Energy: Elements of a Latin American Strategy

If the oil price rise administered 4 years ago by the oil-exporting countries came as a shock to countries with established industrial economies, the impact on developing countries has proved far greater. Higher oil bills have cut into scarce supplies of foreign currencies, exacerbated inflation, and slowed economic development. More important, they have forced many developing countries to reexamine their economic development strategies, which in many instances were modeled after the energy-intensive and oil-dependent examples of the United States, Western Europe, and Japan. There is growing awareness in many countries that energy policy and development patterns are closely linked and that building an industrial infrastructure dependent on imported oil may be a costly mistake.

The connections between energy and development and the possibilities for alternative energy sources for Latin America were explored at a recent meeting in Guaruja, Brazil.* What emerged were the beginnings of energy strategies based on the indigenous resources of Latin American countries and designed to meet their development needs. The meeting also produced new ideas arising from the hybridization of perspectives from North and South America and gave rise to a greater awareness of the special problems of energy strategies for developing countries—in all, a useful starting point for further study by both scientists and policy-makers. The highlights included:

▶ *Hydropower*. South America has an immense hydropower potential exceeding 300 gigawatts (GW), of which less than 10 percent is now in use. In Brazil alone the estimated untapped potential is 150 GW at large dam sites only, and the use of small dams and low-head hydroturbines could expand that total. Although hydropower now provides about 30 percent of Brazil's total energy consumption, planners in that country have tended to downplay hydro's future role. Large hydro sites in the industrialized southeastern region will be fully developed by 1985 and the remaining potential sites are to be found in the Amazon Basin, 2000 kilometers or more to the north.

Two new developments suggest an expanded role for hydropower in Brazil and throughout Latin America. One is the introduction into South America of direct-current transmission lines capable of transporting large blocks of power for long distances (see box). The second is the rapid development of wind and photovoltaic technologies that by 1985 may be capable of competing with other generating technologies, except for the problem of storage. But the hydro network (which by 1985 will total 35 GW in Brazil's industrialized southeast) can be viewed in part as an energy storage system, and wind and solar devices coupled to the electrical grid could extend the generating capacity significantly. In addition, small hydro facilities could provide an energy source in many rural areas.

▶ *Nuclear power*. Joining the nuclear club continues to be of considerable interest to many Latin American countries; Argentina, Brazil, and Mexico already have reactor programs under way. But it became clear at the Guaruja meeting that the controversy and problems that have plagued the nuclear industry in the United States and Europe are developing here too. Some Latin scientists believe that nuclear power will have to be one of the energy sources for developing countries. Others, however, believe that the cost in resources and trained manpower of truly indigenous national programs—especially crash programs—for nuclear power is too high, that simply to buy reactors without indigenous programs is to become dependent on yet another source of imported energy, and that nuclear power does not meet the real needs of their countries.

The arguments over nuclear power have so far been confined largely to the scientific community, but a scandal in Brazil's reactor program that became public just before the meeting got under way was seen by many as a portent of a wider debate. A fire early this year at the Angra dos Reis site, where Brazil's first power reactor is under construction, caused $10 million in damage and several months delay. An official investigation conducted in secret showed an incredible degree of unpreparedness for fire-fighting at the site—fire trucks but no water, hoses without coupling—and a record of carelessness that had given rise to 85 smaller fires in the preceding year. Moreover, the investigation found that the Brazilian nuclear agency had tried to cover up the incident and conditions leading up to it. Engineers in charge were put under pressure to sign a statement saying that there were no problems with safety precautions at the Angra dos Reis plant—which they refused to do. Despite the secrecy surrounding the investigation, the newspaper *O Estado de São Paulo* obtained a copy of the final report and created a sensation by publishing a detailed account and, in effect, initiating public debate in Brazil on the question of nuclear safety.

▶ *Biomass*. Nearly 30 percent of Brazil's energy comes from the burning of wood and sugarcane bagasse, and similar noncommercial energy sources also play a large if often unacknowledged role in other Latin American countries. Brazil is pushing ahead to make biomass a significant commercial energy source as well. In 1977 it produced 700 million liters of ethyl alcohol from sugarcane to blend with gasoline as an automotive fuel, and it expects to raise that figure to 1.5 billion liters in 1978. It is also experimenting with ethanol production from cassava—the first distillery is just coming into production—and with small distilleries in an effort to broaden the sources of supply. Alcohol offers Brazil a hedge against rising oil prices and begins the slow process of transition away from oil, but the weaning process is not cheap. The alcohol program is heavily subsidized; alcohol production costs are estimated at about $1 per gallon, more than the production cost of gasoline from imported oil. But the program also has the explicit aim of promoting rural economic development (and thus, it is hoped, slowing migration to urban areas) and it is based on indigenous resources that are plentiful in Brazil. At Guaruja, the alcohol program attracted attention as an important experiment that may be applicable to other countries.

Brazil is also expanding production of charcoal for use in iron production in place of imported coal, a use of biomass that may be economic today in many coal-poor countries. Charcoal production last year was about 15 million cubic meters. More than 90 percent of the charcoal now comes from felling trees in naturally occurring stands, but the supply is running out in the iron-producing regions. A reforestation program is under way, with about 400,000 hectares of eucalyptus trees planted and more planned. The eucalyptus grow rapidly, producing yields of wood up to four times that of the natural vegetation. They can be harvested as early as 6 to 8 years after planting and they make an excellent charcoal. Brazil is now producing

* "Energy and Development in the Americas," sponsored by the Brazilian Society for the Advancement of Science (SBPC) and the Interciencia Association, Guaruja, Brazil, 13 to 17 March 1978. Proceeding will be published in July 1978, by the SBPC, Caixa Postal 11008, 01000 São Paulo, S.P., Brazil. Reports of five workshops at the symposium will be published in the May-June issue of *Interciencia*, available at $2.50 (postpaid) from Interciencia, Apartado 51842, Caracas 105, Venezuela.

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hundreds of cheap, standardized charcoal furnaces and is conducting research on means of capturing by-products from charcoal production that include acetic acid and methanol. Charcoal, it was pointed out at the conference, is also a more efficient form in which to use wood for cooking and could thus extend rural fuel supplies in regions, such as the Andean countries, where wood is scarce.

Another potential source of fuel that may be especially important for rural areas in tropical and semitropical countries is the oil that can be squeezed from the nuts of several species of palm tree. The African oil palm (*Elaeis guineensis*) and the babassu palm (*Orbignia speciosa*) received particular attention at Guaruja; there are more than 10 million hectares of natural stands of the latter species in northeastern Brazil. Palm oil can be used not only like a vegetable oil in cooking but also, without refining, as a fuel for diesel engines.

▶ *Conservation*. Although some Latin American countries have attempted to promote conservation by raising energy prices and adopting other fiscal controls, there has been little attention to the potential for improving the efficiency of energy use, especially in transportation and industry—the main energy users in Latin America. The conference pointed to a number of opportunities for technical improvements that required less investment (per unit of energy saved) than would additional energy production.

▶ *Unconventional fossil fuels*. Latin America is not rich in conventional hydrocarbon fuels, with the exception of substantial deposits of oil in Venezuela and Mexico and of coal in Colombia. Beyond these, however, lie some significant possibilities for the future. Venezuela has, in addition, huge deposits of petroleum in the form of heavy oils and tar sands. Brazil has oil shale deposits second only to those of the United States. These unconventional resources will be difficult and expensive to recover, but preliminary work is under way in both Venezuela and Brazil.

▶ *Solar and wind energy*. There was general agreement at Guaruja that solar and wind energy will probably be able to make substantial contributions. But it was also acknowledged that the magnitude of the resources is only partially known in most Latin American countries. Many scientists and planners lack familiarity with recent developments in solar conversion technologies, and local industries to build solar components, with few exceptions, do not yet exist. The potential for replacing conventional fuel uses and for contributing to rural development clearly seemed to many participants at the meeting to warrant expanded efforts.

The emerging pattern seems to point to an energy strategy quite different from that, for example, of the United States. Inasmuch as energy is a key element of economic development, the implication seems to be that the pattern of development in Latin America and in other developing countries might also best follow indigenous rather than imported imperatives.—ALLEN L. HAMMOND

Itaipu: Direct-Current Transmission

The world's largest hydroelectric plant is being built by Brazil and Paraguay on the Paraná River, which divides the two countries. The $8 billion Itaipu facility will have a capacity of 12.6 gigawatts and will produce an estimated 70 billion kilowatt-hours per year, more than three times the annual output of the huge Grand Coulee Dam in the United States and nearly equal to Brazil's total power output in 1976. But the significance of Itaipu for energy development in South America may go beyond the sheer magnitude of the project, because it will introduce to that continent a technology for transmitting very large blocks of power over distances of thousands of kilometers. The technology is high-voltage direct-current (HVDC) transmission, already in use in a few applications in other parts of the world. The HVDC technology would make possible the exploitation of Brazil's huge hydropower resources in the remote Amazon Basin and would thus undercut one of the principal rationales for Brazil's nuclear program.

A more favorable location for a hydroelectric facility than that of Itaipu would be hard to imagine. The Paraná is only the third largest of the river systems that drain Brazil, with an average flow of 9000 cubic meters per second. But the river at Itaipu is about 40 meters deep as it drops through a narrow canyon of tough basaltic rock. As a result, a relatively small concrete dam will back up a reservoir containing 28 cubic kilometers of water to a height of about 120 meters. Construction is well advanced, with initial operation scheduled for 1983 and full power expected by 1989.

Itaipu is nearly 1000 kilometers from Brazil's major industrial center and 500 kilometers from the closest industrial city of any size. Transmitting power over these distances is no novelty in Brazil, however, and the Brazilian half of Itaipu's output will be carried with conventional high-voltage alternating-current lines. Much of the remaining output, however, will be transmitted in the form of direct current.

The choice of HVDC transmission represents a technical solution to a political problem. Under the terms of the treaty that established the binational project, Paraguay must sell to Brazil that part of Itaipu's output that it cannot use itself. A complicating factor in this arrangement is that Paraguay uses 50 cycle per second current while Brazil uses 60 cycles; Paraguay, to preserve its options for the future, insists that its half of the power from Itaipu be generated at its frequency, including the power that will be sold to Brazil. Thus half of Itaipu's 18 hydroturbines—at 700 megawatts apiece the largest in the world—will operate at 50 cycles, half at 60 cycles. Brazil will buy nearly 5 gigawatts of Itaipu's power from Paraguay, according to present plans. In order to use this 50-cycle power, Brazil will convert it to direct current at 600 kilovolts and transmit it more than 800 kilometers to São Paulo on two separate HVDC lines. There it will be reconverted to alternating current at 60 cycles per second.

A major factor in the cost of the transmission system and the largest extrapolation from existing technology will be equipment for d-c/a-c conversion of such unprecented blocks of power. Conventional techniques are estimated to cost about $25 per kilowatt, although newer and potentially cheaper methods have been demonstrated at lower power levels. For transmitting power over long distances, however, direct current has some distinct advantages over alternating current—HVDC lines are smaller in size and less expensive. The overall advantage seems to shift to HVDC for distances beyond 800 kilometers, and lines as long as 3000 kilometers may be feasible. Thus HVDC transmission may enable Brazil and other developing countries to make use of hydropower sites formerly considered too remote from the major urban and industrial centers.—A.L.H.