# Alcohol: A Brazilian Answer to the Energy Crisis

*Rio de Janeiro.* While the United States languishes in protracted debate over synthetic fuels and other means of alleviating dependence on imported oil, Brazil has moved decisively in the direction of growing its own fuel. The Brazilian government has launched a bold program to replace much of that country's imported oil with ethyl alcohol produced from sugarcane and other crops. If successful, the alcohol program has the potential to establish Brazil not only as the world leader in renewable energy sources but also as the first developing country without large oil resources to find a path to energy independence—a path uniquely its own.

An energy strategy based on biomass "is a natural for Brazil," says José Goldemberg, director of the physics institute at the University of São Paulo and coordinator of an academic energy policy group (see accompanying article). "We have lots of land, lots of water, and an ideal climate for growth." Indeed, figures released at a week-long symposium* on the national alcohol program held here in December indicate that less than 2 percent of the land area of Brazil could produce enough fuel to replace all imported petroleum. Brazil imports more than 80 percent of its oil, about 700,000 barrels a day, and finding the $3 billion annually to pay for this oil has seriously crimped the country's economic growth in recent years. A measure of the importance attached to reducing this dependence on imports is the amount of money—more than $400 million—that the Brazilian government has committed to the alcohol program since it began in November 1975.

The program has the personal backing of Brazil's President, General Ernesto Geisel, and is one of the few to have emerged unscathed from the recent round of government budget cutting. Already proposed are more than 70 new distilleries and additional sugarcane plantings totaling about 500,000 hectares, although only 15 projects have actually received funding. As a result of the delay, an unofficial but widely mentioned target of the program, producing enough alcohol to replace 20 percent of Brazil's gasoline by 1980, now seems unlikely to be achieved on time. Nonetheless, the program appears to be rapidly gathering momentum, and few Brazilian observers now doubt that it is destined to play a major role in their country's future.

A number of factors account for the rapid emergence of alcohol as a high-priority ingredient in Brazil's energy planning—not least that country's extensive prior experience with alcohol-gasoline blends as motor fuels—but three stand out as having been of paramount importance. One was the demonstration that ethyl alcohol (ethanol) is superior to gasoline as a motor fuel, delivering liter for liter as much power with much less pollution in a properly tuned engine. A second was the realization that the manufacture of alcohol need not depend solely on sugarcane, which requires relatively good soils, but could ultimately utilize the far larger potential of manioc (cassava), a root crop that grows in all parts of the country and for which Brazil is already the world's largest producer. A third and politically decisive factor was the role played by Geisel in establishing a national program to exploit what is now widely described as Brazil's "fuel of the future."

The rapid establishment of an ambitious alcohol plan is apparently due in large part to Geisel's previous experience in the energy field and a chance visit to a little-known research laboratory in 1975. Before becoming President he headed Brazil's national oil company, Petrobras, and he is described as uncommonly knowledgeable about energy matters for a national leader. In the course of a visit to Brazil's space agency in San José dos Campos, he stopped at a newly founded laboratory investigating alcohol as a motor fuel and was fascinated by the experimental results. He is said to have prolonged what was to have been a brief, ceremonial visit into a lengthy session, and to have quickly grasped the possibilities. A few months later the alcohol program was established, elevating what had been a modest research effort largely within the Commerce Ministry to a national program headed by an interministerial council directly responsible to the President.

Using alcohol as a fuel for automobiles actually has a long history in Brazil, dating back to the 1920's. At that time the effort consisted of a few experimental vehicles, including one driven from Rio to São Paulo and back on pure ethanol. By the 1930's it was legal in Brazil to blend alcohol with gasoline, but really large-scale use did not begin until after World War II. Then, in an attempt to make the sugar industry more competitive, Petrobras agreed to purchase the growing quantities of alcohol produced as a by-product of sugar refining and blend it as a minor constituent in essentially all gasoline sold in Brazil. Depending on the region of the country, the alcohol content of Brazilian gasoline has ranged between 2 and 8 percent in recent years—a level for which no adjustments to automobile engines are required.

Following the sharp rise in international oil prices that began Brazil's current economic troubles, however, the Commerce Ministry in 1974 began a research effort to explore the possibility of blending much higher percentages of alcohol in gasoline and of burning pure alcohol. A principal figure in the ethanol utilization effort has been Urbano Ernesto Stumpf, an aeronautical engineer who had devoted years to exploring the properties of alcohol as a fuel and whose expertise has now catapulted him into sudden prominence. Stumpf and his colleagues were rapidly able to show both theoretically and experimentally that ethyl alcohol, despite its low caloric heat content compared to gasoline, is a competitive fuel when burned in a properly designed engine. One reason for this is that an alcohol engine ideally operates at a higher compression ratio than a gasoline engine—a ratio of about 10 rather than the value of 7 appropriate for Brazil's low-octane gasoline. Stumpf's data indicate that, with appropriate engines, pure alcohol delivers 18 percent more power per liter than gasoline and is consumed at a rate between 15 and 20 percent higher. The two factors effectively cancel, leaving neither fuel with a clear advantage from an energy standpoint. Moreover, because an alcohol engine can be tuned to run much leaner than a gasoline-burning motor, the fuel is more completely combusted, giving alcohol a slight practical edge in the kilometers-per-liter figures and dramatically lowering the amount of pollutants emitted—by as much as 50 percent for carbon monoxide and oxides of nitrogen. Since alcohol does not contain hydrocarbons and does not need tetraethyl lead addi-

*Ethanol: Combustivel e Materia-Prima, sponsored by the Ministry of Industry and Commerce, Rio de Janeiro, 1 to 4 December 1976.

tives to boost its octane, emissions of these substances are eliminated altogether.

Stumpf has also shown that alcohol is a far more flexible fuel than gasoline, since it can be used (although less efficiently) in motors designed for gasoline and can be blended with gasoline in proportions as high as 20 percent with no adjustment to ordinary automobile engines. Alcohol can also be burned in a 50-50 mixture with diesel fuel in truck and bus engines through use of an ingenious double-carburetion system and seems to be an ideal turbine fuel for use in electric generating plants. To illustrate these virtues, the Commerce Ministry equipped three automobiles to run on hydrated alcohol (95 percent alcohol and 5 percent water) and toured them all over Brazil, accumulating more than 100,000 kilometers of use in 1976 (Fig. 1).

The publicity stunt and the research data behind it have attracted considerable attention in Brazil and eliminated or at least muted the initial skepticism of automobile manufacturers. Last November, for example, the supervisor of motor engineering for Chrysler-Brazil announced that the company was demonstrating a high-compression engine suitable for pure alcohol; he also said that existing Chrysler motors could operate with up to 20 percent alcohol without retuning and, with the alcohol blend, "could run in California without controls and pass pollution specs." Petrobras is reported to have been conducting large-scale tests of a 20 percent alcohol-gasoline blend by the simple means of increasing the admixture in the gasoline delivered to particular localities. The city of São Paulo, where air pollution is a serious problem, is planning to test a 300-car fleet operating on pure alcohol this year.

Producing enough alcohol to make a major contribution to Brazil's energy supply is a more difficult problem. Some 800 million liters of alcohol are now produced annually from sugarcane, and the technology and economics of the distilling process are well established. Cane production can clearly be expanded and all but two of the proposed new distilleries are to be based on cane. If they are funded, they will nearly triple the current output of alcohol. But cane can be grown in only a few parts of the country and much of the ideal land is already under cultivation, so that a 50-fold increase in alcohol production—which would be required to essentially eliminate oil imports—could probably not be based on cane. Cane, moreover, is a seasonal crop with a harvesting period of at best 160 days and, once cut, must be quickly processed before the sugar content degrades; the distilleries would thus stand idle more than half the year.

Fig. 1. Demonstration vehicles operating on ethanol on tour in Brazil. [Source: Ministry of Industry and Commerce]

Hopes within the government for really large-scale production of alcohol seem accordingly to rest on manioc. With an estimated 2 million hectares already under cultivation, largely for food, manioc is already a major crop in Brazil. The root of the plant contains between 20 and 40 percent starch, depending on the variety, and it is from this material that alcohol is made. Starch cannot be fermented directly, however. Although several methods exist for breaking it down into sugar, ranging from brute-force hydrolysis to the use of enzymes to catalyze the process, their commercial feasibility for manioc was unproved. Then early in 1975 a research group at the National Institute of Technology in Rio obtained promising laboratory results with a particular enzymatic method, and they have since successfully tried the process in commercial-scale equipment. Commercial production of the appropriate enzymes is now beginning, and Petrobras is building the pioneer manioc distillery, which is scheduled to begin operations late this year.

Large-scale production of alcohol from manioc remains in the future, however. Manioc is now grown almost exclusively in backyard plots and the agricultural infrastructure for commercial cultivation will have to be built from scratch. Government officials argue that this is an advantage, since modern techniques for both cultivation and distillation can be introduced from the start. (Many existing cane distilleries employ outmoded techniques, and the sugar industry has shown no great interest in upgrading its plant or operating procedures.) Nonetheless, skepticism abounds among Brazilian observers not directly connected with the alcohol program. Cane distilleries are often self-sufficient in energy, generating heat and electricity by burning bagasse, the fibrous residue of the cane. Manioc residues have too high a water content to burn, however, and so an additional energy source will be needed to operate the distilleries. More crucial to the ultimate feasibility of obtaining alcohol from manioc is the question of the net energy output from this crop when fertilizers and other energy-intensive inputs of large-scale cultivation and production are included in the balance. No detailed assessment of this balance has yet been published and, although government officials assert that making alcohol from manioc is feasible, the subject is hotly debated by Brazilian energy scientists. In any case, the Ministry of Agriculture has established a research institute devoted to manioc and alcohol program officials talk about a "new agricultural frontier."

Officials of the national program estimate that about 4 billion liters of alcohol per year will be required to substitute for 20 percent of gasoline consumption by the early 1980's. This level of production would require either 1.3 million hectares of cane or between 1 and 2 million hectares of manioc. (Typical yields of manioc as it is now grown in Brazil are 10 to 15 tons per hectare, but agricultural planners hope to achieve 30 tons per hectare with modern methods.) The prospect of opening a million hectares of a new crop or even ten times that amount does not seem insuperable to the planners, however, despite the lack of an agricultural infrastructure for manioc. At the Rio symposium, a representative of the Agriculture Ministry, Antonio Licio, pointed out that the area planted to soybeans in Brazil has grown from nearly nothing to 6 million hectares in the span of 8 years. He estimates the arable, readily accessible land in Brazil to be in excess of 40 million hectares.

The key to the economics of the national alcohol program in Brazil is cheap agricultural labor, and it is not in short supply. Brazil has millions of unemployed, especially in the impoverished northeastern part of the country, and a high birth rate. As a result of this and the high gasoline taxes imposed by the government, alcohol is already competitive with petroleum products; it sells for about $1 per gallon, a price fixed by the government, compared to $1.50 per gallon for gasoline. Despite their inefficiencies, existing distilleries operate profitably under these conditions. To stimulate production even further under the alcohol program, new distilleries can

be financed with government loans at low interest rates, and Petrobras guarantees that it will buy all alcohol delivered to it. These conditions are so generous that one observer has described them as "a license to print money," and it is no wonder that companies are standing in line to take advantage.

The financing scheme, moreover, is designed to be self-perpetuating. In December, the government announced the establishment of a revolving fund for financing these projects. The fund is to be continually replenished from the profit that Petrobras realizes from buying alcohol at the wholesale price and selling it, blended with gasoline, at the gasoline price.

The alcohol program seems likely to have an unusually broad impact on Brazil. In addition to providing what is potentially a major and inexhaustible source of energy and reducing the disastrous economic effects of importing foreign oil, it may have equally profound effects in other areas such as the following.

▶ Pollution. Even a partial switch from gasoline to alcohol could substantially reduce the air pollution that in large Brazilian cities is already a substantial health hazard.

▶ Employment. Government officials expect the alcohol program to create between 0.25 and 1 million new jobs, primarily agricultural, in coming years. They also hope the availability of jobs in rural areas will help to slow the migration to the cities that is overwhelming Brazil's major urban areas.

▶ Industrial growth. The proliferation of distilleries is expected to stimulate the capital goods industries by adding a major new internal market. Government officials also hope to develop a complete chemical industry based on alcohol rather than oil. Production of vinyl chloride, for example, is said to be an immediate possibility. In the long run, Brazil may be able to export the resulting technology and know-how.

▶ National self-confidence. The psychological impact of successfully developing a Brazilian solution instead of copying an imported model would be enormous. Indeed, so widespread is the attitude in Brazil that "imported is better" that some opposition to the alcohol program appears to have been based on the fact that it was an indigenous idea. In addition, Brazil would stand to gain substantial international prestige from securing its energy independence, not to mention a market for its alcohol expertise in other land-rich tropical countries. Finally, many scientists believe that the success of the alcohol program would establish the value of research to Brazilian industry, heretofore a skeptical and unenthusiastic customer.

Despite its enormous potential, it is too early to judge the alcohol program a certain success. It requires, for example, a degree of cooperation among several different ministries that is unusual in Brazil. Moreover, as one Brazilian official observed, "we Brazilians are mad for plans but their execution is another matter." Delays in approving financing for new distilleries have given rise to additional concerns. Despite the program's high priority, for example, the first funds were released only in early October 1976, nearly a year after the program was launched, and the rate of approvals continues to be slow. Most Brazilian observers believe that these delays reflect opposition to the alcohol program by entrenched and powerful economic interests; at the Rio symposium two senators commented independently on what they described as "strange forces" holding up the program. Most frequently mentioned in private speculation is the sugar industry, which is controlled by a few families that, in this view, are resisting the entry of potential competitors into the business. It was evident at the meeting that sugar producers are not entirely happy with the alcohol program. Some university scientists believe that Petrobras, a power unto itself in Brazil, was also less than enthusiastic initially.

José Bautista Vidal, Secretary for Industrial Technology of the Commerce Ministry and the government official most closely identified with the alcohol program, denies that there has been any concerted opposition. In an interview he admitted, however, that getting the program off the ground involved "a process of consensus" within the government and that he spent much of 2 years convincing people.

If there is a struggle going on, the alcohol forces clearly seem to have won at least one battle. The Rio alcohol symposium was held at Petrobras headquarters, a fact that Bautista Vidal says is "very significant" because it shows, he told the meeting, that "in Brazil, oil and alcohol are not enemies." General Araken de Oliveira, president of Petrobras, told the meeting that his company "is more interested in the development and welfare of the country than in its own profits."

Clearly the alcohol program has some way to go before it can significantly contribute to Brazil's energy supplies. But the Brazilian alcohol venture is just beginning, its potential is enormous, and it may yet become a model for an energy-hungry, and increasingly oil-poor world.—ALLEN L. HAMMOND

# Energy: Brazil Seeks a Strategy Among Many Options

*São Paulo.* Brazil is a country rich in resources, but not those on which the United States and most other industrial countries have built their energy economies. Brazil's reserves of oil, for example, would suffice to keep the country supplied for only 2 years at current rates of consumption; more than 80 percent is imported. The energy resources that it does have in abundance are not developed to their full potential—much of Brazil's huge hydroelectric potential is located in the remote Amazon jungle, thousands of kilometers from major industrial centers. The sharp increase in world oil prices 3 years ago thus hit Brazil very hard, precipitating serious economic problems and an intense effort to find and develop alternate sources of energy.

The Brazilian government has moved quickly—some would say precipitously—in a number of directions at once. It has launched a controversial nuclear program, the keystone of which is an agreement to acquire eight large reactors from West Germany by 1990, along with a complete fuel cycle and help in training the thousands of engineers and technicians needed to run the nascent industry. It has swallowed its pride and reversed a long-standing policy of keeping out foreign oil companies, inviting the multinational giants to help explore Brazil's vast offshore areas under service contracts; British Petroleum and Shell have signed and others are negotiating. It has begun an ambitious effort to produce alcohol, fermented from sugarcane and other crops, in enormous quantities (see accompanying article). It has set in motion substantial research efforts on solar and other uncon-