REFLECTIONS ON BRAZIL'S ETHANOL INDUSTRY

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Proálcool: Brazil's experience with fuel ethanol

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President Ernesto Geisel created Brazil's National Alcohol Program (Proálcool) in November, 1975, by Executive Decree 76,595, at a time when the oil crisis was a global threat to economies dependent on oil imports. Its purpose was to provide incentives for the production of sugar cane ethanol as an alternative fuel.

Two separate stages in the implementation of this program merit attention. The first was the issuance of the aforementioned Executive Decree, with its extension through 1978, when distilleries were built and the automotive industry became involved in the production of alcohol-burning automobiles, even as ethanol was blended wholesale into gasohol. The second stage, which began in 1979, involved large-scale production of E95 fuel ethanol for vehicles running on straight alcohol. This initiative reached its peak in 1985.

Since the alcohol program's creation in 1975, Brazil's yearly alcohol production went from about 146 million gallons to 4.67 billion gallons – an annual growth rate of 11.8%. In fact, however, there were two distinct growth rates over time. Between 1975-76 and 1978-79 harvests, alcohol production went from 148 million to 648 million gallons. The sharp increase in the rate of growth is clear in the second stage of the program (1979-80 harvest) through its 1985-86 pinnacle. Within the latter time period, production went from 890 million to 3.12 billion gallons, and the geometric mean therefore yields an annual growth rate of 23% – concentrated in the South-Central Region[1].

SINCE THE ALCOHOL PROGRAM'S CREATION IN 1975, BRAZIL'S YEARLY ALCOHOL PRODUCTION WENT FROM ABOUT 146 MILLION GALLONS TO 4.67 BILLION GALLONS – AN ANNUAL GROWTH RATE OF 11.8%.

[1] Brazil's two main producing regions have different harvest seasons. The North-Northeast Region is made up of the states of Alagoas, Bahia, Ceará,

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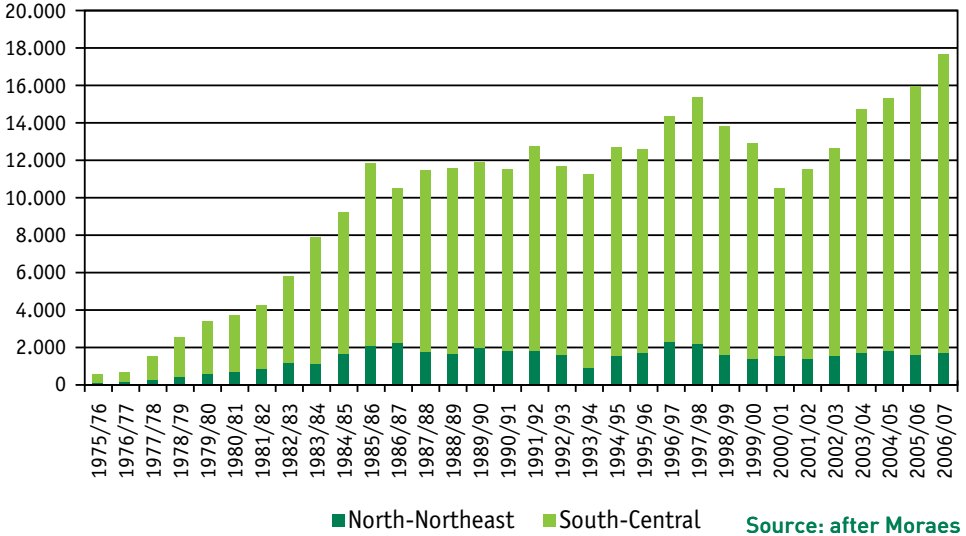
Alcohol production since the beginning of Brazil's National Alcohol Program can be seen in Figure 1.

Figure 1 – Alcohol production in Brazil, 1975-76 through 2006-07



Source: after Moraes (2000) and UNICA

The 1985 peak of the alcohol program was followed, for a time, by stable production at close to 3.2 billion gallons a year into the mid-1990s. Several events in 1986 led the Government to reevaluate its alcohol program. According to Santos (1993), global oil prices had been falling since January of that year, domestic oil production had decreased Brazil's dependence on foreign oil, and government priorities shifted toward controlling inflation and deficit spending. Any

Maranhão, Pará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe and Tocantins, and the South-Central region, São Paulo, Paraná, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás, Rio de Janeiro, Espírito Santo, Rio Grande do Sul and Santa Catarina.

enlargement of the alcohol program would clearly have to come in the form of increased agricultural productivity and more efficient industrial processes, for government funds for increasing the program had dried up.

On the demand side, two alcohol shortages in 1989 and 1990 shook consumer confidence in alcohol-fueled cars. Their sales dropped sharply as buyers went back to conventional cars. That trend was only reversed with the introduction of dual-fuel or flex-fuel[2] vehicles in 2003.

The drop in alcohol production one observes after the 1998-99 harvest may be explained in terms of deregulation of the industry and an end to production incentives, coupled with a sharp drop in demand for cars designed to run on alcohol. This in turn reduced demand for E95 fuel ethanol. Coinciding with sharp cutbacks in government intervention in the industry in 1999, there came a glut in the ethanol market and prices dropped to below production costs, triggering a sharp crisis in the industry. A number of plants were shut down as supply adjusted to market demand levels.

However, an upswing in production and sales of alcohol is discernible beginning in 2002. Environmental issues became a source of worry in many countries, which boosted production of fuel alcohol, inasmuch as it was considered a "clean fuel." Consumption of oxygenated fuels – aimed at reducing carbon dioxide emissions – began rising in developed countries as of the mid-1990s.

[2] A dual-fuel vehicle engine runs on E95 ethanol or gasoline in any proportion, from straight alcohol to straight gasoline, so that the consumer chooses based on the relative prices or availability of the two types of fuel. The first automaker to offer a dual-fuel vehicle was Volkswagen, when it introduced the "Gol".

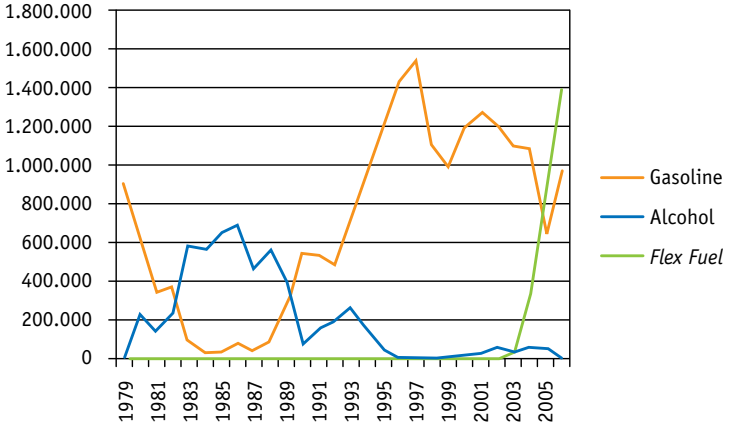
2003 also brought the unveiling of flex-fuel automobiles in Brazil. This, of course, increased demand for fuel ethanol, but more importantly, breathed new life into ethanol fuel production. Consumers were very pleased with the new cars, which allow them to tank up with alcohol and gasoline in any and all proportions.

Rogério Reis/Petrobras

Market forces: flex fuel cars and the international alcohol market

Careful observation showed that, since the beginning of the Alcohol Program, consumers were quick to react to program price incentives and to the relative prices of fuel ethanol and gasoline. The result was that automobile sales based on fuels fizzled out in a matter of months. Consumers were the key to the success of the National Alcohol Program and, in recent years, to the growth of the market for flex-fuel cars. Figure 2 is a time graph showing sales of alcohol-fueled and gasoline-fueled automobiles, plus dual-fuel car sales beginning in 2003.

Figure 2 – Alcohol and gasoline-fueled cars sales versus time.



Source: based on data from Anfavea

Several important changes may be observed from the graph. From 1979 to 1986 there was an overall growth in alcohol-fired vehicle sales. As 1982 drew to a close, there was excess demand for alcohol-fueled vehicles, which had a 38% market share for sales of passenger cars. That figure leapt to 67% in December of that year. From 1983 to 1989, vehicles running on alcohol accounted, on average, for 90% of total car sales.

Beginning in 1989, and probably as a result of an alcohol shortage of crisis proportions, sales of alcohol-fired vehicles began falling off. In 1990 their share of the total market had dropped to 11%, and in 1995 that percentage fell further, to a mere 2.2% of total sales, finally dropping to about 1% in the year 2000.

As pointed out earlier, two important developments in the alcohol agribusiness occurred in 2003 – developments which profoundly altered the medium-term outlook for fuel alcohol demand. The first was arrival on the market of dual-fuel au-

tomobiles (flex-fuel cars), and the second, the emergence of an export market for alcohol.

Observe that the flex-fuel vehicle lets the consumer choose which fuel to use, taking into account issues of efficiency (power, mileage) and relative prices of fuel ethanol as opposed to gasoline.

The impact of flex cars was twofold: first, as we have seen, there is the choice it offers consumers – banishing once-chronic worries over fuel shortages (for in an alcohol shortage they can always tank up with gas). Second, it makes the market self-regulating. As alcohol prices increase relative to gas prices, consumers tend to shift to gasoline. Reduced demand for alcohol drives ethanol prices down until consumers come flocking back.

We mustn't ignore the impact these vehicles have on alcohol production. When price swings favor alcohol, it is reasonable to expect increased sales of dual-fuel vehicles to result in increased demand for ethanol in proportion to those sales. Indeed, every purchaser of a flex fuel car is a potential buyer of E95 ethanol.

THE INTERNATIONAL MARKET FOR ETHANOL IS A GREAT OPPORTUNITY FOR BRAZIL. IN ADDITION TO THE COUNTRY'S COMPARATIVE ADVANTAGE FOR PRODUCING THE FUEL, THERE IS ALSO THE FACT THAT ETHANOL IS A RENEWABLE FUEL LESS POLLUTING THAN GASOLINE.

The international market for ethanol is a great opportunity for Brazil. In addition to the country's comparative advantage for producing the fuel, there is also the fact that ethanol is a renewable fuel less polluting than gasoline. Ever since signatures were gathered on the Kyoto Protocol, a number of developed nations have been seeking alternatives to petroleum in order to reduce their CO_2 emissions. This situation offers a host of opportunities for fuel ethanol.

Although it has indeed arrived, the international alcohol market must be looked upon as a medium to a long-term undertaking. There are hurdles to be overcome – everything from market protectionism in some developed countries, down to cultural differences. Very few countries have actual experience with fuel ethanol on any large-scale, and word of what Brazil has accomplished is bound to get around.

Countries which have shown a real interest in pure ethanol for blending with gasoline, such as Japan, must have a source of supply they can count on – at prices they can work with. They are not willing to gamble on the kind of prices that would result if there were only a single supplier – in this case, Brazil. There are also logistical problems to be worked out, if exports are to increase.

The Growth in Sugar Cane Production

Brazil's increased production of alcohol considerably increased demand for sugar cane, leading to crop expansion into areas that, traditionally, were not cane-producing regions. Between 1975 and 2006, Brazil's sugar cane production went from 88.9 million to 456 million tonnes – a 412% increase. Acreage planted in cane went from 4.7 million to 15.3 million acres – a 226.3% increase.

The observation that the increase in area was smaller than the increase in production points at the significant growth which occurred in agricultural productivity as a result of both public and private sector investment. According to Macedo (2007), 1980 to 1990 saw the introduction of new varieties of sugar cane (developed in Brazil), use of stillage as fertilizer, biological control of sugar cane borers and optimization of farming operations, along with other improvements.

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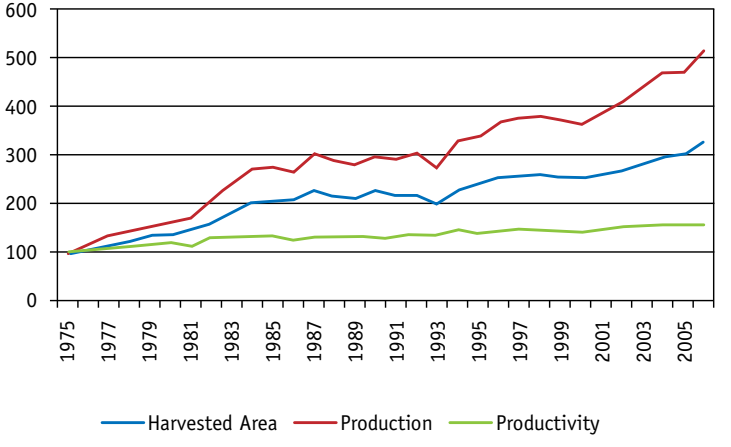
At the beginning of the timeframe below, agricultural productivity was 46.8 tonnes of sugar cane per hectare which, by 2006, had gone to 74.1 tonnes per hectare. Figure 3 shows the relative growth in production, harvested area and productivity, where 1975 is equal to 100.

Figure 3 – Sugar Cane Production, Harvested Area and Productivity



Source: data gathered by the Ministry of Agriculture, Livestock and Food Supply, IBGE and UNICA.

There were also productivity gains in industrial processing. According to Nastari (2005) productivity in agribusiness boasted a 3.77% yearly growth rate in 1975 and 2005. In 1975, productivity stood at 2.024 liters of hidrated alcohol per acre. Thirty years later, that figure reached 5,931 liters per acre. On the industrial side, the bulk of investment went into developing higher-capacity sugar cane crushing systems and achieving energy self-sufficiency (Macedo, 2007).

Brazilian Agribusiness Competitiveness

Increased agricultural and industrial competitiveness resulted in significant production cost reductions over time. Brazil currently has the lowest production cost in the world. Because of the great number of producers using an assortment of productive systems (soil characteristics, land prices, technology levels, mechanization, raised or purchased feedstock, etc.) it is difficult to arrive at exact production costs. Carvalho (2002) offers a comparison for ethanol production costs among the primary feedstocks. Sugar cane ethanol produced in Brazil has the lowest cost, as shown in Table 1.

Table 1 – Average production costs for anhydrous ethanol compared

Country	Anhydrous (US$/L)	Feedstock
BR: South-Central*	0.19	Sugar cane
BR: North-Northeast	0.23	Sugar cane
USA	0.33	Corn
EU	0.55	Wheat, beets

Source: Carvalho, 2002

We see that the expense involved in producing corn ethanol in the United States is 73% higher than for ethanol made in South-Central Brazil, while alcohol made from wheat or sugar beets is 189% more expensive.

Of paramount interest is the energy balance, that is, the ratio of the quantity of energy produced to the quantity of

energy required to produce it. Here again, sugar cane alcohol outperforms everything else. Table 2 shows the energy balance for the primary feedstocks used in ethanol production. Note that for sugar cane, a single unit of fossil fuel yields 8.3 units of renewable energy. That means this product has a highly favorable energy balance.

Table 2 – Energy balance for primary feedstocks

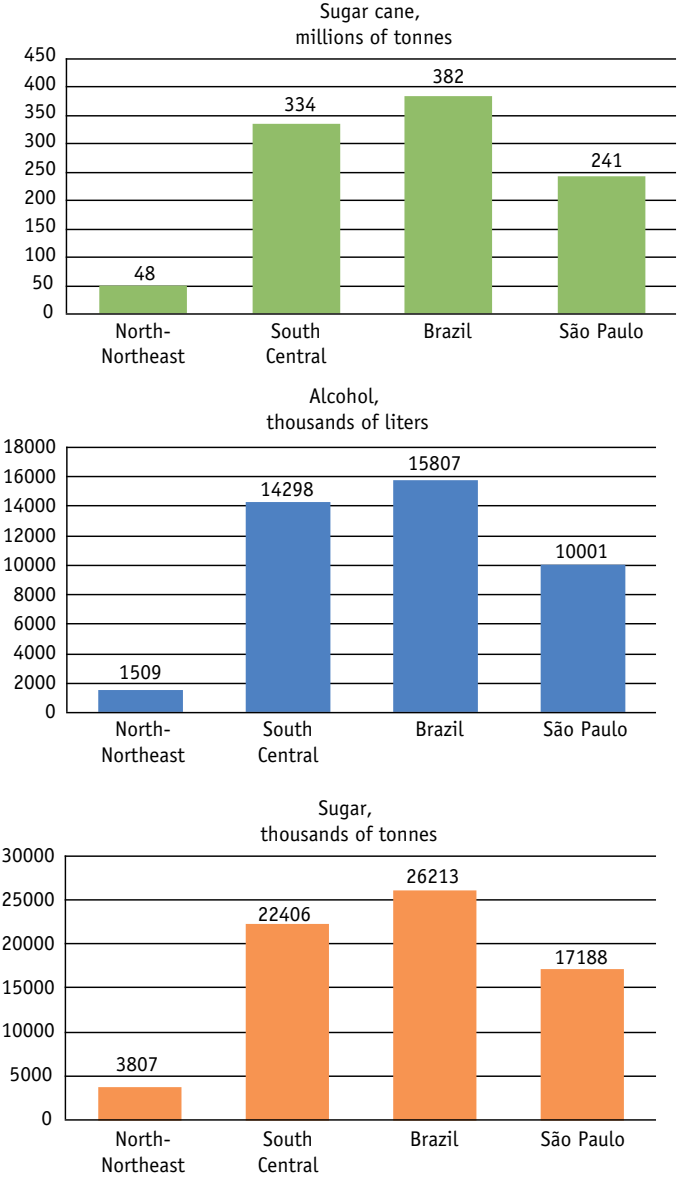
Feedstock	Renewable Energy Produced/ Fossil Energy Consumed
Wheat	1.2
Corn	1.3 – 1.8
Beets	1.9
Sugar cane	8.3

Source: Macedo et alii, F.O. Lichts 2004, International Energy Agency

Production geography and market structure

Alcohol production, as we have seen, has grown primarily in the South-Central region of Brazil. During the 2006-07 harvest, that region accounted for 87.5% of the nation's sugar cane, 85.5% of sugar produced and 90.5% of total alcohol production. That same year, São Paulo – the state with the largest production – accounted for 63% of the entire national sugar cane crop, 63.3% of alcohol made and 65% of all sugar produced. Figure 4 provides a breakdown by regions, for Brazil and for the State of São Paulo.

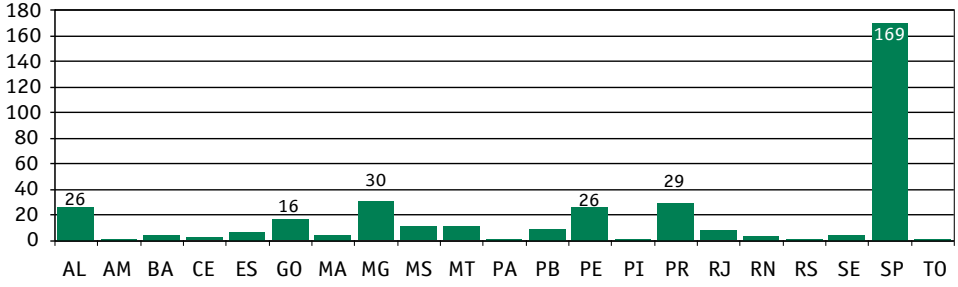
Figure 4 – Sugar cane, sugar and alcohol production, broken down by region



Source: after Ministry of Agriculture, Livestock and Food Supply data.

The bulk of the nation's plants and distilleries are also located in the South-Central region, primarily in the State of São Paulo. One notes that, in 2006, out of a total of 363 units, 45%, or 169, were located in São Paulo.

Figure 5 – Number of plants/distilleries by State – 2006



Deregulation of the industry in 1999, brought an institutional environment favorable to investment, and a number of economic groups formed – through mergers and acquisitions – to produce sugar and alcohol. Foreign capital flowed in from several different directions, such as France (Coinbra-Louis Dreyfus, Tereos), the United States (Cargill, Infinity Bioenergy, Globex, Brenco) and Asia (Noble), but the greater part, by far, is still produced from Brazilian capital. Foreign groups accounted for a 5% share of the 2006-07 harvest.

In 2006, Brazil's 20 largest groups gathered 41.3% of the sugar cane harvest, produced 39.3% of the nation's alcohol and 46% of its tonnage of sugar. Despite the rapid pace of mergers and acquisitions, Brazil's sugar alcohol industry was not concentrated in itself. Its CR_4, or rather, the concentration ratio of the four largest alcohol producer groups, was 14.9%.

Brazil's largest producer is the Cosan Group. In 2006, it had 17 plants and distilleries, accounting for approximately 7% of Brazil's alcohol production, 11.1% of sugar tonnage and 9% of all sugar cane crushed. We should mention that the 34 million metric tons of sugar cane crushed by the Cosan group that year added up to 71% of all production in the North-Northeast region.

Job creation

In 2005, according to Labor and Employment Ministry Administrative Records (RAIS), there were 982,604 people employed in Brazil's sugar cane, sugar and alcohol industry. Table 3 shows the growth in formally-hired workers involved in sugar cane, sugar and alcohol production for both regions, and for Brazil as a whole, from 2000 through 2005.

Table 3 – Number of formally-hired employees per producing region - 2000 through 2005

Producing Region	2000	2001	2002	2004	2005
North-Northeast	250,224	302,720	289,507	343,026	364,443
South-Central	392,624	433,170	475,086	557,742	618,161
Total for Brazil	642,848	735,890	764,593	900,768	982,604

Source: MDS RAIS records (several years)

We see that, taking the three industries together (sugar cane, sugar & alcohol) for Brazil as a whole, from 2003-05 there was a hefty increase of 52.9% in the number of formal

hires, the figures changing from 642,848 employees in 2000 to 982,604 in 2005. Of this number, 63%, that is, 618,161 employees, were in the South-Central region of the country.

Table 4 shows the number of formal hires per producer region and broken down by industry: sugar cane, sugar and alcohol. We note that in 2005 there were 414,668 jobs in sugar cane, 439,573 in sugar production and a smaller, yet still sizable, contingent of 128,363 employees working to produce alcohol.

Table 4 – Number of formal jobs by producer region and industry: 2000 through 2005

	Region	2000	2001	2002	2004	2005
Sugar cane	North-Northeast	81,191	97,496	86,329	104,820	100,494
	South-Central	275,795	302,830	281,291	283,301	314,174
	Total Brazil	356,986	400,326	367,620	388,121	414,668
Sugar	North-Northeast	143,303	183,517	174,934	211,864	232,120
	South-Central	74,421	84,920	126,939	193,626	207,453
	Total Brazil	217,724	268,437	301,873	405,490	439,573
Alcohol	North-Northeast	25,730	21,707	28,244	26,342	31,829
	South-Central	42,408	45,420	66,856	80,815	96,534
	Total Brazil	68,138	67,127	95,100	107,157	128,363
Total for 3 industries		642.848	735.890	764.593	900.768	982.604

Source: Taken from MDS RAIS records (several years)

Between 2000 and 2005, we see that formal employment figures for sugar mills (101.9%) and alcohol distilleries (88.4%) in Brazil grew faster than those for rural workers (16.2%) involved in sugar cane production – probably as a result of the mechanization of the sugar cane harvest. Yet

sugar cane production did indeed grow during this period. Brazil's production in 2000 came to 325.33 million metric tons and, in 2005, 419.56 million metric tons (Ministry of Agriculture, Livestock and Food Supply, 2005), a production gain of nearly 29%. Also, in the year 2000, 55% were rural workers, whereas in 2005 that figure had fallen to 42.2%.

As to the labor market, one should note the high level of formal employment in the three sectors of the sugar cane industry – sugar cane, sugar and alcohol – 982.604 workers in the year 2005. (Other sectors related to the alcohol production chain – such as fertilizers, tractors, and equipment – are not included).

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Closing comments

Brazil has earned international recognition for its pioneering efforts in large-scale production and utilization of renewable fuel from sugar cane – with a high energy balance and one of the world's lowest production costs.

Brazil's National Alcohol Program was first organized to reduce the nation's dependence on oil imports and lessen the effect of those imports on the nation's economic indicators. Beyond that, it made it possible for Brazil to become a world leader in alcohol production technology and develop automobiles powered entirely by fuel ethanol. More recently, Brazil's automakers have released dual-fuel vehicles which earned ready acceptance from Brazilian consumers.

Brazil's sugar cane, alcohol and sugar industries have increased by leaps and bounds since the National Alcohol Program began in 1975. This was due to the sheer size of the country, and to investment in industrial and agricultural technology – including new, more productive varieties of sugar cane. Involving the automobile industry and creating a network of ethanol filling stations throughout the country – complete with tankage and pipelines – were, together with other initiatives, crucial to the success of the program.

At the time the National Alcohol Program was created, his chief attraction lay in reduced dependence on oil imports. To that we must now add the net reduction of carbon dioxide emissions. The fact that it is renewable and less polluting than gasoline has made alcohol an interesting alternative for countries wishing to reduce their CO_2 emissions. This could signify important opportunities for Brazil, given its overall competitiveness and abundance of land.

During this new stage, environmental and social factors have swelled and become as important as economic feasibility. Within this context we should be mindful of the sugar cane industry's potential for creating jobs. Remember that in 2005, an additional 982 new hires entered the market. Given this developing growth, and gain in international momentum, what lies ahead are logistical challenges and sustainable increases in production – ever mindful of the environmental issues and no less concerned with social questions – in hopes of extending the benefits generated by this supply chain to all rural and industrial workers.

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