ENERGY AND TECHNOLOGICAL DEVELOPMENT IN LATIN AMERICA

by

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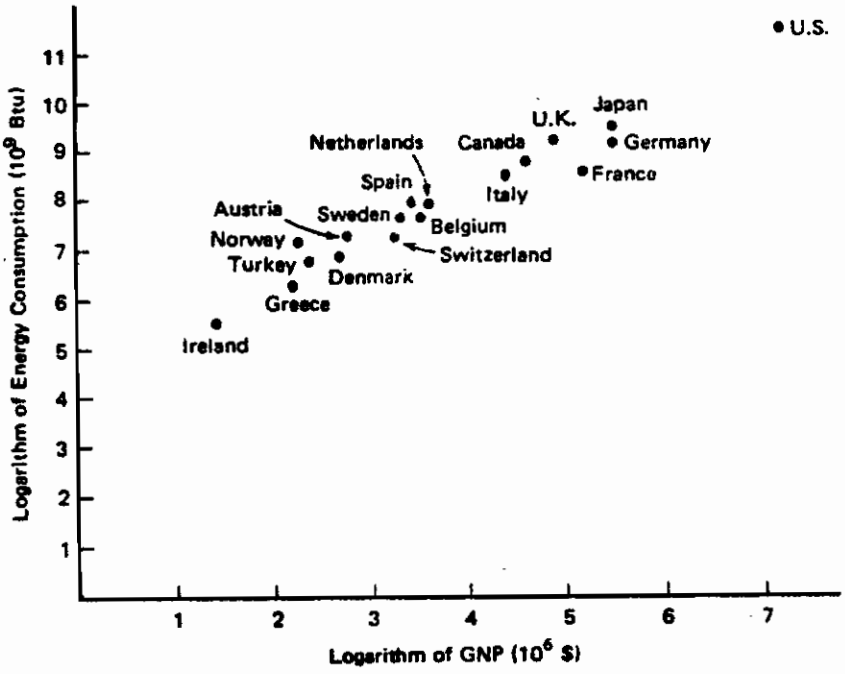
1. ENERGY AND DEVELOPMENT

By now, the relationship between energy consumption and economic growth is familiar to everyone: it is an almost perfect positive correlation which appears across time and in cross-national comparisons. Figure 1 shows the relationship between energy consumption and GNP in 1973 for select countries at different levels of development. The robustness of this relationship will necessitate macroeconomic adjustments due to oil price increases of 1973 and subsequent changes in the world oil market. Low fuel prices, which were instrumental in enabling rapid economic growth rates in the industrial west, can no longer be counted upon for growth in the developing world. While considerable ambiguity remains regarding the direction of causation -- whether from energy to economy or the other way around -- the robustness of energy-economy interactions is not at issue: energy use, a necessary input for economic growth, is also a function of growth. Technological change in the nergy area emerges in the forefront of policy concerns worldwide. Figure 2 shows the energy-GNP association over time for the United States.

This close tracking clearly reveals that for the developed countries there is no correlation between constant ration of energy and gross national product. The relationship varies over

FIGURE 1

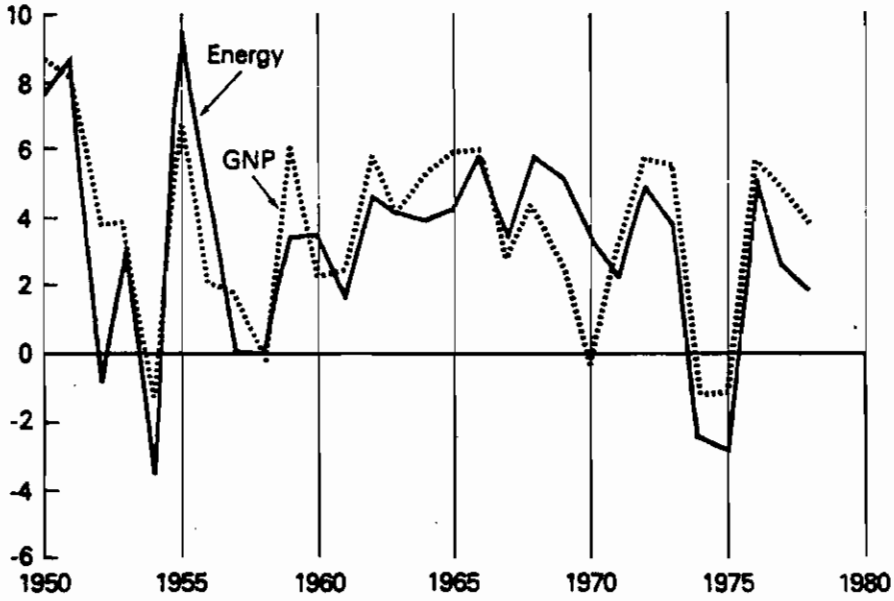
The Relationship Between Energy Consumption and GNP



Sources: OECD, Statistics of Energy (Paris: OECD, 1974). UN, Statistical Yearbook (New York: UN, 1974). As presented in James M. Griffin, Energy Conservation in the OECD: 1980-2000 (Cambridge, Mass.: Ballinger Publishing Co., 1979) p. 3.

FIGURE 2

Changes in Primary Energy and GNP, 1950-1978



Source: The data for GNP changes are from the Economic Report of the President (Washington, D.C.: Government Printing Office, January 1979). The energy data are from the Bureau of Mines for 1950-1974 and from the Department of Energy for 1974-1978. Presented in Landsberg, Hans H. et al. (administered by Resources for the Future) Energy: The Next Twenty Years (Cambridge, Mass.: Ballinger Publishing Co., 1979) p. 78.

time and across countries. Per capita income does not seem to affect the energy-GDP ratio. Sweden and Portugal, for instance, with fundamentally different levels of GDP, have similar ratios. Note that these figures indicate only association of energy with economic growth, not the interaction of energy and economic activity within different sectors of the economy.[1]

The role of technological change has always confounded any simple assessment of energy-economy linkages. With energy price hikes and potential constraints in supply availability, technological changes will appear increasingly as a panacea for the problem at hand. Historically, technological breakthroughs enabling the introduction and utilization of new forms of energy have expanded utilization patterns and rate of consumption, and the use of new fuels has increased the overall resource base and labor productivity.[2] But today these related changes are no longer predictable. Experience in the past provides only the roughest gauge for the future.

The economic growth rate in almost all countries has been adversely affected by increases in the price of oil over the past few years. Against the background of a worsening position in international trade, the demand for petroleum products has dampened somewhat. Although there has been a slight recovery and improvement after each round of price increases, developing countries have been burdened by an increased and economically weakening reliance on foreign resources to meet their domestic energy needs. This situation cannot change overnight. Energy balances are expected to remain tight in the industrial West, with consumption outstripping production until well into the

1990s.

With increasing oil prices, developing countries will continue to be faced with a diminishing availability to conventional development reources. There are some grounds for optimism, however, in that the more petroleum prices rise, the more politically desirable and economically plausible it will become for developing countries to exploit and develop their own indigenous resources. Latin America stands at the forefront of such developments. Experimentation with nonconventional fuels holds promise. Already policy debates about alternatives to petroleum are taking into account the nonconventional sources, with these countries exemplifying willingness to invest in broadening the alternatives available.

It seems evident, however, that technological change plays an important role in determinng future patterns of energy use. Advances in technology -- in terms of generating more efficient combinations of energy uses, or substituting among sources of energy, or bearing upon changes in demand patterns, or generating energy from non-conventional sources -- are endemic to any viable long term strategy for development.

Technological changes must impact upon both the supply and the demand sides of energy use. Clearly, changes in price or availability of energy inputs to industrial processes already have had distinctive macroeconomic effects for all countries. This is especially true for those countries that are high users of petroleum, and do not have readily available substitutes, or cannot easily make adjustments in demand in response to changes

in prices or quantities.

The entire process of development may well be deeply circumscribed by new energy scarcities -- in both the general economy and among individual sectors -- providing new worldwide sets of problems for governments and new concerns for public policy.[3] The transport sector holds the most important key to future changes in patterns of energy use. Technological change in transportation is, however, among the most difficult to envisage. Thus, the efforts in some countries, most notably in Latin America, to explore the technological frontiers for use of renewable sources of energy hold important promise -- socially, politically, and even economically.

2. THE ROLE OF TRANSPORTATION IN DEVELOPMENT

The transportation sector is critical to any economy for two reasons: first, it provides the basic infrastructure for communication and mobility; second, it is frequently the largest consumer of energy. On both counts, investments in transportation and the disposition of transport facilities shape and constrain a country's future policy options for development and energy use.[4]

For developing countries, in particular, investments in transportation are critical to the establishment of a basic industrial and communications infrastructure. Transportation is seen both as a mechanism for national integration -- connecting geographical regions and often disparate communities -- and a necessary prerequisite for integrating market structures and commercial networks. Investments in transportation become effec-

tively realized as investments for facilitating trade, movement of people, and communications between regions. In the modern world, physical networks of communications define the basic parameters of statehood.

Modes, costs and prices, and the number of units transported are the essential features of any transportation network. In developing countrie, modes in place, rather than competitive prices or cost factors, determine the robustness of an existing network. Transportation is more a social service, often subsidized by government policy, than a cost-effective means of meeting the mobility requirements for passengers or materials. As in industrialized countries, energy use was not a critical element in determining the nature of the networks until the oil price increases of the 1970s.

3. ENERGY IN LATIN AMERICA

In a review of the energy situation in developing countries, the World Bank in 1979 noted energy potentials, while highlighting principal problems due to increased imports of oil.[5] The Bank developed an energy classification of these countries based on their oil imports position and the extent of imports. Table 1 reproduces the classification for Latin American countries, and indicate net imports as a percentage of commercial energy demand. The exporters are classified as either OPEC or non-OPEC countries. This classification, while essentially useful, obscures the overall picture in Latin America, where substantial changes in energy supply and demand have occurred

TABLE 1

Latin America and Caribbean: Energy Classification

Net Oil Exporters		Net Oil Importers (with net oil imports -- 1978 figures -- as percentage of commercial energy demand)			
OPEC	Non-OPEC	0-25	26-50	51-75	76-100
Venezuela	Mexico	Argentina	Chile	Brazil	Bahamas
Ecuador*	Peru	Bolivia			Barbados
	Trinidad & Tobago	Colombia			Costa Rica
					Dominican Republic
					El Salvador*
					Grenada*
					Guatemala
					Guyana
					Haiti*
					Honduras*
					Nicaragua
					Panama
					Paraguay
					Uruguay

Source: World Bank, Energy in Developing Countries, August 1980.

over the past thirty years, and where altenatives to petroleum are increasingly plausible. Latin America is a pioneer in the area of technological change. Several countries of the region have made notable advances in generating new sources of energy and in modifying patterns of use. Features of the Latin American experience will be relevant for other countries -- from the most to the least industrialized.

While the demand for primary energy in Latin America has doubled over the past ten years, from 1.46 billion barrels of oil equivalent in 1970 to 2.34 billion barrels of oil equivalent in 1979, the share of energy utilized by different sources has not changed substantially.[6] Petroleum, which accounted for 69.2 percent of all primary energy consumed in 1970, declined to 66.2 percent in 1979. Consumption of natural gas decreased from 15.1 to 13.7 percent, while that of coal increased marginally from 4.8 percent in 1970 to 5.1 percent in 1979. Notable changes in consumption patterns are in hydroelectricity, from 10.3 percent of total energy consumed to 14.5 percent, and nuclear energy, from a negligible proportion in 1974 to some slightly greater reliance in 1979 (about .26 percent). Although these changes are marginal, they do indicate increased diversification of shares of primary petroleum consumption. Table 2 presents comparative energy shares for Latin America as a whole. While the decline in petroleum consumption is perhaps too small to consider as evidence of a definitive trend, it does point to substitution possibilities. The relationship between energy consumption and GNP, noted in industrial countries (Figure 1) is closely replicated for Latin America, reaffirming the role of energy in development

TABLE 2

Energy Consumption in Latin America

(billion barrels of oil equivalent)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
ry	1.46	1.56	1.64	1.76	1.86	1.92	2.04	2.14	2.24	2.34
leum	1.01	1.08	1.11	1.20	1.26	1.28	1.36	1.42	1.48	1.55
re (%)	69.2	69.2	67.7	68.2	67.7	66.7	66.7	66.4	66.1	66.2
al Gas	.22	.24	.27	.27	.28	.29	.30	.29	.31	.32
re (%)	15.1	15.4	16.5	15.3	15.1	15.1	14.7	13.6	13.8	13.7
	.07	.08	.08	.09	.10	.10	.11	.10	.11	.12
re (%)	4.8	5.1	4.9	5.1	5.4	5.2	5.4	4.7	4.9	5.1
	.15	.16	.18	.21	.23	.25	.26	.32	.34	.34
re (%)	10.3	10.3	11.0	11.9	12.4	13.0	12.7	15.0	15.2	14.5
ar	0	0	0	0	.001	.005	.005	.003	.005	.006
re (%)	0	0	0	0	.05	.26	.25	.14	.22	.26

ors due to rounding

ce:

tatistical Review of the World Oil Industry 1979.

(see Figure 3).

Latin America accounted for 7.4 percent of total world oil consumption in 1980, 9.4 percent of world productin, and 10.5 percent of known reserves.[7] These figures, seemingly small, obscure the emerging importance of Latin America in the world oil market, both as a growing claimant on petroleum resource and as a source of production with a growing reserve position internationally. In 1970 the region exhibited the same reliance on oil as did Japan. Subsequent reductions of percentage of oil consumption to total energy consumption shifted the area's position globally.

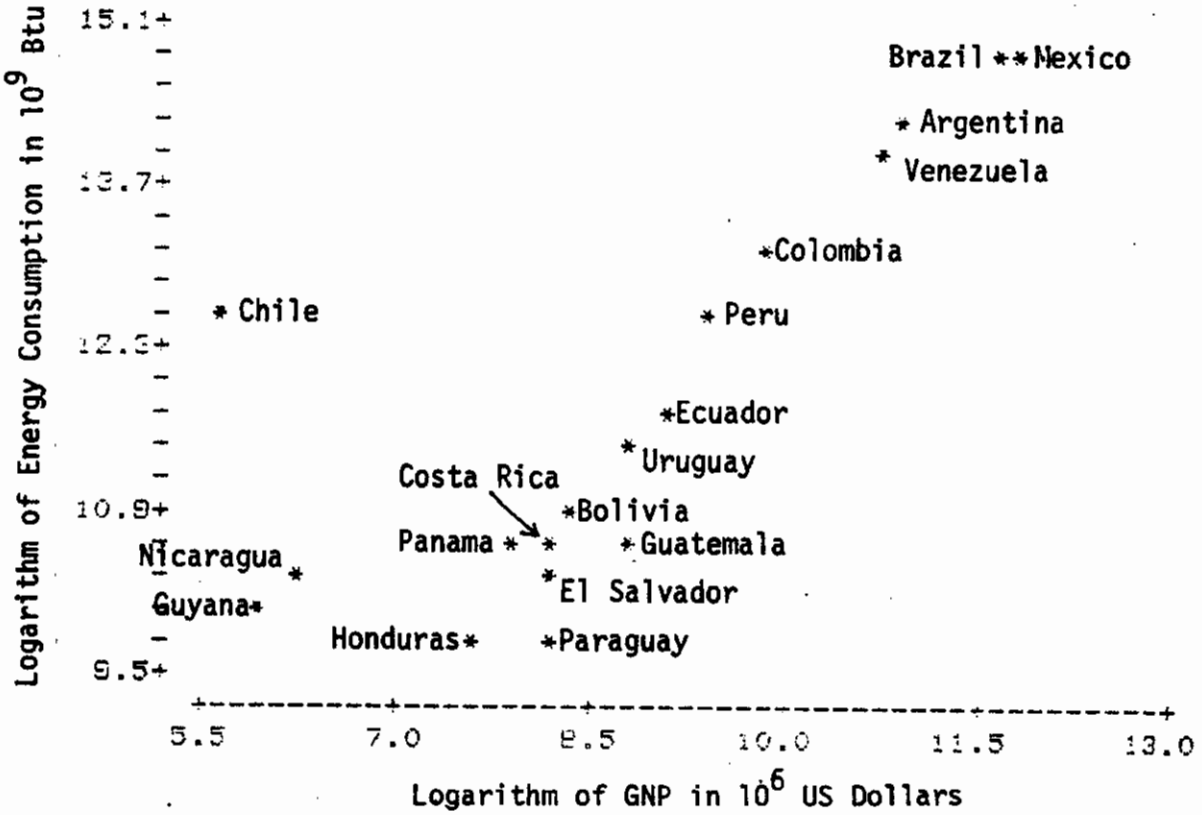
Latin American countries increased their exports of petroleum (crude and products) from 1969 to 1979, as they did their imports. However, exports of petroleum products, by volume, were during this period considerably greater than exports of crude. Indeed, in comparison with other regions, Latin America exhibits a fairly balanced proportion of crude and products in exports of petroleum, while imports are almost uniformly of crude with only little direct import of products.

Although oil production remained fairly steady over this period, the productivity of producing wells is relatively high in comparison with other regions. Well productivity is about the level of Communist bloc wells (USSR, China, etc.), and considerably higher than Canada, the United States (as to be expected), and Western Europe.

Recent revisions of Latin American reserves are noteworthy when compared to previous estimates. The region's proven petro-

FIGURE 3

The Relationship Between GNP and Energy Consumption (1979)



Sources: United Nations, 1979 Yearbook of World Energy Statistics
International Monetary Fund, International Financial Statistics, August 1981

leum reserves expanded from 29.3 billion barrels in 1974 to 69.5 billion barrels in 1980. Almost all of these new reserves were in Mexico. Oil production in Latin American countries for 1980 reveals the dominance of Venezuela and Mexico (at 793 million barrels and 788 million barrels, respectively). Other major producers in 1980 were Argentina (179 million barrels), Ecuador (82 million barrels), and Trinidad (79 million barrels). Latin America as a whole produced 2.133 billion barrels of crude petroleum last year.[8] The oil refining capacity of Latin America has grown steadily during this period, although it still lags behind other major regions (with the exception of Japan, whose refining capability has stabilized, even tapered off, by 1975).

Producers of natural gas are principally Mexico, Venezuela, and Argentina, each revealing an increase in output over the past ten years. For the region as a whole, total production of natural gas jumped from 1.095 trillion cubic feet in 1970 to 2.599 trillion cubic feet in 1980. For only two countries in the region, Bolivia and Chile, is production of natural gas greater than domestic consumption. For other consumers of natural gas, domestic consumption equals or exceeds production.

The coal situation is even more precarious. Only in Colombia is domestic production even marginally greater than consumption. But coal accounts for 24 percent of total energy consumed in the country, rendering that positive balance more significant than it might otherwise be.

Latin America's predominance in hydroelectric power stands in sharp contrast to other regions in the world. Latin America continues to be one of the largest consumers of hydroelectricity

in the world. During 1979, the latest year for which data are available, the 14.7 percent share of energy consumption in the region accounted for by hydroelectric power was notably higher than for any other region or area. This percentage is more than double the world average. There are some clear possibilities for expanding hydroelectric usages. A comparison of Latin America's electricity generation to per capita energy consumption is shown in Figure 4.

4. ENERGY USE AND ECONOMIC ACTIVITY

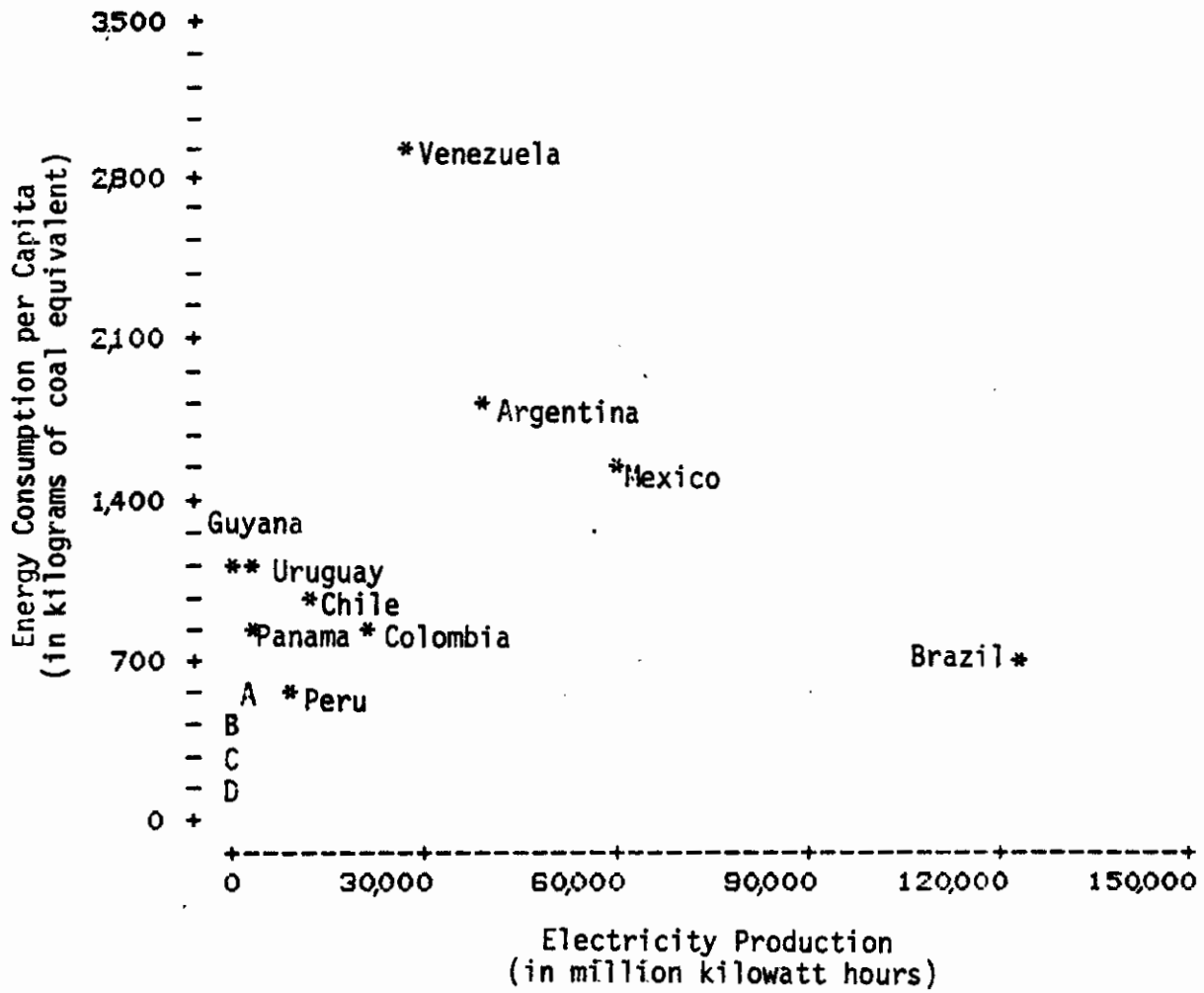
Resolution of Latin America's energy and development problems lies in the region's own capability to adapt and adjust to economic and political constraints. The relationship between energy consumption per capita and GNP per capita is noted in Figure 5 for all countries of the region. This trend is not dissimilar to that for industrial economies.

For the region as a whole, it is believed that industry accounts for 40 percent of fossil fuel use, transport for 35 percent, electricity generation for 15 percent, and 10 percent use is by households.[9] Against this background, Table 3 presents the percentage distribution of energy consumed in each sector of the economy for the five energy giants of the region at a ten-year interval. The predominance of industrial and transportation usages is clear. Only in Argentina has there been a decline in energy usage in transportation, as a percentage of total energy utilization, between 1967 and 1977. Mexico increased slightly and Colombia, Brazil, and Venezuela grew the most rapidly. The

FIGURE 4

Energy Consumption per Capita
in Relation to the Production of Energy

(1979)



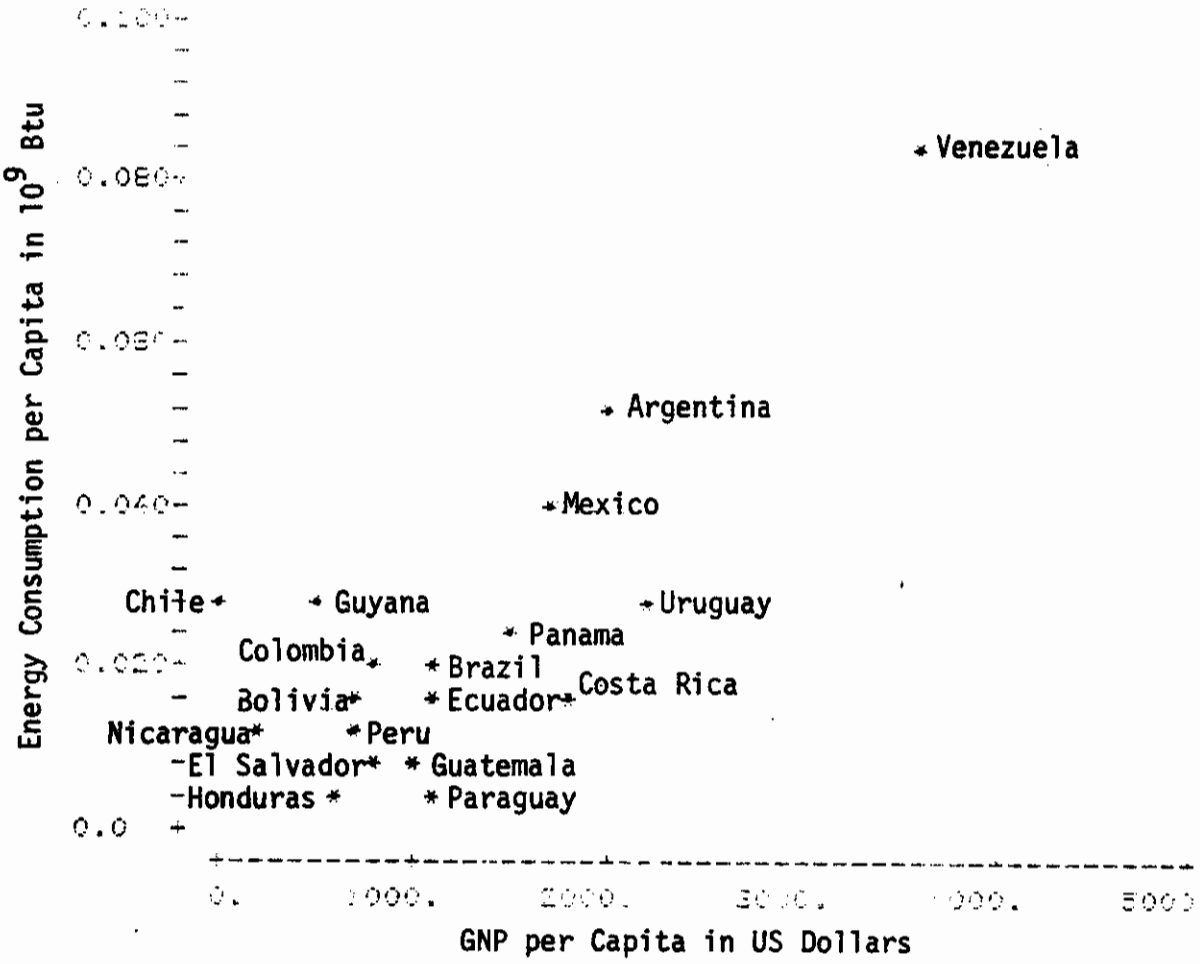
A = Costa Rica, Ecuador,
B = Bolivia, Nicaragua,
C = El Salvador, Guatemala,
D = Honduras, Paraguay.

Source: United Nations, 1979 Yearbook of World Energy Statistics.

FIGURE 5

The Relationship Between GNP and Energy Consumption (1979)

Per Capita



Source: United Nations, 1979 Yearbook for World Energy Statistics
International Monetary Fund, International Financial Statistics, August 1981

TABLE 3

Percent Energy Consumption by Sector

	Industry	Transportation	Agriculture	Commercial	Public Service	Residential
Argentina						
1967	27.54	37.52	0.03	n.a.	n.a.	9.60
1977	33.84	35.86	n.a.	1.64	1.56	17.19
Brazil						
1967	22.04 *	19.84 *	0.11	1.20	n.a.	1.51
1977	28.77 *	25.10 *	n.a.	n.a.	n.a.	n.a.
Colombia						
1967	2.07	14.91	n.a.	n.a.	n.a.	3.82
1977	6.34	20.30	n.a.	n.a.	0.13	6.66
Mexico						
1967	42.69	22.99	0.89	n.a.	n.a.	7.90
1977	52.68	23.71	0.35	0.60	0.41	4.27
Venezuela						
1967	39.90	29.94	0.06	0.28	n.a.	4.60
1977	38.50	35.54	0.03	0.19	n.a.	2.26

*1976 data

Note: Percentage figures do not add up to 100% because of non-energy uses of petroleum products.

SOURCE: International Energy Agency. Workshop on Energy Data for Developing Countries. December 1978. Volume II. Organization for Economic Cooperation and Development. Paris 1979.

differences are most notable in Colombia, where transportation accounted for 14.91 percent of energy utilization in 1967 and increased to 20.3 percent in 1977. This trend is paralleled by the growth of the industrial sector's share of total energy consumption. Together they reflect the overall industrializaion trends in Colombia over this ten-year period. Brazil and Mexico indicate similar trends, although with smaller increases in transportation's energy consumption.

More detailed data on energy in Latin America are unfortunately not readily available. The input-output table for Mexico, 1970, yields some clues as to the share of oil use in different sectors of the economy, as well as distribution of refinery costs for individual sectors. The more recent input-output table (for 1978) is not publicly available at this writing. Table 4 reproduces, with some adjustments of classification, the key row from the 1970 table to provide some indication of uses of refined products.

By this accounting, in 1970 Mexico exported 3.2 percent of its refined products and consumed 22.5 percent in the private sector and 2.7 percent in government agencies. The total inter-industry uses were 71 percent. The major sectoral use was in transportation, with no other sector even approximating the transport level of utilization.[10] Table 4, indicating the share purchased of refined products by various economic sectors, is only partly comparable to Table 3, due, of course, to differences in years, categories, and level of aggregation.

The Mexican case provides the most detailed information available. In Central America, for instance, we know only that

TABLE 4

Oil Consumption by Sector

Sector	Percent of Total Consumption
Agriculture, cattle breeding, forestry, and fishing	7.6
Oil and gas extraction	.9
Food products	4.4
Textiles and paper	1.0
Oil refining	5.3
Chemical production	1.6
Cement and construction	7.5
Manufactureds and other products	1.9
Hotels and services	3.9
Transportation	20.2
Total interindustry	71.0
Private consumption	22.5
Government consumption	2.7
Change in stocks	.7
Exports	3.2

Source: Secretaria de Programacion y Presupuesto, Coordinacion General del Sistema Nacional de Informacion, Matriz de Insumo-Producto de Mexico, ano 1970, Tomo 2, Industria Manufactura. Published by United Nations Development Program, 1970.

in El Salvador the transport sector accounts for 57 percent of all petroleum consumption; industry for 25.4 percent; and the residential and commercial sectors for 11.4 percent of all energy consumed.[11] But these figures are approximations at best.

Some observations on non-commercial energy uses, notably bagasse, including vegetable combustibles, firewood, and charcoal, provide additional insights into orders of magnitude. A more complete view would include dung, peat, tar, wood wastes, vegetal wastes, municipal wastes, and pulp wastes. The following estimates are calculated on the basis of thousand tons of oil equivalent on the basis of initial data including all other formal sources of energy, thereby introducing additional uncertainties. A note of caution is advised in interpreting the following numbers; they represent the best approximation possible, not irrefutable fact.

The five giants -- Argentina, Brazil, Colombia, Mexico, Venezuela -- all revealed a declining percentage of non-commercial energy of total final consumption as a group, from 29 percent in 167 to 20 percent in 1977. This decrease is the result of the more rapid decrease in other sectors' consumption of noncommercial energy (66 percent to 51 percent in 1977) which more than offsets the small overall increase from 26 percent to 28 percent for the five nations during that same decade. However, the range of percentages is so great as to undermine the significance of broad changes. For example, not all the countries experienced a relative decline in the amount of energy coming from non-commercial forms, and the relative increase in

industry's share of total final consumption actually breaks down into two significant increases, one major decrease, and two minor decreases, thus no overall trend.[12]

Argentina, with the second lowest overall non-commercial energy share of final consumption in 1967 (11 percent) was the single exception in increasing to 20 percent by 1977. This was due principally to the large increae in bagasse used by industry (from 1070 th/toe in 1967 to 4970 th/toe in 1977). None of this bagasse was used in either the iron and steel or chemical and petrochemical industries. The use of firewood/charcoal actually decreased in absolute terms, from 1040 th/toe to 980 th/toe during the same period. All of it was consumed in residential use. Thus overall noncommercial energy nearly tripled, from 2110 th/te to 5950 th/toe, a faster growth rate than either commercial energy or total energy.[13]

Brazil experienced a declining share of its energy consumption met by the noncommercial sector over this period, yet still had the highest overall level of noncommercial energy among the five nations, 23,719 th/toe in 1967 and a slight growth to 28,088 th/toe in 197[illegible]. Brazil's growth in industrial use of noncommercial energy (from 28 to 58 percent) is similar in percentage terms to that of Agentina (20 to 48 percent), but no details are readily available on specific industries using bagasse. Firewood/charcoal use in other sectors increased slightly, from 86 to 88 percent. Nevertheless, these two areas of growth were still less than overall energy consumption growth in the economy, so their share declined from 51 percent of the total in 1967 to 32 percent in 1977. The expansion of gasohol use may expand the

use of vegetal wastes, but statistics since 1977 are not detailed.[14]

5. TECHNOLOGICAL DEVELOPMENTS IN ENERGY

Despite claims that Latin America will remain dependent on petroleum for the rest of the century,[15] both the Organization for Latin American Energy Development and a recent report of Argentina's Fundacion Bariloche are optimistic that nonconventional energy will play an important role in Latin America.

The OLADE study of the nonconventional energy sources in Latin America undertaken in connection with the United Nations has drawn an energy development plan for the region.[16] The study claims that by implementing the plan the continent could save three billion barrels of oil by 1995. By then 11 percent of the region's energy would come from nonconventional sources. The environmental benefits would be substantial: a 24 percent drop in deforestation, and an increase in energy supplies for low-income and rural populations. Moreover, the study predicts that by 1995, adoption of non-conventional energy strategies would increase total energy supplies by 5 to 15 percent without increasing the use of conventional sources.[17] The Bariloche Report claims that by 1985 nonconventional energy sources will provide more than 10 percent of Latin America's energy requirements.[18] Hydroelectric power has long been a crucial energy sourc and is expected to increase in importance. Many observers agree that the key issue is how best to exploit the indigenous resources that exist in virtually all countries.

5.1 Vegetable Fuels

The development of alternative sources of energy is a high priority in Brazil. The National Energy Commission, composed of key ministers and heads of state and industrial enterprises, is directing an accelerated energy program to inrease use of coal, alcohol production, and expansion of shale oil and hydroelectric resources. One of the most important programs is production of alcohol from sugar cane.[19] Table 5 presents comparative shares of vegetable fuel production and consumption for the region.

Brazil's gasohol project is evidence of new technologies for energy generation. The project is designed to contribute up to 49 percent of the fuel needs of Brazilian cars by 1985-19986. The vulnerability of Brazil's foreign oil supplies has stimulated both a surge in the sales of alcohol-powered cars and government action to halt sugar exports to provide resources for alcohol production. The price of a litre of alcohol is currently less than half that of petroleum. However, competition from the export sales of sugar suggest that alcohol prices will have to be raised to four times the current price in order to compete with the return on sugar from exports. In 1979 Brazil made its first international contract for its national alcohol program, a US $1.2 billion loan extended in London by a consortium or 51 banks, headed by the Morgan Guarantee Trust.[20] Production of alcohol is projected at 6 billion litres for 1981, enough to power 1.4 million cars. A target of 10.7 billion litres has been set for 1985. This would be the equivalent of only 160,000 barrels of oil per day out of the current 1 million barrels per day that

TABLE 5

VEGETABLE FUELS: SOUTH AMERICA

1975

	% of Country's Consumption	% of Country's Production	% of Region's Consumption	% of Region's Production
Argentina	05.31	04.93	04.03	04.03
Bolivia	43.40	13.41	02.07	02.07
Brazil	20.18	31.39	37.40	37.40
Chile	06.79	05.26	01.37	01.37
Colombia	17.30	14.75	06.65	06.65
Ecuador	38.46	14.54	03.37	03.37
Mexico	09.81	07.54	13.67	13.67
Nicaragua	34.25	77.21	00.99	00.99
Panama	13.70	86.19	00.44	00.44
Paraguay	54.00	74.34	00.11	00.11
Peru	17.86	20.07	04.17	04.17
Uruguay	04.97	23.13	00.25	00.25
Venezuela	03.42	00.48	01.85	01.85

Source: CEPAL, Energy in Latin America: The Historical Record, 1978.

TABLE 5 (continued)

VEGETABLE FUELS: CENTRAL AMERICA AND THE CARIBBEAN

1975

	% of Country's Consumption	% of Country's Production	% of Region's Consumption	% of Region's Production
Bahamas	00.71	100.00	00.01	00.01
Barbados	27.59	100.00	00.15	00.15
Costa Rica	23.52	43.87	00.72	00.72
Cuba	34.87	93.96	09.21	09.21
El Salvador	42.39	81.98	01.32	01.32
Grenada	42.86	100.00	00.04	00.04
Guatemala	51.68	92.65	02.56	02.56
Guyana	32.83	100.00	00.74	00.74
Haiti	90.38	96.38	02.77	02.77
Honduras	47.96	79.68	01.19	01.19
Jamaica	16.49	90.69	00.92	00.92
Dominican Republic	43.81	97.61	02.66	02.66
Trinidad and Tobago	05.63	01.01	00.36	00.36

Source: CEPAL, Energy in Latin America: The Historical Record, 1978.

Brazil now consumes. It is hoped that alcohol will eventually account for 40 percent of consumption and petroleum for 60 percent.

To reach the 1985 goals, some 2 to 3 million extra hectares of land will be needed to grow the necessary sugar cane, an approximate 7 percent increase a year until 1985. Technological developments, however, are not without social costs. Conflicts over land in the competition of alcohol production vs. food production are likely to occur. For example, in the Sao Paulo State, where most of the new sugar plantations have been recently established, there is already considerable pressure on small producers who are currently growing subsistence crops, such as maize and beans.[21] The World Bank has recently offered Brazil $1 billion for the alcohol program, on the condition that provision of equipment be opened up to international competition.[22]

Brazilian authorities are also looking into alternative types of oil as fuel plans now call for the production of an extra 2 to 2.5 billion litres of vegetable oil to substitute for diesel in approximately 16 percent of consumption. Among the crops to be used are soy (despite relatively low yields of 350-400 kg. per hectare) and higher yielding crops such as rape, sunflower, groundnuts, and dende palm oil -- perhaps the highest yielder of oil per hectare. The Amazon region is the site of a proposed new palm plantation (50,000 hectares per year).[23] One fear of concentrating too heavily on vegetables as alternative fuel production is the ultimate scarcity of food crops which would require importation of food. Moreover, some of the crops

being cultivated under the energy program, particularly sugar, rapidly exhaust the soil. In July 1981 the World Bank agreed to lend Brazil $250 million to assure production targets for sugar cane. Brazil's National Alcohol Commission pledged to assist the alcohol-fuel industry with an additional US $244 million for 1981. Energy planners are skeptical about prospects for meeting 1981 targets.[24]

Colombia, as well, is investigating the use of ethyl alcohol, as shown in studies made by the Empresa Colombiana de Petroleos (Ecopetrol) and the Federacion Nacional de Cafeteros, and reported in the Colombian magazine Estrategia. The studies have calculated the cost of producing alcohol from a variety of materials, including cassava, sugar cane, potatoes, maize, and rice. They estimate a minimum production of 15,000 barrels a day, which could easily be combined with normal fuel. In addition to reducing petroleum dependency, the project has been seen as a good opportunity for providing a stable market for increased agricultural production. To produce sufficient quantities of alcohol, it would be necessary to plan 220,000 hectares of sugar cane or 140,000 hectares of cassava at an investment of 11 billion pesos.[25]

These programs are notable but will only help countries with large uncultivated lands -- clearly not the case for the Caribbean, Chile, and El Salvador. Nevertheless, the region's endowments of vegetable residues as a major source of fuel place it in a distinctive position, and, although there is some talk of expanding local production of methane, it cannot be done on short order. The rapid rates of urbanization call into question the

large-scale possibilities of switching to vegetable residues.

5.2 Biogas

OLADE has set up a pilot project for small-scale production of methane in Ecuador. Based on a system extensively used in China, the technology entails feeding human and animal excrement and vegetable waste matter into a digesting tank for the generation of methane. This is seen as a potential important alternative to wood for cooking and heating water, since deforestation is becoming a serious problem in many rural areas. It is particularly appropriate for warmer climates, where crops produce large quantities of vegetable waste as a by-product. It is expected that OLADE's methane program will extend to rural areas of Guyana, Honduras, and Jamaica.

5.3 Nuclear Power

Nuclear energy, a marginal source of power in Latin America, is an option only for Argentina, Brazil, Cuba, and Mexico. These are the only countries apparently willing to generate electricity in that way. Given concern for national autonomy, so dominant in Latin america, prospects of technological dependency emanating from decisions to expand nuclear power capability emerge. Argentina's decision to control its own fuel cycle through utilization of natural uranium is a case in point: cost factors are essential. In the case of Brazil, the country's third nuclear power plant will cost US $2800 per installed kilowatt, in comparison with the initial estimate of US $2,000 which was

regarded as plausible for Brazil's nuclear power.[26] The government has postponed the completion date of the nuclear power program from 1995 to 2000. The first nuclear power plant, Angra I, was expected to enter operation in April 1981.[27]

During 1980, Argentina had the only plant on-line in the region, producing 335 net MW, and two plants under construction with a total of 3116 net MW under construction, and Mexico was building two plants with a total of 1308 net MW. The precise estimates for Cuba could not be found.[28]

Technological advances in energy have been enhanced through international cooperation. For example, Argentina and Brazil are pushing ahead with plans for nuclear development, both individually and jointly. The two countries have also been discussing the formation of a regional body for nuclear development, comparable to Euratom. Both countries have received technological assistance from West Germany, but Argentina would like to form a united front with Brazil to avoid problems of technological dependency. they are also interested in exchanging their own technological resources, such as Argentinian expertise in uranium processing and nuclear engineering, in exchange for the Brazilian experience in detecting uranium deposits. Technological collaboration would also be involved in the areas of radio isotopes, particle acceleration, reactor management, nuclear plasma, and joint training facilities for scientists and technicians.[29]

Despite a poor history in nuclear energy production (for example, the Laguna Verde project in Veracruz State which is six years behind schedule), the Mexican government has placed great

emphasis on the development of this resource. It is confident that Mexico has the reserves to become one of the world's greatest uranium producers. The state uranium company, Uramex, has grown from a staff of 900 to 2000 in an 18 month period, and is expected to grow by 1000 in the coming year, an indication of the importance placed on the development of nuclear power. Mexico has enlisted the technological assistance, in the form of feasibility studies, of Canada, Sweden, and France. In an effort to avoid technological dependence, Mexico is expected to make use of a wide range of expertise from industrialized countries. Energy plans currently call for the construction of 15 to 20 nuclear plants over the next 15 to 20 years, with the aim of achieving the production of 20,000 MW by the end of the century.[30]

5.4 Coal

With respect to coal, Colombia stands out as a country with important long-term prospects. At present, however, coal is being shipped out of Latin America to regions where the installed capacities for efficient use are already in place. The Colombian state coal corporation, Carbocoal, has signed a contract with Exxon, calling for the investment of US $3 billion in exploiting the El Cerrejon coal deposits in the La Guajira Peninsula, which are estimated at 1.6 billion tons of good quality steam coal. The agreement calls for production to begin in 1986, with expectations of reaching 15 million tons a year. The operating company will be the Exxon subsidiary, Intercor. Carbocoal will

own 50 percent of the shares. Part of the project includes construction of a 90 mile railroad to the Caribbean coast and expansion of port facilities Exxon began. The agreement stipulates Exxon to pay a 15 percent royalty fee on its half of the production and taxes based on a sliding scale of profits.[31]

For Brazil, the government's energy plan is to replace 30 percent of present consumption of fuel oil with wood, charcoal, and coal. However, to provide the necessary wood and charcoal, an extra 1.4 million hectares of forestry will have to be planted each year. As with vegetable oils and sugar, the program is limited by land availability. It has been established that 250 hectares of land on the central plateau of Brazil would be required to produce the equivalent of 1000 tons of oil.

5.5 Natural Gas

The recent evolution in the international energy market has had a profound impact on the prospects for natural gas in the region. The discovery of natural gas reserves in Latin America is usually a by-product of oil exploration, since the two are often found together. Few projects have been undertaken in the region in search of natural gas simply because the amount of proven gas reserves has usually been far more than what was required to meet demand. In the past governments have preferred to invest limited capital in the search for and development of oil deposits rather than in the development of expensive systems of gas transmission and distribution needed to release gas reserves for consumption.

Latin American interest in natural gas production has

increased in recent years and can be expected to continue growing with the desire to find alternatives to petroleum.[32] Recent develoment plans associated with natural gas bear out this point. A major pipeline project is being planned to carry gas from Bolivia's gas fields all the way to the industrial center of Sao Paulo in Brazil, a distance of 1200 miles. In 1975 the cost of this project was estimated at $3 billion dollars. Mexico has made plants to construct gas pipeline projects, and in Chile, interest has been shown in shipping gas from its southern gas fields to central and northern centers of energy consumption in the country, as a substitute for the imported oil on which these centers now rely heavily. In general the high price of oil in world markets promises a widespread review of the potential for exploiting Latin America's wealth in natural gas, as the region seeks to diminish its quantity of imported oil.

5.6 Hydroelectricity

Hydroelectricity is undoubtedly the most essential alternative source of energy for Latin America. Although operational costs are low, these will rise over time, accentuating the cost calculations of building new dams and the installations of turbines. While Brazil exhibits the largest usage of hydroelectric power, the harnessing of rivers has already been done in many regions of the country. The Amazon provides important possibilities that remain fraught with technical and environmental difficulties. So, too, Argentina has more unexploited rivers than Brazil, but their location far from population centers

accentuates problems of development. Close to $12 billion is expected to be allocated for expansion of hydroelectric power to 38 percent of power generated by 1985 and 73 percent by 1995.[33] Some countries, like Colombia, have "massive potential," but it is only marginally exploited.[34]

5.7 Geothermal Energy

Hot springs down the whole length of the Andean range are potential sources of thermal energy. However, only Mexico and El Salvador actually operate geothermal power stations. Mexico has 2 units of 37.5 MW each which supply 6.6 percent of Mexico's electricity.[35]

6. CONCLUSION: COOPERATION FOR TECHNOLOGICAL DEVELOPMENT IN ENERGY

Technological development in energy clearly has tremendous potential in Latin America. Three specific problems, however, interact to reinforce the difficulties of expanding the region's alternative sources of energy. These include the magnitude of capital expenditures required, access to technology, and resolution of potentially critical environmental problems. In the past, the multinational companies served as the major source of capital and technology. A return of external corporate domination of the region would signify a change in national policy for almost all countries. Powerful sentiments exist against foreign corporate pressure; however, we may regard recent protests of Mexico and Venezuela against an Argentinian proposal that the Interamerican Development Bank guarantee transnational invest-

ments in the energy sector as an important example of the region's response to prospects of large-scale foreign corporate involvement in energy development.

New patterns of cooperation in the energy field have been developed, involving not only financial flows, but also exchanges of skills for commodities and technical and financial aid to the poorer Latin American countries by the newer powers in the region. These new patterns point to a newly found economic and political power of countries that had not previously enjoyed such positions.

In 1976, members of the Andean Subregional Integration Agreement (Cartagena Agreement) agreed in principle to establish a fund of $400 million to assist in financing their balance of payments deficits. This is an important step towards regional integration, departing from previous cooperation, which was limited to financing projects by the Andean Development Corporation.

The establishment of OLADE further reflects new prospects for regional integration. OLADE's mission is to create more "balanced" production and consumption of petroleum for the countries of the region, in the sense of helping Latin American countries produce energy. For instance, Venezuela announced during the September meeting of eight energy ministers in Caracas that it was increasing sales to Brazil (the region's largest importer) to 60,000 barrels per day with a final target of 100,000 barrels per day. Mexico has just raised its exports to Brazil from 20,000 to 50,000 barrels per day.[36] So, too, in a

three week session of the Sistema Economico Latinoamerica (SELA), convened to evaluate the progress of the United Nations Special Sessions on Develoment, one of the first priorities to emerge was an expansion of the Mexican-Venezuelan energy plan for Central America and the Caribbean.[37] The two countries' leadership, implicit in other contexts, is emerging clearly in the area of energy.

The energy sector specifically has provided the basis for new forms of broader international cooperation. For example, Japan has emerged most prominently in new trade relations with Latin America. Joint Japanese-Mexican economic committees have discussed the exchange of Mexican oil for Japanese investments and technical assistance in the auto, steel, and petrochemical sectors. One specific example is important: Japan has proposed to expand the Las Truches steel complex in a package with the establishment of Japanese oil refineries.[38]

Brazil has tried to bridge its own energy gap by establishing contracts with Iran and Iraq for oil exploration through its foreign subsidiary Braspetro.[39] This case is distinctive because it involves a non-oil exporter contracting for petroleum exploration outside its own boundaries. Since the Iran-Iraq war, Brazil's position as a recipient of Iraqi oil has been favored somewhat by its role as a supplier of light armored trucks and other weaponry.[40] Parenthetically, however, since Brazil obtains half its imports from Iraq, the war has had a clear impact. Brazil is getting only part of the contracted quantity.

Mexico emerges as a particularly strong nation in this context. The current leadership general strategy has been diver-

sity in exports, thereby reducing dependence on the US market, which currently accounts for 80 percent of all Mexican exports. France, West Germany, Sweden, Canada, and Japan all seek Mexican oil. These countries consider providing nuclear technology and agricultural products in exchange for oil.[41] Mexico has taken a particularly independent stand with regards to Japan, which seeks a commitment to increase Mexican oil development. However, Mexico's concern for curbing inflation places some constraints on meeting Japanese requirements. It has been argued that increased oil exports would be possible only if countered by increased Japanese investments.[42] Mexico and Portugal have signed a concerned agreement involving industry, tourism, and technology: Mexico will provide Portugal with oil, and Portugal will provide expertise in heavy industry, petrochemicals, and tourism.[43]

Argentina has suggested to Bolivia that they develop joint pricing and marketing strategies for natural gas deposits. Between them they are the major gas suppliers of the region, with Brazil, Uruguay, Paraguay, Chile, and Peru all potential buyers n a long term strategy. This suggestion has been interpreted as a move towards greater regional and economic integration.[44]

Brazil and Venezuela have begun discussions not only of increasing oil sales but of exchanging heavy oil technology, energy conservation, and petrochemical technology. While Brazil is interested in Venezuela's oil, Venezuela is concerned with acquiring Brazil's developing alcohol fuel technology.[45]

The state oil companies of Brazil and Chile are considering possibilities of joint oil exploration. One aspect of this

venture is the commitment that Brazil buy ten percent of Chile's total copper production.[46]

Trends in regional cooperation, signalled by OLADE, influence the internal development programmes of individual countries as well. For example, the Caracas meeting of September 1980 of the energy ministers of eight countries (Brazil, Colombia, Dominican Republic, Costa Rica, Ecuador, Mexico, Nicaragua, and Venezuela) agreed to form a regional energy plan for the OLADE meeting in bogota in November of that year. The plan was devised to provide more balanced production and consumption flows. It was noted that while regional production of crude is 5.52 million b/d (based on 1979 estimates) and consumption within the region is only 4.40 million b/d, Mexico and Venezuela export most of their production outside the region. Therefore, deficit countries have to import oil from outside. The main points of the proposed plan are: (1) the development of indigenous energy sources aimed at regional self-sufficiency; (2) rationalization of energy production, marketing, and consumption, designed to reduce dependence on hydrocarbons; (3) obtaining increased financial resources for international institutions and industrialized countries, and the creation of additional sources of revenue for developing energy projects.[47] An unwritten presumption underlying OLADE's efforts is that the diversity in energy resources, in level of economic development, in distribution of skills and technology, and in demographic structure now enables the countries of Latin America to consolidate a new basis for technological cooperation and regional integration.

NOTES

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4. Brookhaven National Laboratory Developing Countries Energy Program. Energy Needs, Uses, and Resources in Developing Countries. March 1978, p. 84.

5. There are few comprehensive analyses of energy problems in developing countries. The World Bank Report, Energy in Developing Countries, Washington, D.C., August 1980, is one of the most informative in terms of coverage. However, none of the issues is examined in any depth. See also Latin America and Caribbean Oil Report, published by Petroleum Economist. London: Nichols Publishing Company, 1979; and Peter R. Odell, "Energy Prospects in Latin America," Bank of London & South America Review. Vol. 14, No. II/80 (May 1980), pp. 93-112.

6. These figures refer to commercial energy only, thus excluding vegetable fuels which, as will be noted below, provide a substantial contribution to the energy balance of Latin American countries. For commercial fuels, figures are based on British Petroleum Company, BP Statistical Review of the World Oil Industry, 1979; International Monetary Fund, International Financial Statistics, 1981; Department of International and Social Affairs, United Nations, New York, 1981. The most recent, comprehensive coverage for the region as a whole, in terms of countries and sources of energy, is for 1975, from CEPAL, Energy in Latin America: The Historical Record. Santiago de Chile: The United Nations Press, 1978.

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8. Ibid.

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12. Energy Workshop on Developing Countries, 1979.

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14. Ibid.

15. New York Times, January 1, 1980, pp. 31-32; Petroleum Economist, Vol. 46, No. 7 (July 1979), pp. 283-286.

16. Ibid., for a description; see also the New York Times, February 1, 1980, pp. 9-10.

17. Ibid.

18. Ibid.

19. Petroleum Economist, Vol. 46, No. 9 (September 1979), pp. 383-384.

20. Petroleum Economist, Vol. 47, No. 10 (October 1980), pp. 450-451.

21. Latin America Weekly Report (October 10, 1980), p. 10.

22. Ibid.

23. For a review of Brazil's program see R.F. Colson. "Brazil: the Proalcool Programme -- A Response to the Energy Crisis." Bank of London & South America Review. Vol. 15, No. II (BOLSA) 81, (May 1981), pp. 60-70.

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26. "Latin America: After the Oil Crisis," BOLSA, Vol. 13, No. 12 (December 1979), pp. 708-709.

27. Latin America Weekly Report (February 1, 1980), p. 4.

28. Op. cit. (January 25, 1980), pp. 3-4.

29. Op. cit. (May 16, 1980), p. 6.

30. Op. cit. (November 21, 1980), p. 7.

31. Petroleum Economist, Vol. 47, No. 10 (October 1980), pp. 450-451.

32. Latin America Weekly Report (September 12, 1980), pp. 8-9.

33. Petroleum Economist, Vol. 46, No. 4 (April 1979), pp. 166-167.

34. Latin America Weekly Report (September 12, 1980), pp. 8-9.

35. Op. cit. (March 14, 1980), pp. 8-9.

36. Op. cit. (September 26, 1980), p. 3.

37. Op. cit., pp. 9-10.

38. Op. cit. (November 16, 1979), pp. 29-30. Also see R.F. Colson, op. cit., for a broader review of Brazil's current energy posture.

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40. Op. cit. (March 21, 1980).

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42. Op. cit. (February 15, 1980), pp. 5-6.

43. Op. cit. (September 19, 1980), p. 3.

44. Op. cit. (May 16, 1980), p. 6.

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46. Op. cit. (May 9, 1980) and (May 16, 1980), p. 6.

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