets for more sophisticated biofuels derivatives. Still, the current lack of clarity over biofuels standards, coupled with the myriad support mechanisms and protectionist measures continue to impede international flows. Timely efforts to harmonize biofuels commodity standards, reduce institutional and regulatory barriers, and standardize contract requirements would enable biofuels trade and thereby enhance energy security, reduce overall GHG emissions, and contribute to international economic development.

B) DIVERSIFICATION OF PRODUCING AND CONSUMING COUNTRIES

At present, production capacity is concentrated within a handful of countries, namely Brazil, the United States, China, South Africa and the EU, the majority of which are highly industrialized, energy intensive countries that are not able to meet domestic demand. Indeed, an analysis of supply and demand suggests that energy consuming nations will need to import a substantial amount of their biofuels requirements from the developing world.

There is reason to think that production in developing countries will increase markedly. A recent study published by the International Energy Agency estimates considerable improvements in cane-to-ethanol yields to 2020, assuming countries follow a Brazilian industry model. The scenario illustrated below projects that 240 billion liters of ethanol could be produced globally by 2020, with the largest production in Brazil and India.[2]

Table 5a: Cane Ethanol Blending Supply and Demand 2020 (billion liters)

Region	**Demand 10% gasoline + 3% Diesel**	**Supply** *(E4 Scenario)*	**Balance**
Africa	9	22	13
ASEAN	10	29	19
India	6	49	43
Other Asia	56	23	-33
Brazil	7	62	55
Other South America	8	17	9
North/Central America	88	31	-57
Oceania	4	7	3
Europe/Russia	52	0	-52
World	**239**	**239**	**0**

Source: Stockholm Environment Institute[3]

These projections illustrate the significant asymmetries between supply and demand centers, but they do not reflect the aggressive policies of some countries already implementing a 10% or greater minimum blending requirement. For example, Brazil already implements a 23% blending requirement with an attainable 5% biodiesel target for 2013, statistics that significantly increase total global demand in 2020.

Table 5b: Ethanol Supply Statistics for Selected Producers

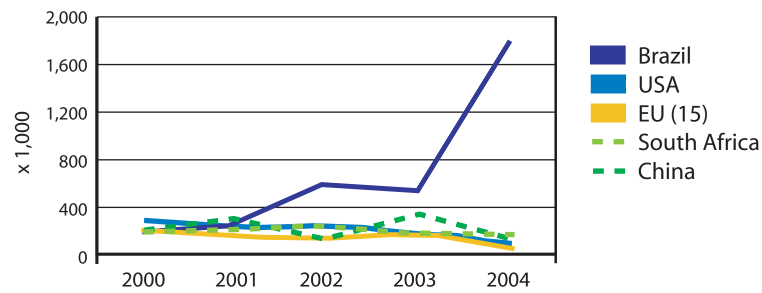
Country	Legislation	Ethanol Prod. *(2005)*	Ethanol Proj. Demand	Ethanol Proj. Capacity	Shortfall/ Future Outlook
Brazil	Blending requirement 23%	16.04 billion liters			
United States	Renewable Fuels Standard Program: current blending default of 2.78% for 2006	16.19 billion liters	28.5 billion liters RFS requirement by 2012.	28.39 billion liters by 2012.	In January 2006, 16.4 billion liters capacity with additional 7.4 billion capacity under construction. Still, in 2005, U.S. consumption reached 15.2 billion liter high with 4.5 billion liters imported to the U.S. through the CBI.
EU		2.7 billion liters			In 2005, imports hit record high of almost 635 million liters up from 395 in 2004; exports fell to 70 million liters from 87 in 2004.
China	Renewable Energy Promotion Law, E10 law in 5 states	3.8 billion liters (fuel ethanol 1.3 billion liters)	2020: 22.8 million tons	2020: 8 million tons	10% blend, China will be able to produce 50% of demand.
India	Ethanol 5% compulsory nationwide in 2006	1.7 billion liters (fuel ethanol 200 million liters)	2006: 5% blend or 506 million liters; 2007: 10% or 1.12 billion liters	n/a	In short term, India is expected to need to import ethanol to meet the 5% target. (India imported 410 ml of Brazilian ethanol in 2005
South Africa		389.78 million liters			

Brazil, the US, the EU, China, and India, among others, have drafted, and in many cases, passed legislation including biofuels blending requirements, increasing the global demand for biofuels. Strong agricultural traditions and influential lobbies in many of these countries have successfully garnered government support for biofuels development, which is revitalizing depressed agricultural sectors. Still, biofuels will not resolve energy security issues. Unexpected and adverse weather conditions, disease or other unexpected factors may reduce crop yields and domestic production capacity. Some bioenergy proposals carry a nationalistic tone and rely excessively on projected domestic capacity to meet future demand. While the primary producers have invested heavily in domestic capacity and encouraged biofuels consumption, an exclusive reliance on domestic production enhances risk and limits the efficiency gains that an internationally competitive market would yield. As the global demand for ethanol grows, it becomes increasingly important to diversify the geographic production of biofuels and create a functioning market to provide equilibrium in supply and demand.

Although the current discussion relates specifically to the ethanol market, increased biofuels production will most likely lead to additional trade in feedstock for fuel biodiesel production. While statistics in ethanol trade are more readily available, international trade in vegetable and seed oils have also grown significantly in the last five years. Rapid increases in soybean and palm oil trade in recent years may in part be the result of increased biodiesel production.[4]

The ethanol trade is still relatively small due to the youth of the industry and to a lack of appropriate market mechanisms. In 2004, international ethanol trade amounted to approximately 3 billion liters[6] (compared to 920 billion liters of traded crude oil).[5] In 2005, world trade grew to 5 billion liters. Brazil exported 2.6 billion liters of ethanol[7], accounting for 53% of global ethanol trade, with the EU a distant second at 12%.[8] As global demand increases, it will be imperative to diversify production centers to decrease the risks associated with concentration and ensure price and supply stability.

Chart 5a: Exports of Undenatured ethanol of strength >=80% (HS220710) from the five leading world exporters (in tons):

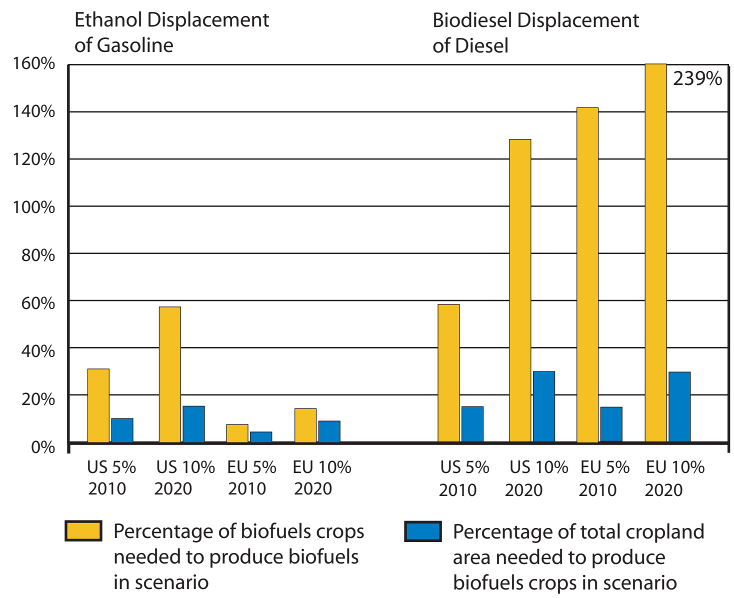


Source: UNCTAD[9]

Beginning in 2001, Brazil captured the majority of the export market by significantly expanding its capacity (beyond domestic demand) and establishing a number of bilateral ethanol agreements. The absence of a formalized biofuels markets has, to a certain extent, impeded other producers from fully developing their industries and becoming competitive in the export market.

Constraints on land, feedstock, and other resources virtually ensure that the highly industrialized high-energy consumption countries will not be able to satisfy their demand with domestic production alone and will increasingly look to the international market. To meet the demand generated by a 5% ethanol fuel blend requirement by 2010 and a 10% ethanol fuel blend requirement by 2020, the US and the EU would need to dedicate nearly 60% of biofuels crops (including corn, sugar, and soybeans) to biofuels production rather than for food or other uses.[10]

Chart 5b: Estimated Required Crops and Cropland Needed to Produce Biofuels under 2010/2020 Scenarios:



Source: International Energy Agency[11]

Prepared by Garten Rothkopf

Table 5c: Brazil's International Biofuel Agreements

Country	Description of Bilateral Agreement
Central America: Guatemala, Honduras, Nicaragua, Costa Rica, El Salvador	"Technical Cooperation in the Area of Production Techniques and the Use of Ethanol" – cooperation in technology research and development.
Jamaica	Signed letter of intent for technical Cooperation
Mexico	Mexico interested in Implementing Brazilian Production Methods
China	Brazil expects China to become its No. 1 trade partner in the near future; Petrobras has office in Beijing; See Article below.
India	Relations between India and Brazil are the most intense that they have been with India seeking to implement a program similar to Brazil's PROALCOOL to promote biofuels and flex fuel vehicles.
Japan	Challenges to investment include infrastructure, excess tax issues, protectionist regulation, bureaucracy and market fluctuations; in May 2005, Japan and Brazil signed a US$500 million loan agreement to finance domestic infrastructure development projects as well as capital investments made by Brazilian exporters, which include local Japanese affiliates; considering an E5 blending mandate based on imports from Brazil, In March this year, Petrobras set up a joint venture with state-owned Japanese firm Nippon Alcohol Hanbai to export ethanol. The new company, Brazil-Japan Ethanol Co., serves as Petrobras' agency in Japan; Japan JBIC To Invest $568 Mln in Brazil Biodiesel, Ethanol Projects.
South Korea	Possible trade of ethanol in the works.
Vietnam	Ethanol Technology Offered
Thailand	Partnership for Development Initiative. In 2004 Brazil signed a contract to export 300,000 liters of ethanol to Thailand.
EU Bloc	The European Union will not forbid ethanol imports from Brazil, said the EU Agriculture Commissioner Mariann Fischer Boel on Monday. According to her, the bloc will continue to buy Brazil's bioethanol.
France	France's Dagris, co-investing in castor beans biodiesel plant in the Brazilian state of Bahia.
Germany	Brazil, world's largest ethanol producer and Germany, Europe's largest biodiesel producer, have agreed on technology exchange opening up trade for sugarcane based ethanol and soybean based biodiesel.
Italy	Fiat Automotives, the Brazilian branch of Italy's Fiat reversed 2004 losses to a profit in 2005 attributed to success of bio-fuel models.
Pakistan	Interested in obtaining technology that Brazil has already dominated in systems for compression of natural gas, production of ethanol for use as vehicle fuel and in the chemical industry. Sugarcane is one of the main agricultural products of Pakistan.
Nigeria	Technical and commercial support from Petrobras. The present agreement envisages technical and commercial support for the addition of ethanol to petrol, as well as support for the development of the industrial process for fuel ethanol, co-operation in production of primary materials, negotiation of ethanol supply contracts and biodiesel production information exchange.

Given agricultural, fiscal and political constraints, countries may not be able to dedicate the additional land necessary to provide domestic supply stock. Further, relying on sustained agricultural yields would make nations vulnerable to adverse climate and weather conditions that are capable of destroying domestic feedstock and paralyzing production.

Existing agreements between Brazil and other developing countries [Table 5c]
Brazil has embarked on an international campaign for the development and exchange of biofuels. Diplomatic missions have resulted in bilateral agreements for the transfer of technology and expertise with other countries. The Brazilian government supports the expansion of global ethanol production and is making concerted efforts to support other countries' biofuels development initiatives. Through the global promotion of biofuels, Brazil will provide its institutional and technological expertise to countries seeking to develop their domestic industries, a process which will strengthen the country's international commercial relationships and generate support for a global biofuels market. Cognizant of growing global demand and Brazil's productive efficiency, the country stands to gain tremendously from enhanced commercial relationships, trade agreements, and a global market through which it can competitively export to demand centers.

Brazil has identified biofuels as a tool for international economic development and seeks to enhance global capacity to develop and sustain a liquid commodity market for biofuels. As one of the world's leading biofuels producers, Brazil continues to establish various commercial relationships with public and private sector entities interested in acquiring Brazil's technology and expertise. Fostering growth and healthy competition within the biofuels market will breed efficiency and generate positive social, economic and environmental returns.

C) GLOBAL STANDARDS AND TRADE ISSUES

The Need for International Standards

A more robust biofuels trade will require a more sophisticated market and standardized means through which the commodity can be efficiently and profitably traded. International standards for biofuels have yet to be codified, and the harmonization of different national regulations is imperative to facilitate trade, diversify global energy sources, and satisfy rapidly increasing global demand. An international minimum standard would assure buyers and sellers that the fuel purchased in the international marketplace would be of standard quality and would not pose risks to the end user. Further, standardization would reduce barriers currently distorting international markets and enable suppliers to trade more readily, fomenting competition and breeding efficiency.

Designing a globally recognized standard will be an exceptionally complex task, in large part because national biofuels industries have agricultural, industrial, political and other stakeholders. Interested parties must agree on specifications and criteria to be applied consistently in the classification of and terminology for each fuel and in their manufacturing processes, testing, and analysis.

Industry leaders, notably Brazil and the US, could in theory provide a basic template and set of best practices for smaller producers. Yet, there are significant variations even between Brazilian and US ethanol standards and measurements. As a result, entrepreneurial countries seeking to define their national standards lack a consistent framework from which to work, leading to the proliferation of individualized standards. Some countries such as Australia[12] have mixed and matched elements from the US and Brazilian standards and applied them to their domestic industries.

Current Position of the WTO
A further complication is the World Trade Organization's failure to distinguish between fuel and non-fuel ethanol under its Harmonized System. Current classifications fail to differentiate products by their chemical composition.[13] Further, ethanol fuels are rec-

ognized as agricultural products whereas biodiesel products are labeled as industrial, thereby incurring substantially different treatment under international trade rules for subsidies and other domestic policies.

Amending the Harmonized System and creating explicit criteria for biofuels in terms of chemical composition, processing characteristics, and end-use is a possible approach. However, the Harmonization System is reviewed only once every four years, and WTO decisions must be unanimous. There is also the danger that supplementary WTO agreements such as the agreements on Agriculture, Subsidies and Countervailing Measures, and Sanitary and Phytosanitary Measures will permit countries to erect and maintain barriers to protect their domestic industries.

The Agreement on Technical Barriers to Trade (TBT) is the WTO's principal agreement on standards, regulations, and labeling and could serve as a channel for the codification of biofuels regulations. The Agreement allows countries to establish standards at their discretion, as long as they do not discriminate or create illegal barriers to trade. The TBT could support the development of international biofuels standards insofar as it applies mandatory measures that specify the characteristics of products and their related processes and production methods.[14] On the other hand, exceptions under the GATT General Exceptions provision may actually assist countries to access desirable export markets. The General Exceptions clause allows parties to trade directly and circumvent some of the barriers resulting from regulatory ambiguity or uncertainty regarding biofuels. The GATT General Exceptions clause would prevent countries from being victims of arbitrary or unjustifiable trade discrimination from other countries attempting to unfairly protect their domestic industry.

Establishing a Common Standard

While the WTO provides general classifications, individual stakeholders have spearheaded efforts to devise a minimum standard to be applied within their industries. In 2005, the Government of Australia sought to define a fuel standard by comparing other existing national standards on ethanol. The group drew primarily on the experiences of the US, EU, and Brazil and established a set of 13 key parameters for ethanol that impact fuel emissions, fuel consumption, and engine durability and operability. The Sao Paulo Sugarcane Agroindustry Union conducted a similar comparison to identify specification trends and isolate common features.

As discussed, ethanol can be divided into various categories according to its chemical composition and processing, including bio-based, synthetic, hydrous, anhydrous, proprietary grades, denatured and undenatured. The Australian study indicates that anhydrous ethanol is used most commonly in petrol, with the exception of Brazil. The majority of countries therefore use high-purity anhydrous ethanol as a point of departure for fuel ethanol standards.[15] Anhydrous fuel ethanol is ethyl alcohol with an extremely low water content, generally derived from biomass such as sugarcane, sugar beet, corn, grains, and cellulose stock.[16] Due to the varying feedstock and processing procedures associated with anhydrous ethanol, there exist a myriad of specifications that differ across sectors.

Table 5d: Comparison of Specifications for Anhydrous Ethanol

Specification	Brazil	USA	Sweden	Poland	Canada
Aspect/Appearance	x	x	x	x	x
Color	x		x		x
Ethanol Content	x	x	x	x	x
Water Content		x	x	x	x
Total Acidity (as acetic acid)	x	x	x	x	x
Density	x		x		x
Hydrocarbon content or denaturant	x	x	x		x
Electrical conductivity	x				
Methanol Content		x	x*		
Aldehydes (as acetaldehyde)			x	x	
Copper	x	x		x	x
Chlorine				x	x
Sulfur		x			
Non-volatile Matter					x
pHe		x			
Solvent-washed Gum		x			
Fusal Oils				x	
Esters				x	

Source: UNICA[17]

Both global surveys determined that it would be necessary to define the type of ethanol, harmonize its specifications, and determine whether the specification refers to denatured fuel or not. The United States has taken the position that ethanol should be sold as denatured fuel ethanol given that US ethanol will be sold on the market as denatured. However, given that countries have differing denaturing requirements and that the majority of global producers export undenatured ethanol, a general standard for undenatured fuel ethanol will not only apply to a greater percentage of traded ethanol stocks, but it will allow individual countries to then maintain their own denaturing requirements.[18] Given the fact that Brazil currently supplies approximately 53% of global ethanol, it is more likely that an international standard will be based on Brazilian practice. In any case, it is critical that such issues be addressed in an inclusive and coordinated manner to facilitate international exchange and ensure global supply.

Seizing the opportunity

Discussions of international standards have been slow to materialize, and at the recent G8 summit in Saint Petersburg, President Lula da Silva called for more urgent international participation in the creation of harmonized biofuel standards. In order to facilitate this dialogue, Brazil is currently proposing an "Ethanol Forum" to bring together various industry stakeholders and establish international standards. Given that the US will be Brazil's largest ethanol export market in 2006, President Lula is seeking to cooperate closely with the United States in this endeavor. In February 2007, US Secretary Undersecretary of State for Political Affairs visited Brazil and Argentina to discuss hemisheric cooperation in ethanol and other biofuels. The Brazilian Trade Ministry has indicated that the US and Brazilian industrial standards agencies have already begun cooperation on defining standards such as levels of impurities and solid residues.[19]

The European Union has yet to develop a common standard for ethanol or biodiesel. The European Commission along with the Dutch Standardization body (NEN) that currently holds the CEN Secretariat for Automotive Fuels Standards and the International Fuel Quality Center (IFQC) have coordinated a biofuels standards conference for February 2007. The EC collaborated with the US Department of Commerce and received contributions from Brazil to prepare the agenda for the international conference that will address both ethanol and biodiesel standards.[20]

Harmonizing inconsistent national standards and clarifying trade regulations are therefore urgent priorities. Ethanol is the natural starting point, but any progress made on standards for ethanol will benefit the rest of the biofuels sector as the expanding biodiesel industry will inevitably require similar attention.

D) GAPS AND IMPEDIMENTS

A lack of consistent standards is not the only obstacle to an international biofuels market. A variety of trade barriers including tariffs and other measures are also obstructing international trade. The United States has an ad valorem tariff of 2.5% plus an additional tax of $0.54/gallon. Similarly, the ad valorem tariff on Canadian ethanol was $0.19 per gallon; $0.65 per gallon in the European Union; and $1.35 per gallon in Japan.[21] Non-tariff barriers such as sanitary and phytosanitary measures and national origin requirements, among others, also restrict international exchange. Numerous incentives exist for governments to protect their domestic industries. Governments view biofuels development not only as a means of diversifying their energy supply, but also as a means to revitalize depressed agricultural sectors. Protectionist trade policies will likely remain in the short to medium term as governments argue that their "infant industries" would be unable to survive in an internationally competitive market.

Domestic regulations such as mandatory blending requirements, property or performance specifications, labeling, health and safety as well as environmental regulations may also restrict trade flows. An international minimum standard would be needed to assist exporters and importers to transcend these barriers.

E) A FUNCTIONING MARKET: Tools for Efficient Biofuels Trade

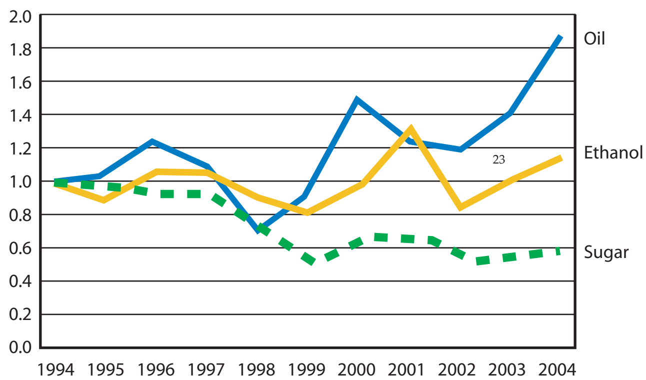
The Role of Futures Contracts
Futures contracts allow producers and buyers of agricultural commodities to insulate themselves from future price fluctuations. By agreeing now on the price for a commodity to be delivered months in the future, buyers and sellers can protect themselves against market fluctuations. In an industry where output can vary precipitously from year to year, the role of futures contracts must not be underestimated: they allow sellers and buyers to budget, allocate resources, and conduct their operations without paralyzing levels of uncertainty.

The Importance of a Futures Market to the Fuel Ethanol Industry
The fundamental task of any futures exchange then is to allow producers and buyers of a commodity to insulate themselves from risk associated with unexpected short and medium-term price fluctuations. In the specific case of ethanol, this risk is significant, and can be divided into six distinct (though not entirely exhaustive) categories:

- *Demand*: The most important determinant of the price of ethanol is the quantity demanded by consumers. Demand will fluctuate with the price of complimentary goods like gasoline, which must be consumed alongside ethanol, and with the price of substitutes, like MBTE.
- *Input Prices*: The price of ethanol is tied to the prices of the commodities that are its inputs. Since these inputs are agricultural, their prices can fluctuate greatly. In addition, since the inputs to ethanol production can be used for food as well as ethanol, producers also face price risk associated with demand and supply variations in the food market.
- *Public Policy*: Uncertainty about the adjustments that governments will make to ethanol-related regulations adds to the price risk faced by ethanol producers and buyers.
- *Technology*: Technological advances in ethanol production and transport are significant and unpredictable, and can have important effects on price.
- *Transportation*: Fossil fuel prices affect the day-to-day price of ethanol transportation and, ultimately, the end price of ethanol. In addition, as international trade in ethanol increases, parties to ethanol transactions will face low-probability but high-severity risks associated with transportation accidents—the classic example being the sinking of a tanker. Futures markets do not provide a direct hedge against this risk, but they allow all of the participants in the markets to hedge against the scarcity-related price effects of such catastrophic loss.

A risk-mitigation strategy that addresses only one of those variables can never be successful. Ethanol producers can neutralize their exposure to an increase in price of sugar by "going long" in the sugar futures market, and can hedge against the risk of higher fossil fuel prices by doing the same in the oil futures market, but they cannot fully protect themselves from fluctuations in the end price of ethanol itself, because that price depends on factors other than the price of sugar and oil. Empirical data (see chart below) reveal the imperfect correlation between the prices of the three commodities. An ethanol producer that sought to use sugar and oil futures as a hedge against price risk over the last 10 years would have been stymied.

Chart 5c: Prices of Oil, Sugar and Ethanol 1994-2004[22]



History of Ethanol Futures Exchanges to Date

As the international fuel ethanol market has emerged, futures exchanges have started to offer fuel ethanol contracts. So far, three institutions have offered ethanol futures contracts: the New York Board of Trade, the Chicago Board of Trade, and the Brazilian Mercantile and Futures Exchange.

- *The Brazilian Mercantile and Futures Exchange* (BM&F): BM&F began offering futures contracts in March 2000 and as of 2006 remains the only exchange offering a viable sugar-based fuel ethanol instrument. However, insufficient liquidity means that excess ethanol is often liquidated on the spot market. In addition, unclear tax regulations have tended to discourage participation in the exchange.
- *The Chicago Board of Trade* (CBOT): CBOT began offering futures contracts for US corn-based ethanol in March 2005. The board went electronic in 2006 as participation accelerated. CBOT was acquired in October by the Chicago Mercantile Exchange, the world's largest commodities exchange.
- *The New York Board of Trade* (NYBOT): NYBOT, a smaller exchange that focuses on coffee, sugar, and cocoa, introduced a sugar-based ethanol futures contract in May 2004, but the product failed to attract sufficient interest and is now mostly defunct. Recently, NYBOT has been exploring the possibility of re-introducing an internationally-targeted ethanol instrument, and there are unsubstantiated rumors of a partnership with the BM&F.[23] NYBOT was acquired by the energy-focused Intercontinental Exchange in September 2006.[24]

Table 5e: Leading Futures Exchanges:

Rank	Exchange	Traded Contracts *January thru August 2005*
1st	Chicago Mercantile Exchange (CME)	548,314,309
2nd	Eurex Deutchland (EUREX)	512,190,217
3rd	Chicago Board of Trade (CBOT)	383,639,398
4th	Euronext	322,359,754
5th	Brazilian Mercantile & Futures Exchange (BM&F)	118,799,059
6th	New York Mercantile Exchange (Nymex)	109,917,845
7th	Mercado Mexicano de Derivativos (MexDer)	80,280,532
8th	National Stock Exchange of India (NSE)	65,538,054
9th	Dalian Commodity Exchange (DCE)	62,624,317
10th	London Metal Exchange (LME)	44,214,137

Source: Brazilian Mercantile and Futures Exchange[25]

In addition to the above referenced exchanges, in January 2007, the Monetary Authority of Singapore (MAS) approved the launch of the Crude Palm Oil or CPO Futures Contract on the Joint Asian Derivatives Exchange (JADE). JADE is an electronic commodity derivatives exchange created as a joint venture between CBOT and the Singapore Exchange. The project was established to provide the Asian market with a developed, electronic and real-time trading infrastructure.

None of the other large commodity exchanges in the US, Europe, and Asia have expressed interest in offering an international sugar-based ethanol instrument, though it is conceivable that they might do so in the future.

Outlook for the Future

Exchanges that wish to enter the ethanol market must address four key challenges to effectively serve the needs of the ethanol production community. The most important challenge is liquidity: the volume of futures contracts traded to date have not been large enough to guarantee that any party who wishes to buy or sell a contract can do so at any time. Liquidity is a prerequisite of any market, and its absence can create a vicious cycle: participants do not want to enter the market unless they are comfortable with its liquidity, but the market will not be comfortably liquid until a sufficient number of participants enter. Another challenge for ethanol is that its uniqueness as a hybrid agricultural-fuel product may allow it to slip under the radar of futures speculators that specialize in either agriculture or fuel, but not both.[26] Finally, liquidity is also inhibited to some extent by consolidation in the ethanol market.[27] When prices are high, buyers have less incentive to enter into futures contracts, because the probability that price will rise even further is low. In a decentralized free-market environment, they will be forced to enter into contracts, because producers will not want to sell their product any other way. But when a relatively small number of buyers have market power—as they do in the ethanol market—they can use that leverage to force producers to sell them the commodity on the spot market, without the protection of a futures contract. Consolidation thus tends to encourage buyers to go outside the futures market.

The second challenge is the promulgation of effective ethanol standards. As discussed previously, standardization is the cornerstone of exchange-traded futures contracts, because it allows an exchange to successfully match relatively smaller numbers of buyers to sellers (and thereby facilitate liquidity). Futures contracts must specify easily verifiable and internationally applicable measurements of quantity (e.g., weight at a specific temperature), quality grades (color, appearance, hydrocarbon content, etc.), ports of delivery, and fees. No internationally-accepted standards currently exist. The US defines ethanol based on 9 measurements, Brazil uses 16, and their requirements vary on all shared measurements except appearance, which they agree should be clear and free of suspended matter.[28] Another particularly important factor for the international success of an ethanol futures instrument is that it stipulates the right ports of delivery. The now-defunct NYBOT contract made significant progress by allowing delivery in eight Latin American and Caribbean countries in addition to the US.

The third challenge is the development of trustworthy financial infrastructure. The CBOT and the NYBOT have robust electronic trade boards, use respected clearing houses to handle their transactions, and are governed by relatively transparent and respected US-based regulators. The BM&F, by contrast, labors under a regulatory and taxation environment that has yet to win the confidence of the international trading community. In addition, it does not yet have an electronic trade board, making transactions less efficient and dissuading some participants.

There is no evidence to suggest that any one of these challenges is serious enough to prevent the emergence of a viable futures exchange. If the BM&F gains the trust of international speculators, or if already-trusted US-based exchanges like CBOT or NYBOT make a commitment to serving the international market, these infrastructure concerns will become irrelevant. The standardization challenge will likely become less formidable as an exchange gains experience serving the fuel ethanol market. And the market concentration that apparently inhibits liquidity will naturally tend to erode as the ethanol industry matures and begins to behave more like a "normal" commodity. As the fuel ethanol market matures, and as producers become increasingly aware of the extent of price volatility, a robust futures market is all but guaranteed to grow up alongside it in order to serve this demand—just as a sugar futures market grew up around the sugar market almost a century ago.[29]

The primary outstanding question, then, is which particular exchange will end up hosting this market. CBOT and NYBOT benefit enormously from their physical and regulatory location in the worldwide financial capital markets, where they naturally attract the trust of international traders. But the BM&F, which is almost as big as CBOT and bigger than NYBOT, is uniquely located in the center of global production and consumption of sugar-based ethanol. Further, while US imports of sugar-based ethanol have spiked recently as the US fills the ethanol shortage created by its MBTE-replacement legislation, it has a clear long-term political commitment to meeting its domestic needs through the use of domestically-produced corn ethanol. If this commitment is maintained, it will likely distance the US from the rest of the world, where sugar-based ethanol continues to extend its dominance. If the BM&F is able to attract foreign traders and if it offers internationally-acceptable standardized contracts, it could well emerge as the center of the international fuel ethanol derivatives market.

According to the chief economist at CBOT, biodiesel production for 2006 was 1/40 of the size of the US ethanol market. In 2006, US ethanol production was 15.14 billion liters valued at $8 billion dollars. The biodiesel industry would need to produce a value of $1-2 billion annually in order to support a futures contract. Valued at approximately $200 million for 2006, the biodiesel market would need to grow by 4-5 times in order to meet the minimum threshold. CBOT contends that it will be 3-5 years before the market will require a risk management tool for biodiesel.[30] However, CBOT's figures are based on US production and trade of biodiesel. Rapid increases in both capacity and demand in on international markets, particularly in the EU, may push require futures contracts to develop more quickly.

Meanwhile, a number of banks and financial management institutions are responding to increased trade of biofuels feedstock. The UBS Diapason Global Biofuels Index[31] is published in US dollars, euros, Swiss francs and Japanese yen. The index is made up of futures contracts on 10 physical commodities, including corn, two types of sugar, wheat, barley, rice and lumber in the ethanol group and rapeseed, canola and soybean oil in the biodiesel group. The index provides market participants with precise price fluctuation information for the various feedstock. The index is not a risk management or hedging tool per se, but it has been useful for investors to track prices and speculate direction within the market.

Also on the European market, the international derivatives arm of Euronext launched the first derivatives contract for rapeseed oil, the primary ingredient used in the production of biodiesel. Euronext.liffe is the only exchange in the world that offers contracts for three of the principal components of biofuels, including wheat, sugar and rapeseed.[32] The new rapeseed contract comes in response to a high demand for biodiesel from the EU, which has targeted a doubling of production to more than 13 million tons by 2010.

F) CONCLUSION

The growing number of government sponsored renewable fuel programs and mandatory blending requirements contribute significantly to the burgeoning global demand for biofuels. As renewable fuel programs expand, limited arable land and constrained feedstock capacity will require a functioning biofuels market to transfer needed supply from efficient producers to growing consumer markets. The International Energy Administration states that growing demand for biofuels could replace petroleum by a share of 6%. While cost and technological barriers have historically impeded the sector's development, elevated international oil prices, superior agricultural and industrial processes, and sophisticated biotechnology are now making the economics of biofuels increasingly efficient and competitive. However, protectionist measures, heterogeneous classifications and undeveloped trading mechanisms impede the cross -border flow of biofuels which ultimately undermines countries' ability to diversify their energy portfolios and reduce their exposure to oil price volatility.

The pronounced asymmetry between global supply and demand centers underscores the need for a functioning biofuels market. Despite significant production capacity in countries such as the United States, Brazil, China, South Africa and the EU, aggressive biofuels mandates and intensive energy consumption will undoubtedly outstrip domestic supplies. Enhancing national energy security will not only require augmented domestic capacity, but it will demand a market through which energy intensive countries can readily access supplies from global producers in Latin America, Africa, East Asia and elsewhere in the developing world.

Due to the price and supply volatility of oil, many nations are embracing biofuels as a means of reducing their oil dependence. However, in the drive to augment domestic production capacity, few countries have recognized biofuels trade as an integral component of their energy security strategy. While domestic investment will assist countries' to diversify their energy supply portfolios, adverse weather conditions or damage to domestic feedstocks could actually undermine energy security if there is not a functioning, liquid market to rapidly supply shifted demand.

While biofuels are currently traded on a limited scale, a defined set of production and exchange standards will need to be established in order to facilitate the free flow of supply stocks. Establishing an international, cooperative trading framework is undoubtedly complex and will require the participation and agreement of nations currently employing (and promoting) unique standards. With the exception of recent, preliminary discussions within the World Trade Organization, there has not been a collective international effort to harmonize biofuels standards and to develop a trading mechanism to facilitate the exchange. The WTO has acknowledged the difficulty of classifying biofuels due, in part, to the agricultural and industrial nature of ethanol and biodiesel. The WTO does not currently define fuel and non-fuel ethanol and, further, has not determined the appropriate treatment for biofuels given the substantial subsidies and state support that currently characterizes the industry. As pioneer and leading global producer of ethanol, Brazil has, however, engaged in an international diplomatic and commercial campaign to promote global biofuel exchange. Through a variety of political and commercial agreements, Brazil contributes its technology and biofuels expertise in an effort to augment global capacity to drive the development of a liquid biofuels market.

Timely efforts to harmonize standards, reduce trade barriers, and standardize contract requirements will help provide a basic framework for a functioning futures market allowing buyers and sellers to reduce their exposure to the various risks associated with commodity trade. At present, the Brazilian Mercantile Futures Exchange (BM&F), the Chicago Board of Trade (CBOT) and the New York Board of Trade (NYBOT) offer ethanol futures contracts, although on a limited scale. In order for one of the referenced Boards to gain the confidence of traders and become the primary mechanism for international biofuel exchange, it must incorporate a harmonized set of international standards, provide sound financial infrastructure and have sufficient liquidity. While barriers remain, the global demand for biofuels continues to grow and the need for a functioning global market is becoming increasingly acute.

- As part of the Global Centers of Excellence Initiative, the IDB could support the creation of a Global Standards Initiative to develop, promote and foster the adoption of global standards in biofuels production, processing, transportation, etc. At the outset, the IDB and other International Financial Institutions could jointly sponsor an international conference bringing together governmental, industrial, agricultural, and commercial stakeholders to draft preliminary biofuels standards;
- Provide financial, political and organizational support for the development of an international biofuels certification board that guarantees the quality and composition of exported biofuels;
- Support the creation of a strategic ethanol reserve in Brazil to prevent disruptions in the domestic supply of ethanol and preserve Brazil's global reputation as a reliable producer.
- Support the BM&F as a preferred biofuels exchange board and assist in the modernization of exchange such that the BM&F will operate at a level on par with the NYBOT and CBOT;
- Coordinate with other International Financial Institutions such as the African Development Bank, Asian Development Bank and others to support technology transfer to diversify and increase global capacity and assist producers in adapting current facilities for bio-fuel conversion;
- Cultivate dialogue with the automobile industry to develop more efficient engine technology and promote flex-fuel vehicles around the world;
- Incorporate all stakeholders including the petroleum industry into periodic global biofuels strategy sessions to enhance cooperative 'buy-in' and to broaden the scope of biofuels promotion.

As this industry progresses, total global demand will be a combined function of political will, sustained investment, regulation, oil prices and other endogenous and exogenous factors. Given current positive trends in biofuels, the number of buyers and sellers requiring a tradable market for biofuels will only grow. The IDB is uniquely positioned to engage the various stakeholders and play a leading role in promotion of biofuels as an effective and sustainable tool for development.

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