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-

ventional energy forms. And it is debating whether to build the world's first commercial oil shale refinery; the technology, developed in Brazil, has been demonstrated in a large pilot plant, but the staggering cost of a full-scale facility seems to be giving the government pause.

With few exceptions, the Brazilian scientific community has had little role in shaping these initiatives. Relations between the military government and the universities are still characterized more by mistrust than by collaboration. Although many university scientists serve as consultants to state and federal science agencies, there has been little input to energy policies at the national level.

The Brazilian nuclear program is a case in point. Although Brazilian nuclear scientists have long advocated beginning a truly domestic nuclear industry, most of them first learned of the government's plans when the signing of the West German reactor deal was announced in the newspapers. Many believe the program is unwise, asserting that a crash program of this scale is out of context with Brazil's present energy problems and that the light water reactor technology is not the best choice. A more realistic approach, they believe, would be to pursue the Canadian natural uranium reactor technology by building a Brazilian prototype that could serve to train the people needed for an indigenous industry. This approach would also avoid the nuclear proliferation controversy associated with enriching technology. But the government appears to have taken little note of these suggestions and is going ahead with its plans.

Despite the lack of a tradition of science policy advice on major national questions, however, there is evidence of attempts to establish new channels of communication between the government and the scientific community and, within the latter, to formulate proposals for a coherent national policy on energy. In what appears to have been a first for this type of endeavor, the opposition political party, the Brazilian Democratic Movement (MDB), solicited a study of the country's energy options from a group of prominent academic scientists headed by José Goldemberg of the University of São Paulo. The mechanism used to create the study was an agency of the Congress known as the Institute of Research, Studies and Assessments, which is, on paper, somewhat analogous to the U.S. Office of Technology Assessment. Goldemberg, who is director of the Institute of Physics at São Paulo and current president of the Brazilian Physical Society, put together a panel of a dozen specialists and produced a report* that surveys energy use, assesses new supply options, and makes recommendations.

The Brazilian energy situation is substantially different from that of the United States in both sources of supply and consumption patterns, with the exception of a common heavy dependence on oil. Per capita use of energy in Brazil is low by world standards, about one-tenth the U.S. level, and total energy use in 1972 amounted to about 3 quadrillion Btu's, compared to 65 quads in the United States. Of this, nearly 53 percent was consumed in domestic and commercial applications, 29 percent in industry, and 18 percent in transportation. Oil is the largest source of energy, now accounting for 45 percent and climbing rapidly. Hydroelectric power accounts for 21 percent and coal for less than 4 percent. As recently as 1950, wood supplied half of Brazil's energy, but the figure has now dropped to 27 percent, with sugarcane bagasse and charcoal adding another few percent.

The Goldemberg group, surveying all this, concludes that Brazil needs not only to be more self-sufficient but also to change its consumption patterns to reflect the real needs of the country. They propose an emphasis on electrified mass transport, rail transport, and stricter measures to conserve oil, including rationing if necessary. Among potential energy sources, the report singles out biomass as having enormous possibilities not yet explored, and asserts that alcohol production in particular could have a profound effect on social and economic problems, in addition to the value of alcohol as a fuel and chemical feedstock. The report also says that solar energy offers possibilities for rural areas and for decentralizing some aspects of energy production. Nuclear energy is described as an important supplement to the existing sources of electricity, largely hydroelectric, but the report emphasizes the importance, in the German-Brazilian agreement, of ensuring that the technology and the competence to manage it are transferred along with the reactor hardware. Oil shale, the group concludes, should be ultimately used as a raw material for the chemical and pharmaceutical industries and not primarily as a source of fuel. They end by making a plea for a national energy counsel to formulate and implement a national policy that would be more coherent than the somewhat piecemeal approach that has prevailed so far.

There is considerable evidence that the Brazilian government itself is still feeling its way into the energy problem. Energy conservation has not been seriously pursued other than by raising gasoline prices sharply, a tactic that has had little observable impact on the country's spiraling oil consumption. Discussion of gasoline rationing and other conservation measures is just beginning. Instead the emphasis has been almost entirely directed toward new energy sources or ways to more fully utilize existing sources, including some futuristic schemes. For example, a proposal to tap remote hydroelectric sites by using hydrogen, pumped thousands of kilometers through pipelines, as an energy carrier has been circulating amoung government and university scientists alike, although the emerging consensus seems to favor using the electricity to produce ammonia or some more readily shipped commodity. The supply initiatives that have been adopted seem in some instances to be half-way measures and may reflect differences of opinion within the government. The terms of the contracts under which foreign oil companies have been invited to explore Brazil's offshore area, for example, are widely described as so restrictive that only token efforts are likely, although government spokesmen dispute this characterization.

There does not appear to be any government-wide understanding of or commitment to research as a means of solving Brazil's energy problems. The Ministry of Energy and Mines, for example, does not support any significant energy research with the exception of that done by Petrobras, the national oil company, which is technically part of the ministry. Indeed, with the exception of the controversial nuclear program—a program that still exists only on paper, although there is some indication that training programs are about to get under way—the Ministry of Energy and Mines has not been the originator of any of the energy initiatives ultimately adopted by the government. The energy research programs that do exist are run in virtually complete isolation from one another along ministerial lines, and only the Planning Ministry has strong ties to and makes any significant use of the research capability in Brazil's universities.

But Brazil is hardly alone in its search for an energy strategy. It has at least made a vigorous beginning.—A.L.H.

Problemas de Energia no Brazil, Instituto de Pesquisas, Estudos e Assessoria do Congresso (Brasilia, 1976).