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Energy development is critical to Central America's (CA) future. This second of two volumes on energy and development in CA provides energy assessments for six CA countries to supplement the regional energy assessment given in Volume I. Each profile outlines in-country geographic, social, and economic factors affecting energy consumption; assesses energy resources and institutions; describes current energy-use patterns and applies Volume I methods to forecast energy needs to the year 2000; and develops basic energy strategies. Besides specifying the regional recommendations given in Volume I, the report recommends the following for USAID support: (1) in Guatemala—a conservation office/program, rural energy development (e.g., technology centers and education programs), extension of rural electrification, reforestation, and institution-building for technology transfer; (2) in Honduras—institution-building in energy research and development in minihydro, coal, and solar energy, and determining the feasibility of proposals regarding charcoal, cement, and agricultural residues; (3) in Nicaragua—geothermal development (financial support), assessing minihydro potential, and controlling brine-related air and water emissions; (4) in Costa Rica—integrating energy/transportation planning, reducing/displacing petroleum use in irrigation, food processing, packaging, transportation, and fertilizer operations, hydrocarbon research, and wind and solar assessments; and (5) in Panama—a national energy organization (as a prerequisite to further USAID support), energy-conservation skills (in all USAID assistance), energy-related curriculum development at the University of Panama, resource assessments, and Panamanian participation in regional energy initiatives. Also recommended are efforts to derive ethanol from sugarcane in Nicaragua, Guatemala, and Honduras; use of Peace Corps Volunteers in rural energy programs in the latter two countries; and training for government officials in natural resource assessment and energy/environmental planning in Honduras and in fossil fuels and energy planning in Nicaragua. El Salvador requires further study before recommendations can be made. Bibliographies follow each section.

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C. Duisberg

Energy and Development in Central America

Volume II: Country Assessments

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ABSTRACT

This volume presents a country-by-country energy assessment of six Central American countries: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama. For each country it includes an assessment of geographic, social, and economic aspects of energy development, an assessment of energy resources, current and projected energy use, potential strategies for energy development, and finally recommendations to USAID for the orientation of its energy development programs. Each country assessment is supplemented with a summary of energy R&D activities and a description of each country's energy-related institutions.

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1.0 INTRODUCTION

This is the second volume of a two-volume report on energy and its relationship to development in Central America. The first volume contains a regional overview of the energy situation in Central America, suggests energy strategies for the future, and makes recommendations to the U.S. Agency for International Development (USAID) for energy assistance programs in the region.

This second volume looks at energy in Central America on a country-by-country basis. It provides the data base for analysis in Volume I and it refines regional energy information to the national level.

Each country has a separate section in this volume. A common outline is used for each of these sections for the purpose of uniformity and comparison.

Each country section opens with a brief description of geographic, social, and economic aspects of the country that affect its energy future. This is followed by an assessment of the energy resources available to each country and a breakdown of current energy use patterns. In the fourth section of each country report, the forecasting methodologies defined and described in Volume I are applied. Two forecasting cases are used: Case I and Case II. A breakdown of the forecast year 2000 fuel use is presented for each case. The fifth section then looks at the Case I country impacts of the energy strategies proposed in Volume I. Finally, a section is devoted to making specific country recommendations to USAID for country energy programs.

Each country section has its own bibliography and two appendices. The first appendix contains a table summarizing the energy research and development activities. The second appendix presents information on the key energy and energy-related institutions.

The bulk of the data presented in this volume is based on information obtained from country visits by joint teams from The MITRE Corporation and Energy/Development International. With the assistance from USAID mission offices, these teams met with energy officials in each country. The information provided by these officials and agencies has been invaluable to the success of this effort. We refer the reader to the Appendix at the conclusion of Volume I for a list of the individuals and agencies contacted in each country.

2.0 GUATEMALA

2.1 Geographic, Social, and Economic Aspects of Guatemala Energy Development

Geography

Guatemala occupies the northwestern tip of the Central American isthmus. It is bounded by Mexico to the north and west, Belize and the Gulf of Honduras to the northeast, Honduras to the east, and El Salvador to the southeast. The Pacific Ocean lies directly to the south.

Topographically, Guatemala's 108,780 square kilometers of land area can be divided into four regional types: mountains, Pacific lowlands, Caribbean coast, and El Peten. The Mountains of the Sierra de los Cuchumatones, Sierra Madre, and Sierra de Chuacas comprise half the country's land area, ranging from 3,000 to 13,000 feet above sea level.

The Pacific lowlands to the south, form a narrow agricultural belt consisting mostly of savannah plains near the coast, and forest in the foothills and lower slopes of the highlands.

The Caribbean coast and northern river valleys are made up of tropical rain forests, which support some agricultural activity, and serve as transportation corridors to the outside world.

El Peten, a tropical limestone plateau jutting into the Yucatan peninsula, accounts for a third of Guatemala's territory. El Peten is undeveloped, but holds considerable potential for lumber and hydrocarbons.

Guatemala's population is the largest in Central America. It was estimated at 6.5 million in 1978, and is growing at an annual rate of 2.8 percent.

Economy

Guatemala occupies a leading economic position among Central American nations. It produces the largest Gross Domestic Product in Central America ($4,363 million, 1978), and has developed the largest industrial sector ($490.7 million, 1978). Per-capita income was $846 in 1978, third highest in the region.

The sectoral composition of GDP is illustrated in Table 2-1; agriculture and manufacturing were the most important sectors in terms of contribution to GDP in 1976.

The agricultural sector is the most important in terms of employment and contribution to exports. Key export commodities include: coffee ($243 million: 1976), sugar ($110 million: 1976), cotton ($84 million: 1976), bananas ($41 million: 1976), meat ($21 million: 1976) and processed agricultural products ($13 million: 1976). Crops are raised in the large agribusiness landholdings of the Pacific lowlands and, to a lesser extent, the Caribbean lowlands. In the central highlands, a significant non-commercial farming economy supports the Indian population. Here, maize and other subsistence crops are grown for local consumption.

The mining sector has assumed greater prominence in recent years as the country seeks to diversify exports and lessen dependence on imported petroleum. A private company, EXMIBAL, is beginning to mine and export Guatemala's nickel reserves. Also, oil production in the

TABLE 2-1

GUATEMALA

GROSS DOMESTIC PRODUCT BY SECTOR, 1970-1976

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976
GROSS DOMESTIC PRODUCT	2,762.7	2,915.1	3,153.0	3,362.6	3,542.5	3,646.7	3,921.6
Agriculture	754.6	807.6	691.9	938.1	988.2	1,022.8	1,072.1
Mining	2.6	2.6	2.3	2.5	3.1	3.3	4.2
Manufacturing	436.1	466.9	496.3	536.0	555.1	552.3	609.5
Construction	43.8	43.9	53.1	63.2	58.5	68.0	128.1
Public Utilities	33.1	35.0	39.9	43.9	46.7	50.8	54.8
Transport and Storage	151.3	162.5	183.6	202.3	226.4	233.7	258.2
Commerce	798.2	834.8	884.0	944.1	1,006.2	1,005.5	1,090.7
Banking, Insurance and Finance	65.2	67.1	72.5	82.6	88.6	95.0	101.5
Housing	192.3	196.2	201.6	205.2	206.9	215.0	173.6
Public Administration and Defense	133.9	135.7	151.3	154.7	163.5	183.2	195.9
Personal Services	151.5	162.8	176.5	190.0	199.4	217.0	233.1

Source: World Bank.

province of El Peten recently increased from 3,000 barrels/day to over 10,000 barrels/day following the completion of a pipeline to the country's principal Caribbean port, Puerto Barrios.

The manufacturing sector has been the fastest growing sector of the Guatemalan economy in recent years. Industrial growth has been concentrated in food processing, clothing, footwear, textiles, chemicals, and non-metallic minerals. Nevertheless, two thirds of the industrial labor force is involved in low-productivity cottage industries.

The commercial, service, government, and miscellaneous sectors have grown in parallel with GDP in recent years. A noted exception has been the public sector, where energy and other public services have exhibited much higher growth rates.

Balance of Payments

Guatemala's foreign trade position has improved considerably since 1974 when escalating petroleum prices produced several years of net trade deficits. Since then, government efforts to restrict unnecessary imports, increase domestic energy production, and accelerate and diversify exports have paid off. Guatemala's foreign exchange reserve holdings reached record highs in 1976. (See Table 2-2.)

Historically, Guatemala's exports have been dominated by agricultural products, particularly coffee. Dependence on coffee earnings has decreased over time, but coffee still accounts for one third to one half of total export earnings. (See Table 2-3.)

Guatemala's industrial sector exports manufactured products to fellow members of the Central American Common Market (CACM). In

TABLE 2-2

GUATEMALA

BALANCE OF PAYMENTS, 1970-1976

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976
Exports (goods and n.f.s.)	349.5	338.5	391.4	529.5	701.6	792.0	951.8
Imports (goods and n.f.s.)	336.7	371.0	387.3	514.3	807.6	858.0	1,136.3
Resource Balance	12.8	-32.5	4.1	15.2	-106.0	-66.0	-184.5
Net Factor Services and Transfers	-20.7	-16.6	-13.6	-4.1	16.6	3.6	180.7
Current Account Balance	-7.0	-49.1	-9.8	11.1	-99.4	-62.4	-3.8
Change in Reserves	-29.1	-11.5	-46.9	-98.7	23.9	-105.7	-221.3
Net International Reserves	76.4	87.9	134.6	200.5	176.6	282.3	503.6

Source: World Bank.

TABLE 2-3

GUATEMALA

VALUE OF EXPORTS BY PRODUCT, 1970-1976

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976
Agricultural Products	163.5	154.5	190.2	241.6	309.7	294.7	309.2
Coffee	100.6	96.3	105.3	145.6	172.9	164.2	242.5
Cotton	27.2	26.0	40.9	47.9	71.0	74.0	83.7
Bananas	13.6	14.5	25.6	24.7	31.5	34.5	41.3
Others	22.1	17.7	18.4	23.4	34.3	22.0	21.7
Mineral Products	4.4	3.4	3.8	6.6	8.4	8.2	8.2
Industrial Goods	129.2	129.0	141.8	193.4	264.1	338.0	306.9
Processed Agricultural Products	21.9	27.3	34.1	47.0	71.1	132.5	131.8
- Sugar	9.2	9.9	16.1	21.9	49.6	115.6	111.0
- Beef	12.7	17.4	18.0	25.1	21.5	16.9	20.8
Manufactured Goods[1]	107.3	101.7	107.7	146.4	193.0	205.5	265.1
Total Value	297.1	286.9	335.8	441.6	582.2	640.9	794.3

[1]Includes miscellaneous processed agricultural products.

Source: World Bank.

spite of cyclical patterns in the volume of trade and continuing political uncertainty in the region, Guatemala's participation in the CACM has strengthened its economy, especially since Honduras and El Salvador lost market shares during their 1969 border war and subsequent mutual trade embargo.

Prospects for Development

The near-term prospects for economic growth in Guatemala are excellent. The country enjoys an unusually low level of foreign indebtedness, and holds the potential for significant export growth, particularly in the agricultural sector. Moreover, domestic energy supplies are increasing, and the government is implementing an ambitious, four-year, $7.1 billion private and public investment program.

Regarding foreign debt, Guatemala enters the 1980s in an enviable situation. According to World Bank estimates, Guatemala's debt-service ratio was only 1.9 percent in 1976, far lower than the average for Central America. The Bank projects that Guatemala's debt service ratio will peak in 1981 at about 7 percent, and decline thereafter.

In the agricultural sector, production and exports are likely to grow because additional land can be brought into production and because of potential for improved crop yields and increased labor productivity. Since Guatemala presently imports basic grains, import substitution can also improve the country's balance of payments.

Domestic energy supply projects also contribute to Guatemala's optimistic development outlook. The nation is developing the only commercially productive oil wells in Central America, and hopes to displace about one third of its current import levels by the mid 1980s. In addition, the government is pursuing a large hydroelectric project on the Chixoy River (Alta Verapaz District), which, upon its completion in 1982, will supply about 270 MW to the Guatemalan electrical grid. This will allow the Instituto Nacional de Electrificacion to retire almost all of its oil-fired generating capacity. Increased reliance on hydropower should be a real boost to the Guatemalan economy, thanks to the lower cost of hydroelectricity relative to electricity from imported oil.

The final ingredient in Guatemala's favorable development outlook is an aggressive four-year national development plan. The government is planning $1.9 billion in public sector investments between 1979 and 1982, with another $5.2 billion in private sector investment. Private investment will be stimulated, in part, through government incentives for the geographic decentralization of industry. Planned public sector investments are weighted toward energy (32 percent), housing (20 percent) and transportation (11 percent).

Considering low debt, significant agricultural potential, domestic energy growth, and strong investment, the MITRE/E/DI study team has assumed an average 6.7 percent a year growth in GNP in Guatemala over the period 1977 to 2000. This projection is consistent with World Bank estimates, and is within the range of projections used by the Economic Commission for Latin America (ECLA).*

2.2 Guatemala Energy Resources

Table 2-4 summarizes the energy resources of Guatemala. The estimates are discussed by resource in this section. Figure 2-1 shows the locations of major energy resources in Guatemala.

*ECLA, Economic Projections for Central America, 1979, Mexico, CEPAL, 1979.

TABLE 2-4

GUATEMALA

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential

Theoretical Capacity: 10,900 MW[1]

Installed Capacity: 101 MW[2] (26% of total installed capacity)

Geothermal

- Potential at Zunil site has been estimated in the range of 70 to 370 MW for 30 years. The electrical capacity scheduled at Zunil in 1985 is 55 MW.
- Another promising but untested field is located at the north side of Amatitlan with 1,800 MW potential.[3]

Oil Reserves

Proven: 10,300,000 barrels.[4]
Estimated: 20,000,000 barrels.[5]
Refining Capacity: 15,200 barrels/day.[5]

Gas Reserves

Proven: 240 million cubic meters.[5]

Coal

No deposits are known. Some lignite and peat layers have been found in southwestern Peten.

Wind

Southern coastal winds have a uniform diurnal pattern. Winds in the country are generally strongest in dry seasons, December through March.[6]

Solar

The average solar radiation is 0.21 to 0.35 kw/square meter.[7]

Biomass

Forests: There are 5.8 million hectares of forest and woodland.

Sugar: Some 77,000 hectares of sugarcane have been harvested in 1978.[8]

[1] Master Plan for Electricity Supply, Vol. 1, INDE.
[2] Informe Estadistico, 1977, INDE.
[3] Obiols, The Situation in the Energy Sector in Member Countries of the Central American Common Market, 1979.
[4] Actualidad Petrolera en Guatemala, enero a junio de 1979, no. 1.
[5] Petroleum and Energy Policy - Guatemala, Chapter 6: "Analysis."
[6] Personal communication with INSIVUMEH.
[7] Based on Huehuetenango and Escuintla five-year reports.
[8] FAO Production Yearbook, 1978, Vol. 32.

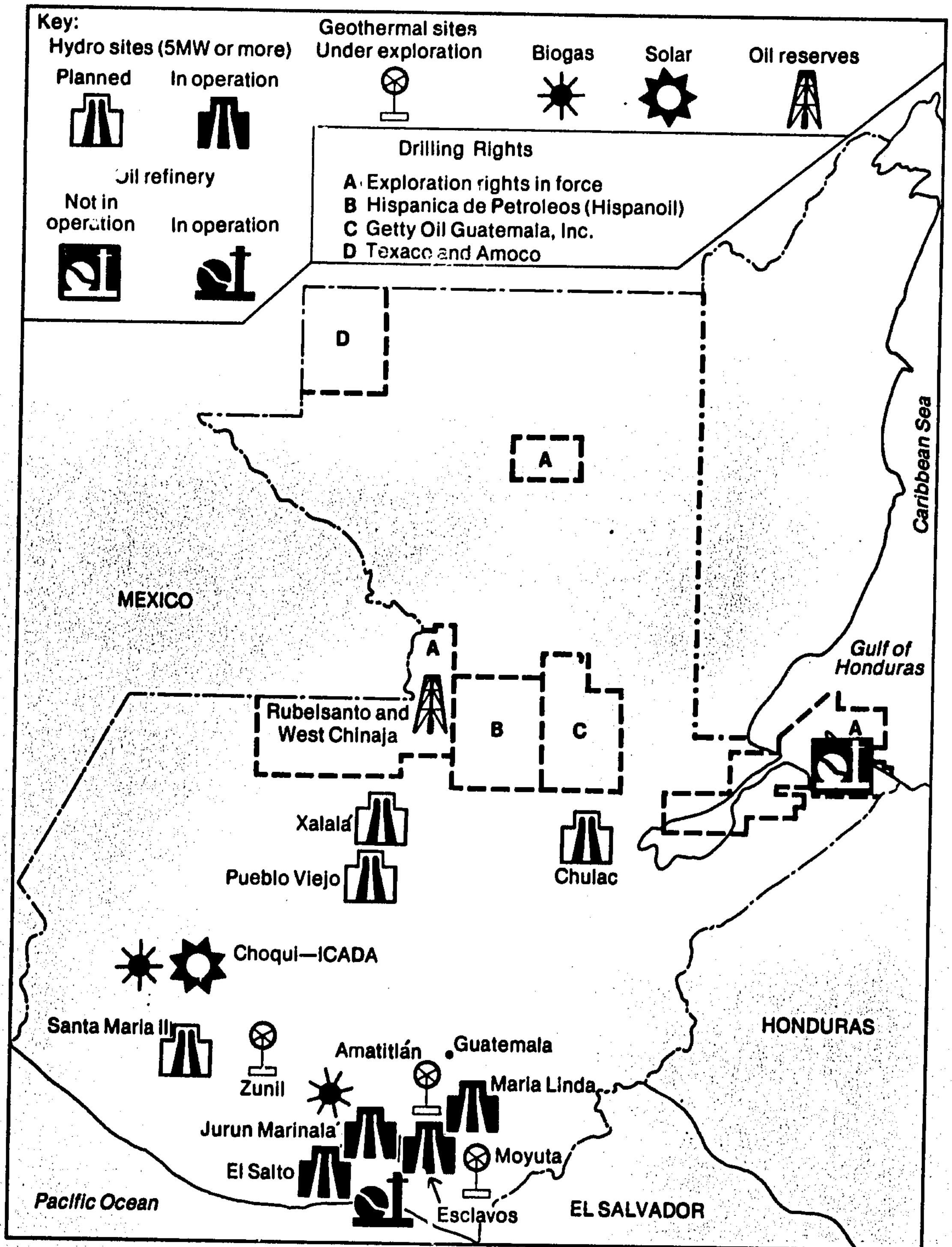


FIGURE 2-1
ENERGY RESOURCES OF GUATEMALA

Hydro

Through the efforts of the Instituto Nacional de Electrificacion (INDE), Guatemala is just beginning to tap its substantial hydroelectric resources. As of 1977, only 101 MW of hydro capacity had been installed. This compares to a total theoretical capacity of 10,900 MW, based on total water flow and the vertical drop of rivers in Guatemala with a potential of at least 10 MW.

Currently, 390 MW of hydroelectric capacity are being developed. Existing electric development plans indicate the installation of more than 3600 MW of hydroelectric capacity through the year 2000.

Geothermal

Geothermal investigations in Guatemala began at Moyuta, located 25 KM across the border from the successful geothermal project at Ahuachapan in El Salvador. Although shallow wells showed promising temperature gradients, deeper wells produced only moderate temperatures (less than 200°C). Geothermal interest shifted from Moyuta to an active thermal site to the northwest near the small village of Zunil. Exploratory drilling began at the Zunil site in March of 1977. The second well there yielded temperatures above 250°C at depths of 500 to 550 meters. Eleven shallow wells have now been drilled and preparations are under way for the drilling of three commercial-size wells (more than 1000 meters deep). INDE is planning to install a 55-MW steam generation facility at Zunil in the mid 1980s.

Another promising geothermal site is located at Amatitlan to the south of Guatemala City. This site is yet to be evaluated.

Oil

Guatemala is the only Central American country with known domestic petroleum reserves. Recent discoveries of crude in the Chinaja and Rubelsanto fields in Alta Verapaz are estimated at approximately 10.3 million barrels. Proven reserves now total approximately 20 million barrels.

The current production of 10,000 to 12,500 barrels/day is extracted from relatively shallow cretaceous plays. Jurassic strata at 17 to 20 thousand feet are the subject of current exploration activities. These strata represent geological extensions of oil-bearing strata in the Reforma Basin in Mexico. Up to 100 million barrels may lie in the Reforma Basin, northwest of Guatemala.

Guatemala has only one operating refinery with a capacity of 15,200 barrels/day. This refinery, run by Texas Petroleum Company, is located south of the town of Escuintla on the Pacific coastal plain.

Gas

Currently, only the Rubelsanto oil field is producing natural gas. The total amount of proven natural gas in this field is 240 cubic meters. The gas make-up is about one-third methane, one-third hydrogen-sulfide, and the remaining third, mostly propane and butane.

This gas is presently flared. However, plans are underway with a Guatemalan consortium, FABRIGAS, to extract and return dry methane gas to the Rubelsanto developer, Petromaya, to power turbines, and pumps. From the remaining "wet gas," FABRIGAS would extract LPG. They estimate an annual production of 3 million cubic feet of LPG from the Rubelsanto field.*

*Personal interview with Petromaya.

Coal

Guatemala contains no known high quality coal deposits. However, in southwestern Peten there are occasional lignite and peat layers. The quantities of these low grade fuels have not been estimated.

Wind

Fourteen meterological stations in Guatemala have measured wind and solar data for more than five years. This raw data has not yet been put into a readily usable format. For the country as a whole, winds are strongest at Lake Atitlan but only for a short period each day. Coastal winds along the Pacific have a consistent diurnal pattern: 12 km/hour offshore breezes in the morning and strong onshore breezes 25 to 20 km/hour from about 1:00 PM to midnight.* In general, winds in Guatemala are strong during the dry seasons--December through March.

Solar

Solar insolation measured over a period of five years at two sites, Huehuetenango and Escuintla, shows monthly averages ranging from about .21 to .35 kw/square meter. The University of San Carlos is restructuring available Guatemalan solar data.

Biomass

Although Guatemala has a significant highland deforestation problem, large forest reserves are found in the eastern and El Peten regions of the country. Recent estimates of total Guatemalan forest cover vary from 27.1 percent to 41.1 percent.**

---

*Personal interview with Claudio Urrutia, INSIVUMEH.
**Ismael Ponciano Gomez, Cubierta Arborea de Guatemala, 1978.

Sugar and coffee comprise a large portion of the Guatemalan cultivated biomass production. FAO estimates that 77,000 hectares of land were dedicated to sugarcane growth in 1978.

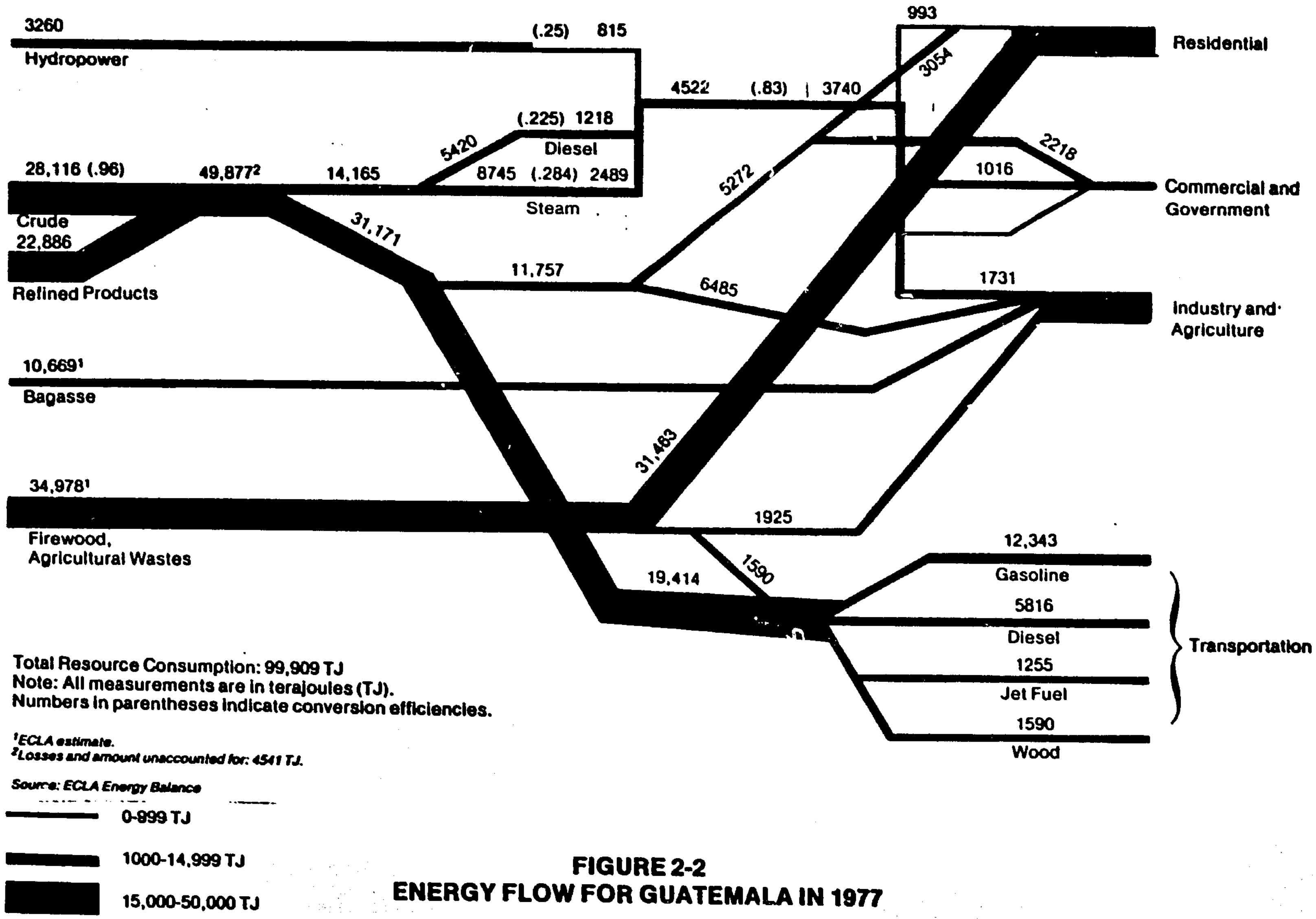
2.3 Current Energy Use in Guatemala

Energy resource consumption in Guatemala reached 99,909 terajoules in 1977. End-use consumption was divided among petroleum (51 percent), non-commercial energy (46 percent), and hydroelectricity (3 percent). Figure 2-2 depicts the flow of energy resources to all sectors of final demand. The resource inputs to electric generation are also indicated. The following sections describe the principal features of Guatemala's energy utilization, first covering the supply of energy (petroleum and electricity), and second covering major sectors of final demand: industry, transportation, and households.

Electric Sector

Guatemala has experienced rapid growth in electricity demand averaging 11.6 percent annually over the last fifteen years. This demand resulted from steady economic growth and the gradual integration of private industries. To meet this demand, the country's electric sector responded with a construction program of vast dimensions. The Instituto Nacional de Electrificacion (INDE), the government agency charged with primary responsibility for the country's electric sector, increased its installed capacity 655 percent over the period 1967 to 1977.

These herculean efforts, while meeting national demand, exacted a severe price penalty beginning in the early seventies. Newly installed capacity consisted almost exclusively of thermal equipment. Between late 1970 and early 1980, the Guatemalan electric sector failed to bring on-line a single significant non-thermal generating unit. Even as world petroleum prices began to escalate, hydro's



Total Resource Consumption: 99,909 TJ
Note: All measurements are in terajoules (TJ).
Numbers in parentheses indicate conversion efficiencies.

[1]*ECLA estimate.*
[2]*Losses and amount unaccounted for: 4541 TJ.*

Source: ECLA Energy Balance

FIGURE 2-2
ENERGY FLOW FOR GUATEMALA IN 1977

share of total installed capacity continued to decline, owing to the substantial lead time required to build hydro plants. By 1978, Guatemala's generating capacity was 85 percent thermal and 15 percent hydro. Aging, inefficient thermal plants supplied base load demand. Thus, the petroleum price increases of 1973-74 caught Guatemala badly unprepared, resulting in an accelerating petroleum import bill.

Besides INDE, there are three other categories of producers and distributors of electricity. The Empresa Electrica de Guatemala, S.A. (EEGSA) was the country's original and once foreign-owned utility. It is now 92.5-percent owned by the government. This utility forms, with INDE, the major part of the national grid. While INDE is primarily a producer of electricity (twenty-seven major plants--ten hydro and seventeen thermal--and a generating capacity of 267.3 MW), distributing mostly in peripheral areas of the country, EEGSA's major function is to distribute electricity to Guatemala City and Escuintla, the main demand centers. However, EEGSA still generates approximately 25 percent of its electricity from four thermal plants, and purchases the remainder from INDE. EEGSA will transfer at least one plant to INDE's control in the coming year, continuing its trend toward specialization in distribution.

Private and municipal utilities form a peripheral part of the national system, producing some of their own electricity but purchasing the major portions from INDE. These entities have an installed capacity of 76 MW, and produced 13.2 GWh of electricity in 1977. Of the installed capacity, the nickel ore processing plant, EXMIBAL, has a 57.6-MW steam generator and a 10.9-MW diesel generator. The remaining 7.5 MW is made up of small hydro or thermal plants of less than one MW capacity.

Table 2-5 summarizes Guatemala's electric utility capacity and generation for the period 1973 to 1977.

Private industries often produce electricity for their own needs. These entities, known as "autoproductores," account for a yet significant but diminishing share of national electricity production. (See Table 2-6.) As the national grid expands, a growing proportion of industrial consumers are linking up with it.

In 1977, petroleum inputs to electric generation by public and private utlities amounted to 22 million barrels of which 82,000 barrels were diesel and 1.32 million barrels were residual fuel oil. (See Table 2-7.)

Petroleum Sector

Guatemala is the only Central American country with proven and productive petroleum reserves. Since late 1978, approximately 1,500 barrels/day have been pumped from the Rubelsanto and West Chinaja fields in the department of Alta Verapaz, near the Peten region of Guatemala. Current estimates are that anywhere from 5 to 20 million barrels of recoverable oil exist in 15 or 20 separate structures.

Until November 1978, Petromaya, the company producing the oil, trucked the output to the highlands for consumption either by EEGSA (500 to 1,000 barrels/day at its 25-MW Amatitlan thermal plant) or by Cementos Progreso, a private cement producer (1,000 barrels/day). With the November 1979 inauguration of a processing plant and a 10"/12" pipeline to Puerto Barrios on the Caribbean coast, Petromaya initially schedules crude production increases to 10,000 barrels/day and within a short time to 12,500 barrels/day.

TABLE 2-5

GUATEMALA

ELECTRIC SECTOR DATA[1]

	1973	1975	1977	Growth Rate (%) 1974-1977
Total Installed Capacity (MW)	214	226	395	
Hydro	103	103	101	
Thermal	124	124	294[2]	
Maximum Demand (MW)	143	185	237	
Generation, Net (GWh)	542	947	1,197	
Hydro	294	289	233	
Thermal	248	658	964	
Sales, Total (GWh)	719	834	1,039	9.6
Residential	208	238	277	7.3
Industrial[3]	298	362	481	12.8
Commercial	111	123	165	10.5
Government/Public Lighting	102	114	115	3.0

[1]Data from INDE, EEGSA, and other public utilities unless otherwise indicated.

[2]Includes EXMIBAL Nickel Plant, which began operations in 1977 (estimates by Van Meurs and Assoc.).

[3]Includes agriculture and irrigation.

Source: INDE, EEGSA, Direccion General de Estadistica and Van Meurs and Assoc.

TABLE 2-6

GUATEMALA

AUTOPRODUCTORES, ELECTRIC CAPACITY AND GENERATION, 1975

	Total	Hydro	Diesel	Bagasse
Installed Capacity (MW)	100	18	64	18
Generation (GWh)	131			
Industry	22			
Agriculture	94			
Other	15			

Source: Van Meurs and Associates, Limited, Final Report: Petroleum and Energy Policy, 1978.

TABLE 2-7

GUATEMALA

PETROLEUM TO ELECTRIC GENERATION

(10^3 Barrels)

	1973	1975	1977
Diesel	341	515	882
Fuel Oil	913	1,083	1,319
Total	1,254	1,598	2,201

Source: INDE and EEGSA.

The destination of the new production is uncertain. Some oil will be exported, offsetting imports to the country's only operating refinery on the Pacific coast near Escuintla. Cementos Progreso, with the recent opening of a second kiln, will boost its consumption to approximately 2,000 barrels/day. The electric utilities may purchase additional quantities for their thermal plants, replacing imported supplies. An INDE official also mentioned plans to construct a large steam plant to run on domestic crude.

Debate exists, however, as to the optimum production of the current fields. One official interviewed suggested that some staff members within the Secretaria de Mineria e Hidrocarburos, the government agency charged with responsibility for the petroleum sector, have objected to Petromaya's planned level of production and are seeking to scale it back. Inasmuch as a standard formula for determining overproduction exists which can objectively determine the optimum level and which is included in the contract signed between the government and the concessionaire, parties should be able to reach an amicable agreement. However, the possibility remains that production may be scaled downward, and if that happens, plans for allocation of domestic production would be modified.

Current production provides less than half of Guatemala's 30,000 barrels/day petroleum requirements. The country's hopes for petroleum independence reside with exploration of the deeper (17 to 20 thousand feet) jurassic layer, a geological extension of the Mexican oil-producing Reforma Basin, 200 miles to the northwest. Substantial oil--up to 100 million barrels--may exist in this area.

By April 1980, Petromaya will have in place a heavy National 1320 rig capable of reaching the jurassic layer. However, drilling is a time-consuming process, and locating oil may take many dry wells and several years.

Three additional firms--Getty, Hispanoil, and Texaco--are drilling in shallow layers throughout the Peten.

High-sulphur natural gas accompanies the oil in the present fields. Petromaya holds a two-year permit to flare this gas. It recently initiated negotiations with a local consortium, FABRIGAS, to permit the Guatemalans to refine the gas, extract products and return methane to Petromaya to power its turbines and pumps while retaining and selling the remaining 50 percent (consisting of 60 percent LPG, 30 percent natural gasoline, and 10 percent sulphur). A rough estimate indicated that FABRIGAS might obtain three million cubic feet of LPG annually, nearly sufficient to meet present estimated domestic consumption.

Table 2-8 shows net petroleum imports and domestic production 1978. Approximately 25 percent of imports went to the generation of electricity and the remaining 75 percent was divided among transportation, industrial, agricultural, commercial, and residential uses.

Non-Commercial Energy

Estimates by the Economic Commission for Latin America (ECLA) indicate that fully 45.7 percent of Guatemala's 1977 energy production was derived from "non-commercial" fuels, primarily bagasse and firewood. Of 99,952 TJ of energy input, 34,978 came from wood and 10,669 from bagasse. However, the efficiency of final conversion of these fuels was on the order of five percent.

Guatemala's large and traditional rural Indian population, along with the urban poor, consumed a major portion of the country's fuelwood, primarily for residential purposes (31,463 TJ). Small industries, such as bakeries, limestone and brick kilns, also consumed a significant share. Increasing population combined with the

TABLE 2-8

GUATEMALA

PETROLEUM CONSUMPTION, 1978

(thousand barrels)[1]

	Imports	Domestic Production	Refinery Production	Exports	Consumption
Crude	5,829.4	220.7	-	-	222.5
Propane/Butane	467.3	-	51.3	60.0	457.6
Premium Gasoline	582.7	-	579.5	-	1,179.5
Regular Gasoline	728.6	-	649.3	-	1,379.4
Kerosine/Jet Fuel	162.6	-	564.6	-	730.9
Diesel	1,702.0	-	1,885.7	-	3,579.2
Fuel Oil	522.5	-	2,160.2	-	2,695.1
Other	356.4	-	-	-	386.7
Refinery Use	-	-	48.7	-	48.7
Losses	-	-	22.8	-	22.8
Total	10,381.5	220.7	5,958.5	60.0	10,702.3

[1]Numbers do not always add up due to rounding and changes in stock.

Source: Secretaria de Mineria e Hidrocarburos.

costliness of petroleum fuel substitutes has led to increased deforestation and the creation of a rural energy crisis of unknown proportions. One estimate concluded that the percentage of national forest cover decreased from 64.7 percent in 1950 to 41.1 percent in 1977, with no sign of abatement.* Others have put the forest cover even lower.**

Bagasse is used by the sugar-refining industry for heat and electricity generation. Low efficiency conversion due to the high moisture content and primitive technology means that the sugar industry, in spite of its large energy potential, is still a net importer of energy. Specific figures for this demand, however, were not available.

Residential Sector

The residential sector consumes the highest share of Guatemala's total energy, 36 percent. Most household energy use, 31,463 TJ, is fuelwood and, to a lesser extent, charcoal. Kerosene and LPG provide 3054 TJ, or 14 percent of total residential consumption. Use of electricity by households is low--277 GWh (993 TJ) or less than five percent in 1977. Of an estimated 1,180,000 households, approximately 260,000, or only 22 percent, were serviced by the national, municipal, and private electric utilities in 1978.*** This is due to the presence of a rural population encompassing 65 percent of the country's inhabitants, to the high cost of electricity, and to the lack of priority of rural electrification.

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*W.H. Mittack, Estudios para la Reforestation Nacional, 1977.

**Ismael Ponciano Gomez, Cubierta Arbarea de Guatemala, 1978; and T. Hederstrom, Informe Final Guatemala: Analysis de la Situacion Actual y Futura del Sector Forestal, 1977.

***Based on personal communication with INDE and EEGSA, and assuming an average 5.5 persons/household in a 1978 population of 6.5 million.

Industrial Sector

Industry consumed 20,810 TJ of electric energy in 1977 or 20 percent of total energy demand. Industrial consumption is concentrated in the highland area in and around Guatemala City; industry is the largest consumer of electricity, approximately 482 GWh (1731 TJ), or 46 percent of total electricity sales in 1977. Industry and the agricultural sector are also significant consumers of petroleum, bagasse, and fuel wood: petroleum products constituted 6485 TJ of energy for industrial use in 1977, bagasse 10,669 TJ, and fuelwood 1,925 TJ.

Transportation Sector

Transportation is the major consumer of petroleum products. ECLA estimated that 42 percent of total petroleum consumption, or 19,414 TJ, went to the transport sector in 1977.* This reflects the almost complete dependence of the country's transportation sector on road transport. An antiquated railroad connects Guatemala City with Puerto Barrios on the Caribbean coast. ECLA calculated that the steam engines of this railroad used 1590 TJ of fuelwood in 1977. Under the current National Development Plan, the railroad is undergoing a financial curtailment, eliminating unproductive spurs and streamlining administration.

2.4 Future Energy Use in Guatemala

2.4.1 Electric Sector Expansion Plans

Guatemala is seeking to reduce its dependence on thermal generation of electricity by developing hydro and geothermal generation. Fortunately, Guatemala has, among the Central American countries, one of the largest hydro potentials--10,900 MW, capable of producing

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*ECLA, Istmo Centroamericano: Estadisticas sobre Energia, 1977, CEPAL, June 1979.

43,300 GWh in an average year and 32,000 GWh in a dry year. Little of this rich potential is utilized, either on the populated and drier Pacific side, where 18 relatively short rivers drop steeply to the coast, or on the rainy, underpopulated, Caribbean side. INDE has launched a major hydroelectric plant construction program, expanding hydro capacity from 97 MW in 1977 to a proposed 2600 MW by the year 2000. The first stage consists of four large (90 to 440 MW) sites: Maria Linda (90 MW) and Santa Maria II, ready in the spring of 1980; Pueblo Viejo (300 MW), ready by early 1983; Chulac (440 MW), entering into generation in 1986; and Xalala (350 MW), in operation by 1989. With the completion of Pueblo Viejo, more than half of Guatemala's installed capacity will be hydro. During this stage, INDE planners envision the utilization of hydro for 100 percent of base load needs, leaving thermal capacity for daily peak loads and dry seasons.

Once the major sites have been exploited, planners anticipate the introduction of smaller hydroelectric plants in the period 1990 to 2000. However, barring the development of alternative energy resources, Guatemalan planners once again envision the construction of thermal plants in the latter half of the decade.

Geothermal development is uncertain. At one time, planners envisioned a 70 MW geothermal plant at Moyuta, near the Salvadoran border. When tested steam temperatures proved inadequate, INDE dropped Moyuta from the list of projects. However, encouraging results at Zunil have led INDE staff to predict that geothermal may provide at least 55 MW installed capacity by 1985. Should Zunil prove infeasible, standby plans exist for the construction of a thermal plant.

Under a UNDP grant, INDE is considering minihydro for isolated rural communities. These small sites would replace existing diesel generators in one region of the country.

2.4.2 Energy Growth Projections

Future energy requirements for Guatemala are calculated on the basis of an average yearly growth rate of GNP of 6.7 percent for the period of 1977 to 2000. Overall population growth is estimated at 2.87 percent per year, reaching more than 12.7 million inhabitants by the year 2000 or about one third of the total population in the region. The proportion of rural population in the year 2000 is estimated to be just under one half of total inhabitants, down from 69 percent in 1978.*

Electric Sector Projections

Electricity generation is projected to grow at 10.1 percent per year in Guatemala, based on a 6.7 percent growth in GNP and a ratio between electricity growth and GNP growth of 1.5, as used for other countries in this analysis. Applying this growth rate to the 1977 base, we obtain a total generation requirement of 11,178 GWh in the year 2000 (see Table 2-9). This is a nine-fold increase in electricity use for a 23-year period and appears to be extremely high. On a per-capita basis, however, the projected annual consumption would reach 839 KWh, the current per-capita level of Panama. The percentage of population with access to electricity is one of the lowest in the region because of the existence of large and relatively isolated Indian communities. A number of isolated communities will probably still be without electricity by the end of this century. Others may have obtained electricity from small thermal or hydro generators.

*CELADE, Centro Latinoamericano de Demografia, "America Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985 y 2000," Boletin Demografico, 1979.

TABLE 2-9

GUATEMALA

ELECTRICITY DEMAND PROJECTIONS

	1977	2000	Growth Rate (%) 1977-2000
Total Electricity Sales			
(GWh)	1,039	9,499	10.1
(TJ)	3,740	34,196	
Losses			
(GWh)	217	1,679	9.3
(TJ)	782	6,046	
Total Generation			
(GWh)	1,256	11,178	10.0
(TJ)	4,522	40,242	

Source: MITRE/E/DI.

The projection of 11,178 GWh is consistent with that of ECLA's interconnection study,* but it is significantly lower than the 16,000 GWh projected by INDE.

Petroleum Demand Projections

The demand for petroleum fuels by the final consumption sectors is escalated at a growth rate of 7.4 percent per year for Case I and 5.1 percent per year for Case II. These growth rates are obtained by applying the income and price elasticities discussed in Volume I to a GNP growth rate of 6.7 percent and a real price increase of petroleum averaging 5 percent per year over the projection period. Present consumption of 5.1 million barrels would grow to 26.3 million barrels in Case I and 16.0 million barrels in Case II. (See Table 2-10.)

Non-Commercial Fuel Projections

For projection purposes, non-commercial fuels are escalated at the rate of total population growth, estimated to be 2.87 percent per year. On the basis of the ECLA estimate of non-commercial energy use of 45,647 TJ, we obtain a yearly 2000 demand of 87,509 TD. This projection is viewed only as a benchmark; firewood in Guatemala is the source of fuel for the majority of population, and its availability has become a serious concern. A near doubling of the use of firewood may not be sustainable.

2.4.3 Future Energy Resource Consumption

In this section, we present a final balance of energy resource consumption for Guatemala in the year 2000. The resources required to produce the projected 11,178 GWh are summarized in Table 2-11. Hydroelectricity is projected to supply nearly two thirds of the

*ECLA, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, October 1979.

TABLE 2-10

GUATEMALA

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

		Year 2000	
	1977	Case I	Case II
Total Direct Uses	31,171	161,009	97,862
Industry and Agriculture	6,485	33,497	20,360
Transport	19,414	100,280	60,951
Residential and Commercial	5,272	27,232	16,551

Source: MITRE/E/DI.

TABLE 2-11

GUATEMALA

ELECTRICITY SUPPLY BALANCE, YEAR 2000

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use (TJ)
Hydro	1,491	6,785	24,426	97,704
Existing	101			
Planned	790			
New Sites	600			
Geothermal	245	1,395	5,022	20,088
Existing	0			
Development	245			
Thermal	694	3,000	10,800	43,200
Existing	294			
Expansion	400			
Total Generation		11,180		
Total Demand		11,178		

Source: MITRE/E/DI.

electricity; the existing 101 MW and the planned 790 MW would be supplemented by an additional 600 MW during the decade of the 1990s. Total hydro capacity in the year 2000 would be 1491 MW, or almost 15 percent of the country's theoretical hydro potential estimated for this resource. A development of 245 MW of geothermal energy is envisioned for Guatemala in this projection, assuming that appropriate sites are identified and prove to be cost effective alternatives to further hydro development. Thermal capacity is scheduled to more than double, from 294 MW to 694 MW; part of this production may be fueled with domestic crude. In the case of geothermal, the use of petroleum-based generating plants will have to be compared on a cost basis with increased hydro expansion.

A final summary of Guatemala's resource requirements for the year 2000 is shown in Table 2-12. Included for comparison are the present levels of use for each of the resources.

2.5 Energy Strategies for Guatemala

Substitution of Oil

MITRE/E/DI projections show Guatemala's annual petroleum requirements for electricity generation to be seven million barrels by the year 2000. However, several alternative fuel sources exist, including hydroelectricity, natural gas, and coal.

Hydroelectric generation appears to be the most readily available option. Current plans are for only 1,500 MW of an available 10,900 MW of hydroelectric potential to be exploited by the year 2000. A total substitution of hydro for petroleum would require about an additional 700 MW of installed capacity. High capital costs would be incurred with this alternative, however.

TABLE 2-12

GUATEMALA

TOTAL RESOURCE USE, YEAR 2000

(Terajoules)

	1977	Year 2000 Case I	Year 2000 Case II
Hydro	3,260	97,704	97,704
Geothermal	0	20,088	20,088
Petroleum	51,002	204,209	141,062
Direct Uses	31,171	161,009	97,862
Electric Generation	14,165	43,200	43,200
Losses and Unaccounted for	5,666		
Non-Commercial	45,647	87,509	87,509
Total Resources	99,909	409,510	346,343

Source: MITRE/E/DI.

A second option for electricity generation is the use of natural gas produced from domestic oil fields. At present, gas is used internally at the gas processing (liquids separation) plant, in reinjection processes or in flaring. No definite plans exist for expanded utilization once petroleum production increases. The possibility of piping gas to EXMIBAL has been discussed, and negotiations with a private firm for LPG production are in progress. Total substitution of gas for petroleum would require 32,000 to 43,000 TJ of natural gas per year.

A third alternative might be coal. While domestic resources, if any, are currently unknown, imported coal might become feasible. Coal's potential advantages over oil include price, greater abundance, and more suppliers.

Petroleum is used in both the industrial and transportation sectors. The extent of possible substitution of electricity for petroleum in industry has yet to be quantified. Detailed studies of the EXMIBAL nickel plant or the cement industry could establish a basis for replacing low-grade process heat with heat from electricity-based devices. The transport sector is projected to consume 100,280 TJ (Case I) in the year 2000, of which about 60 percent will correspond to gasoline, assuming a continuance of the current breakdown among diesel, gasoline, and jet fuel. Limited introduction of electric automobiles could displace some petroleum. More likely, however, is a substitution for gasoline by gasohol mixtures. A total substitution of gasoline with 15-percent alcohol gasohol would require about 9,000 TJ of alcohol. Dedicating 25 percent of current sugarcane land to alcohol would yield no more than 2000 TJ per year. The remainder could be methanol from wood. The MITRE/E/DI team calculated a potential yearly production of methanol of 48,400 TJ. Assuming 10 percent of this amount were available by the year 2000, a total 6,900 TJ of oil could be replaced by ethanol and methanol. Further substitutions could come about by means of methanol-diesel mixtures or conversion of methanol directly to gasoline or diesel oil. In a time horizon of two decades, such developments seem unlikely, but planning for future substitution should soon take place.

Conservation

The lack of a detailed data base precludes listing specific strategies dealing with an evaluation of conservation potential. However, general statements can be formulated. The effect of reducing oil demand in industry by 15 percent through conservation is a saving of 5020 TJ. In transportation, a 20-percent reduction in demand frees an additional 20,000 TJ (applied to Case I). Assuming that a 10-percent cutback in electricity can be achieved through conservation (i.e., replacing oil generation), 16,000 TJ can be saved.

Table 2-13 summarizes the contribution of oil substitution and of conservation measured as a percentage of total projected petroleum demand. For comparison, it also includes the potential contribution of alcohol fuels as a percentage of current gasoline use.

2.6 Recommendations to USAID for Guatemala Energy Programs

The recommendations in this section are intended as a refinement and in some cases as an expansion of the regional recommendations presented in Volume I. Where regional recommendations do not appear as national recommendations, then the regional recommendations still hold.

Energy policy making in Guatemala is divided primarily between three government offices: The Consejo Nacional de Planificacion Economica (CNPE), the Instituto Nacional de Electrificacion (INDE), and the Secretaria de Minerales, Hidrocarburos, y Energia Nuclear.

TABLE 2-13

GUATEMALA

IMPACT OF SELECTED STRATEGIES

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substituting 100% of petroleum Used in electric generation with natural gas, coal or hydro	21%	---
b. Production of 10% of ethanol potential[2]	0.04%	7%
c. Production of 25% of ethanol potential[2]	1%	17%
d. Production of 0.5% of methanol potential[3] (∿1 plant)	1.2%	20%
e. Production of 1.0% of methanol potential[3] (∿2 plants)	2.4%	39%
f. Substitution of electricity for petroleum-based processes, vehicles, vehicles	?	----
II. Conservation		
a. Conservation in industry (15%)	2.5%	----
b. Conservation in transportation (20%)	9.8%	----
c. Savings in electricity use (10%)	7.8%	----

[1]Using Case I petroleum demand as a basis.

[2]Percentage of current land devoted to sugar cane to be dedicated to energy production, or equivalent area added to cultivation.

[3]Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

Although Guatemala would benefit by having a policy-making body for coordinating national energy policies, its formation is clearly a Guatemalan political decision. The project team found that each of the three offices was well versed on energy. From our overview, USAID does not need to assist in staff development.

As applied to Guatemala, we concur strongly with the other regional recommendations presented in Volume I. Of these, the conservation recommendation is especially appropriate. The publicity program run by the Empresa Electrica for energy conservation in Guatemala is seen only as a temporary effort to weather the present high consumption of oil for electricity. We uncovered no government analysis or program on end-use conservation. We feel USAID could effectively support Guatemala's energy development with assistance in establishing a conservation office and program.

Fuel ethanol is a subject of current interest throughout Guatemala. There have been requests from the sugar industry itself for a broad economic assessment of the feasibility of sugarcane to fuel ethanol.* USAID could effectively integrate its regional efforts with Guatemala energy needs in sponsoring such a study.

Finally, USAID in Guatemala should support efforts in rural energy development. This support includes:

- the development of rural energy technology centers and education programs
- the strengthening of institutions capable of effective rural energy technology transfer, such as:

*James F. McSweeney, "Caña de Azucar: Solucion Energetica? O Projecto Utopico?" Gerencia, 1979.

- DIGESA
- Junta Nacional de Educacion Extraescolar
- Regional agricultural schools
- University extension programs.

- the support of national reforestation campaigns through

  - training of forestry professionals
  - establishing community wood supply and use programs

- integration of the U.S. Peace Corps into rural energy dissemination programs

- extension of rural electrification, both by grid extension and by non-petroleum driven electric generation systems for isolated areas.

APPENDIX 2-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

The following table lists national institutions that are active in energy research. It contains a short description of each institution's activities.

TABLE 2.A-1

ENERGY RESEARCH AND DEVELOPMENT

GUATEMALA

Technology/Resource	Institution	Product or Activity
ALCOHOL	Melazas de Escuintla, S. A.	Requested AID financing of fuel alcohol marketability study for Guatemala. Company is presently constructing alcohol distillery for non-fuel market.
	Instituto Centro Americano de Investigacion y Tecnologia Industrial (ICAITI)	Performed gasohol research.
BIOGAS	Instituto Centroamericano de Investigacion y Tecnologia Industrial (ICAITI)	Undertaking UNDP-funded pre-feasibility study.
	Centro de Experimentacion en Tecnologia Apropriada (CETA) Universidad San Carlos	Carried out experimental project to produce methane from human wastes in the village of San Pedro La Laguna. Has biogas plant near Lake Atitlan.
	Estacion Experimental Choqui	Built and demonstrated one biogas digester.
COAL		No activity.
GEOTHERMAL	Instituto Nacional de Electrificacion	Completed feasibility study for the Zunil geothermal field. Preliminary exploration being carried out in other areas, particularly Amatitlan.
MINIHYDRO		No activity.
PETROLEUM	Secretaria de Mineria e Hidrocarburos	Petromaya, a private consortium holding drilling rights, plans to drill near Mexican border in a continuation of Mexico's nearby oil-rich Reforma Basin structure, beginning mid-1980. Additional risk contracts have been signed by Getty, Texaco, and Hispanoil for nearby tracts in the El Peten region.

TABLE 2.A-1 (Continued)

ENERGY RESEARCH AND DEVELOPMENT

GUATEMALA

Technology/Resource	Institution	Product or Activity
SOLAR	Universidad de San Carlos	Has extensive solar research program. Includes solar water heaters, solar distillation, food driers, photovoltaic, collection of solar energy data.
	Estacion Experimental Choqui	Building and demonstrating small solar crop driers for farmers.
WIND	Universidad de San Carlos	Collecting wind-force data.
	Estacion Experimental Choqui	Building and demonstrating wind generators utilizing local materials (oil drums, wood) and teaching small farmers how to build and use them.
WOOD	Universidad de San Carlos	Experimenting with Lorena stoves.
	Instituto Nacional Forestal	Small-scale reforestation project.
	Instituto Centroamericano de Investigacion y Tecnologia Industrial	Researching more efficient use of fuel wood (ROCAP Project).
	Estacion Experimental Choqui	Designed and demonstrated Lorena stove, a sand mud stove utilizing significantly less fuel wood for cooking purposes. Small number of volunteer extension agents are showing small farmers how to construct these stoves.

APPENDIX 2-B

ENERGY-RELATED INSTITUTIONS

During the MITRE/E/DI visit to Guatemala, a number of institutions were contacted, including:

- government agencies
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in Guatemala; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audience
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION:	Centro Mesoamericano de Estudios sobre Tecnologia Apropiada (CEMAT)
CONTACT:	Rodolfo Castillo
LOCATION:	Guatemala, Guatemala
TELEPHONE:	8-65-12
DESCRIPTION OF INSTITUTION:	• Investigates affordable technology options for rural population • Uses available resources • Promotes dissemination of low cost technologies through workshops and conferences • Seeks simple, labor-intensive solutions to solve rural technology problems • Improves basic level of life
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Private organization conducting extension work in Guatemala • A contact for additional international agencies
PRODUCTS, SERVICES, CAPABILITIES:	• Investigation of nontraditional energy sources for rural areas including solar energy implements, biogas digestors, and Lorena stoves (mud stoves) • Development of low-cost building materials; improving health with traditional medicine, improvement of village nutrition by teaching communities how to cook plants that are easily grown, and nonformal education to increase working skills in the field

INSTITUTION: Consejo Nacional de Planificacion Economica

CONTACTS: Larry Andrade
Jose Juis Torron

LOCATION: Ministerio de Finanzas, Nivel 11
Centro Civico
Guatemala, Guatemala, C.A.

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- This office recently prepared the Four Year Development Plan setting out the Lucas Administration's objectives and long-range strategy for development. The program is based on "Rural Transformation," a concept encompassing all sectors of the economy, from agriculture to tourism.
- Science and Technology Education, Technical Assistance Branch, is located within this agency.

TARGET AUDIENCE:

- Coordinates planning by other governmental agencies in all fields.

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- A government entity created by Congress and made part of the President's Office.

PRODUCTS, SERVICES, CAPABILITIES:

- The Planning Department is interested in the promotion of appropriate energy-related technologies as an element of a total technological approach.

INSTITUTION: Choqui-ICADA (Appropriate Technology Experimental Station)

CONTACT: Hugo Pineda
Apartado Postal 15 9

LOCATION: Quezaltenango,
Guatemala

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Small nonprofit research development organization which operates on a local level

TARGET AUDIENCE:

- Rural poor of central highlands

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- It is legally incorporated.
- Some funds are received from the Canadian government, but most work is unremunerated.

PRODUCTS, SERVICES, CAPABILITIES:

- It is responsible for the development and commercialization of the Lorena Stove which improves cooking efficiency and decreases wood consumption. The stove is constructed out of local materials.
- The staff works with small wind units, biogas projects, solar energy implements, and low-cost building materials.
- Volunteers offer demonstration courses and work as extension agents among highland Indian farmers.

INSTITUTION:	Instituto Centroamericano de Investigacion y Tecnologia Industrial (ICAITI)
CONTACTS:	Francisco Aguirre
LOCATION:	Avenida Reforma 4-47 Zona 10 Apartado Postal 1552 Guatemala, Guatemala, C. A.
TELEPHONE:	310631/5
DESCRIPTION OF INSTITUTION:	

- Nonprofit regional organization which:
  - provides technical services to the region's industrial sector,
  - conducts appropriate technical research on products and processes which use raw materials and natural resources
  - performs market and feasibility studies
- Staff of 148 employees including 55 professionals covering fields of chemistry, engineering, biology, and geology
- Facilities which include an organic chemistry laboratory; an inorganic chemistry laboratory; a leather technology laboratory; a laboratory and pulp and paper pilot plant; a laboratory and textile pilot plant; a food technology laboratory; an industrial microbiology laboratory; a special analysis laboratory with spectrophotometers and gas chromascopes; and a reference center and research service
- NTIS representative for Central America

TARGET AUDIENCE:

Businesses, governments, universities, research organizations, investment institutions, and public associations

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- Founded in July, 1956, by the five Central American republics and managed by a Board of Directors composed of the five Central American Ministers of the Economy
- Established with director nominated by the Board of Directors
- Had as of August, 1979, 75 projects contracted for a total cost of $1.9 million
- Suffered financial losses, in 1978 and 1979, attributed to the fact that project-related revenues do not cover project costs. (For example, laboratory services and the Norms and Standards Division cost the institute $282,000 in 1978 and it cannot charge the projects.)
- Increased budget 65 percent between 1976 and 1979, while Central American government contributions have remained at the 1976 level

PRODUCTS, SERVICES, CAPABILITIES:

- Research activities include:
  - development of solar grain dryers
  - production of biogas from coffee and agricultural waste
  - gasohol research
  - standardization of solar data collection systems
  - minihydro development

- In cooperation with CATIE, ICAITI will work on the ROCAP program concerning fuelwood. Specifically, it will help national counterparts test fuel-efficient stoves for home use, wood efficient kilns and charcoal makers, coffee, or other agricultural dryers, as well as biogas and pyrolitic devices. Throughout the project period, ICAITI will collaborate with national and international counterpart organizations.

- Development of efficient process to extract and ferment sucrose from cane has been developed; excellent sugar consumptions and ethanol yields are obtained from the "Ex-Ferm process."

- Preparation of standards for products and industrial raw materials; analyses and certification on composition and quality of raw materials and industrial products; appraisals of equipment and other fixed assets, general studies and consultations on industrial sectors and their economic perspectives; special tests on raw materials; processes, and products; training on research methods; and geologic and mining studies.

INSTITUTION:	Instituto de Ciencias y Tecnologias Agricolas (ICTA)
CONTACT:	
LOCATION:	7 Av. y 12 Calle Zona 9 Plaza Espana 5° Piso Guatemala, Guatemala
TELEPHONE:	6-4950
DESCRIPTION OF INSTITUTION:	Under the aegis of the Ministry of Agriculture, this small, semi-autonomous agency undertakes research in agricultural technology, including development of seeds, fertilizer, and improved farming methods.
TARGET AUDIENCE:	Farmers
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	
PRODUCTS, SERVICES, CAPABILITIES:	

INSTITUTION:	Instituto Nacional de Electrificacion (INDE)
CONTACTS:	Luis Francisco Saenz, Vice President and Carlos Quintana, Carlos Mancilla, Raul Sanchez Pellecer, Engineers
LOCATION:	6a Ave. 2-73 Zona 4 Guatemala, Guatemala, C. A.
TELEPHONE:	315221/315240
DESCRIPTION OF INSTITUTION:	National electric utility
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	AID recently financed a rural electrification project at the cost of $8.6 million; the intent is to hook up approximately 70,000 low-income rural families in over 600 villages located in the western and central highlands, eastern and southern coast regions of Guatemala.
PRODUCTS, SERVICES, CAPABILITIES:	Major effort is underway to alter composition of electric sector; of 300 MW of installed capacity, a third is hydroelectric and two-thirds are thermal. By 1982, 90 percent of installed capacity will be hydroelectric due to construction of two plants: Aguacapa and Chixoy. • Planned facilities include a number of 350- to 400-MW dams and upgrading of Santas Marias facilities. • INDE will develop Zunil geothermal site.

- **INDE is interested in minihydro projects; studies are now being conducted on possible sites and resulting reports will be included in master plan**

INSTITUTION: Instituto Nacional de Forestacion (INAFOR)

CONTACT: Jorge Espana

LOCATION: Ave. 7-09, Lona 13
Finca la Aurora,
Gualemala, Guatemala, C.A.

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- This is the primary public forestry entity concerned with problems of deforestation and reforestation.
- It administers national laws on forest use and, together with an administratively separate national reforestation campaign, coordinates the nation-wide public and private reforestation efforts. INAFOR also maintains statistics on forest coverage and production, the latter by species.
- Approximately fifty Peace Corps volunteers work under INAFOR, primarily in the rural sector as reforestation staff.

TARGET AUDIENCE:

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

PRODUCTS, SERVICES, CAPABILITIES:

INSTITUTION:	Instituto Nacional de Sismologia, Vulcanologia, Meteorologia, e Hidrologia (INSIVUMEH)
CONTACTS:	Claudio Urrutia, Director
LOCATION:	15 Avenida 6-04 Zona 13 Guatemala, Guatemala, C. A.
TELEPHONE:	63362
DESCRIPTION OF INSTITUTION:	
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Publicly financed
PRODUCTS, SERVICES, CAPABILITIES	Operates forty monitoring stations in the country with data on solar, wind, geothermal, and hydroresources

INSTITUTION:	Junta Nacional de Educacion Extraescolar (JNEE)
CONTACTS:	
LOCATION:	13 Calle 4-08 Zone 11 Guatemala, Guatemala
TELEPHONE:	42946
DESCRIPTION OF INSTITUTION:	Semi-autonomous educational and community development organization
TARGET AUDIENCE:	Rural communities
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Supported by several entities including USAID and UNICEF • Run by a director appointed by a board of representatives from several ministries
PRODUCTS, SERVICES, CAPABILITIES:	• Employs 300 promotors who undertake educational programs responding to priorities identified by respective communities • Collaborates with government programs including Direccion General de Servico Agricola (DIGESA) and Instituto Nacional de Forestacion (INAFOR) • Constructs and demonstrates Lorena stoves in rural areas

INSTITUTION:	Oficiana Profesional de Ingenieria e Agronia (OPINA)
CONTACT:	Mario David Penagos
LOCATION:	
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Incorporated as a for-profit business entity
PRODUCTS, SERVICES, CAPABILITIES:	Designs and constructs biogas plants to produce methane

INSTITUTION: Secretaria de Mineria, Hidrocarburos, y Energia Nuclear

CONTACT: Lic. Jorge Luis Monzon

LOCATION: Guatemala, Guatemala

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Cabinet-level secretariat
- Regulator of domestic petroleum production

TARGET AUDIENCE: Other government agencies, Texaco refinery, petroleum and mining corporations, and universities

LEGAL AND FINANCIAL SETTING OF INSTITUTION: Government agency, responsible to the President and to Congress

PRODUCTS, SERVICES, CAPABILITIES:

- Regulates universal mining and petroleum rights concessions, including EXMIBAL
- Leases with the Texaco refinery
- Has theoretical responsibility for nuclear energy and related developments
- Has two representatives on the ad hoc national energy commission

INSTITUTION:	Secretariat for the Economic Integration of Central America (SIECA)
CONTACTS:	Rafael Perez Riera
LOCATION:	Apartado N° 1237 Guatemala, Guatemala, C.A.
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Primary role is as a policy-coordinating body of the Central American Common Market and as a force for regional integration and coordination of efforts in a multitude of fields, including energy. • Functions include insurance of the application of the General Treaty, interpretation of economic treaties, insurance of implementation of resolutions adopted by the Economic and Executive Councils, performance of functions, work, and studies assigned by the councils. • Energy-related efforts include updating of data, identification of problems, analysis of regional problems, and monitoring of national and regional energy efforts.
TARGET AUDIENCE	Governments, technicians, professionals, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Legal international entity, formed in 1960, to act as the permanent secretariat for Central American Economic Council (composed of Ministers of the five Central American republics) and the Executive Council (composed of a delegate from each country)

PRODUCTS, SERVICES, CAPABILITIES:

- As a regional administrative organization, SIECA coordinates its functions with the councils, ICAITI, International Monetary Council, the Central American Bank for Economic Integration (CABEI), other regional organizations, the United Nations, and the Economic Commission for Latin America (ECLA).

- SIECA conducts research in response to various integration efforts.

- It also serves as secretariat for COMENER, an energy policy body consisting of the subsecretaries of the Economic Ministries of CACM governments. During COMENER's first meeting, it was resolved to encourage the use of renewable energy resources (including biomass, geothermal, and hydro), assist with the transfer of energy-related technologies, encourage the rational use of petroleum in the transportation sector, discuss financial arrangements for the purchase of petroleum with Venezuela, etc.

- It participates in UNDP Regional Energy Program by serving as a conduit for information exchange and dialogue among members.

INSTITUTION: United Nations Development Program (UNDP)

CONTACTS: Carlos Alberto Avalos

LOCATION: Edificio El Triangulo, Nivel 15
Apartado 23-A
Guatemala, Guatemala, C. A.

TELEPHONE: 310811-62033

DESCRIPTION OF INSTITUTION: Channels international technical cooperation by providing five basic services:

- Surveys and evaluates assets as farm lands and forests; rivers and sub-surface waters; mineral deposits; fuel reserves; and manufacturing, commercial, tourism, and export potentials
- Stimulates capital investments
- Trains in a wide range of vocational and professional skills
- Helps countries select and apply technologies and strengthen technological capabilities
- Assists in economic and social planning, regional as well as national

TARGET AUDIENCE Governments, technicians, professionals, students, domestic service corps, general public

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- The UNDP Energy Development Program in Central America is substantially funded by a grant from the OPEC Special Fund whose total contribution is $1,500,000.

The total Central American contribution is $783,000 and the UNDP contribution is $509,000.

- Assistance is provided at the request of the developing country governments.

PRODUCTS, SERVICES, CAPABILITIES:

- Development of data base for energy balances to be used for training in collection, analysis and use of data
- Evaluation of petroleum information and laboratory experiments on hydrocarbons
- Development of geothermal resources (pilot projects and training seminars)
- Studies of electrical interconnections
- Research of nonconventional energy sources and prefeasibility studies for an alcohol distillery plant
- Development of three small hydroelectric pilot plants

INSTITUTION:	Universidad de San Carlos Centro de Investigaciones de Energia
CONTACTS:	Emilio Beltranena Matheu, Director, Centro de Investigaciones de Energia
LOCATION:	Ciudad Universitaria Zona 12 Guatemala, Guatemala, C.A.
TELEPHCNE:	460321-25, Ext. 353
DESCRIPTION OF INSTITUTION:	• The Energy Research Center, attached to the School of Engineering of the University of San Carlos, provides educational services which have been extended to three private universities, testing and analysis services for government agencies and private enterprise, and research projects. • The staff is comprised of 49 professional and technical members and 37 administrative and auxiliary members.
TARGET AUDIENCE:	Students, government agencies, general public, businesses, and researchers
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• The Engineering Research Center, to which the Energy Research Center belongs, was established in 1963. • The Center is financed by the government of Guatemala, the University of San Carlos, the Municipality of Guatemala, and private enterprise. • The Center's total budget for 1979 was $340,000.

- Management is carried out under the Director and the heads of the Administration and Laboratories. An Advisory Committee gives general guidance in relation to policies and development of the Center.

PRODUCTS, SERVICES, CAPABILITIES:

- Evaluates solar water heaters and solar distillation units, solar voltaic units, and solar food dryers
- Designs, constructs, and tests a biogas digestor
- Tests wood-burning stoves
- Develops solar and wind energy data for Guatemala
- Disseminates current information relative to research works and publishes undergraduate theses which normally involve research performed at the Center

Bibliography

American Embassy in Guatemala. Quarterly Economic Report: Guatemala. Guatemala, Guatemala: American Embassy, March 1978.

Banco de Guatemala. Boletin Estadistico. Guatemala, Guatemala: Banco de Guatemala, March 1979.

CELADE (Centro Latinamericano de Demografia). "America Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985, y 2000," Boletin Demografico, Ano XII, No. 23. Santiago, Chile: CELADE, January 1979.

CEPAL (Commission Economica para America Latina). Economic Survey of Latin America, 1978: Advance Summary. La Paz: United Nations, April 1979.

_____. Estudio Regional de Interconexion Electrica del Istmo Centroamericano, CEPAL/MEX/SRNET/28. Mexico: CEPAL, October 1979.

_____. Istmo Centroamericano: Estadisticas sobre Energia, 1977, E/CEPAL/CCE/SC.5/129. Mexico: CEPAL, June 1979.

Di Pippo, Ronald. Geothermal Power Plants of Mexico and Central America: A Technical Survey of Existing and Planned Installations, COO-4051-26; DOE Contract No. E Y-76-5-02-4051.A001. Providence, Rhode Island: Brown University Press, July 1978.

Dominiguez, Alfredo Mendez. Fuelwood Use and Attitudes in Guatemala, Salvador, Honduras, and Costa Rica. Guatemala, Guatemala: Regional Offices for Central American Programs (ROCAP), August 1979.

Escobar, Ismael and Mario E. Ibacache. Contribution to the Analysis of the Development of Unconventional Energy Sources in Latin America. Washington, D.C.: Inter-American Development Bank, April 1977.

FAO. "Explanatory Notes," 1978 FAO Production Yearbook, Vol. 32. Rome: FAO, 1978 (extracts).

Gomez, Ismael Ponciano. Cubierta Arborea de Guatemala (Primera Aproximacion). Guatemala, Guatemala: Universidad de San Carlos, January 1979.

Hederstrom, T. Informe Final--Guatemala: Analysis de la Situacion Actual y Futura del Sector Forestal, GUA/72/006. Guatemala, Guatemala: FAO, January 1977.

ICAITI, USAID, NAS. Report on the Central American Workshop on the Environment and Development; Antigua, Guatemala, July 25 to 30, 1971. TA/OST-AN-71-7-3. Washington, D.C.: USAID, 1971.

INDE (Instituto Nacional de Electrificacion). Plan de Electrificacion Rural, No. 2 (Per-2), Vol. 1. Guatemala, Guatemala: INDE, no date.

_____. Reporte Financiero y Estadistico 1971-1977. Guatemala, Guatemala: INDE, no date.

INSIVUMEH (Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia). Registros Climaticos. Guatemala, Guatemala: Ministerio de Comunicaciones y Obras Publicas, no date.

Obiols, Julio E. The Situation of the Energy Sector in the Member Countries of the Central American Common Market, SIECA/INFRA/79-14. Guatemala, Guatemala: SIECA, November 1979.

ROCAP (Regional Offices for Central American Programs). Fuelwood and Alternative Energy Sources, 596-0089. Washington, D.C.: USAID, August 1979.

Rolz, Carlos. A New Technology to Ferment Sugar Cane Directly: The Ex-Ferm Process. Guatemala, Guatemala: Central American Research Institute for Industry (ICAITI), no date.

SIECA, La Situacion Energetica en Centroamerica y Perspectivas para el Futuro. Guatemala, Guatemala: SIECA, August 1978.

UNDP. Requerimentos Futuros de Fuentes No Convencionales de Energia en America Latina. Quito, Ecuador: UNDP, June 1979.

Van Meurs and Associates Limited. Final Report: Petroleum and Energy Policy. Ottawa: Van Meurs and Associates, Ltd., June 1978.

World Bank. Economic Report. Washington, D.C.: The World Bank, no date.

3.0 EL SALVADOR

3.1 Geographic, Social, and Economic Aspects of El Salvador Energy Development

Geography

El Salvador lies on the Pacific coast of the isthmus of Central America, adjacent to the republics of Guatemala and Honduras. With a land area of only 20,850 square kilometers, it is the smallest mainland nation in the entire Western Hemisphere.

The Cordillera Central, a mountain range running northwest to southeast through all of Central America, divides El Salvador into three distinct geographic regions, differentiated largely in terms of climate.

A narrow, tropical, coastal area, extending the entire length of El Salvador, borders on the Pacific Ocean. The region is primarily agricultural. Fishing is also important near the port city of Acajutla.

The central highlands consist of a plateau about 2,000 feet above sea level which lies between the peaks of the Cordillera Central. This region is the heartland of El Salvador. It contains the best farmland and the concentrations of population, agriculture, and industry. The capital, San Salvador, and most of the cities in El Salvador are located in this area.

Formed by the Upper Valley of the Lempa River and a mountain range known as the Sierra Madre, the extreme northwestern corner of El Salvador forms a temperate but isolated area of the country. Once heavily forested, the "Cold Land" is today arid, semibarren and largely uninhabited, the result of extensive deforestation.

The population of El Salvador totaled about 4.3 million in mid-1978, and has been growing at the rate of over 3 percent a year since 1970. Given the nation's limited land resources, competition for arable land has been a growing problem since the late 1960s. The problem is aggravated by the disproportionate pattern of land ownership in El Salvador. As of 1971, 78 percent of all land in El Salvador was owned by 10 percent of the population. In 1978 the population density in El Salvador averaged 321 persons per square kilometer of arable land. That density is far higher than its neighbors'.

The continuing pressures of population have manifested themselves in (1) the migration of landless farmers to the cities (as of 1970, the population was estimated to be 40 percent urban), and (2) migrations into the Honduran highlands, where Salvadorans rent land or settle illegally as squatters. In 1969, these latter migrations contributed to the eruption of a border war between Honduras and El Salvador. Relations between these countries remain fractious, and are a continuous impediment to trade in the Central American Common Market and to other forms of regional cooperation.

Economy

The Salvadoran Gross Domestic Product (GDP) totaled about $3.073 billion in 1978, or about $714 per capita. Table 3-1 describes the sectoral composition of GDP. The most important sectors are agriculture, manufacturing, and commerce, which together accounted for 67.5 percent of GDP in 1978.

The agricultural sector dominates the economy, contributing about 28.5 percent of GDP, and about two thirds of export earnings. Coffee is by far the most important export product, accounting for 48 percent of export earnings in 1978 ($448 million of $935 million

TABLE 3-1

EL SALVADOR

GROSS DOMESTIC PRODUCT BY SECTOR, 1969-1978

(millions of current colones)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
GROSS DOMESTIC PRODUCT (at market prices)	2,571.4	2,703.8	2,882.1	3,331.5	3,943.8	4,477.7	5,676.1	7,103.6	7,683.0
Agriculture	731.2	729.0	728.1	922.4	999.0	1,028.2	1,616.6	2,364.3	2,191.0
Mining	4.2	4.3	4.4	5.6	7.3	7.4	7.8	8.2	8.0
Manufacturing	484.7	519.2	562.6	610.5	706.6	831.3	923.6	1,035.0	1,178.0
Construction	72.4	80.1	102.1	104.0	146.4	219.4	216.3	288.6	370.0
Public Utilities	38.9	40.3	43.1	48.5	54.3	56.6	63.3	74.4	90.0
Transport and Communications	128.3	131.6	139.6	146.4	173.4	189.6	211.1	240.8	289.0
Commerce	543.6	587.0	644.0	741.9	964.9	1,112.1	1,414.9	1,633.9	1,846.0
Banking, Insurance, etc.	57.5	62.1	65.5	85.1	103.9	128.2	156.9	234.4	269.0
Housing	94.9	100.3	107.0	118.0	142.2	171.9	192.2	213.3	259.0
Public Administration and Defense	200.2	219.0	238.6	278.6	338.1	383.8	485.7	580.1	693.0
Personal Services	215.5	230.9	247.1	270.5	307.7	351.2	387.7	430.6	490.0

Source: World Bank.

total). Other significant export commodities in 1978 included cotton ($92.3 million), sugar ($23.4 million), and shrimp ($15 million).

The manufacturing sector accounts for about 15 percent of GDP (1978) and employs about 10 percent of the occupied labor force. As indicated in Table 3-2, manufacturing activities are weighted toward food processing (28 percent), beverages (11 percent), textiles (10 percent), clothing and footwear (9 percent) and chemical products (9 percent). Together, these subsectors account for about 67 percent of the value added in manufacturing.

The commercial sector accounts for 24 percent of GDP, and is oriented primarily toward food and beverages. A survey of retail operations conducted in 1966 revealed that nearly two thirds of the 5,882 retail businesses registered with the government were selling food stuffs or alcoholic beverages. Of the remaining one quarter, most dealt in specialty goods such as drugs, hardware, furniture, or gasoline. It should be noted that a great deal of commercial enterprise conducted at provincial marketplaces by farmers, street vendors, and booth operators is not accounted for in official statistics.

Balance of Payments

El Salvador's post-1973 balance of payments performance reflects the effects of rapidly increasing oil prices and large fluctuations in the world coffee market.

Table 3-3 indicates El Salvador's balance of payments during the period 1970 to 1978. El Salvador's import/export trade deteriorated rapidly in the years from 1973 to 1975. During 1976 and 1977, however, the value of Salvadoran exports rebounded strongly--until trade was again in virtual equilibrium. The reason for this dramatic turnaround is that world coffee prices rose sharply during 1976 and 1977

TABLE 3-2

EL SALVADOR

GROSS VALUE ADDED IN MANUFACTURING, 1970-1978

(millions of current colones)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Food Processing	139.0	146.4	159.7	169.7	186.2	257.5	286.0	314.1	333.7
Beverages	50.3	57.7	61.6	65.4	80.2	96.1	106.8	119.3	123.7
Tobacco	16.7	18.9	20.6	22.9	26.9	31.0	34.4	38.5	45.7
Textiles	63.6	67.9	72.7	76.8	87.7	83.2	92.4	102.0	120.2
Clothing and Footwear	51.3	48.9	61.6	68.1	62.1	72.3	80.3	93.7	107.9
Wood Products	2.0	2.4	3.2	4.6	5.4	6.3	6.9	7.8	8.5
Furniture	10.5	8.4	7.9	8.6	11.3	12.9	14.3	16.2	19.6
Paper and Paper Goods	7.5	6.6	7.0	9.0	10.3	12.0	13.3	15.1	20.0
Printing Materials	8.0	9.4	9.2	10.7	13.7	13.4	15.0	18.0	22.7
Leather Products	3.8	4.2	4.5	4.8	6.3	9.3	10.3	11.7	13.8
Rubber Products	3.3	3.5	3.4	3.7	4.8	5.1	5.6	6.5	11.0
Chemical Products	37.2	42.9	46.5	51.1	60.5	69.9	77.7	87.8	104.6
Petroleum Products	20.2	25.0	28.7	30.7	43.9	44.7	49.7	55.8	64.8
Non-Metallic Products	16.6	20.4	23.5	26.4	31.5	34.6	38.4	43.3	53.0
Basic Metal Industries	4.5	4.6	8.0	8.4	11.0	13.3	14.8	18.0	20.0
Metal Products	6.9	7.4	7.7	8.3	9.5	10.2	11.4	12.8	17.0
Machinery, excluding electrical	4.9	5.3	5.2	5.4	6.5	7.7	8.6	10.4	16.1
Electrical Machinery	14.1	14.9	16.7	18.4	20.3	22.6	25.1	28.1	29.1
Transportation and Equipment	7.2	7.5	8.3	9.1	10.4	8.7	9.7	10.1	10.6
Others	17.1	16.9	16.6	18.3	18.3	20.6	22.9	25.8	36.0
Total	484.7	519.2	562.6	610.4	706.8	831.4	923.6	1,035.0	1,178.0

Source: World Bank.

TABLE 3-3

EL SALVADOR

BALANCE OF PAYMENTS, 1970-1978

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Exports (goods and n.f.s.)	257.0	267.5	336.7	401.1	513.4	594.1	821.1	1,050.2	934.7
Imports (goods and n.f.s.)	253.8	287.6	324.0	438.6	646.0	685.3	843.4	1,053.6	1,190.7
Resource Balance	3.2	-20.1	12.7	-37.5	-132.6	-91.2	-22.3	-3.4	-256.0
Net Factor Services and Transfers	5.5	7.2	1.4	-0.7	-2.8	-1.6	15.7	12.9	17.1
Current Account Balance	8.7	-12.9	14.1	-38.2	-135.4	-92.8	-6.6	9.5	-238.9
Change in Reserves	-15.0	3.1	-18.6	11.7	-12.4	-31.3	-84.0	-40.9	-28.6
Gross International Reserves[1]	..	64.9	82.4	61.8	98.4	126.9	205.2	232.5	290.9

[1] Gross international reserves data were taken from International Financial Statistics, International Monetary Fund (IMF), December 1978 and April 1979. The IMF figures may not total exactly from the World Bank data as the IMF provides gross international reserves while the World Bank provides change in net international reserves.

.. Not available.

Source: World Bank and International Monetary Fund.

after frost destroyed a large portion of Brazil's coffee trees in 1975. As Brazilian coffee production came back on stream in 1977 and 1978, coffee prices began to fall, prompting the Salvadoran government to hold coffee off the market in anticipation of higher prices. Coffee sales were resumed in September 1978, but the trade deficit for 1978 was almost $240 million--by far the largest deficit since 1969.

Prospects for Development

Near-term growth prospects for El Salvador depend heavily on political events. Recent civil strife and changes of government have resulted in an atmosphere of uncertainty for business investment. An optimistic projection of economic growth in El Salvador, such as the one presented here, is predicated on a quick resolution of political problems and the return of a favorable climate for continued investment and growth. Should political developments continue to disrupt economic activities, these projections must be adjusted accordingly.

Coffee export prices will also be a significant determinant of the economy's performance for the next few years. The current relatively low prices will be only partially offset by expected increases in production over the next few years.

High energy prices will also slow El Salvador's economic growth. However, current efforts in geothermal and hydro development have put the country in a relatively better position, at least for the short term, than its regional neighbors. In 1979, electricity generation required almost no petroleum.

Population growth is (3 percent per annum) and will remain for some time the largest problem faced in El Salvador. Family planning programs are now starting to become available to large portions of the population, and should help slow down population growth in the future.

The encouragement of manufactured exports to close deficits in the balance of trade and to help reduce excessive dependence on coffee sales will prove a stimulus in the future.

Assuming progress in the areas outlined above, prospects are good for long-term growth.

3.2 El Salvador Energy Resources

Table 3-4 summarizes the energy resources of El Salvador as of 1979. Each of the resource estimates is discussed below. The map in Figure 3-1 describes the location of major energy sites in El Salvador.

Hydro

El Salvador has three principal hydroelectric plants along the Rio Lempa, which winds across the northern tier of the country and then South into the Pacific. Installed generation capacity is 232 MW, but with the construction of the San Lorenzo dam (expected to be completed in 1982), capacity will increase by 180 MW. Petroleum imports to meet electrical needs are insignificant. Although three additional hydro sites are being analyzed (Paso del Oso, Zapotillo, and El Tigre), the total potential hydroelectric resource in El Salvador is estimated to be no more than 1351 MW, the lowest in the region.

Geothermal

The Ahuachapan geothermal field has an installed capacity of 60 MW and has already made a major contribution to El Salvador's power network since its completion in 1976. The Berlin, Santiago de Maria,

TABLE 3-4

EL SALVADOR

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential

Theoretical Capacity: 1,351 MW[1]

Installed Capacity: 232 MW[1] (55% of total installed capacity)

Geothermal

Sixty MW of geothermal capacity have been installed at Ahuachapan. The potential is estimated to be 720 MW.[3]

Oil Reserves

Proven: None.

Estimated: Unknown.

Refining Capacity: Acajutla, 16,000 barrels/day.[4]

Gas Reserves

Proven: None.

Coal

No known reserves exist.

Wind

Wind velocity of 90 km/hr to 108 km/hr could possibly generate 200 MW of electricity per year.

Solar

Average solar radiation is 0.23 kw/m^2; estimated solar potential is 6,000 GWH per year.[1]

Biomass

Forests: There are 263,000 hectares of forest and woodlands.

Sugar: Some 41,000 hectares of sugarcane were harvested in 1978.[5]

[1] Chiquillo Alas, Alberto, Recursos Naturales Propios de Generacion Electrica en El Salvador--Pasado, Presente y Futuro.
[2] Comision Ejecutiva Hidroelectrica del Rio Lempa, Informe Anual 1978.
[3] Obiols, The Situation in the Energy Sector in Member Countries of the Central American Common Market, 1979.
[4] SIECA, La Situacion Energetica en Centroamerica y Perspectivas para el Futuro.
[5] FAO Production Yearbook, 1978, Vol. 32.

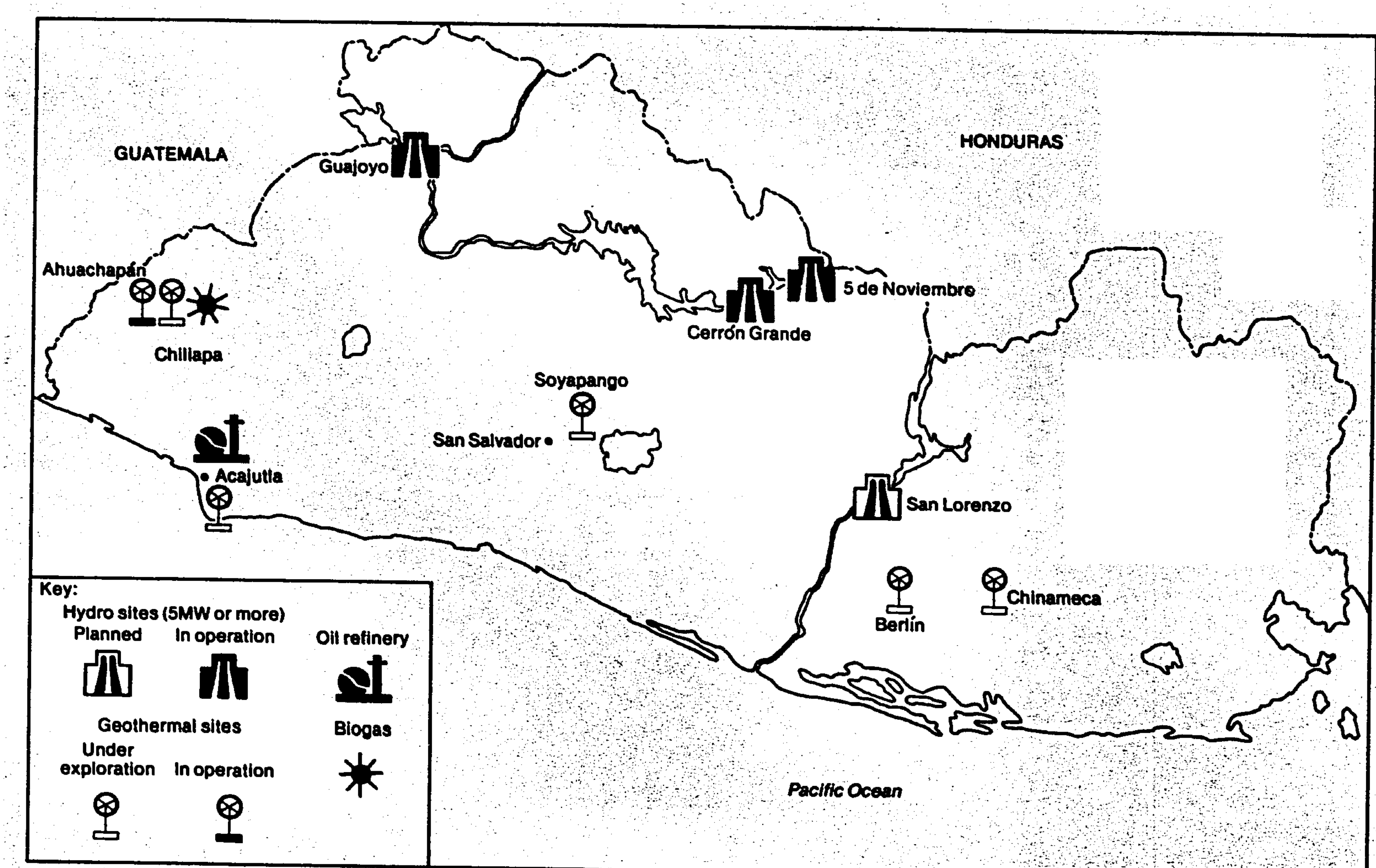


FIGURE 3-1
ENERGY RESOURCES OF EL SALVADOR

and Zona de San Vincente fields are being analyzed for quality and cost. Potential geothermal resources are estimated to be 450 MW with an estimated energy output of 3,200 GWh. The Rio Lempa Hydroelectric Executive Commission (CEL) is providing technical assistance to several governments in Central America on the technologies and techniques of commercially producing geothermal energy.

At the Ahuachapan site, experimentation on the disposal of condensed steam from the turbines is being conducted. Successful reinjection processes have been initiated. Thus far, no precipitation of minerals has occurred in the substrata which could interfere with the rocks' permeability and ability to provide steam. This fact appears to be explained by the relatively high temperature of waste waters (95°C).

<u>Oil</u>

No petroleum exploration exists at present. In December, 1979, CEL requested Venezuela's assistance in designing the legal structure to permit the government to solicit bids for drilling on the Pacific continental shelf.

<u>Coal</u>

There are no known reserves nor any current exploration.

<u>Wind</u>

The Meteorological Institute of El Salvador has been traditionally oriented to serve the agricultural sector, but during the last two years wind velocities have been measured in regard to energy use. In certain zones, velocities reach 90 to 108 km per hour during the period of November through March. Further analysis is necessary to determine whether wind could serve as an energy resource.

Solar

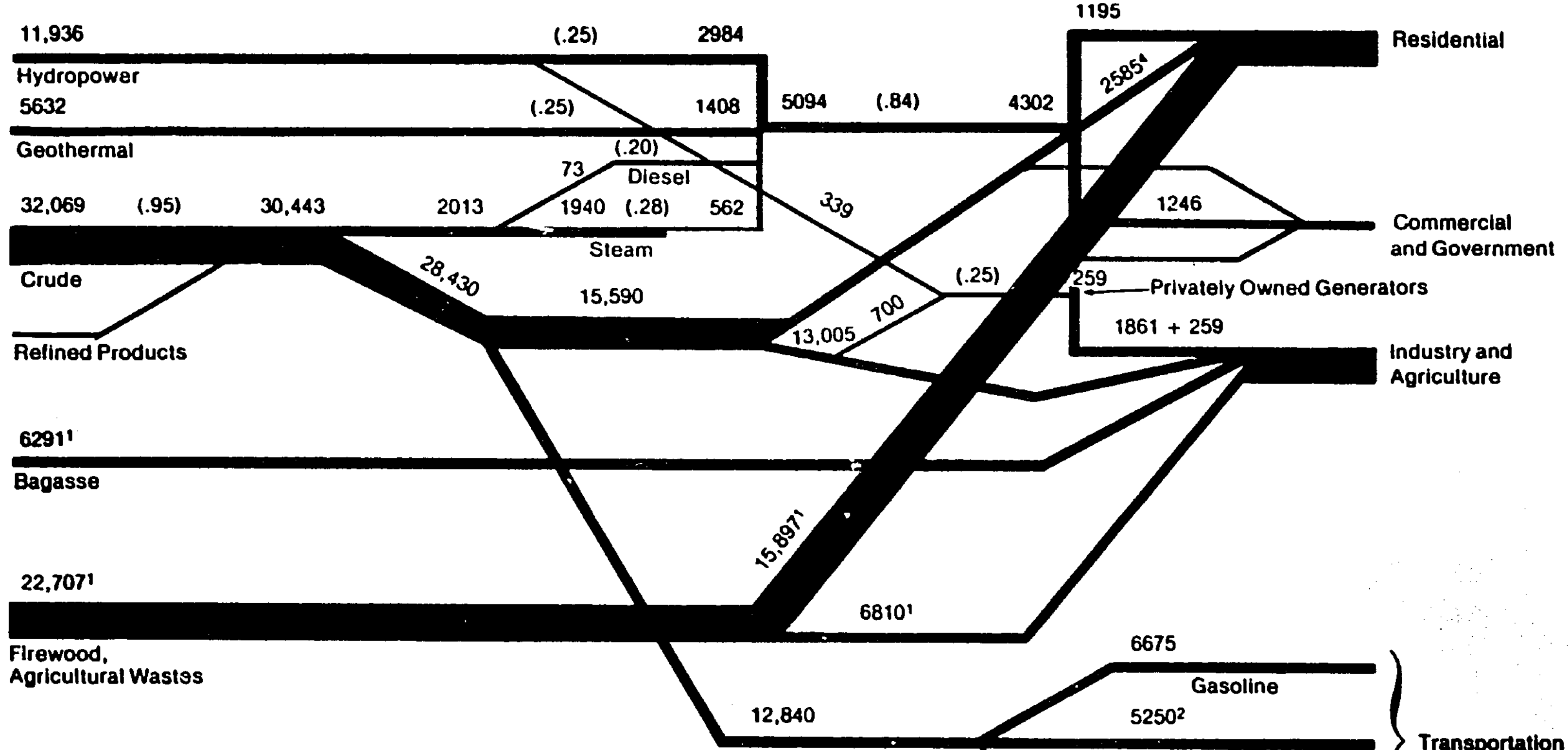
After hydro and geothermal resources, solar energy is considered the most significant source of energy in El Salvador. Average daily solar radiation is measured at 0.23 kW/m^2. CEL has speculated on the use of the central power tower system and photovoltaic cells for commercial electric generation purposes; preliminary analyses have been performed, and 5400 GWh is the estimated energy output of these alternatives.

Biomass

Fuels from biomass production, principally coffee pulp, are under investigation to determine a more consistent framework of price, incentive, technology, and potential. CEL is investigating the use of water hyacynths and other biomass resources for the generation of biogas in commercial quantities which could ultimately displace existing or potential electricity demand in the rural residential sector.

3.3 Current Energy Use in El Salvador

Energy resource consumption in El Salvador amounted to 73,662 TJ in 1977 and 78,635 TJ in 1978. Petroleum resource consumption decreased its share of the total from 45 to 41 percent between 1977 and 1978, while hydroelectricity and geothermal consumption increased from 17 percent to 20 percent. The share of noncommercial energy remained stable at 38 to 39 percent. Figure 3-2 depicts the flow of energy resources to all sectors of final demand for 1978. The resource inputs to electric generation are also indicated. The sections that follow describe the principal features of El Salvador's energy utilization, in particular the petroleum and electricity supply sectors. Because of the limited time spent in the country, essentially no information was collected on energy use patterns in the final demand sectors.



Total Resource Consumption: 78,635 TJ.
Note: All measurements are in terajoules (TJ).
Numbers in parentheses indicate conversion efficiencies.

[1]ECLA estimate.
[2]Derived from the ECLA breakdown between diesel used in transport and other sectors.
[3]Derived from ECLA breakdown of kerosene used in transport and other sectors.
[4]LPG and kerosene used in households, ECLA breakdown.

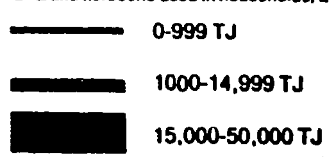


FIGURE 3-2
ENERGY FLOW FOR EL SALVADOR IN 1978

Electric Sector

El Salvador's electric generation system is the only one in Central America making use of geothermal energy. In fact, its 60 MW Ahuachapan field represents 14 percent of total installed capacity and in the first six months of 1979 geothermal electricity accounted for 31 percent of total generation in the country, the highest such proportion in the world today. This field, in operation since 1975, together with a 135-MW hydro project, introduced in 1977, have reduced petroleum consumption for electric generation to minimal amounts in 1979 from a peak of about 7000 TJ (about one million barrels) in 1975. As recently as 1978, oil-fired generation accounted for 29 percent of the total and utilized 1940 TJ (12.3 million gallons) of bunker fuel and 73 TJ (0.5 million gallons) of diesel.

Table 3-5 presents electric sector data for 1978 for El Salvador. The electric sector is unique in that about 30 percent of installed capacity is idle, but is reserved for peak demands; these thermal plants will likely remain as support systems despite demand growth rates of nearly 10 percent (projected by CEL) because of a 180 MW hydro plant coming on line in 1982 and a 35-MW expansion in geothermal capacity soon after.

Electricity sales amounted to 1195 GWh (4302 TJ) in 1978, and have been growing at 11.6 percent for the period 1973 to 1978. Of total sales, 43 percent goes to industry, 28 percent to households, and the rest to commercial establishments, government, and public lighting. An additional 72 GWh is generated within industry ("autoproductores"), an amount equivalent to 14 percent of public utility sales to industry. As shown in Table 3-6, installed capacity of autoproductores is 30 MW, less than 7 percent of total capacity in the country.

TABLE 3-5

EL SALVADOR

ELECTRIC SECTOR DATA, 1978

		Growth Rate (Where Available) 1973-1978
Installed Capacity (MW)[1]	420	
Hydro	232	
Geothermal	60	
Steam, Oil Fired	63	
Gas Turbines, Oil Fired	65	
Maximum Demand (MW)	265[2]	
Generation (GWh)[3]	1,376	11%
Hydro	829	
Geothermal	391	
Thermal, Oil Fired	156	
Generation, Other Utilites (GWh)	39	
Total Sales[4]	1,195	
Residential	332	12.5[6]
Commercial[5]	346	10.1
Industry	517	12.0

[1] Represents the Comision Ejecutiva Hidroelectrica del Rio Lempa (CEL) only, El Salvador's state-owned utility.

[2] 1979 datum.

[3] CEL data. In the first six months of 1979, hydroelectricity contributed 69.4% of generation, geothermal 30.5%, and petroleum 0.1%. The 0.9 GWh generated from petroleum are limited to meeting peak demands.

[4] All utilities.

[5] Includes Government, municipalities, and public lighting.

[6] Growth rates for electric sales are for the period of 1977-1978.

Source: Comision Ejecutiva Hidroelectrica del Rio Lempa, Boletin Estadistico, No. 9, Junio de 1979.

TABLE 3-6

EL SALVADOR

AUTOPRODUCTORES, ELECTRIC CAPACITY AND GENERATION

Installed Capacity (MW)	
Hydro	12.0
Thermal (Steam)	18.3
Total	30.3
Generation (GWh)	72.2

Source: Comision Ejecutiva del Rio Lempa.

Petroleum Sector

El Salvador currently meets the internal demand for petroleum products with the output of its refinery. In recent years, a part of the domestic consumption of residual oil was imported directly, but with the current electric generation system independent of oil, the refinery output of residual is sufficient to meet internal demand.

Table 3-7 shows the breakdown of petroleum fuel use in El Salvador in 1978. Total domestic consumption amounted to 30,443 TJ of which 28,430 TJ were utilized by the final demand sectors. In 1978, electric generation still required 2,013 TJ. Gasoline comprised 23 percent of the total direct uses and diesel 36 percent. Residual oil, assignable to industry, amounted to 7,927 TJ, or 28 percent of total use. This amount is the difference of the total output of the residual from the refinery and the use by the electric utility. Residual fuel uses are limited to industries, such as cement, and self-generation of electricity.

Sectoral Consumption: The industrial sector in El Salvador is relatively energy-intensive, consuming 50 percent more energy than in Nicaragua or Costa Rica. A textile industry produces cotton yarn and cotton woven fabrics (Nicaragua is the only other Central American country with such an industry), and a chemical plant produces fertilizer in amounts only second to Guatemala. Cement production is 330 million tons (1977 figure), close to the median in Central America. The food and beverage industries are also relatively large, reflecting the second largest population in the region. On the other hand, consumption of fuel for transportation is relatively small, and quite low on a per-capita basis. This is related to El Salvador's small area. The use of diesel, for example, which is estimated to be only 5250 TJ (about 800,000 barrels), is probably explained by the shorter distances for freight from farms to cities and the main port. El Salvador also has a well developed railroad system.

TABLE 3-7

EL SALVADOR

PETROLEUM CONSUMPTION, 1978[1]

	Refinery Output		Yearly Growth Rate
	10^3 bbls	TJ	1973-1978
Gasoline	1,204.9	6,675	5.6%
Kerosene/Jet Fuel[2]	382.6	2,288	0%
Diesel	1,682.2	10,337	7.7%
Residual	1,499.3	9,940	0.8%[3]
LPG	284.4	1,203	4.5%
Crude Oil[4]			
Total	5,053.4	30,443	

[1]Direct imports of petroleum products were limited in 1976 and 1977 to residual oil (ECLA statistics). For 1978, these residual imports were presumably not necessary because CEL's requirements dropped by about 350,000 barrels, which is roughly the amount imported in 1977.

[2]Jet fuel is 40 percent of this amount (from ECLA's energy balance for 1977).

[3]The 1973-1976 growth rate was 4.5 percent per year; the reduction in requirements of residual oil by the utility will reduce consumption in 1979 to pre-1973 levels.

[4]In 1978, 5,472,000 barrels were imported and 5,240,000 barrels were processed.

Source: CEL Proyecto Balance de Energia, Analysis Preliminar de las Energias Primarias y Secundarias Comerciales, March 1979.

3.4 Future Energy Use in El Salvador

3.4.1 Electric Sector Expansion Plans

In response to rising oil prices, El Salvador is rapidly developing domestic energy resources to keep pace with growing electricity demand. The twin pillars of expansion of electrical generating capacity are (1) the development of the hydroelectric potential of the Lempa River, and (2) the tapping of the geothermal resources of the volcanic belt which runs the length of the country.

The Lempa River, whose watershed includes about one half of the country's land area, is estimated to hold a total hydroelectric potential of 1,300 to 1,500 MW. At present, 232 MW are in existence. Four additional sites have been studied, incuding the San Lorenzo hydroelectric project (180 MW) on the lower part of the river.* CEL may also expand two of the existing hydro plants by 1996, increasing hydro capacity by an additional 190 MW.**

From a 1978 geothermal capacity of 60 MW, El Salvador hopes to have at least 330 MW by 1992, with additional expansion in the years leading up to the end of the century.*** CEL is investigating the geothermal potential of other areas, including Berlin-Usalatan, Chinameca-San Miguel, and San Vicente.****

In order to meet the country's escalating electricity demand, ECLA incorporates petroleum-based generation increases of about 300 MW by the early 1990s.***** CEL hopes to use alternative energy sources such as biomass to generate electricity in this time period to reduce this potential oil demand.

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*CEL, Electrificacion Nacional: Presente y Future, 1978.

**ECLA, Estudio Regional, 1979.

***ECLA, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, 1979.

****CEL, Planta Geotermica de Ahuachapan, 1976.

*****ECLA, Estudio Regional, 1979.

3.4.2 Energy Growth Projections

Future energy requirements in El Salvador are based on a postulated growth rate of GNP of 5 percent per year for the period between 1978 and 2000. Underlying this relatively optimistic projection of economic growth is a population growth of slightly over 3 percent per year, from 4,658,000 in 1978 to 8,708,000 in the year 2000. Rural population is projected to decrease from 55 percent in 1975 to about 42 percent in 2000, which translates to an urban population growth of 4.42 percent per year.

Electric Sector Projections

Using the methodology of this study relating growth in electricity demand and growth in GNP, we calculate a growth rate for electricity sales of 7.5 percent per year, leading from a 1978 base of 1,195 GWh to consumption of 5,866 GWh (21,118 TJ) in the year 2000 (see Table 2-8). This estimate contrasts with ECLA's higher 9.6 percent projection in its interconnection study, and with an 11-percent annual historical rate in the mid 1970s.* However, we feel it is justified given lower economic growth rate used in this study, the changes in consumption resulting from higher electricity prices, and the fact that much of the integration of private "autoproductores" into the grid will have taken place by the late 1980s.

Petroleum Demand Projections

The demand for petroleum fuels is escalated at 5.2 percent per year for Case I and at 3.4 percent per year for Case II. These growth rates are obtained by applying the income and price elesticities discussed previously to a GNP growth of 5 percent and a real price increase of petroleum averaging 5 percent per year over 22 years. These growth rates raise present consumption levels of about 28,430 TJ (4.6 million barrels) to 86,721 TJ (14.2 million barrels)

*CEL, Boletin Estadistico No. 9, 1979.

TABLE 3-8

EL SALVADOR

ELECTRICITY DEMAND PROJECTIONS

	1978	2000	Growth Rate (%) 1978-2000
Total Electricity Sales			
(GWh)	1,195	5,866	7.5
(TJ)	4,302	21,118	
Losses			
(GWh)	220	1,080	7.5
(TJ)	792	3,888	
Total Generation			
(GWh)	1,415	6,946[1]	7.5
(TJ)	5,094	25,006	

[1]CEPAL has a total generation projection of 10,780 GWh for the year 2000.

Source: MITRE/E/DI.

for Case I and 52,323 (9.7 million barrels) for Case II. (See Table 3-9.)

The growth rates obtained in the analysis compare with historical 1973 to 1978 growth rates for gasoline of 5.6 percent, for diesel of 7.7 percent, and for LPG of 4.5 percent. The historical growth rate for residual oil used by industry is not known; its total consumption has been predominantly determined by its use in electric generation, which changed radically during the period cited above. Gasoline sales are likely to grow more slowly in the future when compared to the 1970s because of increases in fuel efficiency. The growth in diesel use will be linked in part to agricultural output, both in farm use of fuel and in transportation of farm products by trucks to population centers. Based on recent trends, agricultural output is estimated to grow at a slower rate than the overall economy. According to ECLA estimates, diesel use in industry historically is about 20 percent of its total direct use. With industrial growth, this share is expected to rise during the projection period.

Non-Commercial Fuel Projection

For this study non-commercial fuel use is escalated at the rate of total growth of population, estimated to be 3.02 percent per year. This yields approximately 57,996 TJ by the year 2000, a doubling of 1978 levels. Current estimates of non-commercial energy use are tentative.* Moreover, the assumption that the consumption of non-commercial fuels grows at the rate of population growth, although adequate for this study, should be treated with caution. For one, although an unknown portion of urban population utilizes firewood and charcoal, rural-to-urban migration results in a declining proportion

*A more accurate estimate will soon be forthcoming based on a detailed survey undertaken by CEL.

TABLE 3-9

EL SALVADOR

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

	1978	Year 2000	
		Case I	Case II
Total Direct Uses	28,430	86,721	52,323
Industry	13,005	39,670	23,935
Transport	12,840	39,166	23,631
Residential	2,585	7,886	4,757

Source: MITRE/E/DI.

of the population having access to non-commercial fuels. In addition, inasmuch as nearly one-third of the total amount of non-commercial fuels consumed in 1978 is represented by bagasse (based on ECLA estimates), its supply constitutes a significant variable influencing total non-commercial fuel consumption. The availability of this resource is linked to sugarcane production which varies with the world sugar prices.

3.4.3 Future Energy Resource Consumption

In this section, we present a final balance of energy resource consumption for El Salvador in the year 2000. With limited hydro resources, and to meet the projected required generation of 6946 GWh in that year, El Salvador will have to embark on an ambitious expansion of geothermal energy. In spite of indications that total geothermal resources could be very large, for purposes of this analysis we have assumed that there are limits to the rate in which the potential can be exploited; the result is that El Salvador will require expansion of its thermal capacity.

The expansion of hydropower included in the analysis considers the expansion of one existing site and the development of one new site; this would bring the total installed capacity along the Rio Lempa to 656 MW, which is about 50 percent of the estimated potential of the entire river basin. Because portions of the river's watershed lie in neighboring Honduras, it is unlikely that the entire potential of the river will be exploited in the near future.

We projected new geothermal capacity to grow fourfold from the existing 60 MW plus the 30-MW expansion planned for the same site, to a total of 360 MW. While this seems to be a very steep growth, actual expansion could be even faster. The economics and characteristics of potential sites cannot be evaluated until actual drilling has been done, so all estimates are extremely tentative. The ECLA interconnection study actually projects a larger expansion through the year 2000, totalling some 475 MW.

In our projections, we fill the remainder of electric generation demand with existing and new thermal generation (see Table 3-10). An additional 330 MW would be needed over the existing 128 MW, generating 2000 GWh (7200 TJ). This would require the utilization of some 4.4 million barrels of residual oil (28,800 TJ) or a mix of residual and diesel of comparable magnitude. In view of the uncertainty of the relatively cautious expansion of hydropower assumed in this analysis, this large use of petroleum for electric generation is tentative; it could be even larger or considerably lower. It can be seen that El Salvador has a considerable incentive in either dampening the growth rate of electricity demand, or establishing links with neighboring countries that may have surplus hydropower.

A final summary of El Salvador's resource requirements for the year 2000 is shown in Table 3-11. Included for comparison are the present levels of use of each resource.

3.5 Energy Strategies for El Salvador

Table 3-12 summarizes the impact or the contribution of oil substitution and conservation, as a percentage of total projected petroleum demand. In addition, the potential contributions of ethanol and methanol are shown as a percentage of current gasoline use.

Substitution of Oil

Of all countries in the region, El Salvador has the fewest options regarding trade-offs between hydro and electric generation based on petroleum. The projected installed capacity of 656 MW of

TABLE 3-10

EL SALVADOR

ELECTRIC SUPPLY BALANCE, YEAR 2000

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use[1] (TJ)
Hydro	656	2,870	10,332	41,328
Existing[2]	412			
Expansion[3]	124			
Additional Sites	120			
Geothermal	360	2,080	7,488	29,952
Existing	60			
Planned Addition	30			
Other Additions	270			
Thermal	458	2,000	7,200	28,000
Existing	128			
Additions	330			
Total Generation		6,950	25,020	100,080
Total Demand		6,946	25,006	

[1]Expressed in petroleum equivalent, utilizing a conversion of 0.25.

[2]Includes site under construction.

[3]Expansion of 5 de Noviembre site.

Source: MITRE/E/DI

TABLE 3-11

EL SALVADOR

TOTAL RESOURCE USE, 1978 and 2000 (TJ)

	1978	Year 2000 Case I	Year 2000 Case II
Hydro	11,936	41,328	41,328
Geothermal	5,632	29,952	29,952
Petroleum	32,069	115,521	146,119
Direct Uses	28,430	86,721	59,323
Electric Generation	2,013	28,800	28,800
Losses	1,626	NA	NA
Non-Commercial	22,707	57,996	57,996
Total Resources	78,635	244,800	217,399

TABLE 3-12

EL SALVADOR

IMPACT OF SELECTED STR[illegible]IES

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substituting 50% of petroleum used in electric generation with coal, geothermal or imports	12.5%	----
b. Same as (a) for 100% substitution[2]	25.0%	----
c. Production of 10% of ethanol potential[2]	0.4%	6%
d. Production of 25% of ethanol potential[2]	0.9%	15%
e. Production of 0.5% of methanol potential[3]	0.9%	10%
f. Production of 1.0% of methanol potential[3]	1.9%	32%
g. Substitution of electricity for petroleum-based processes, vehicles	negligible	----
II. Conservation		
a. Conservation in industry (15%)	5.2%	----
b. Conservation in transportation (20%)	6.8%	----
c. Savings in electricity use (10%)	8.7%	----

[1]Using Case I petroleum demand as a basis.

[2]Percentage of current land devoted to sugarcane to be dedicated to energy production, or equivalent area added to cultivation.

[3]Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

hydro in the year 2000 represents nearly 50 percent of the theoretical potential for the Lempa River basin, suggesting that a substitution of 458 MW of oil-based capacity would have to be based on geothermal, coal, or other alternative energy resources. The estimated potential geothermal resource base is 450 MW, which would be 80 percent developed according to our year 2000 projections. Thus, replacement of the oil-based generation, which would drop oil demand by 25 percent, is a problem in El Salvador. Electricity interconnections may prove to be an effective way of substituting oil. Nonconventional energy resources such as wind, biomass, and solar should be considered for electricity generation.

The potential contribution of ethanol and methanol for El Salvador is 3180 TJ, based on the assumption that 25 percent of the present day sugarcane cultivation area is devoted to ethanol production, and that 1 percent of the total national forest growth is converted to methanol. This represents 8 percent of the projected year-2000 transportation fuel needs or 47 percent of the 1978 gasoline consumption, a significant amount for near-term use.

Conservation: The lack of a systematic data base precludes an evaluation of conservation potential; only general statements can be formulated. The results of reducing oil demand by 15 percent through conservation in industry are 5,950 TJ. A reduction of 20 percent in transport fuel use results in an additional savings of 7,800 TJ (applied to Case I). Assuming that a 10-percent cutback in electricity can be achieved, replacing oil generation, 10,000 TJ will be saved.

3.6 Recommendations to USAID for El Salvador Energy Programs

The MITRE/EDI team was unable to spend adequate time in El Salvador to justify making specific recommendations to USAID.

However, as seen in this energy assessment, El Salvador's energy situation differs slightly from its neighbors. We thus suggest that USAID's role in El Salvador's energy development be further investigated.

APPENDIX 3-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

The following table lists national institutions that are active in energy research. It contains short descriptions of each institution's activities.

TABLE 3.A-1

ENERGY RESEARCH AND DEVELOPMENT

EL SALVADOR

Technology/Resource	Institution	Product or Activity
ALCOHOL		No activity.
BIOGAS	Comision Ejecutiva Hidroelectrica de Rio Lempa	Experiments with methane production form water hyacynth.
COAL		No known reserves, no activity.
GEOTHERMAL	Comision Ejecutiva Hidroelectrica de Rio Lempa	In-place geothermal capacity covered 32.2% electric demand in 1979.
MINI-HYDRO		No activity.
PETROLEUM		No known reserves. CEL has recently requested assistance from Venezuela in elaborating legal framework for off-shore exploration by foreign firms.
SOLAR	Asociacion de Energia Solar de El Salvador	Unavailable.
	Universidad Centroamericana	Holds annual symposium on Basic Human Needs and Technology. Individual research projects. Collaboration with San Salvador city government in providing solar hot water for public market.
WIND		No activity. CEL interested in evaluation of wind resources.
WOOD		No activity.

APPENDIX 3-B

INSTITUTIONAL ANALYSIS

During the MITRE/E/DI visit to El Salvador, a number of institutions were contacted, including:

- government agencies
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in El Salvador; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audience
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION:	Centro National de Tecnologia Agropecuaria (CENTA), Ministry of Agriculture
CONTACT:	Francisco Garcia
LOCATION:	San Salvador, El Salvador
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	Government agency within the Ministry of Agriculture
TARGET AUDIENCE:	Landowners, farmers, agricultural extension agents
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Government agency
PRODUCTS, SERVICES, CAPABILITIES:	• An investigation in development of low-cost solar grain dryers

INSTITUTION:	Comision Ejecutiva Hidroelectrica del Rio Lempa (CEL)
CONTACT:	Alberto Chiquillo
LOCATION:	9a Calle Poniente 950 San Salvador, El Salvador
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Government-owned electric company which sells power to a variety of power distribution companies which in turn serve the country's industrial and residential sectors • Primary energy policy making entity for El Salvador • Developer of alternative energy sources
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Much of the company's financing comes from international lending institutions such as the World Bank and Inter-American Development Bank, as well as from revenues.
PRODUCTS, SERVICES, CAPABILITIES:	• Development of geothermal resources and utilization of geothermal wastes • Collaboration with UNDP Energy Balance Project • Experimentation with biogas production • Projections of solar energy use • Development of solar and wind data base for municipal requirements

INSTITUTION:	Ministry of Planning
CONTACT:	Alirio Bernal Gaitan, Director, Department of Science and Technology
LOCATION:	
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	The Department of Science and Technology has three goals: - Formulation of quality control for manufactured goods - Encouragement of transfer of technology - Formation of national advisory board on science and technology
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Government agency
PRODUCTS, SERVICES, CAPABILITIES:	

INSTITUTION: Universidad Centroamericana

CONTACT: Ricardo A. Navarro

LOCATION: Apartado (01) 168
San Salvador, El Salvador

TELEPHONE: 240011

DESCRIPTION OF INSTITUTION:

TARGET AUDIENCE: Students, researchers, community groups, general public

LEGAL AND FINANCIAL SETTING OF INSTITUTION: Private university affiliated with the Catholic Church, and supported by tuition and church revenues

PRODUCTS, SERVICES, CAPABILITIES:

- Development of courses in solar and conventional energy
- Research on biogas generators, solar-driven water pumps, and gasoline-alcohol mixtures
- Plans to further research in appropriate technologies and disseminate results to community groups
- Initiation of a program in alternative uses of energy sources with emphasis on solar energy (e.g., solar cookers, solar ovens, and small solar water heaters)
- Organization of seminars on appropriate technologies
- Dissemination of information on alternative energy resources

INSTITUTION:	**National University of El Salvador**
CONTACT:	**Ethelvia Murillo de Escobar and Rafael Gavados Vasquez**
LOCATION:	
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	
TARGET AUDIENCE:	**Students, researchers**
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	**National university founded and supported by the central government**
PRODUCTS, SERVICES, CAPABILITIES:	• **Theoretical work on utilization of solar energy** • **Biogas investigations**

Bibliography

Blutstein, Howard I., et al. Area Handbook for El Salvador, DA PAM 550-150. Washington, D.C.: U.S. Government Printing Office, 1971.

CEL. Analysis Preliminar de las Energias Primarias y Secudarias Commerciales en El Salvador. San Salvador: CEL, March 1979.

_____. Boletin Estadistico, No. 9. San Salvador: CEL, June 1979.

_____. Electrificacion Nacional, Presente y Futuro. San Salvador: CEL, 1978.

_____. Informe Anual 1978. San Salvador: CEL, 1978.

_____. Planta Geotermica de Ahuachapan. CEL, 1976.

CEPAL (ECLA). Estudio Regional de Interconexion Electrica del Istmo Centroamericano. CEPAL, October 1979.

Chiquillo Alas, Alberto. Recursos Naturales Propios de Generacion Electrica en El Salvador; Pasado, Presente y Futuro.

FAO Production Yearbook (1978), vol. 32. Rome, 1978.

SIECA. La Situacion Energetica en Centroamerica y Perspectivas para el Futuro. Guatemala, Guatemala: SIECA, August 1978.

World Bank. Economic Report. Washington, D.C.: The World Bank, no date.

4.0 HONDURAS

4.1 Geographic, Social, and Economic Aspects of Honduras Energy Development

Geography

Honduras, with a land area of 112,088 square kilometers, is the second largest country of Central America. It is bordered on the west by Guatemala, on the southwest by El Salvador, and on the southeast by Nicaragua. It has a 400-mile coast on the Caribbean Sea to the north and a 77-mile access to the Pacific between El Salvador and Nicaragua in the Gulf of Fonseca.

Numerous mountain ranges, extensions of the Central American Cordillera, separate the country and provide Honduras with large hydroelectric potential. Young active volcanic features, prominent in all three of Honduras's neighbors, are not as evident here. However, hot springs are prevalent throughout the country.

As in all of Central America, the temperate climate marks the highlands of Honduras, while the narrow lowlands along both coasts are tropical. The dry season occurs from November to March with rain prevalent throughout the remainder of the year.

Great tropical forests cover the highly uninhabited eastern areas of Honduras. The highlands, once heavily wooded, are suffering from deforestation.

The population of Honduras totaled 3,148,000 in 1978 with a growth rate of 3.5 percent. The population is predominately rural (62 percent). The only two cities of more than 100,000 persons are the highland capital city of Tegucigalpa, and the industrial town of San Pedro Sula near the northern coast.

Economy

The Honduran economy is the least developed in Central America: per capita Gross Domestic Product was $528 in 1978. As Table 4-1 illustrates, the economy is primarily agricultural, with important manufacturing and commercial components. Together, these three sectors contributed 51 percent of Gross Domestic Product in 1976.

The agricultural sector is most important, contributing about one-third of total Gross Domestic Product, and accounting for about 75 percent of total exports. About two-thirds of the labor force is employed in agriculture. Historically, bananas have been the most important agricultural product. After Ecuador, Honduras is the second largest banana producer in the world.

A second export crop is coffee, which, in periods of high coffee prices (such as 1977) becomes as important as bananas in terms of foreign exchange earnings. Coffee is grown on small land holdings with the result that more Hondurans are employed in the coffee industry than in the banana industry.

Other agricultural products include sugar, an export item since the early 1960s, beef, and staple foods such as corn and beans. Table 4-2 summarizes the values of all Honduran exports over the period 1970 to 1976.

The manufacturing sector accounts for about 15 percent of GDP and is dominated by the processing of food, beer, and the production of clothing, textiles, lumber, and printing. Food products account for almost a third of all manufacturing activities. Lumber is the major export from the manufacturing sector; it accounted for 9 percent of all exports in 1976. Other industrial products include paper, chemicals, petroleum distillates, cement, glass, and metals.

TABLE 4-1

HONDURAS

GROSS DOMESTIC PRODUCT BY SECTOR, 1970-1976

(millions of Lempiras)

	1970	1971	1972	1973	1974	1975	1976[1]
GROSS DOMLSTIC PRODUCT (at market prices)	1,430	1,516	1,648	1,813	1,995	2,112	2,431
Agriculture	429	461	499	563	578	562	639
Mining	30	228	30	44	64	53	59
Manufacturing	181	198	218	244	280	314	376
Construction	65	62	69	73	96	108	128
Public Utilities	18	20	23	27	27	36	40
Transport and Telecommunications	86	92	101	114	124	138	157
Commerce	171	175	184	197	216	242	278
Banking, Insurance and Finance	37	41	47	53	64	68	79
Housing	94	101	109	118	127	137	148
Public Administration and Defense	44	49	62	58	62	68	79
Personal Services	136	146	155	153	157	166	196

[1]Preliminary.

Source: World Bank.

TABLE 4-2

HONDURAS

VALUE OF EXPORTS BY PRODUCT

(millions of U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976
Bananas	75.3	95.7	90.7	94.0	79.7	61.5	106.7
Coffee	25.9	23.3	27.3	47.8	43.9	56.9	100.3
Lumber	16.2	19.2	27.1	39.1	40.7	38.8	38.0
Beef	9.7	12.5	16.1	21.9	16.8	18.3	25.6
Sugar	1.2	1.6	2.0	-	4.5	7.0	2.2
Petroleum Derivatives	6.2	3.0	3.4	4.1	14.5	12.3	1.1
Others	49.0	41.1	45.5	59.7	98.8	113.1	129.6
Total Value[1]	183.4	196.4	212.1	266.6	298.9	307.9	403.5

[1] Including non-monetary gold.

Source: World Bank.

Balance of Payments

Honduras's trade balance has eroded significantly since the 1973 oil embargo. Two separate time series of balance-of-payment information are presented in Tables 4-3 and 4-4. The first table shows the significant penalties in the Current Amount Balance with increased fuel import costs after 1973. The second table shows further deterioration since 1976.

As a percentage of exports, imports increased in value from 105 percent in 1976 to 110 percent in 1978. A key factor is the sharp drop in coffee prices during 1978, which reduced the value of Honduran exports. Honduran exports are still growing, both in volume and in value, but the rate of growth in value has suffered.

Trade deficits notwithstanding, Table 4-3 shows that Honduras continues to maintain a positive balance of payments. Capital Account movements have counterbalanced the negative trade situation through capital inflows and stepped up disbursements from development loans.

Prospects for Development

The near-term prospects for growth in Honduras are good, based on recent economic performance, and the imminent completion of several major private and public export-oriented projects. GDP has grown almost 25 percent since 1976, and Gross Domestic Product per capita has grown at least 12 percent over the same period. In the agricultural sector, the volume of coffee exports should increase as the result of more fertilization. Banana exports should also increase barring unforeseen natural disasters. Lumber exports are expected to grow significantly as government sponsored sawmill/lumbering operations in the Olanchos area reach full production.

TABLE 4-3

HONDURAS

BALANCE OF PAYMENTS, 1970-1976

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976
Exports (goods and n.f.s.)	201.8	217.2	235.0	293.8	331.3	343.5	443.1
Imports (goods and n.f.s.)	246.6	222.8	226.6	302.1	456.0	452.4	509.0
Resource Balance	-44.8	-5.6	8.5	-8.3	-124.7	-108.9	-66.0
Net Factor Services and Transfers	-16.0	-17.9	-21.0	-26.2	19.1	-10.6	-42.9
Current Account Balance	-60.8	-23.6	-12.5	-34.6	-105.7	-119.6	-108.9
Change in Reserves (-=increase)	14.0	-5.6	-12.0	-3.4	-1.9	-16.9	-23.0
Gross International Reserves[1]	..	21.9	35.2	41.8	44.4	97.1	131.0

[1] Gross international reserves data were taken from International Financial Statistics, International Monetary Fund (IMF), December 1978 and April 1979. The IMF figures may not total exactly from the World Bank data as the IMF provides gross international reserves while the World Bank provides change in net international reserves.

.. Not available.

Source: World Bank and International Monetary Fund.

TABLE 4-4

HONDURAS

VARIATIONS IN EXTERNAL TRADE

	1976	1977	1978[1]
	[illegible]		
Value of Exports	31.1	29.4	16.3
Volume of Exports	11.9	3.5	18.8
Unit Value of Expor	17.1	25.0	-2.1
Value of Imports	13.1	28.8	21.1
Volume of Imports	4.6	16.1	15.1
Unit Value of Impor	8.1	10.9	4.9
	.ance Dollai		
Exports (FOB)	403	522	607
Imports (FOB)	427	550	666
Net Non-Factor Services	-42	-53	-62
Trade Balance	-66	-81	-121
Payments of Profits and Interest	-56	-68	-73
Balance on Current Account	-118	-145	-178
Capital Account	157	202	207
Balance of Payment	39	57	29

[1]Preliminary.

Source: ECLA, Economic Survey of Latin America, 1978.

Sugar exports should expand as well, once new sugar mills come on line. Beef and cotton exports should grow as more land becomes devoted to production.

Infrastructure investments over the next few years will be concentrated in the power sector, with the El Cajon Hydroelectric project accounting for a major share of investment funds ($413 million). Significant road and port building activities are also planned, much of it with funding from the IDB.

Given these developments, we expect that real GDP will grow at about 5 percent per year in Honduras over the long term. This estimate assumes that major investments currently contemplatetd are completed on schedule, and that Honduras continues experiencing success in its efforts to expand and diversify exports. This estimate also assumes that Honduras will experience no large natural disasters, such as Hurricane Fifi, which struck Honduras in 1974.

4.2 Honduras Energy Resources

Table 4-5 summarizes the energy resources of Honduras as of 1979. Each of the resource estimates is discussed below. The map shown in Figure 4-1 describes the location of major energy sites in Honduras.

Hydro

Honduras has large hydroelectric potential which is just beginning to be tapped. The national electric company has estimated a country hydroelectric potential of 2800 MW and annual energy potential of 12,300 GWh.* A CEPAL study, completed in 1964,

*Congreso Nacional de Energia Electrica.

TABLE 4-5

HONDURAS

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential Theoretical Capacity: 2,800 MW[1] Installed Capacity: 109 MW (58% of total installed capacity)
Geothermal Some 109 geothermal manifestations have been identified.[3] No reliable estimate of potential exists.
Oil Reserves Indications exist. No commercial-scale deposits are known. Refining Capacity: 15,000 barrels/day.[4]
Gas Reserves Proven: None.
Coal Fifteen million tons of lignite are in Ocotopeque Province.[5]
Wind Usable data have not been currently collected.
Solar Data are limited to number of sunlight hours for some regions of Honduras.
Biomass Forests: The forest cover is over six million hectares.[6] There are 4.5 million hectares of hardwoods. Pine forests equal 50 million cubic meters. Sugar: Six refineries produce 158 thousand metric tons/year. 73,000 hectares of sugarcane were harvested in 1978.[7]

[1] CEPAL.
[2] Empresa Nacional de Energia Electrica.
[3] UNDP.
[4] Oil and Geothermal, December 1978.
[5] Personal communication with CONADI.
[6] USAID Agriculture Sector Assessment for Honduras.
[7] FAO Production Yearbook, 1978, Vol. 32.

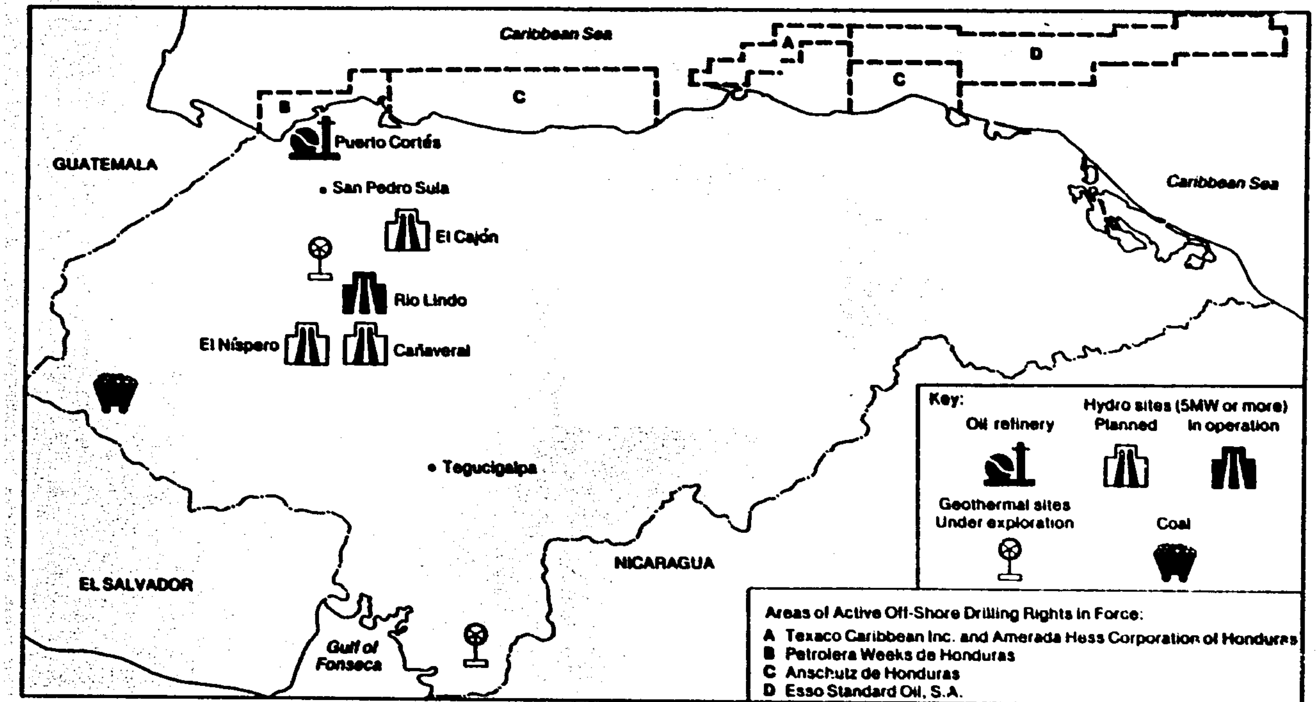


FIGURE 4-1
ENERGY RESOURCES OF HONDURAS

estimated a potential of almost 5900 MW.* A more current study performed for Honduras estimated a hydroelectric potential of nearly 35,000 GWh per year.** A good portion of this potential is scheduled to be developed with three large-capacity hydroelectric systems: El Cajon 292 MW, Cuyamel - 525 MW, Piedros Amarillos - 210 MW.

Minihydro potential, likely a portion of the previous energy estimates, is beginning to be investigated for the replacement of isolated community generation systems.***

Geothermal

The United Nations Development Program (UNDP) has sponsored a survey of geothermal sites in Honduras. One hundred and nine geothermal manifestations have been identified. These sites are distributed throughout western and central Honduras. The areas of highest surface temperature (70 to 100°C) and greatest conductivity appear in an area about 60 km south of San Pedro Sula and near the Nicaragua border south of Choluteca.**** Original UNDP plans included the drilling of shallow wells at the site near Pavana. Financial limitations have prevented exploration. The only estimate of geothermal potential identified in this study was a value of 100 MW.*****

*CEPAL, Studies for Electricity in Latin America, Volume I, 1964.

**Wetering and Hargraves, A Proposed Water Resources Program for the Ministry of Natural Resources, 1978.

***Based on initial results of ENEE small hydro project.

****Maps provided by UNDP.

*****Geothermal Energy Magazine, 5 (1977), p. 34.

Oil

Oil exploration in Honduras has not resulted in any significant discovery of petroleum. Drilling concessions have been granted for shelf areas off the north coast, and Texaco is currently drilling in this area.

Coal

The estimates of coal reserves are very inexact both in terms of quantity and quality. The National Investment Corporation (CONADI) asserts that proven reserves in Ocotepeque total over 15 million tons of high-ash lignite contained within unfractured seams of two to four meters thick. Economic studies are now required to determine whether mining is feasible.

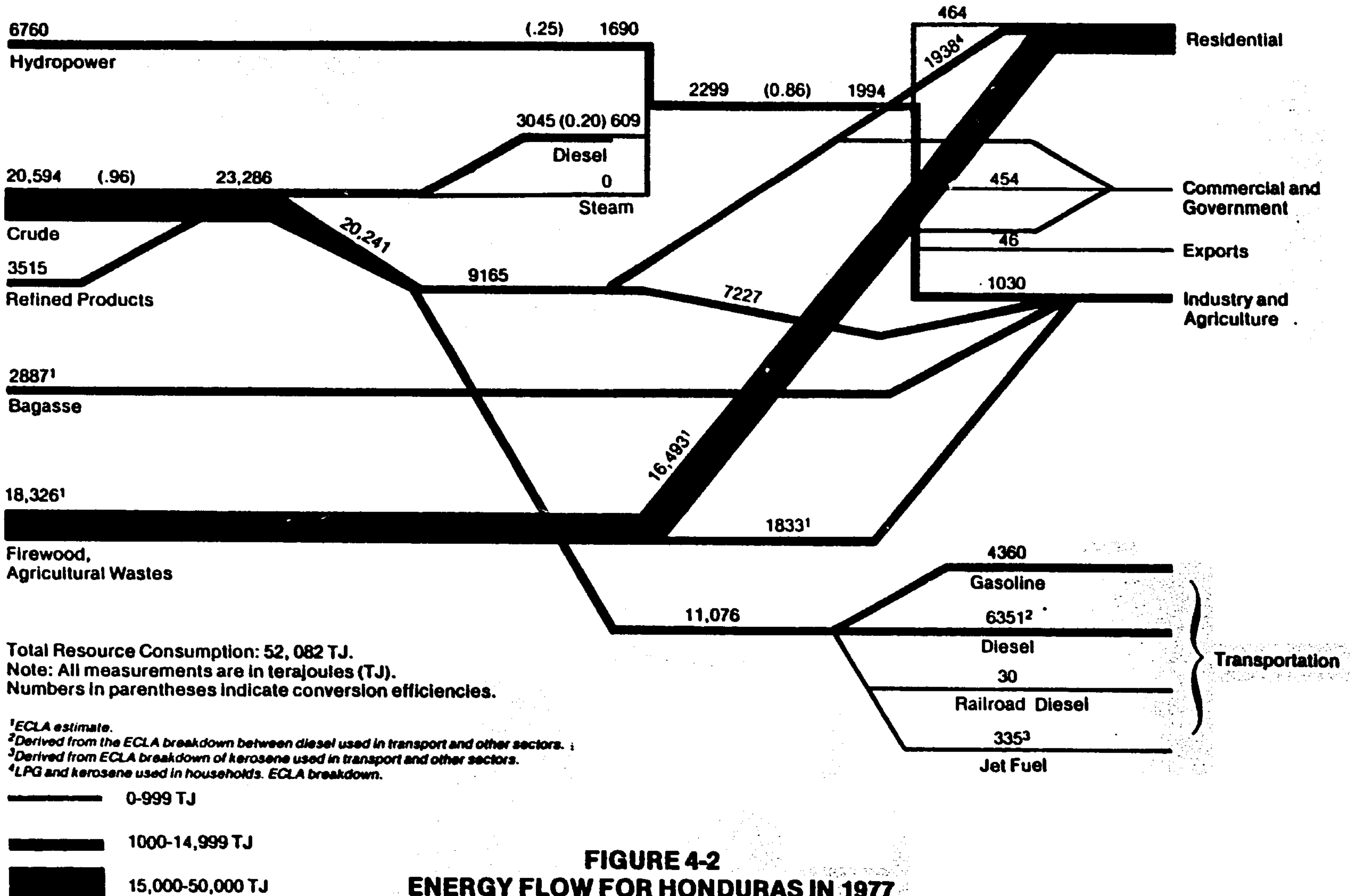
Biomass

The forests of Honduras are its greatest biomass resource. USAID reports that Honduran forests cover more than six million hectares. A large portion of this resource is located in the unpopulated eastern section of the country.

Other biomass energy resources include sugarcane and coffee wastes. Honduras cultivated 73,000 hectares of sugarcane in 1978.

4.3 Current Energy Use in Honduras

Energy resource consumption in Honduras in 1977 amounted to 52,082 TJ, of which 46 percent were in petroleum use, 47 percent, non-commercial fuel use and 13 percent, hydroelectric consumption. Figure 4-2 depicts the flow of energy resources to final demand sectors. Resource inputs to electric generation are also shown. The following sections describe the principal features of Honduras's energy utilization. They cover first the main supply sectors (petroleum and electricity), and then major sectors of final demand:



Total Resource Consumption: 52, 082 TJ.
Note: All measurements are in terajoules (TJ).
Numbers in parentheses indicate conversion efficiencies.

[1]ECLA estimate.
[2]Derived from the ECLA breakdown between diesel used in transport and other sectors.
[3]Derived from ECLA breakdown of kerosene used in transport and other sectors.
[4]LPG and kerosene used in households. ECLA breakdown.

FIGURE 4-2
ENERGY FLOW FOR HONDURAS IN 1977

industry, transport and households (including the uses of non-commercial fuels).

Electric Sector

Major electrical generation, distribution, and sales in Honduras are the responsibility of the Empresa Nacional de Energia Electrica (ENEE). Installed capacity totalled 146.2 MW in 1977 and is divided between hydro (46.2 percent), diesel (34.6 percent), and gas turbines (19.2 percent). Isolated systems account for 7.2 percent (or 10.7 MW) of installed capacity, and consist almost entirely of diesel generators, although there are a few small hydroelectric sites. Municipalities and industries also produce a significant amount of electricity. It is estimated that industrial self generators produce 60.86 GWh yearly.

Nearly all current projects are hydroelectric, as shown by the 1978 completion of the 40-MW expansion of the Yojoa-Rio Lindo facility. Of planned facilities, the Cajon hydroelectric project is the most important. The first stage is scheduled for completion in 1983 and the second stage in 1985. It will then have a capacity of 292 MW, more than doubling the capacity of the interconnected system. Substantial decreases in the petroleum use for electric generation will be possible at that time.

As shown in Table 4-6, total generation in Honduras during 1977 was 638.5 GWh. Of this amount, 469.4 GWh or 74 percent was produced by hydroelectric plants while 169.1 GWh or 26 percent was produced by thermal plants. This indicates low plant factors for thermal capacity while hydro capacity is much more intensively utilized. Total system plant factor for ENEE in 1977 was 0.50.*

*ENEE, Datos Estadisticos, 1977.

TABLE 4-6

HONDURAS

ELECTRIC SECTOR DATA

	1973	1974	1975	1976	1977	1978
Total Installed Capacity						
MW	118.3	147.6	146.1	146.2	146.2	186.2
Hydro	68.6	68.6	68.6	68.7	68.7	108.7
Thermal[1]	49.7	79.0	77.5	77.5	77.5	77.5
Maximum Demand						
Generation (GWh)	383.9	459.2	510.5	558.9	638.5	NA
Hydro	359.3	399.9	419.7	342.0	469.4	
Thermal	24.6	59.3	90.8	126.9	169.1	
Sales, Total (GWh)	328.0	395.7	435.9	478.7	554.1	NA
Residential	77.3	94.3	103.1	113.1	129.0	
Commercial[2]	69.2	84.3	91.2	100.4	126.0	
Industry[2]	180.7	216.2	240.7	257.1	286.1	
Sales to Other Systems	0.8	0.9	0.9	8.1	13.0	

[1]Units are diesel or gas turbines.

[2]Commercial includes government and public lighting; industry includes large consumers.

Note: Data includes INEE accounts only.

Source: CONSUPLANE, Plan Nacional de Energia 1979-1983.

Industry (including "large consumers") is by far the most important user of electricity in Honduras, and consumed 286.1 GWh in 1977 or 52 percent of total sales. Commercial (including sales to this government and public lighting) and residential consumption accounted for 126.0 GWh and 129.0 GWh, respectively. Thirteen GWh were sold to Nicaragua in 1977 via the only international transmission line currently in operation in Central America. Sales to Nicaragua could become particularly important when El Cajon is completed in 1983 in order to fully utilize its capacity.

Total sales of electricity from all sources grew at an average annual rate of 14.9 percent from 1967 to 1977. Industrial use has grown the fastest, indicated by the 26.8-percent increase in industrial electricity use between 1976 and 1977.*

Petroleum Sector

Table 4-7 shows the breakdown of petroleum consumption in Honduras for 1977. Consumption of petroleum products amounted to 23,286 TJ (3,855,000 barrels). Of this amount, 84 percent was refined by Texaco at Puerto Cortes on the Gulf of Honduras. This refinery has a capacity of 16,000 BPD but is presently operating at 70-percent capacity. Since 1976, the refinery has been processing reconstituted crude in order to avoid excessive production of bunker fuel. Imports of refined products are concentrated in gasoline, diesel, and LPG.

Total oil consumption (excluding refinery losses) grew at a rate of 7.3 percent per year from 1973 to 1977. Consumption of bunker has grown faster than consumption of other products, increasing its share of total oil use from 15.6 percent in 1973 to 21.4 percent in 1977, an annual average growth rate of 16.7 percent. Growth in consumption

*ENEE, Datos Estadisticos, 1977.

TABLE 4-7

HONDURAS

PETROLEUM CONSUMPTION, 1977

	Refinery Production		Imports		Consumption	
	10^3 bbls	TJ	10^3 bbls	TJ	10^3 bbls	TJ
Gasoline	690	3,823	91	537	787	4,360
Kerosene/ Jet Fuel	343	2,051	16	96	303 56	1,812 335
Diesel	1,345	8,265	447	3,853	1,972	12,118
Residual	810	5,370	-167	-1,107	643	4,263
Aviation Gas	NA	-	NA	-	NA	-
LPG	62	262	32	136	94	398
Total	3,250	19,771	419	3,515	3,855	23,286

Sources: Production from Plan Nacional de Energia, CONSUPLANE.
Consumption from the Comision Energetica Interministerial.
Imports obtained by differences.

of gasoline was very low from 1973 to 1977, at 1.8 percent per year on the average, indicating slow growth in use of passenger cars.*

Honduras is currently in the process of allowing internal oil prices to rise to world market levels from previously subsidized levels. According to Minister of Economy, subsidies will be eliminated by the end of 1980.

Non-Commercial Fuels Sector

Use of firewood and charcoal is substantial in Honduras and amounted to an estimated 18,326 TJ in 1977. The Corporacion Hondurena de Desarrollo Forestal (COHDEFOR) has estimated that approximately 10 percent, or 1833 TJ, was consumed in cottage industries, while the remainder was used in the residential sector.

Bagasse is used extensively in sugar refineries. It is estimated that 2887 TJ were derived from this source in 1977. This amount was used for process heat and electric generation for sugar production.

Industrial Sector

The Honduran industrial sector is the country's largest user of electricity, consuming nearly half of all generation (1030 TJ in 1977). Industry also accounts for almost one-third of national petroleum consumption (7227 TJ), using mainly bunker and diesel fuel. As just mentioned, a significant amount of non-commercial fuels are consumed by industrial processes in Honduras. Non-commercial fuel use is not, however, limited to the more traditional and less technically advanced industrial sectors. Sugar refining, which is important both in terms of value added and foreign exchange, derives

*ENEE, Datos Estadisticos, 1977.

most of its required energy from agricultural residues in the form of bagasse. Although sugar refineries currently use some diesel fuel and some firewood as well, improvements are planned in several plants that will enable bagasse to supply energy needs.

Another industry with the potential for use of non-commercial fuels is lumber and other wood products. Honduras has extensive forest resources and government-financed development projects oriented toward export of wood products which will be completed this year. Although the sawmills are currently powered by diesel fuel, possibilities for utilizing wood wastes are under investigation. The government is also planning a pulp and paper factory for the mid to late 1980s with significant possibilities for use of internally generated energy.

The largest industrial consumer of petroleum products is the cement industry which expects to grow substantially over the next few years, due to large construction projects, most notably the El Cajon hydroelectric project. According to industry executives there is great potential for improvements in efficiency of energy use in the cement industry.* Steps are currently being taken to accomplish this, and fuel use efficiency should meet or exceed world industry standards within the next two to three years.

Residential Sector

Residential fuel use in Honduras is dominated by firewood. An estimated 16,493 TJ of firewood were burned in the residential sector in 1977. There is a small but growing use of electricity in households, although many have yet to be connected to the system. According to the 1974 housing census, 32.8 percent of urban and 94.5

*Personal interview with Rafael Kafie of Cimentos de Honduras.

percent of rural households did not have electricity. Thus, a large potential for growth in consumption exists as the electrical grid is extended to new areas.

The government would like to switch household consumption of energy to electricity and away from kerosene and LPG. Care is being taken, therefore, to avoid a return to fuelwood consumption since kerosene use is discouraged through higher prices.

Transportation Sector

The transportation sector in Honduras is currently under rapid development. With the help of substantial financing from international lending agencies, the country's basic highway network is under construction. This development is expected to continue throughout the 1980s. Railroads are currently confined to the northern coastal areas and are engaged primarily in hauling wood, bananas and wheat to ports and markets. Railroads are fueled entirely by oil products (30 TJ in 1977), but electrification is being considered for the future.

Transportation consumed 11,076 TJ of petroleum products in 1977 or 55 percent of national consumption. Gasoline accounted for 4360 TJ or 39 percent of the total transport consumption, assignable primarily to private cars. Diesel and jet fuel accounted for the remaining 61 percent. The transport sector consumed 42 percent of national diesel consumption.

The government is currently trying to suppress gasoline consumption by discouraging use of private cars. Gasoline prices are being raised to world market levels from their previous subsidized levels, and gas stations are closed on Sundays and after 9 p.m. Although these measures were instituted only six months ago, they have had a visible effect already, according to the Comision Nacional de Energia.

4.4 Future Energy Use in Honduras

4.4.1 Electric Sector Expansion Plans

The Empresa Nacional de Energia Electrica (ENEE) has an installed capacity of 186 MW with hydro and thermal components. ENEE's expansion plans have made no mention of exploring geothermal resources, but discuss plans for two hydroelectric projects and one thermal plant. This thermal plant, Puerto Cortes, is expected to add 30 MW by 1980.* The major hydro project is El Cajon on the Humaya River. In two stages, El Cajon will increase the electric power generating capacity of ENEE by 292 MW of installed capacity by 1985.** A smaller 23 MW hydro plant is planned for El Nispero.***

CEPAL projections show the electric sector in Honduras reaching 625 MW by the late 1990s.**** ENEE projects 650 MW.*****

4.4.2 Energy Growth Projections

Future energy requirements for Honduras are based on a postulated GNP growth rate of 5 percent per year for the next two decades. The population growth rate is 3.27 percent per year, the highest in the region (CELADE estimate) totalling nearly 7 million people by the year 2000. The growth in urban population is also the highest in the

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*Secretaria Tecnica del Consejo de Planificacion Economica, Plan Nacional de Energia: 1979-1983.

**ENEE, Department of Planning Statistics.

***ECLA, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, 1979.

****ECLA, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, 1979.

*****Plan Nacional de Energia, op. cit.

region, 5.4 percent, resulting in a drop from current levels of rural population of 62 percent to a projected 44 percent. This rapid rate of urbanization approximates current levels of Panama's urban population.

Electric Sector Projection

As shown in Table 4-8, electricity sales are estimated to grow at 7.5 percent per year through 2000, at a rate 1.5 times higher than the projected growth rate of GNP. In the short term, the Honduran National Energy Plan projects higher growth rates, in line with the nearly 15 percent annual growth experienced in the decade between the late sixties and late seventies. In the years immediately after the start-up of El Cajon hydro project, there may be a surplus of generation capacity and the opportunity for electricity export. In the past, excess electricity has been sold to Nicaragua. In this case, total Honduran generation would exceed the year 2000 demand (3370 GWh) using a 7.5 percent growth rate.

Petroleum Demand Projection

The demand for petroleum products for direct uses is assumed to grow at 5.2 percent per year for Case I, and at 3.4 percent per year for Case II. The results of projections are presented in Table 4-9. Growth rates are obtained by applying the income and price elasticities discussed in Section 2.0 to a postulated 5 percent annual GNP growth rate and a postulated 5 percent per year growth in world oil prices over the period through 2000. The result is petroleum consumption by industry, transportation and households of 64,952 TJ (10.6 million barrels) for Case I and 43,672 TJ (7.1 million barrels) for Case II.

Non-Commercial Energy Projections

For projection purposes, non-commercial energy is escalated at the rate of growth of total population--3.27 percent per year. On

TABLE 4-8

HONDURAS

ELECTRICITY DEMAND PROJECTIONS

	1977	2000	Growth Rate (%) 1977-2000
Total Electricity Sales			
(GWh)	554	2,923	7.5
(TJ)	1,994	10,523	
Losses			
(GWh)	85	447	7.5
(TJ)	305	1,610	
Total Generation			
(GWh)	639	3,370	7.5
(TJ)	2,299	12,133	

Source: MITRE/E/DI.

TABLE 4-9

HONDURAS

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

Total Direct Uses	20,241	64,952	43,672
Industry	7,227	23,191	15,593
Transport	11,076	35,542	23,898
Residential	1,930	6,219	4,181

Source: MITRE/E/DI.

the basis of ECLA's estimated non-commercial energy use in 1977, we obtain a total projected annual resource use of 44,464 TJ.

4.4.3 Future Energy Resource Consumption

The final energy balance for Honduras assumes that the generation of electricity by the year 2000 will be essentially hydroelectric. Clearly, however, oil-fired electric generation will continue until the first major hydro facility comes on line. The 3370 GWh in the year 2000 would require hydro additions of some 300 MW to the existing 109 MW and the planned 315 MW. This is only a fraction of the 800 MW or more than the CEPAL interconnection study cites as available in Honduras. The availability of geothermal resources in Honduras is uncertain, so none has been included in the electricity supply balance summarized in Table 4-10.

A final balance of total resource requirements is presented for Honduras in Table 4-11.

4.5 Energy Strategies for Honduras

Substitution of Oil

Honduras is the only country in the region where interest was expressed to members of our team on electricity substitution for oil-fueled thermal processes in industries. The country's hydroelectricity endowment is large, and some aspects of its industrial sector such as cement, tobacco, and sawmills are large relative to the other nations in the region. It is not possible to quantify to what extent this substitution could be made; the share of industrial consumption of total oil used by the final demand sectors is the highest in the region at 36 percent.

The contribution of ethanol and methanol totals 6,520 TJ, assuming for ethanol that cultivation dedicated to fuels production

TABLE 4-10

HONDURAS

ELECTRICITY SUPPLY BALANCE, YEAR 2000

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use (TJ)
Hydro	624	3,370	10,800	43,200
Existing	109			
Planned	315			
New Sites	300			
Geothermal	0	0	0	0
Thermal	106	0[1]		
Existing	76			
Planned	30			
Expansion	0			
Total Generation		3,370		
Total Demand		3,370		

[1]By the year 2000, it is likely that these plants will not be needed; They will probably be in use at times during the next decade as large hydro projects come on line.

Source: MITRE/E/DI.

TABLE 4-11

HONDURAS

TOTAL RESOURCE USE, YEAR 2000

(Terajoules)

	1977	Year 2000 Case I	Year 2000 Case II
Hydro	6,760	43,200	43,200
Geothermal	0	0	0
Petroleum	24,109	64,952	43,672
Direct Uses	20,241	64,952	43,672
Electric Generation	3,045	0	0
Losses	823	NA	NA
Non-Commercial	21,213	44,464	44,464
Total Resources	52,082	152,616	131,336

Source: MITRE/E/DI.

amounts to an equivalent of 25 percent of the area currently planted with sugarcane, and for methanol that 1 percent of the total national potential is converted to methanol. This amount, 90 percent of which is methanol, represents 18 percent of total demand for transport fuels in the year 2000. Compared with current gasoline consumption, the potential methanol contribution is substantial.

Conservation

The lack of a systematic data base precludes a full evaluation of conservation potential; only general statements such as outlined in Section 2.0 of Volume I can be formulated. Reducing oil demand industry by 15 percent through conservation would save 3,500 TJ; in transportation an additional 7,100 TJ (applied to Case I) could be saved, or 20 percent of oil demand.

Table 4-12 summarizes the contribution of oil substitution and conservation, as a percentage of total projected petroleum demand. For comparison, the potential contributions of ethanol and methanol are shown as a percentage of current gasoline use.

4.6 Recommendations to USAID for Honduras Energy Programs

The recommendations provided here are intended as a refinement, and in some cases an expansion of the regional recommendations presented in Volume I. Where regional recommendations do not appear as national recommendations, the regional recommendations still stand.

Technical Training in Energy Planning and Resource Management

We believe the Honduran government could benefit from specialized training of personnel in the techniques of natural resource assessment and energy and environmental program planning. Moreover, for officials working in the hydrocarbons section of the Ministry of

TABLE 4-12

HONDURAS

IMPACT OF SELECTED STRATEGIES

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substitution of petroleum used in electric generation	lot applicable	-----
b. Production of 10% of ethanol potential[2]	0.4%	6%
c. Production of 25% of ethanol potential[2]	9.9%	14%
d. Production of 0.5% of methanol potential[3]	4.5%	68%
e. Production of 1.0% of methanol potential[3]	9.0%	136%
f. Substitution of electricity for petroleum-based processes, vehicles	?	-----
II. Conservation		
a. Conservation in industry (10%)	5.0%	-----
b. Conservation in transportation (20%)	10.0%	-----

[1]Using Case I petroleum demand as a basis.

[2]Percentage of current land devoted to sugar cane to be dedicated to energy production, or equivalent area added to cultivation.

[3]Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

Natural Resources, instruction in the procedures and technologies used in offshore exploration and development would be extremely helpful in dealing with international oil companies. USAID should explore the opportunities for working through the National University to develop curricula in these areas.

Support for Honduran Institutional Development

USAID should help Honduras develop its own energy R&D capabilities. One good opportunity is the energy research group at the National University in Tegucigalpa which lacks the financial resources to carry out energy research programs.

Resource Assessment

In several instances, our research pointed out the lack of reliable data concerning the location, extent, and quality of Honduran energy resources. USAID should therefore consider initiatives in the following areas:

minihydro: help the Ministry of Natural Resources identify, and set priorities for, minihydro sites;

coal: help the National Investment Corporation assess the location and extent of Honduran coal reserves;

solar: help begin a data collection program regarding solar insolation rates and wind velocities.

Technical Analysis

In several instances, USAID technical assistance would be useful in evaluating the economic and technical feasibility of specific energy development proposals. Among the options which USAID should help evaluate are the following.

charcoal: USAID should support the Ministry of Natural Resources in evaluating the environmental and economic feasibility of large-scale charcoal production. In particular, this proposal needs to be assessed regarding the environmental impact of monoculture reforestation with eucalyptus trees.

cement: USAID should assess the feasibility of process modifications to increase the energy efficiency of cement production in Honduras. This sector is expected to grow significantly as a result of the rapid expansion of hydro capacity. Since energy efficiency in the cement industry is presumably below world averages, the potential for energy savings may be large.

agricultural residues: USAID should assess the feasibility of technologies to capture the energy value of coffee, banana, and wood wastes. Exports of these products are expected to grow between 1980 and 2000, and they may offer renewable, cost-effective energy resources.

Demonstration Projects

There are at least two instances in which USAID's financial and planning support could facilitate the implementation of energy projects.

ethanol: The Azucarera Cantarranas sugar refinery is contemplating a $20 million capital investment to distill ethanol from sugar cane, and is seeking project financing. USAID should assess the economic and technical feasibility of this proposal, and consider financial participation.

rural energy: USAID should consider strategies for mobilizing the Peace Corps as rural energy volunteers. USAID could help Honduran authorities train Peace Corps volunteers when they first arrive in Honduras, and could help make recommendations for the design of a Peace Corps rural energy assistance program.

APPENDIX 4-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

The following table lists national institutions that are active in energy research. It contains short descriptions of each institution's activities.

TABLE A.4-1

ENERGY RESEARCH AND DEVELOPMENT

HOUNDURAS

Technology/Resource		
ALCOHOL	Azucarera Cantarranas, S.A.	Seeking financing for 120,000 litres/day distillery
BIOGAS		No activity.
COAL	Corporation Nacional de Inversiones	Completed feasibility study for extraction of 15+ million tons lignite deposits in Ocotepeque Province.
GEOTHERMAL	UNDP/World Bank	Making inventory of potential sites. Measuring temperature and conductivity. As of 1979, no possible sites had been identified.
MINIHYDRO	Empresa Nacional de Energia Electrica and Taiwan Power Commission	Completed feasibility studies for three projects of others on Potuca River with 2000-4200 KW capacity.
PETROLEUM	Ministerio de Recursos Naturales-Direccion de Minas e Hidrocarburos	Signed risk contracts with ESSO, Union Oil, Shell and Texaco for off-shore exploration.
SOLAR		No activity.
WIND		No activity.
WOOD	Consejo Superior de Planificacion Economica	Completed survey of national firewood use.
	Corporacion Hondurena de Desarrollo Forestal (COHDEFOR)	Experimenting with fast-growing Leucaina for fuel use. Responsible for reforestation program, research, and teaching.

APPENDIX 4-B

INSTITUTIONAL ANALYSIS

During the MITRE/E/DI visit to Honduras, a number of institutions were contacted, including:

- government agencies
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in Honduras; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audiences
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION: Comision de Energia

CONTACT: Omar de Cid, Felipe Molina

LOCATION:

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Interministerial group comprised of the Ministry of Economy, Ministry of Natural Resources, Central Bank, and CONSUPLANE
- Principal missions are:
  - to recommend administrative or institutional changes to deal with energy-related problems
  - to make short-term policy recommendations, particularly with respect to oil pricing
- Main priorities include:
  - an inventory of natural resources
  - conservation
  - the creation of an energy ministry

TARGET AUDIENCE: Government agencies, general public, and other Central American countries in its capacity as a regional coordinating body

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

PRODUCTS, SERVICES, CAPABILITIES:

- The Commission has recommended four energy projects:
  - a study of the use of a 20-percent gasohol mix

- a study of charcoal use and potential users

- a study of wood wastes

- a study of municipal wastes

- Three recommendations have been implemented

  - Gas stations are closed on Sundays and after 9:00 p.m.

  - The workday is no longer divided into two parts, as is the tradition in Latin America; this eliminates the need to go home for lunch and return to work

  - An advertising campaign has been initiated to raise public awareness of the energy situation

INSTITUTION:	Consejo Superior de Planificacion Economica (CONSUPLANE)
CONTACT:	J. Ochoa, Director, Seccion Energia
LOCATION:	Tegucigalpa, Honduras
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Responsible for national economic planning • Responsible for the development of the national energy plan for 1979 to 1983 and short-term recommendations on energy-related matters • Seven professionals are employed in the energy division and two more will be hired in 1980
TARGET AUDIENCE:	Government agencies, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	
PRODUCTS, SERVICES, CAPABILITIES:	

INSTITUTION: Corporacion Hondurena de Desarrollo Forestal (COHDEFOR)

CONTACT: Dagoberto Gomez Suazo

LOCATION: Edificio Midence Soto 4° Piso
Tegucigalpa, Honduras

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Formed in 1974 as a semi-autonomous institution

- Governed by Board of Directors headed by chief of state; members include Secretary of Economy, Secretary of Natural Resources, Secretary of Treasury, and the Executive Secretary of the Superior Council of Economic Planning

- Mandated to utilize, protect, and conserve forests, reforest denuded areas, and establish sound organizational systems

- Allowed to industrialize, harvest, and manufacture forest products through joint ventures, contracts with the private sector, or a development and operation of a corporation

- Able to export and domestically wholesale wood products

- Permitted to form and operate commercial wood-using industries, joint credit or guarantees to forest enterprises, and borrow money from domestic or international sources

- Staffed with about 1600 professionals and non-professionals

TARGET AUDIENCE:	Government agencies, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTIONS:	• The corporation must generate its own funds and may not participate in national budget allocations. • Programs must be in harmony with National Development Plan. • It may hire personnel and determine salary levels without regard to civil service system. • It sponsors National School of Forest Sciences at Siguatepeque.
PRODUCTS, SERVICES, CAPABILITIES:	• Planned and implemented projects include: - construction of administrative facilities - roads and access to forest reserves - fire protection and disease control - development of experiment stations and nurseries - training at the National School of Forestry Services - forest inventories and soil studies - reforestation - social forest programs through organized groups - timber harvesting by existing and new mills - plywood production

- turpentine and resin production

- construction of pulp and paper mill

- dry kiln at La Ceiba

INSTITUTION: Direccion de Minas e Hidrocarburos

CONTACT: Jose Orlando Morena and Marta de Zambra

LOCATION: Ministerio de Recursos Naturales
Tegucigalpa, D.C.
Honduras

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- The four main responsibilities of this agency are:
  - mineral exploration
  - mineral exploitation
  - petroleum refining
  - transportation of petroleum and other minerals
- It also negotiates contracts with foreign energy corporations

TARGET AUDIENCE: Government agencies, petroleum companies, general public

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

PRODUCTS, SERVICES, CAPABILITIES:

INSTITUTION: Universidad Naciona

CONTACT: J. Zuniga, Departmento de Fisica

LOCATION: Tegucigalpa, D.C.
Honduras

TELEPHONE:

DESCRIPTION OF INSTITUTION: Promotes training, research, and community services

TARGET AUDIENCE: Students, general public

LEGAL AND FINANCIAL SETTING OF INSTITUTION

PRODUCTS, SERVICES, CAPABILITIES:

Student research activities include projects on wind, solar, and small-scale hydrogeneration.

Faculties of mechanical, civil, and electrical engineering, physics, and chemistry have formed a study group to discuss energy-related research.

Equipment includes meteorological station.

INSTITUTION:	Direccion de Recursos Hidricos, Ministeris de Recursos Naturales
CONTACT:	Hugo Elvir, Director
LOCATION:	Comayaguela, Honduras
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Responsibilities include multiple use water projects • Emphasis is on potable water and irrigation project identification and appraisal, but power generation is also important
TARGET AUDIENCE:	Farmers, municipalities, government agencies, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Recently established as part of the Ministerio de Recursos Naturales
PRODUCTS, SERVICES, CAPABILITIES:	• Evaluation of ENEE's inventory of hydroelectric sites to identify projects with multiple use possibilities • Sponsorship of a study on a multiple use dam in Choluteca

INSTITUTION:	Empresa Nacional de Energia Electrica (ENEE)
CONTACT:	Angel A. Boesch, General Manager
LOCATION:	Tequcigalpu, D.C. Honduras
DESCRIPTION OF INSTITUTION:	• National electric company • Responsible for the identification of feasible hydroelectric sites, the construction of hydro and thermal electric generation facilities, the addition of transmission capacity, and maintenance and operation • Authorized to buy power from and sell power to foreign countries
TARGET AUDIENCE:	Electricity consumers
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• State monopoly which functions as autonomous entity • Capital requirements provided by its own and government revenues
PRODUCTS, SERVICES, CAPABILITIES:	Currently, ENEE's priority is the development of the El Cajon hydroelectric project. Continuing extensions and reinforcement of the transmission system are also planned.

INSTITUTION:	Ministerio de Economia
CONTACT:	Manuel Zeron, Minister
LOCATION:	Tegucigalpa, Honduras
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	In charge of nacional economic affairs with emphasis on processes of private and public asset creation
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Cabinet level organization
PRODUCTS, SERVICES, CAPABILITIES:	Determines prices of petroleum products in Honduras by evaluating costs and returns

Bibliography

Background Notes: Honduras. Washington, D.C.: U.S. Government Printing Office, May 1979.

Consejo Superior de Planificacion Economica. Plan Nacional de Energia 1979-1983. Tegucigalpa, Honduras: CONSUPLANE, no date.

Corporacion Nacional de Inversiones. Resumen Informativo. Tegucigalpa, no date.

Economic Commission for Latin America (ECLA). Economic Survey of Latin America, 1978: Advanced Summary, E/CEPAL/1075. Mexico: CEPAL, April 1979.

_____. Economic Projections for Central America, 1979. Mexico: CEPAL, 1979.

_____. Estudio Regional de Interconexion Electrica del Istmo Centroamericano, CEPAL/MEX/SRNET/28. Mexico: CEPAL, October 1979.

ENEE (Empresa Nacional de Energia Electrica). Datos Estadisticos 1977. Tegucigalpa, Honduras: ENEE, 1978.

_____. El Cajon. Tegucigalpa: ENEE: no date.

_____. Programa de Electrificacion Rural. Tegucigalpa, Honduras: ENEE, February 1971.

FAO (Food and Agriculture Organization). 1978 FAO Production Yearbook, Volume 32. Rome: FAO, 1978.

Geothermal Project of Honduras Activities Reports, RLA/76/012. Honduras: UNDP, 1979.

Gormaz Gonzalez, Manuel. Reforestacion en La Mosquita. Honduras: Corporacion Hondureno de Desarrollo Forestal, 1979.

International Monetary Fund. International Financial Statistics. New York: IMF, April 1979.

Planeamiento Energetico y Balance de Honduras, Encuesta Piloto sobre Consumo de Lena, RLA. 76/012. Honduras, no date.

Power Technical Mission, Republic of China. Marale Hydro-Power Study Report. Tegucigalpa, Honduras: ENEE, September 1979.

______. Planning Report on Santa Maria del Real Hydro Power Rehabilitiation Project. Tegucigalpa, Honduras: ENEE, July 1979.

USAID (U.S. Agency for International Development). Agriculture Sector Assessment for Honduras (with annexes). Washington, D.C.: USAID, August 1978.

______. Honduras Country Development Strategy Statement. Washington, D.C.: USAID, January 1979.

Van de Wetering, H. and George H. Hargreaves. A Proposed Water Resources Program for the Ministry of Natural Resources. Consortium for International Development (CID), July 1978.

World Bank. Economic Report. Washington, D.C.: The World Bank, no date.

5.0 NICARAGUA

5.1 Geographic, Social, and Economic Aspects of Nicaragua Energy Development

Geography

Nicaragua lies squarely in the middle of the Central American isthmus. It is bounded by Honduras to the north, Costa Rica to the south, and the Atlantic and Pacific Oceans to the east and west, respectively. Total land area is 130,000 square kilometers.

Two-thirds of the population live in the lowland and lake areas of the West, between the Gulf of Fonseca and the Costa Rican border. This region is called the Great Rift depression and is dominated by two large fresh water lakes: Lake Managua and Lake Nicaragua. An active chain of volcanoes intrudes the center of the depression and these volcanoes have frequently caused damage to people, crops, livestock, and buildings.

The highland frontier lies to the north, with peaks ranging up to 7000 feet above sea level. The highlands are formed by a mountain chain which runs north and south, from the Mexican state of Chiapas to the Costa Rican highlands. The drier, western portions of the highlands are settled by subsistence and commercial farmers.

The empty lands lie to the east of the highlands and are characterized by uninhabited rain forests. The East is composed of lowland areas bordering the Caribbean Sea. This area accounts for one-third of Nicaragua's land area and is known as the Mosquito Coast. The term Mosquito Coast, which refers to an area originally inhabited by the Mosquito Indians, extends to include parts of Costa Rica and Honduras. It is composed of alluvial plains and valleys separated by low watersheds and volcanoes.

In the wet, tropical climate of Eastern Nicaragua, the temperature is warm throughout the year. The highlands enjoy mild temperatures, rarely above 85°F.

The Nicaraguan population was estimated at 2,393,000 in 1978, and is growing at an annual rate of 3.3 percent a year. Fifty-six percent of the population is urban, concentrated mainly in Managua, Leon, Granada, and Matagalpa.

Managua, the capital, is located in the northwestern part of the Great Rift depression. Although it is located in an area of seismic instability, it has grown rapidly in recent years.

Economy

The economy of Nicaragua is changing rapidly, due to the political revolution which was consummated there in July 1979, when the Somoza government was replaced by the Sandinista government. Recognizing that traditional relationships may no longer be valid in Nicaragua, the following data is presented to indicate the starting point for the political, economic, and social transformations now under way.

Historically, Nicaragua's economy has been dominated by the commercial, agricultural, and manufacturing sectors, in that order. In 1977, these sectors accounted for about 70 percent of the Gross Domestic Product (GDP), which totaled $1.56 billion or $649 per capita (see Table 5-1).

The commercial sector accounted for about 25 percent of GDP in 1977. The agricultural sector contributed 23 percent of GDP and was the only sector in which output grew during 1978. The manufacturing sector accounted for 20 percent of GDP during 1977, and employed

TABLE 5-1

NICARAGUA

GROSS DOMESTIC PRODUCT BY SECTOR, 1970-197

(millions of current cordobas)

	1970	1971	1972	1973	1974	1975	1976	1977[1]
GROSS DOMESTIC PRODUCT (at market prices)	5,482.9	5,785.7	6,058.7	7,600.4	10,606.4	11,079.6	12,941.2	15,583.0
Agriculture	1,367.4	1,410.3	1,364.3	1,837.4	2,563.8	2,426.3	2,939.6	3,560.0
Mining	173.3	188.2	205.1	312.6	606.3	601.2	621.2	721.6
Manufacturing	1,110.8	1,207.6	1,309.3	1,615.4	2,124.8	2,458.2	2,761.9	3,067.1
Construction	173.3	188.2	205.1	312.6	606.3	601.2	621.2	721.6
Public Utilities	84.1	87.4	121.7	85.0	124.8	194.1	234.3	220.4
Transport and Communications	293.1	309.5	343.7	436.8	599.7	612.2	733.2	932.6
Commerce	1,153.3	1,217.4	1,352.3	1,718.4	2,359.4	2,408.7	2,867.4	3,858.7
Banking, Insurance and Finance	143.6	163.6	130.8	199.2	318.3	307.8	394.7	447.5
Housing	351.2	366.4	370.3	401.8	556.8	597.6	644.8	738.6
Public Administration and Defense	407.4	419.9	411.0	431.9	597.3	709.5	838.9	914.7
Personal Services	365.2	383.1	420.4	524.8	700.9	728.2	858.8	1,079.7

[1]Preliminary.

Source: World Bank.

about 16 percent of the labor force. Manufacturing was dominated by food processing activities ($106 million, or 34 percent of the value added in manufacturing). Other major components were: beverages ($31 million, or 10 percent), chemicals ($27 million, or 9 percent), textiles ($22 million, or 7 percent), and petroleum products ($23 million, or 7 percent). For more detail on the components of this sector see Table 5-2.

Cotton and coffee comprise over 50 percent of the total value of exports. The value of exports by product is shown in Table 5-3.

Balance of Payments

Nicaragua's balance of payments situation is precarious. The nation's trade balance has fluctuated since 1972, and foreign debt now totals more than $1.5 billion. To make matters worse, the economy is at a standstill in many sectors.

Nicaragua's economic problems began in 1972, when an earthquake destroyed downtown Managua and surrounding areas. Lost production and the importation of goods and services needed for reconstruction produced a trade deficit of $76 million in 1973 (see Table 5-4).

In October 1973, the economy was disturbed again, this time by the unilateral increase in world oil prices. Nicaragua was particularly vulnerable, since its electricity system depended primarily on oil-fired generation.

During 1975 and part of 1976 the country made steady progress toward balance of payments recovery, but by the latter half of 1976 and continuing in 1977, the situation deteriorated again. The reason: individual agencies of the Nicaraguan government were borrowing vast sums from the international banking community in a manner largely uncontrolled by the Central Bank of Nicaragua.

TABLE 5-2

NICARAGUA

VALUE ADDED IN MANUFACTURING, 1970-1977

(millions of current cordobas)

	1970	1971	1972	1973	1974	1975	1976	1977[1]
Food Processing	422.3	483.3	515.8	567.3	676.3	899.8	966.6	1,039.8
Beverages	104.1	105.4	110.1	151.5	203.4	244.0	268.2	310.8
Tobacco	64.4	65.2	64.5	78.1	88.1	111.9	138.2	148.4
Textiles	74.8	78.7	109.2	114.7	144.0	162.6	197.1	222.4
Clothing and Footwear	67.2	78.3	81.1	92.5	111.3	111.4	132.8	152.0
Wood Products	38.1	41.5	45.1	53.1	68.0	71.4	90.8	96.9
Furniture	14.6	14.0	13.8	13.2	20.1	21.2	24.5	28.5
Paper and Paper Products	11.2	10.7	9.4	17.4	24.7	25.2	27.7	30.1
Printing Materials	25.1	26.6	32.9	34.2	47.8	48.7	59.4	65.3
Leather Products	13.4	17.7	20.6	17.8	16.7	15.4	19.1	21.7
Rubber Products	5.9	5.5	6.2	6.0	7.4	8.2	9.5	10.3
Chemical Products	87.5	84.7	108.2	145.2	208.5	205.5	230.2	268.5
Petroleum Products	34.0	39.7	40.0	84.6	155.5	179.7	200.5	230.3
Non-Metallic Products	44.5	46.9	56.5	89.9	124.3	118.5	128.1	144.5
Basic Metal Industries	46.9	48.9	64.6	83.7	131.2	124.5	137.6	149.5
Machinery (including electrical)	17.1	19.0	22.0	26.8	32.5	46.0	57.5	65.4
Transportation Equipment	2.5	3.0	2.0	3.4	6.9	9.2	9.9	11.3
Others	37.2	38.5	29.0	35.6	58.1	55.0	64.2	71.4
Total	1,110.8	1,207.6	1,331.0	1,615.4	2,124.8	2,458.2	2,761.9	3,067.1

[1] Preliminary

Source: World Bank.

TABLE 5-3

NICARAGUA

VALUE OF EXPORTS BY PRODUCT, 1970-1977

(millions of U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977[1]
Cotton	34.2	41.3	62.9	63.2	135.9	95.6	130.6	150.4
Coffee	32.1	29.3	33.0	44.4	46.1	48.1	119.4	198.8
Sugar	9.8	11.6	15.2	13.5	12.3	42.6	52.8	27.8
Beef	26.6	28.7	38.3	44.5	21.9	27.0	37.6	35.2
Shrimp	5.9	5.8	8.7	7.2	9.7	14.9	19.7	22.0
Other	69.2	69.8	90.5	161.7	153.7	146.7	181.1	200.5
Total Value	177.8	186.5	248.6	277.5	379.6	374.9	541.2	634.7

[1] Preliminary estimate.

Source: World Bank.

TABLE 5-4

NICARAGUA

BALANCE OF PAYMENTS, 1970-1977

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976	1977
Exports (goods and n.f.s.)	170.8	186.5	248.6	277.5	379.6	374.9	541.2	634.7
Imports (goods and n.f.s.)	177.7	189.5	205.0	326.2	540.2	482.2	496.2	704.0
Resource Balance	-16.2	-16.1	51.0	-76.2	-214.1	-147.6	-2.3	-126.7
Net Factor Services and Transfers	-21.9	-26.6	-29.3	11.1	-42.7	-36.4	-61.7	-62.1
Current Account Balance	-38.1	-42.7	21.7	-65.1	-256.8	-184.0	-64.0	-188.8
Change in Reserves	-15.9	-12.1	-43.1	-75.8	74.2	-6.6	-48.7	107.5
Gross International Reserves[1]	..	58.8	80.5	116.9	105.3	122.3	146.8	149.4

[1] Gross international reserves data were taken from International Financial Statistics, International Monetary Fund (IMF), December 1978 and April 1979. The IMF figures may not total exactly from the World Bank data as the IMF provides gross international reserves while the World Bank provides change in net international reserves.

.. Not available.

Source: World Bank and International Monetary Fund.

World Bank data are not available for the years 1978 and 1979, but a recent U.N. report finds that Nicaragua's foreign debt now totals \$1.53 billion.* About \$619 million of this amount is due this year. The gravity of the situation is underscored by the fact that Nicaragua's debt service and amortization payments in 1979 amounted to 103 percent of export earnings, even under optimistic export assumptions. Clearly, renegotiation of foreign debt is necessary to avoid default.

Prospects for Development

The government faces a tremendous rebuilding task following the revolution. One of the most pressing problems is that agricultural production dropped precipitously during the 1978/79 and 1979/80 growing seasons. Coffee production is off due to war time disturbances and excessive rains in September and October 1979. The cotton crop, which represents the second largest export item in Nicaragua has dropped 80 percent from 1978/79 levels. Among the subsistence crops (i.e., corn, beans, and rice), yields are off 55 percent, 24 percent, and 15 percent, respectively. Livestock losses during the revolution, particularly poultry and cattle, are estimated at almost \$30 million.

The industrial base has also been damaged. The U.N. Economic and Social Council estimated that about 10 percent of the nation's industrial capacity was destroyed in the war.

In the commercial sector, an estimated \$220 million in damage was sustained in lost inventories, uncollectible accounts, and damage to buildings, furniture, and equipment.

*CEPAL, Nicaragua: Economic Repercussions of Recent Political Events, 1979.

Table 5-5 summarizes U.N. estimates of the destruction throughout all sectors of the Nicaraguan economy.

To deal with these problems, the government has developed a National Reconstruction Program which aims to restructure the economy on the basis of: efficiency, equity, and ample participation. The new economy is to be broken into well-defined private, public, and mixed sectors. Agriculture constitutes the highest priority for reconstruction. Approximately 55 percent of the land confiscated after the flight of ex-President Somoza will be used as the basis for extensive agrarian reforms.*

The major factors which will constrain economic growth in Nicaragua over the near-term include the following:

- Nicaragua has amassed a very substantial foreign debt; much of it at unusually high rates of interest.
- Former President Somoza and members of his government took an estimated $315 million when they fled the country in July 1979.
- Much of Nicaragua's productive capacity has been destroyed, both by the war and by the earthquake of 1972.
- The business community is apprehensive about existing assets and is reluctant to make additional investments until the relationship between public and private sectors is clarified.

The MITRE/E/DI study team has assumed that, after a recovery period of two to three years the Nicaraguan economy will settle down

*CEPAL, Nicaragua: Economic Repercussions of Recent Political Events, 1979.

TABLE 5-5

NICARAGUA

SUMMARY OF MATERIAL DAMAGES

(millions of dollars)

Sector	Total	Physical Plant	Equipment and Furniture	Materials, Inventories and Raw Materials	Uncollectible Portfolio
Total	480.7	99.1	99.5	182.1	100.0
Physical and social infrastructure	78.0	60.5	16.6	0.9	--
Agriculture	27.7	3.6	23.9[1]	0.2	--
Industrial	150.0	15.0	35.0	60.0	40.0
Commerce	220.0	20.0	20.0	120.0	60.0
Others	5.0	--	4.0	1.0	--

[1]Includes the decrease in cattle assets.

Source: CEPAL, Nicaragua: Economic Repercussions of Recent Political Events, E/CEPAL/G.1091, September 1979.

to an average growth rate of 5 percent a year through the year 2000.*

5.2 Nicaragua Energy Resources

Table 5-6 presents Nicaragua's energy resources as of 1979. Each of the resource estimates is discussed below. The map shown in Figure 5-1 describes the location of the major energy sites in Nicaragua.

Hydro

Estimates of hydroelectric potential in Nicaragua exceed 4,000 MW. Although detailed data are not available, 560 MW could be contributed through two large-scale projects, Copalar and Brito.

Geothermal

Activity in the area of geothermal energy has been going on for nearly a decade in Nicaragua. Exploration has been technically justified at three fields: the Managua area, the Masaya-Nandaime area, and the Marrabios Range. These areas have estimated resources inexcess of 1,000 MW for periods of more than thirty years.

The Momotombo field, near Managua, is expected to be developed and have installed capacity of 35 MW by 1981. Thirty-two wells have been drilled, and it is expected that twenty-one will be productive. The high temperature water of Momotombo contains high concentrations of dissolved mineral salts and silica, which make it difficult to discard substantial quantities of geothermal water without causing unacceptable surface pollution. Reinjection techniques will be tested in the near future. Aside from being an environmental problem, these deposits are also a serious cost item.

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*Rapid GDP growth as high as 15 percent is expected during the year 1980, as idle capacity is brought back on line.

TABLE 5-6

NICARAGUA

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential Theoretical Capacity: 4,416 MW[1] Installed Capacity: 100 MW[2] (33% of total installed capacity)
Geothermal For 1981, 35 MW are scheduled at Momotombo. The potential is for 4,000 to 6,000 MW.[2]
Oil Reserves Proven: None. Estimated: Unknown. Refining Capacity: 20,000 barrels/day.[3]
Gas Reserves Proven: None.
Coal Small unexploited deposits exist.[4]
Wind There are a small number of potential sites.[4]
Solar Data are limited to the number of sunlight hours.
Biomass Forests: Forests and woodlands cover 6.3 million hectares. Sugar: The sugarcane harvested in 1978 amounted to 45 thousand hectares. The land available to sugarcane for alcohol is 7 thousand hectares.[5]

[1] Master Plan for Electricity Supply, Vol. 1, Instituto Nacional de Electrificacion (INDE), Guatemala.
[2] Instituto Nicaraguense de Energia.
[3] Interview with Rodolfo Narvaez, Esso Standard Oil, S.A.
[4] Interview with Jorge Jenkins, Director, Instituto de Recursos Naturales (IRENA).
[5] Interview with Saul Lewites, Director, AGRO-INRA.

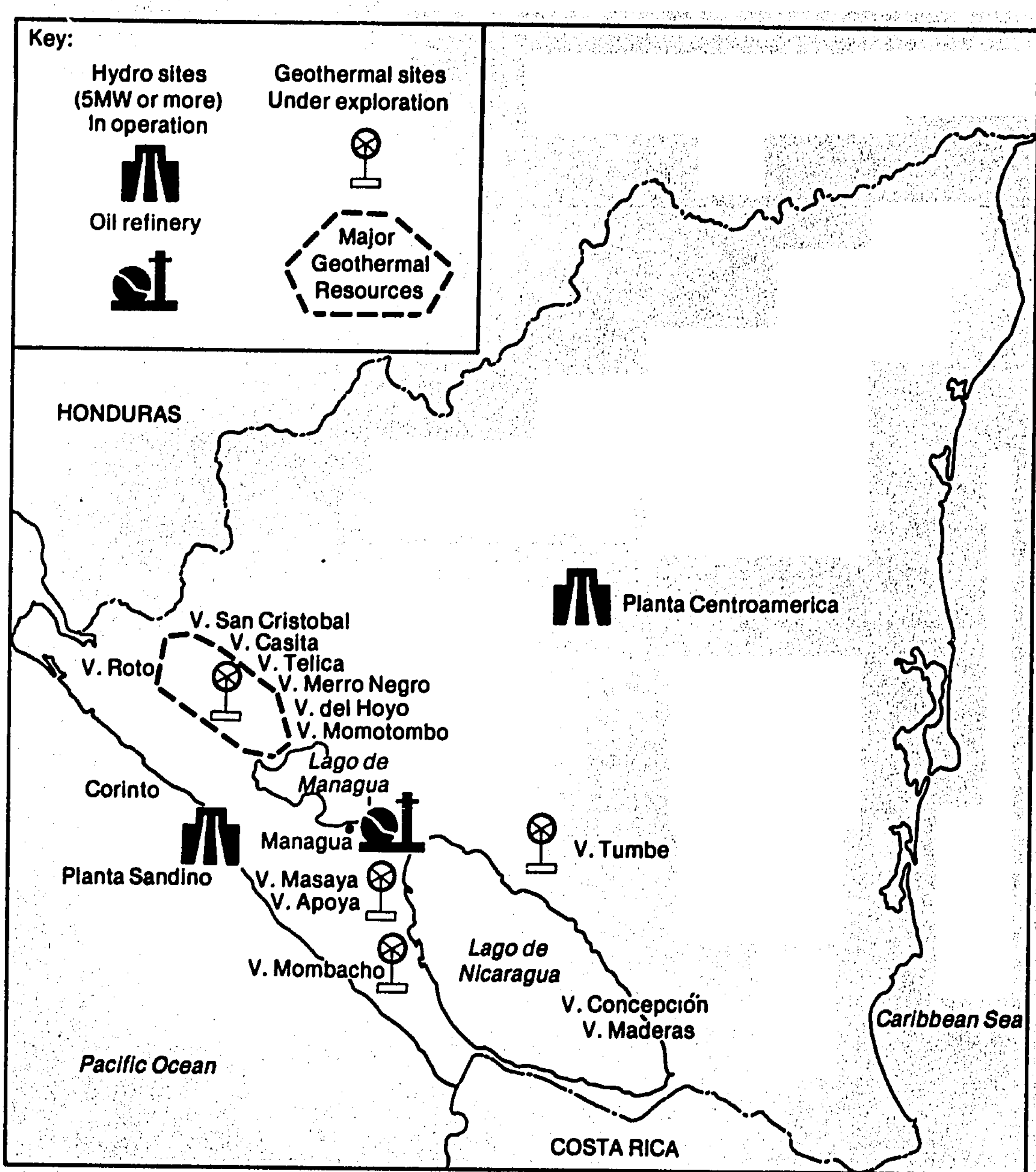


FIGURE 5-1
ENERGY RESOURCES OF NICARAGUA

Other problems concerning geothermal development include availability of funds, use of drilling personnel with experience in advanced technologies, resolution of environmental concerns, utilization of waste heat, and fuel transportation and maintenance factors. To complete the Momotombo field, the Italian government and the United Nations have agreed to finance the venture at the cost of $981,000. The design, fabrication, and installation of the turbo-generating equipment will be in collaboration with the Japanese, who will finance the Momotombo plant for 25 years at 8.5 percent interest.

<u>Oil</u>

A series of offshore exploratory wells have been drilled on both the Atlantic and Pacific sides of Nicaragua. Indications of petroleum deposits have been found, but no official estimates exist.

<u>Coal</u>

Scant deposits of coal may exist, but it is unknown if they are exploitable.

<u>Wind</u>

The exploitation of wind energy is attractive for a variety of purposes, but to date no specific research and development on windpower applications in Nicaragua have been performed.

<u>Solar</u>

Solar energy represents a vast energy resource in Nicaragua, but information and experience are not readily available on the extent or validity of solar as an energy resource.

<u>Biomass</u>

Forest products in Nicaragua are used in 77 percent of the households for cooking purposes, according to 1971 national census figures. Lumber exports, however, have been the major source of forest exploitation. Reforestation programs have been undertaken on the east coast to offset the losses. From the viewpoint of economic development, it is anticipated the favorable climatic and ecological conditions of Nicaragua will serve to increase commercial extraction of lumber for newsprint, paper board, domestic tissues, containers, packaging, textiles, clothing, and wood panels.

The Instituto de Recursos Naturales (IRENA) intends to establish priorities for environmental forest projects, rural development forest projects, institution building projects (training, education, and research), and industrial forest projects in order to eliminate the undesirable effects of uncontrolled forest exploitation.

The Instituto de Reforma Agraria (INRA) is investigating the use of Taiwan grass and leucaena, a fast growing tree, for fuel replacement in thermal electric plants. A private firm in Rama is installing a gasifier, and hopefully it will agree to experiment with leucaena, at the request of INRA. It is estimated that 4,900 hectares are needed to replace current fuel use in two Managua plants. INRA estimates that Nicaragua has sufficient land for energy crops, and local experimentation with leucaena and Taiwan grass is already underway to determine the work involved in growing, harvesting, and collecting plant material. Numerous questions must be addressed including ecological management of lands, evolution of schemes for maximum productivity, and efficient fertilizers, training of persons, etc., but the theoretical potential of leucaena and Taiwan grass appears large.

AGROINRA is highly interested in pursuing a gasohol program with alcohol derived from sugarcane. The government owns 7,000 hectares of idle land which could be dedicated to sugar cane for alcohol extraction. A feasibility study was performed during the Somoza regime. Financial support for this project is uncertain, although availability and appropriateness of raw materials and current technologies appear to present no serious concerns. The effort, however, appears to have strong agency rather than federal government support and interest at this time.

5.3 Current Energy Use in Nicaragua

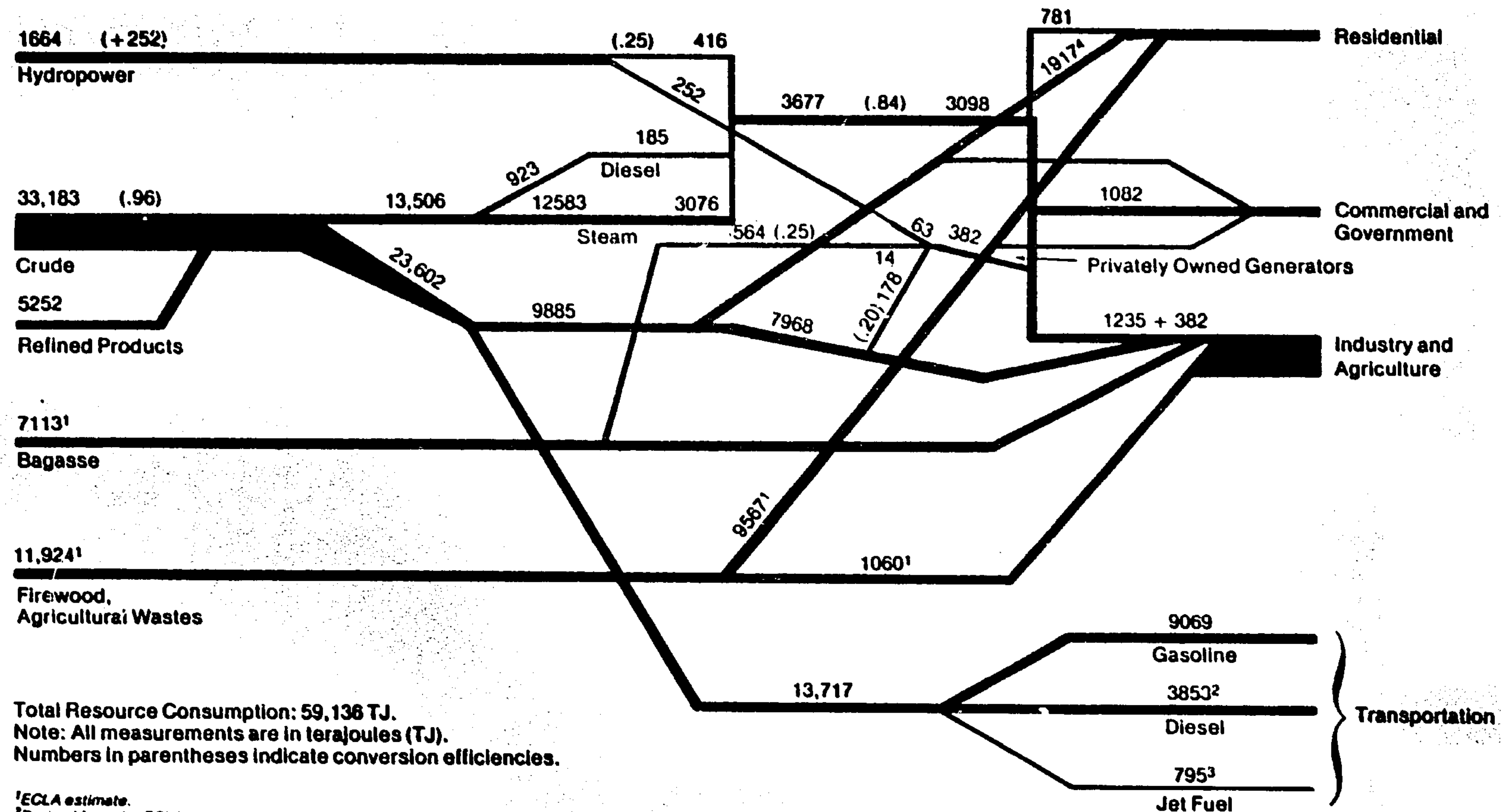
Energy consumption in Nicaragua amounted to 59,136 TJ in 1977 of which 65 percent represents petroleum use, 22 percent represents non-commercial fuel use and less than 3 percent is hydroelectricity. Figure 5-2 depicts the flow of energy resources to the final demand sector. Resource utilization by the electric utility sector (for both public utility and industrial autoproductores) is also indicated. The following sections describe the principal features of Nicaragua's energy use patterns, starting with the main supply sectors (i.e., petroleum and electricity) followed by the major demand sectors: industry, transportation, and households.

Electric Sector

The growth rate of electrical sales was approximately 14 percent in the period 1973 to 1977, with the largest growth in sales to the public works and commercial sectors. Industry is the major electrical consumer, but its consumption is growing at a much slower rate (9 percent) than the other sectors.

Electricity in 1974 was 43 percent hydro, and the remainder thermal, but in 1977 hydroelectricity generation was only 11 percent of the total. The installed hydro capacity remained constant, but thermal capacity more than doubled in the period 1975 to 1977.

The thermal generating capacity of Nicaragua has been growing steadily over the years. The largest oil-steam driven plant, Planta



Total Resource Consumption: 59,136 TJ.
Note: All measurements are in terajoules (TJ).
Numbers in parentheses indicate conversion efficiencies.

[1]ECLA estimate.
[2]Derived from the ECLA breakdown between diesel used in transport and in other sectors.
[3]Derived from ECLA breakdown on kerosene used in transport and other sectors.
[4]LPG and kerosene used in households, ECLA breakdown.

0-999 TJ
1000-14,999 TJ
15,000-50,000 TJ

FIGURE 5-2
ENERGY FLOW FOR NICARAGUA IN 1977

Nicaragua, went into operation in 1977 with an installed capacity of 100 MW. Planta Managua, the other oil-steam driven plant, has an installed capacity of 75 MW.

The Instituto Nicaraguense de Energia (INE) is Nicaragua's principal energy supplier with an installed capacity of 305 MW. The hydro generating capacity has remained constant over the years at 100 MW, with two 50 MW plants. The remaining installed capacity consists of a 15-MW plant and several smaller plants driven by diesel or gas turbines. (See Table 5-7.)

In addition to INE, electricity generated by small diesel or gas turbine plants amounts to 55.6 MW. (See Table 5.8.)

Electrical energy generation and consumption has decreased considerably since 1977 due to political unrest in late 1978 culminating with the change in government in July of 1979. The economic situation is expected to stabilize, and electrical consumption is expected to reach 1977 levels by 1981.

Petroleum Sector

Crude petroleum imports amounted to 5.4 million barrels in 1977, constituting 87 percent of all petroleum imports. Refined product imports amounted to 0.8 million barrels or 13 percent of imports.

Total consumption of petroleum products was 6.2 million barrels (37,515 TJ) in 1977, of which 36 percent went to the transport sector in the form of gasoline, diesel and jet fuel, 38 percent was used to generate electricity, and the remaining 26 percent was consumed inindustrial, residential, and commercial sectors in the form of kerosene, asphalts, feedstocks, etc. (See Table 5-9.)

TABLE 5-7

NICARAGUA

ELECTRIC SECTOR DATA

	1973	1974	1975	1976	1977
Total Installed Capacity					
MW	217	217	205	255	305
Hydro	NA	NA	100	100	100
Steam	NA	NA	75	125	175
Diesel and Gas Turbine	NA	NA	30	30	30
Maximum Demand (MW)					
Generation, Gross (GWh)	618	770	827	950	1,074
Generation, Net (GWh)	NA	NA	799	917	1,021
Hydro			355	380	121
Steam			452	541	899
Diesel and Gas Turbine			20	29	54
Sales, Total (GWh)	506	636	674	777	861
Residential	117	146	174	192	217
Industrial	242	298	289	324	343
Commercial[1]	79	111	116	137	157
Public Works[2]	68	81	95	125	143

[1] Includes government and public lighting.

[2] Irrigation and water pumping (drinking supply).

Source: Instituto Nicaraguense de Energia (INE).

TABLE 5-8

NICARAGUA

AUTOPRODUCTORES, ELECTRIC CAPACITY AND GENERATION, 1977

	Total	Hydro	Diesel Gas Turbine	Steam
MW				
Sugar	26.8	.6	.7	25.5
Mining	14.4	2.4	12.0	0
Cement	2.8		2.8	
Refinery	1.7		1.7	
Other			9.9	
Total	55.6	3.0	27.1	25.5
GWh				
Sugar	41.1	.7	1.3	39.1
Mining	47.8	16.9	30.9	0
Cement			0.1	
Refinery			8.0	
Other			9.0	
Total	106.0	17.6	49.3	39.1

Source: Instituto Nicaraguense de Energia (INE).

TABLE 5-9

NICARAGUA

PETROLEUM CONSUMPTION, 1977

	Production		Imports		Total Supply	
	10^3 bbls	TJ	10^3 bbls	TJ	10^3 bbls	TJ
LPG	184.9	782	-	-	184.9	782
Gasoline	1,491.0	8,260	146.1	809	1,637.1	9,069
Kerosene/Jet Fuel	337.9	2,021	41.6	249	379.5	2,270
Diesel	1,387.6	8,527	330.0[1]	2,028	1,717.6	10,555
Residual	1,754.4	11,632	326.7	2,166	2,081.1	13,798
Asphalts and Other	113.0	692	-	-	113.0	692
Feedstocks	57.0	349	-	-	57.0	349
Total	5,322.8[2]	32,263	844.4	5,252	6,167.2	37,515

[1] Includes gas oil.

[2] Crude imports 860.8×10^6 lts. = $5,422 \times 10^3$ bbls

Source: Banco Central de Nicaragua, Departamento de Estudios Economicos.

Non-Commercial Fuels Sector

Nicaragua's total energy supply is comprised of 35 percent non-commercial fuels, 22 percent fuelwood and agricultural wastes,and 13 percent bagasse. The 7113 TJ of bagasse are allocated solely to the sugar industry. However, firewood and agricultural wastes, areused predominately in the residential sector, with small quantities consumed in the industrial sector. The breakdown is approximately 9567 TJ (80 percent) for the residential sector, and 1060 TJ (20 percent) for industry. Households account for 90 percent of firewood consumption.

Industrial Sector

Industrial fuel use in Nicaragua comprised of both commercial and non-commercial fuels, is a combination of electricity, petroleum products, firewood, and bagasse.

All of the bagasse and some firewood is consumed by the sugar mills, while the remainder of the fuelwood allocated to industry is consumed in a number of small industries such as bakeries and salterns. Twenty-four percent of the electricity consumed by industry is produced by the autoproductores for their own use, and the rest purchased from the national electrical system. Industry bought 343 GWh of electricity in 1977, 40 percent of the public utilities' total sales. The autoproductores produced and consumed another 106 GWh of electricity.

Residential Sector

According to the 1971 Census of Housing, about 80 percent of households use firewood and charcoal for cooking and the rest use LPG and kerosene. Less than 1 percent use electricity (see Table 5-10). A significant amount of urban households use firewood for cooking which is transported by truck and sold commercially. Water heating

TABLE 5-10

NICARAGUA

RESIDENTIAL SECTOR COOKING FUELS

	Percent of Households
LPG	10
Firewood	77
Electricity	0.7
Charcoal	2.6
Kerosene	10

Source: Censo de Poblacion y Vivienda, Nicaragua, 1971.

and air conditioning are rarely used in private homes. Public buildings such as offices, stores and restaurants are air conditioned in Managua.

Transportation Sector

The transportation sector in Nicaragua depends heavily on motor vehicles for both freight and passengers. The railroad, which connects the country's main port, Corinto, with the three principal cities of Leon, Managua, and Granada, needs repairs. Its volume of traffic declined during the mid-seventies (see Table 5-11) and by the end of the decade it provided minimal service.

Gasoline use in 1977 amounted to 1637 thousand barrels (9069 TJ). The use of diesel fuel is not known. ECLA allocates 51 percent of diesel's final use (excluding consumption by electric public utilities) to the transportion sector, while one of the petroleum distributors, which may be representative of all four in the country, claims it sells only 25 percent of its diesel to service stations. Also unknown is the breakdown among diesel- versus gasoline-operated trucks, buses and autos. Only the overall distribution of registered vehicles is known for the mid-seventies (see Table 5-12). It was resolved to allocate 3853 TJ (40 percent) of final consumption of diesel to transportation. Jet fuel consumption is estimated at 133 thousand barrels (795 TJ) based on ECLA's proportion of kerosene used in the transportation sector.

The state of urban public transportation system is poor, especially in the capital. The parts of Managua which have been rebuilt after the 1972 earthquake have been deliberately dispersed, thus giving the city the appearance of North American cities with shopping centers along highways and with scattered housing. Public transportation is served, due to a shortage of buses, by an ad-hoc

TABLE 5-11

NICARAGUA

RAILROAD STATISTICS

(Millions)

	Passenger Km	Ton Km
1972	28.0	13.9
1973	22.9	12.5
1974	21.8	11.1

Source: Wilbur Smith Assoc. and Cisneros y Coronado Co. Ltda., Nicaragua National Transport Study, 1975.

TABLE 5-12

NICARAGUA

VEHICLE REGISTRATION

(Thousands)

	1972	1973	1974	
Total	45.2	45.4	52.2	
Passenger Cars[1]	30.3	29.9	33.8	(65%)
Buses	2.5	1.7	1.9	(4%)
Trucks	4.7	5.0	5.8	(11%)
Small Trucks and Vans	6.8	8.3	10.1	(19%)
Other	0.9	0.5	0.6	(1%)

[1] Includes jeeps and taxis.

Source: Wilbur Smith Assoc. and Cisneros y Coronado Co. Ltda., Nicaragua National Transportation Study, 1975.

system of private individuals driving small trucks that pick up passengers along certain routes.

Intercity traffic takes place largely along the Pacific coast. Freight, mainly agricultural products moves by truck to ports, and trade with neighboring countries takes place via the Panamerican Highway. The Atlantic region, which covers about one half of the country, but is sparsely inhabited, has no road system; traffic moves east-west on river barges to the ports on the Atlantic. Utilization of Lake Nicaragua as a waterway to access remote farming areas is planned for the future, but at present little shipping exists on the system of lakes.

5.4 Future Energy Use in Nicaragua

5.4.1 Electric Sector Expansion Plans

Nicaragua's electricity demand is largely met by thermal plant generation. The public utility, INE (Instituto Nicaraguense de Energia), provides most of the electricity for the country, and the installed capacity is made up of 100 MW hydro and 205 MW thermal.

Plans for the development of a 35-MW geothermal plant by 1985 are being executed, while funding for a 300-MW hydroelectric project at Copalar is being negotiated. ECLA postulates that the first stage of the Copalar plant will be in operation by 1991, and an expansion of another 300 MW will occur by 1995.* ECLA also expects geothermal generation to grow substantially in the 1980s and 1990s to an installed capacity of 245 MW by the year 2000, by means of a series of small plants of approximately 35 MW each.**

*CEPAL, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, October 1979.

**CEPAL, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, October 1979.

Events were disrupted by the July 1979 revolution, and the time frame discussed by ECLA must be rearranged according to the economic stabilization, and the new government's plans.

5.4.2 Energy Growth Projections

Future energy requirements in Nicaragua are calculated in this section on the basis of a projected GNP growth rate of 5 percent per year for the period of this analysis. As discussed in Section 5.1, all economic indicators, including electricity and petroleum consumption, have fallen. Also, as a result of the war, an estimated 1 to 2 percent of the population lost their lives. Despite these events, we assume that during the next twenty years the long-term trends will prevail. Thus, we use CELADE's population projection of 3.23 percent per year (one of the highest in the area), based on pre-war trends.* Urban population growth is estimated at 4.9 per cent, and by the year 2000 it will represent 68 percent of total population. Historically, Nicaragua has the second highest ratio of urban population of the region, next to Panama.

Electric Sector Projections

Electricity sales are escalated at an average annual growth rate of 7.5 percent, 1.5 times the growth in GNP, for a 23-year period. As previously mentioned, in 1980 or 1981 electricity sales will reach the levels of 1977 or 1978, but when economic stability is achieved, electricity sales should increase faster than 7.5 percent per year. The rates observed during the mid 1970s are the order of a 14-percent average per year, with the residential and commercial sectors growing at about 18 percent and the industrial sector at 9 percent. If this

*CELADE, "America-Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985 y 2000," Boletin Demografico, January 1979.

trend continues (due to urban migration, amplification of the interconnected electricity system and the predominance of air conditioning in buildings and stores), industry will fail to achieve its 40-percent share in total electricity purchases. Another factor to be underscored is the "autoproductores," whose generation constitutes nearly one quarter of total industrial use of electricity. If autoproductores were to connect to the grid, the share of total electricity consumed by industry would tend to increase.

Electricity sales and generation in the year 2000 are projected to be 4541 GWh and 5390 GWh respectively (see Table 5-13). The latter is considerably lower than ECLA's demand estimate observed for other countries. Nicaragua's electricity growth in large part will depend on generation costs. It appears that its limited hydro resources are very costly to develop (that is, more than neighboring countries) and that the cost of widespread geothermal electricity will not be known until more exploration is undertaken.

Petroleum Demand Projections

The demand for petroleum fuels by industry, transport, and households is estimated at 5.2 percent per year for Case I and 3.4 percent per year for Case II. These growth rates are obtained by applying the income and the price elasticities discussed in Section 2.4.1 to the postulated GNP growth of 5 percent and a real increase in the price of oil of 5 percent per year over the period of the projection. Consumption levels of 1977 of some 3.9 million barrels (23,602 TJ), excluding electric generation, grow to 12.4 million barrels (75,737 TJ) in Case I and 8.3 million barrels (50,924 TJ) in Case II (see Table 5-14).

TABLE 5-13

NICARAGUA

ELECTRICITY DEMAND PROJECTIONS

	1977	2000	Growth Rate (%) 1977-2000
Total Electricity Sales			
(GWh)	861	4,541	
(TJ)	3,098	16,348	7.5
Losses			
(GWh)	160	849	
(TJ)	579	3,055	7.5
Total Generation			
(GWh)	1,021	5,390	
(TJ)	3,677	19,403	7.5

Source: MITRE/E/DI.

TABLE 5-14

NICARAGUA

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

		Year 2000	
	1977	Case I	Case II
Total Direct Uses	23,602	75,737	50,924
Industry	7,968	25,569	17,192
Transport	13,717	44,017	29,596
Residential	1,917	6,151	4,136

Source: MITRE/E/DI.

Non-Commercial Energy Projections

For projection purposes, non-commercial energy is escalated at the rate of growth of total population, estimated at 3.23 percent per year. By applying this growth rate a total non-commercial energy use of 39,549 TJ is obtained, using ECLA's estimate of total use in 1977. Indications are that actual use is likely to be higher, but no other quantification is available at this time. Relative to other countries in the region, Nicaragua probably has the greatest potential growth in agricultural production due to its size and the availability of underdeveloped land. Sugar production rose by a factor of five in the decade up to the mid-seventies, which indicates rapid growth in bagasse output. Projects exist involving biomass for use in electric generation. On the other hand, the availability of charcoal and firewood in urban areas, where a majority of the population will live by the year 2000, could also impact total future consumption. At present, the urban dwellers are able to purchase non-commercial fuels which are transported by trucks into cities.

5.4.3 Future Energy Resource Consumption

A final energy balance for the year 2000 in Nicaragua requires a calculation of the estimated resource mix to meet the electric generation requirements. Historically, the country has depended on oil for a large part of its electric generation, and will continue to, unless geothermal energy proves feasible and extensive resources can be effectively allocated in the near future. Table 5-15 summarizes a possible scenario for Nicaragua in meeting its electricity demand in the year 2000. Hydropower, which appears to be more costly to build than in other countries in the region, is expanded by 400 MW to a total of 500 MW. This would either involve one of the large 300-MW sites for which there are feasibility studies or a number of smaller sites. Smaller sites are estimated to be more expensive on a cost-per-kilowatt-hour basis, but may be a more attractive option on account of total investment required.

TABLE 5-15

NICARAGUA

ELECTRICITY SUPPLY BALANCE, YEAR 2000

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use (TJ)
Hydro	500	2,200	7,920	31,680
Existing	100			
New Sites	400			
Geothermal	245	1,500	5,400	21,600
Planned	35			
Other Development	210			
Thermal	405	1,700	6,120	24,480
Existing	205			
Expansion	200			
Total Generation		5,400		
Total Demand		5,390		

Source: MITRE/E/DI.

More importantly, the capacity expansion scenario involves the installation of 245 MW of geothermal, which is rather high considering that at present little experience exists in the country and that the first 35 MW may not be in place until 1982 or 1983. The alternative would be to rely more heavily on hydroelectricity, which is costly, or on electric linkages with neighboring countries that may have surplus hydro.

Finally, an additional 200 MW of oil-fired generation would be added to the existing 205 MW. Under the assumption that these plants cannot substitute imported coal or biomass derived domestic fuel, their requirements by the year 2000 would amount to about 3.7 million barrels, a considerable increase over the 2.0 million barrels used for electric generation in 1977.

A tabulation of the total resource consumption for Nicaragua in the year 2000 is presented in Table 5-16, with the year 1978 included for comparison.

5.5 Energy Strategies for Nicaragua

Table 5-17 summarizes the impact or the contribution of oil substitution and conservation, as a percentage of total projected petroleum demand. In addition, the potential contribution of ethanol and methanol are shown as a percentage of current gasoline use.

Substitution of Oil

The electricity demand projections for Nicaragua show petroleum supplying a significant part of total generation. Petroleum substitution could be achieved by a more rapid expansion of the hydroelectric potential; 500 MW are assumed to be developed by the year 2000, out of an estimated total potential of 4,400 MW. Little is known, however, about feasible sites amounting to more than 500 MW. The

TABLE 5-16

NICARAGUA

TOTAL RESOURCE USE (TJ)

	1978	Year 2000 Case I	Year 2000 Case II
Hydro	1,664	31,680	31,680
Geothermal	0	21,600	21,600
Petroleum	38,435	100,217	75,404
Direct Uses	23,602	75,737	50,924
Electric Generation	13,228	24,480	24,480
Losses, Other	1,605	NA	NA
Non-Commercial	19,037	39,549	39,549
Total Resources	59,136	193,046	168,233

Source: MITRE/E/DI.

TABLE 5-17

NICARAGUA

IMPACT OF SELECTED STRATEGIES

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substituting 50% of petroleum used in electric generation with hydro, coal, geothermal or imports	12.0%	---
b. Same as (a) with 100% substitution	24.0%	---
c. Production of 10% of ethanol potential[2]	0.3%	4.0%
d. Production of 25% of ethanol potential[2]	0.8%	9.0%
e. Production of 0.5% of methanol potential[3]	2.5%	28.0%
f. Production of 1.0% of methanol potential[3]	5.0%	57.0%
g. Substitution of electricity for petroleum-based processes, vehicles, etc.	negligible	---
II. Conservation		
a. Conservation in industry (15%)	3.8%	---
b. Conservation in transportation (20%)	8.8%	---
c. Savings in electricity use (10%)	7.8%	---

[1]Using Case I petroleum demand as a basis.

[2]Percentage of current land devoted to sugar cane to be dedicated to energy production, or equivalent area added to cultivation.

[3]Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

two decades which our analysis considers is not enough lead time to assume a total replacement of oil-based electric generation with hydro. Another alternative is the biomass fuel substitution with leucaena or other fast growing species; the feasibility of converting the 100 MW Managua thermal plant to leucaena via direct combustion or by gasification is being investigated. Lastly, importing electricity from Honduras, which has been done in a limited fashion during the late 1970's also ought to be considered.

The contribution of ethanol and methanol, assuming that the equivalent of 25 percent of the area presently cultivated with sugar cane is devoted to ethanol production and that 1 percent of yearly forest growth is converted to methanol, amounts to 5,980 TJ. This represents 14 percent of fuel demand by the transportation sector; over 85 percent of the fuel is methanol.

Conservation

The lack of a systematic data base precludes a full-evaluation of conservation potential; only general statements such as outlined in Section 2.6.2 of Volume I can be formulated. The results of reducing oil demand through 15-percent conservation in industry are 3,800 TJ and through 20-percent conservation in transportation are an additional 8,800 TJ (applied to Case I). A 10-percent reduction in total electricity demand would reduce petroleum use by 7,700 TJ.

5.6 Recommendations to USAID for Nicaraguan Energy Programs

The following recommendations are intended as a refinement, and in some cases an expansion of the regional recommendations presented in Volume I. Where regional recommendations do not appear as national recommendations, the regional recommendations are still valid.

Technical Training

Site visits revealed that Nicaraguan government personnel could benefit from technical training in the following areas:

Fossil Fuels

In order to develop its geothermal and hydrocarbon resources, Nicaragua needs petroleum engineers and geologists. While it is not expected that Nicaragua will be in a position to conduct petroleum exploration and development programs for some time, government officials, nevertheless, need to understand hydrocarbon geology and technologies, if only to protect Nicaraguan interests when entering into leasing agreements. Where geothermal resources are involved, the government needs geoscientists, trained drilling crews, and equipment in order to conduct its own exploration and development programs. Also, hands-on geothermal experience is needed to maintain plant and equipment. USAID should therefore consider an educational program which would allow Nicaraguan students and officials to attend American universities with specialized curricula in geophysical exploration and development (e.g., the University of Texas).

Energy Planning

Officials in the Ministries of Transportation, Planning, and other agencies could benefit from training in the techniques of integrated planning. As indicated in the section, "Technical Analyses" which follows, Nicaragua needs to address energy objectives as part of its transportation expansion program. Another major opportunity for the application of planning skills is in developing specific objectives for the use of nonconventional energy resources in Nicaragua. Again, educational programs should be considered.

Financial Support

Nicaragua has significant geothermal resources, 4,000 MWe to 6,000 MWe, but exploration and development activities are hindered by lack of investment funds. USAID should consider direct financial aid to help develop geothermal sites.

Resource Assessment

In many cases, accurate data regarding Nicaraguan domestic energy resources are not available. USAID should therefore consider initiatives to collect and integrate data. USAID could make an important contribution by implementing a program to identify, and assign priorities for, sites for minihydro development. The economic and social tradeoffs between minihydro development versus extension of the existing electric grid should also be explicitly identified and measured as part of this program.

Technical Analyses

In several instances, USAID could make a significant contribution to Nicaraguan energy development by providing technical support in critical areas such as the environmental sciences.

One of the problems with the use of geothermal energy in Nicaragua, for example, is the lack of a clear strategy for controlling the air and water emissions associated with brines. While it is our impression that Nicaragua plans to develop its geothermal resources in spite of environmental costs, USAID's assistance in minimizing enviromental damage would be very helpful.

USAID should also explore possibilities for providing technical support to the Nicaraguan Institute of Agrarian Reform in optimizing processes for producing ethanol from sugar cane. A substantial amount of adaptive and development research must be done to make use of the existing feasibility study. Cultivation and management of biofuels is another area that should be targeted for USAID support. Nicaragua's farm land mass exceeds its needs for food production, and considerable interest exists in the country for biomass to energy projects.

APPENDIX 5-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

Table 5.A-1 lists Nicaraguan institutions that are active in energy research and development. It contains descriptions of each institution's activities.

TABLE 5.A-1

NICARAGUA

ENERGY RESEARCH AND DEVELOPMENT

Technology/Resource	Institution	Product or Activity
ALCOHOL	Ministerio de Industria y Comercio	Prepared gasohol feasibility study.
	Instituto de Reforma Agraria	Produced plan for alcohol distillation from cane. Alcohol program is first priority of institution.
BIOGAS	Ministerio de Industria y Comercio, Centro de Investigacion Tecnologico	Prepared study on production of biogas from bamboo, cana brava, Taiwan grass and eucalyptus.
	Instituto de Reforma Agraria	Plans to develop a project for cultivation of Leucaena and Taiwan grass for biogas production to fuel thermalelectric plants.
COAL		No activity.
GEOTHERMAL	Instituto Nicaraguense de Energia	Thirty-two wells drilled during Samoza government at Momotombo site. Plans a 35-MW plant at Momotombo in 1981. Estimates national geothermal potential at 4,000 MW to 6,000 MW.
MINIHYDRO	Instituto Nicaraguense de Energia	In collaboration with UNDP, has identified 3 demonstration sites, with a capacity of 50 KW each.
PETROLEUM	Instituto de Recursos Naturales	Plans to evaluate drilling activities by various multinational oil companies.
SOLAR		No activity.
WIND		No activity.
WOOD		See "biogas" above.

APPENDIX 5-B

ENERGY-RELATED INSTITUTIONS

During the MITRE/E/DI visit to Nicaragua, a number of institutions were contacted, including:

- government agencies
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in Nicaragua; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audiences
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION:	AGROINRA
CONTACT:	Saul Lewites
LOCATION:	Kilometro 3, Carretera Masaya, Managua, Nicaragua
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Restores and expands agricultural production in government-owned farms, sugar mills, coffee beneficiation plants • Improves of farm productivity through increased use of fertilizers, introduction of better-yielding and disease-resistant crops, and provision of credit and marketing facilities
TARGET AUDIENCE:	General public, farmers, agro-industrial workers
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	A branch of the Instituto de Reforma Agraria.
PRODUCTS, SERVICES, CAPABILITIES:	• Plans to begin ethanol production from sugar crops

INSTITUTION:	Instituto de Recursos Naturales (IRENA)
CONTACT:	Jorge Jenkins Director
LOCATION:	Managua, Nicaragua Kilometro 12 1/4 Panamericana Norte
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Deals with forestry, mining, fishing, environment, soils and hydrocarbons • Emphasizes rational development and commercialization of natural resources, including fossil fuels • Serves as a link between government developmental plans and industrial endeavors in natural resource sectors • Analyzes environmental problems in light of development options
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Created in 1979 by combining elements from several organizations
PRODUCTS, SERVICES, CAPABILITIES:	• Introduction of natural resources reform legislation and formulation of policies • Development of incentives and mechanisms for exploitation of natural resources

INSTITUTION: Instituto Nacional de Reforma Agraria (INRA)

CONTACT: Noel Somarriba

LOCATION: Managua, Nicaragua

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Organizes and develops government-owned farmlands
- Researches and develops quick-growing plants (Leucena, Taiwan grass, and bamboo) with biomass potential

TARGET AUDIENCE: General public, farmers

LEGAL AND FINANCIAL SETTING OF INSTITUTION: Responsible for formulating and implementing agricultural and land-ownership policies

PRODUCTS, SERVICES, CAPABILITIES:

- Experiments with unharvested lands as a potential source of fuels
  - Major resources are Taiwan grass, bamboo, and Leucaena, a fast-growing tree.
  - Major goals are to produce low-cost fuels that are available in sufficient quantities to replace fossil fuels used in thermal electric plants by INE.
- Performs economic assessment projects
  - Leucaena and Taiwan grass have been planted and periodically conditions at sites are measured and performance of crop yields are analyzed.

- Transportation and production of chemicals from raw materials will be done by INE.

- A privately owned plant in Rama is now installing a gasifier, and INRA is negotiating with the plant to use Taiwan grass to generate electricity. The Rama plant's use of an alternative source of energy will provide practical experience.

INSTITUTION:	Instituto Nicaraguense de Energia (INE)
CONTACT:	Alejandro Guerrero Director, Division de Sistemas de Planificacion
LOCATION:	Managua, Nicaragua
TELEPHONE:	26639
DESCRIPTION OF INSTITUTION:	• Provides electrical energy to residential, commercial, industrial, and governmental sectors as the national electric institute (formerly ENALUF) • Establishes requirements for new electric power generating capacity and related options • Defines technology options mainly for electric utility market • Computes costs of competing technologies • Develops analytical methods for projecting capacity requirements, program assessments, and planning efforts
TARGET AUDIENCE:	Consumers of electric energy
LEGAL AND FINANCIAL SETTLING OF INSTITUTION:	• Reorganized in 1979 • In addition to thermal and hydro-electric power generation, INE is responsible for nonconventional energy sources (including geo thermal) • Local counterpart for two UNDP projects: the minihydro and the energy balances projects

PRODUCTS, SERVICES, CAPABILITIES:

- Performs engineering designs, economic assessments, technical assessments, plant constructions, and RD&D projects (related to the electric sector)

- Emphasizes substitution of thermal power generation; current knowledge of geothermal resources enabled INE to estimate development cost for geopressured resources are less expensive than development costs for large-scale hydro projects. It is anticipated that geothermal will provide 35 MW of future base load in 1980 and reach 800 MW by the year 2000.

- Considers and studies alternative energy technologies (biomass, direct solar, wind) as partial solutions to substitution of thermal electric power capacity. It is aware that information and R&D are needed to substitute local resources for imported fossil fuels.

INSTITUTION:	Ministerio de Planificacion Nacional
CONTACT:	Patricia Fulgueria Ciencia, Tecnologia, Cooperacion Tecnica
LOCATION:	Managua, Nicaragua
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Reviews policy-making at higher levels • Coordinates relations among government agencies • Emphasizes the establishment of economic and social goals by precise specification of target and governmental allocation of resources
TARGET AUDIENCE:	General public, business, government
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	The role of the organization is not fully defined; at this point, however, the Ministry is to respond pragmatically to the need for development in various areas
PRODUCTS, SERVICES, CAPABILITIES:	• Reviews all governmental proposals and establishes criteria for selecting projects including energy-related endeavors • Reviews and approves budgetary allocations • Examines ways to increase domestic growth rate and to reduce income inequalities

Bibliography

CELADE (Centro Latinoamericano de Demografia), "America-Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985 y 2000," Boletin Demografico, Ano XII, No. 23 (January 1979).

Censo de Poblacion y Vivienda, Nicaragua, 1971.

ECLA. Economic Projections for Central America, 1979. Mexico: CEPAL, 1979.

____, Estudio Regional de Interconexion Electrica del Istmo Centroamericano, CEPAL/MEX/SRNET/28. Mexico: CEPAL, October 1979.

____, Nicaragua: Economic Repercussions of Recent Political Events, E/CEPAL/G.1091. Mexico City: CEPAL, September 1979.

German Agency for Technical Cooperation, Ltd. Masterplan for Electricity Supply, Volume I (text). Guatemala: INDE, May 1976.

Wilbur Smith Associates and Cisneros y Cornado Co., Ltda. Nicaragua National Transport Study, 1975.

World Bank. Economic Report. Washington, D.C.: World Bank, no date.

6.0 COSTA RICA

6.1 Geographic, Social, and Economic Aspects of Costa Rica Energy Development

Geography

Costa Rica is located in the southern half of the isthmus of Central America, between Nicaragua and Panama. It comprises the second smallest land area (20,000 square kilometers).

Topographically, Costa Rica can be divided into four regions: the Meseta Central, the Pacific coastal plains, the Caribbean lowlands, and the southwestern plains.

The Meseta Central is a plateau 3,000 to 4,000 feet above sea level which is formed by the Cordillera Central, a mountain chain running northeast to southwest through the center of Costa Rica. The slopes of the Meseta Central provide ideal growing conditions for coffee, corn, rice, and sugar. San Jose, the capital and largest city, is located at the eastern end of the Meseta.

The Pacific coastal plains lie between the Meseta Central and the Pacific Ocean. Despite a three-month dry season, this region is noted for cattle ranching, banana growing, forestry, and fishing.

The Caribbean lowlands are the coastal areas north of the Meseta and south of the Caribbean Sea. A hot, tropical area, this region is densely forested, but does support some agricultural production (e.g., cacao, hemp, rubber, corn, yucca, and fruit).

The southwestern plains lie between the Pacific Ocean and the Meseta Central at the southeastern end of Costa Rica, and include the Osa Peninsula. African oil palms, rice, cacao, and corn are produced here, although a trend toward urbanization--spurred by construction of the Inter American Highway and an irrigation project in the Tempisque Valley--is beginning to compete for available land.

The population of Costa Rica totalled 2.154 million in mid-1977 and is growing at about 2.4 percent a year. About 70 percent of all Costa Ricans live in the Meseta Central; about 44 percent live in cities.

Economy

Costa Rica's Gross Domestic Product totaled $2.37 billion in 1978, or $1,099 per capita. Table 6-1 indicates growth and composition of GDP during the period 1970 to 1975.

The agricultural sector dominates the economy, generating about 20 percent of GDP and about two-thirds of the nation's export earnings. Thus, this sector helps to minimize imports of costly foodstuffs, while providing the major portion of foreign exchange. Over a third of the labor force is employed in the agricultural sector. Production is weighted toward coffee ($155 million) and bananas ($145 million); but also includes beef ($36 million), sugar ($25 million), and cocoa ($6 million). However, banana and coffee sales represent over 50 percent of total export earnings, making Costa Rica vulnerable to fluctuations in world commodity markets (see Table 6-2).

The industrial sector accounts for about 22 percent of GDP and, contributes one-third of the nation's export earnings. About 12 percent of the labor force is employed in industry. Production is concentrated in finishing operations, since two-thirds of all raw materials must be imported. Thus, the manufacturing sector's contribution to the balance of payments is not completely positive; materials and equipment for manufacturing account for a large share

TABLE 6-1

COSTA RICA

GROSS DOMESTIC PRODUCT BY SECTOR, 1970-1975

(millions of current colones)

	1970	1971	1972	1973	1974	1975
GROSS DOMESTIC PRODUCT (at market prices)	6,524.5	7,137.0	8,215.8	10,162.4	13,178.0	16,507.2
Agriculture	1,469.3	1,443.4	1,601.6	1,962.9	2,522.4	3,283.2
Mining and Manufacturing	1,192.2	1,325.0	1,507.1	1,903.3	2,677.9	3,302.7
Construction	277.4	343.3	423.8	507.1	654.9	833.2
Public Utilities	109.8	127.8	147.9	160.3	205.9	288.5
Transport and Communications	274.2	316.0	362.0	435.6	590.7	776.2
Commerce	1,371.3	1,502.0	1,651.3	2,054.5	2,754.7	3,252.5
Banking, Insurance and Finance	302.7	321.0	404.5	508.5	635.3	832.0
Housing	498.7	524.9	553.4	626.5	784.8	987.2
Public Administration and Defense	693.2	813.6	998.0	1,196.6	1,576.4	2,141.9
Personal Services[1]	335.7	420.0	566.2	807.1	775.0	809.8

[1] Includes statistical discrepancy.

Source: World Bank.

TABLE 6-2

COSTA RICA

VALUE OF EXPORTS BY PRODUCT, 1970-1976

in millions of U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976[1]
Coffee	73.1	59.3	77.9	94.0	124.8	96.9	154.8
Bananas	66.8	64.0	82.8	90.7	98.4	144.1	144.9
Beef	18.0	20.5	28.3	31.5	34.2	32.1	36.4
Sugar	10.1	12.9	13.1	21.5	24.4	48.2	24.6
Cocoa	1.9	1.5	3.0	4.4	5.9	5.3	5.8
All other goods	61.3	67.2	75.8	102.4	152.6	166.7	220.0
Total	231.2	225.4	280.9	344.5	440.3	493.3	586.5

[1]Estimate.

Source: World Bank.

of the total import bill. Most export products are sold to members of the Central American Common Market (CACM).

Balance of Payments

Costa Rica's balance of payments performance over the last two decades has been impressive: exports have grown at an average rate of 10 percent a year in real terms since 1960. However, accompanying this strong export growth has been an even faster growth in imports. As a result, Costa Rica's trade deficit has increased over time (see Table 6-3).

The country's most severe balance of payments crisis occurred in 1974, the result, indirectly, of the October 1973 oil price increases. The OPEC price hike caused Costa Rica's oil import bill to double from $29.8 million in 1973 to $63.0 million the following year. The value of Costa Rica's exports did not grow as quickly during 1974, 1975, and 1976 as the value of its imports, hence the heavy trade deficits during those years.

The government responded by expanding credit, with the result that GDP did grow in Costa Rica in 1974 (4.4 percent) and 1975 (3 percent), despite a world-wide recession. But the price for this growth was a rapidly escalating trade deficit. Expressed as a percentage of GDP, the trade deficit doubled between 1973 and 1974, from 8.4 percent of GDP to 17 percent.

When the government realized that expansionary policies were exacerbating the deficit, it took steps to stem the growth of imports and boost exports. Consumer credit for installment buying was tightened, consumption and sales taxes were raised, support prices for basic grains were increased, and export taxes were reduced generally.

TABLE 6-3

COSTA RICA

BALANCE OF PAYMENTS, 1970-1976

(millions of dollars)

	1970	1971	1972	1973	1974	1975	1976[1]
Exports (goods and n.f.s.)	280.2	283.8	346.4	418.7	528.6	596.4	714.5
Imports (goods and n.f.s.)	346.5	390.7	418.2	499.6	765.7	770.3	866.0
Resource Balance	-66.3	-106.9	-71.8	-80.9	-237.1	-173.9	-151.5
Net Factor Services and Transfers	-7.7	-7.1	-28.2	-31.0	-33.4	-44.1	-53.5
Current Account Balance	-74.0	-114.0	-100.0	-111.9	-270.5	-217.0	-205.0
Change in Reserves	11.7	-11.5	-5.8	-17.9	22.9	-20.9	-64.7
Gross International Reserves[2]	..	29.4	42.9	51.0	44.7	51.2	97.8

[1] Estimate.
[2] Gross international reserves data were taken from *International Financial Statistics*, International Monetary Fund (IMF), December 1978 and April 1979. The IMF figures may not total exactly from the World Bank data as the IMF provides *gross* international reserves while the World Bank provides change in *net* international reserves.

.. Not available.

Source: World Bank and International Monetary Fund.

These measures were effective, and the Current Account deficit decreased in 1975. Higher coffee prices, growth in exports of manufactured goods, and continued restrictions on imports caused another decrease in the Current Account deficit in 1976.

Prospects for Development

The prospects for growth in Costa Rica over the near term are qualified. World inflation and lower coffee prices can only exacerbate the country's foreign trade imbalance, which is already described as Costa Rica's most pressing economic problem. The nation's debt service ratio now stands at about 10 percent.

Rapid growth, the traditional cure for trade deficits, will be harder to maintain in Costa Rica than in the past. The agricultural sector will be constrained by the limited amount of virgin land which can be brought into production, while the industrial sector will be limited by the deterioration of the Central American Common Market. The demise of the CACM is eliminating markets for Costa Rica manufactured goods, and is discouraging private investment in Central America generally.

Inflation is another major problem. Fueled by the government's inability to curb expansionary monetary policies, inflation was running at about 18 percent a year as of August 1979.

One bright spot on Costa Rica's economic horizon is the energy sector: the nation has considerable untapped energy resources. About 85 percent of the Costa Rica's electrical energy is generated from hydroelectric sources, and the proportion will increase in the near future. Costa Rica also has coal and petroleum resources of as yet undetermined extent. Clearly, the potential for increased domestic energy production, if realized, will exert a stabilizing influence over future trade patterns.

With these factors in mind--foreign debt, reduced export growth, inflation, and domestic energy potential--the MITRE/E/DI study team has assumed a GDP growth rate of 5.0 percent a year in Costa Rica over the period 1980 to 1985. This rate is consistent with World Bank projections, but conflicts with official Costa Rican projections of 6.5 percent a year and U.N. projections of 6.5 percent a year.

6.2 Costa Rican Energy Resources

Table 6-4 summarizes the energy resources of Costa Rica as of 1979. Each of the resource estimates is discussed below. Figure 6-1 shows the location of major energy resources in Costa Rica.

Hydro

Costa Rica is endowed with hydroelectric potential many times its present utilization rate. The Instituto Costarricense de Electricidad (ICE) has installed and monitored rainfall and waterflow measuring equipment throughout Costa Rica since its founding. ICE has defined 75 potential hydroelectric sites with a total capacity of 9000 MW, and an annual potential energy output of 37,000 GWh. This potential capacity compares with current installed hydro capacity of 290 MW and a total electric capacity of 449 MW. ICE has made a preliminary selection of six of the potential sites to cover expected demand growth to the year 2000. The total capacity of the six new sites is 1544 MW, again only a fraction of total potential.

TABLE 6-4

COSTA RICA

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential Theoretical Potential: 9,000 MW[1] Installed Capacity: 290 MW[2] (65% of total installed capacity.
Geothermal Forty MW are now scheduled at Las Hornillas de Miravalles.[3] The potential is estimated to be 720 MW.[4]
Oil Reserves Proven: None. Estimated: Zero to 50,000 barrels/day for 10 years depending on source. Refining Capacity: 10,000 barrels/day.[5]
Gas Reserves Proven: None.
Coal Estimates have been made of 100 million tons.[5]
Wind There are areas of strong wind potential. Average midday wind speeds are 13 to 35 km/hour.[1]
Solar The average is 0.38 to 0.54 kw/square meter.[1]
Biomass Forests: Forest and woodlands cover 2.5 million hectares.[6] Sugar: Sugarcane harvested in 1978 amounted to 44 thousand hectares.

[1] Fuentes de Energia No Convencionales, ICE.
[2] Politicas sobre el Desarrollo Electrico de Costa Rica, ICE.
[3] Geothermal Power Plants of Mexico and Central America: A Technical Survey of Existing and Planned Installation.
[4] Obiols, The Situation in the Energy Sector in Member Countries of the Central American Common Market, 1979.
[5] Personal communication, ICE.
[6] FAO Production Yearbook, 1978, Vol. 32.

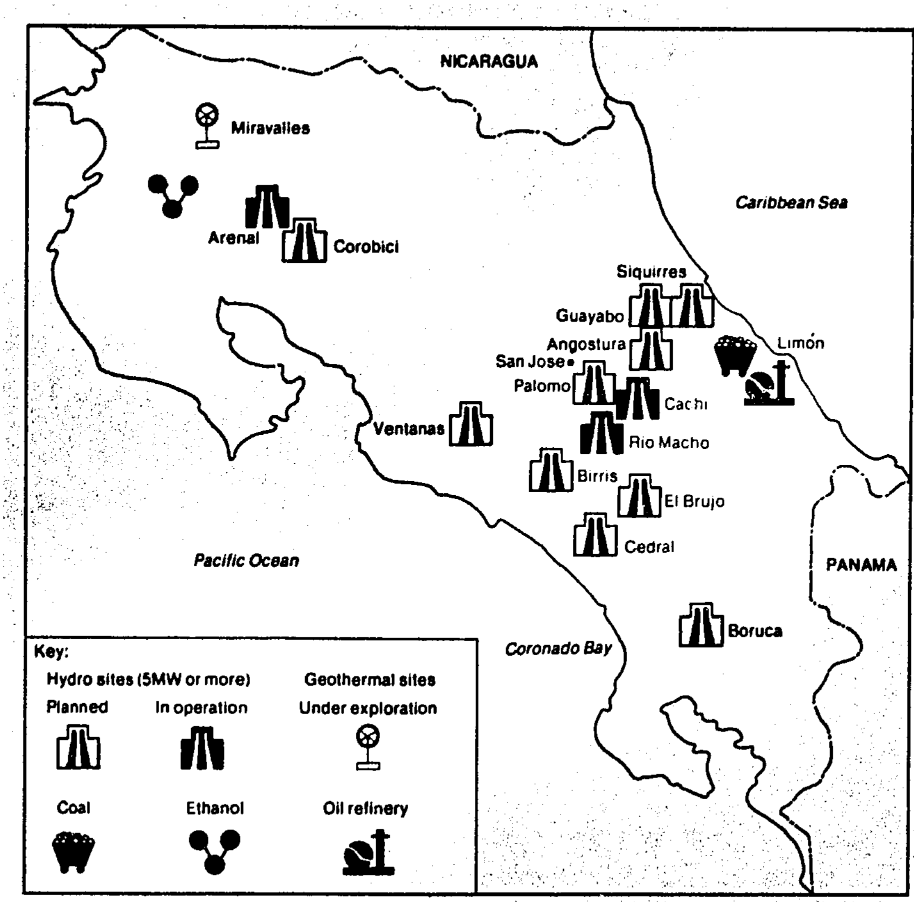


FIGURE 6-1
ENERGY RESOURCES OF COSTA RICA

Geothermal

The geothermal potential of Costa Rica has only recently been estimated. Of the three sites identified to date, the site at Los Hornillas de Miravalles in Guanacaste province in northwestern Costa Rica is the most promising. Active fumaroles cover 50 hectares; surface temperature gradients exceed 1°C per meter over a 200-hectare area. Among the numerous exploratory wells drilled, a 200-meter hole drilled at La Fortuna in 1977 showed a temperature of 150°C; a 300 meter hole at Los Hornillas achieved temperatures near 200°C. U.S. Geological survey models estimate the field temperature to exceed 240°C. Site development is continuing and ICE is now planning for 40 MW of electric generation capacity at the Miravalles site by 1985.

Two other potential geothermal sites have been identified at Las Pailas and Borinquen. However, exploratory wells at these sites, although shallow, have not exhibited temperatures exceeding 100°C.

Oil

Oil exploration in Costa Rica has been carried out by multinational corporations with the approval of La Direccion de Geologia y Minas of the Costa Rica government. Both shallow and deep wells have been drilled in the offshore shelf area in the Caribbean, south of Limon.

On the Pacific side, a University of Texas team has prospected the offshore area of Coronado Bay. Although natural gas was found, no oil estimates are available. The Coronado Bay field is listed as "promising" by the Direccion.

All oil prospecting activities in Costa Rica are today at a standstill awaiting the passage of a new Hydrocarbons Law which will regulate the petroleum industries' activities.

Costa Rica owns and operates a 10,000 barrel per day refinery under a state controlled corporation called Refinadora Costarricense de Petroleo (RECOPE). This refinery is being expanded to produce 14,000 barrels per day.

Coal

ICE performed an evaluation of the coal reserves in the Bolio zone and report that that field contains 100 million tons of high quality coal which could be extracted by open pit mines.

There are indications of some lignite and shale resources in Costa Rica.

Wind

Costa Rica has fourteen wind measuring stations located primarily in the province of Guanacaste and the Central Valley. Specific areas have already been identified as promising for wind power generation. The first lies along the full length of the slopes of Barlovento of the Guanacaste range. The second is within the Central Valley.

For the years 1973 through 1975, the midday wind velocities at a site in the Guanacaste range averaged 25.4 km per hour with monthly midday averages ranging from 13.8 to 35.0 km per hour.

Solar

Costa Rica has twenty-one stations measuring solar radiation levels. ICE reports that stations represent about a 50-percent coverage of the country. The period of highest solar availability throughout the country occurs at the end of the dry season in the month of March. During this time, the areas of highest potential are the Pacific and Atlantic coasts and the Central Valley with a monthly average of .53 to .54 kW per square meter. The lowest potential in this season was measured in the far northern regions with .38 KW per square meter monthly average. During the rainy seasons from June through October, based on the variation in measurement of hours of direct sunlight, solar insolation would likely be about one-half of the dry season values.

Biomass

Forest reserves in Costa Rica have decreased at an alarming rate over the past two decades. From an estimated 71 percent coverage in 1955, forest reserves have diminished to 53 percent in 1973, indicating a cutting of approximately 50,000 hectares per year over an 18-year period.

Apparently, most of this cutting was for agricultural expansion, not for exploitation of the wood resource.

6.3 Current Energy Use in Costa Rica

Energy resource consumption in Costa Rica amounted to 78,931 terajoules in 1978, and 69,638 terajoules in 1977. Petroleum accounted for about 45 percent of total consumption, while hydroelectricity accounted for about 27 percent, the highest in the region. Non-commercial energy use represents 27 percent of total consumption. Figure 6-2 depicts the flow of energy resources to all fuel-demand sectors for 1978. The following sections describe the principal features of Costa Rica's energy use patterns, including the main supply sectors (petroleum and electricity) and final demand sectors of industry, transportation (auto, truck, bus and railroad) and households.

Electric Sector

Electricity generation in Costa Rica is predominantly hydroelectric, but in the last three years the petroleum use has increased

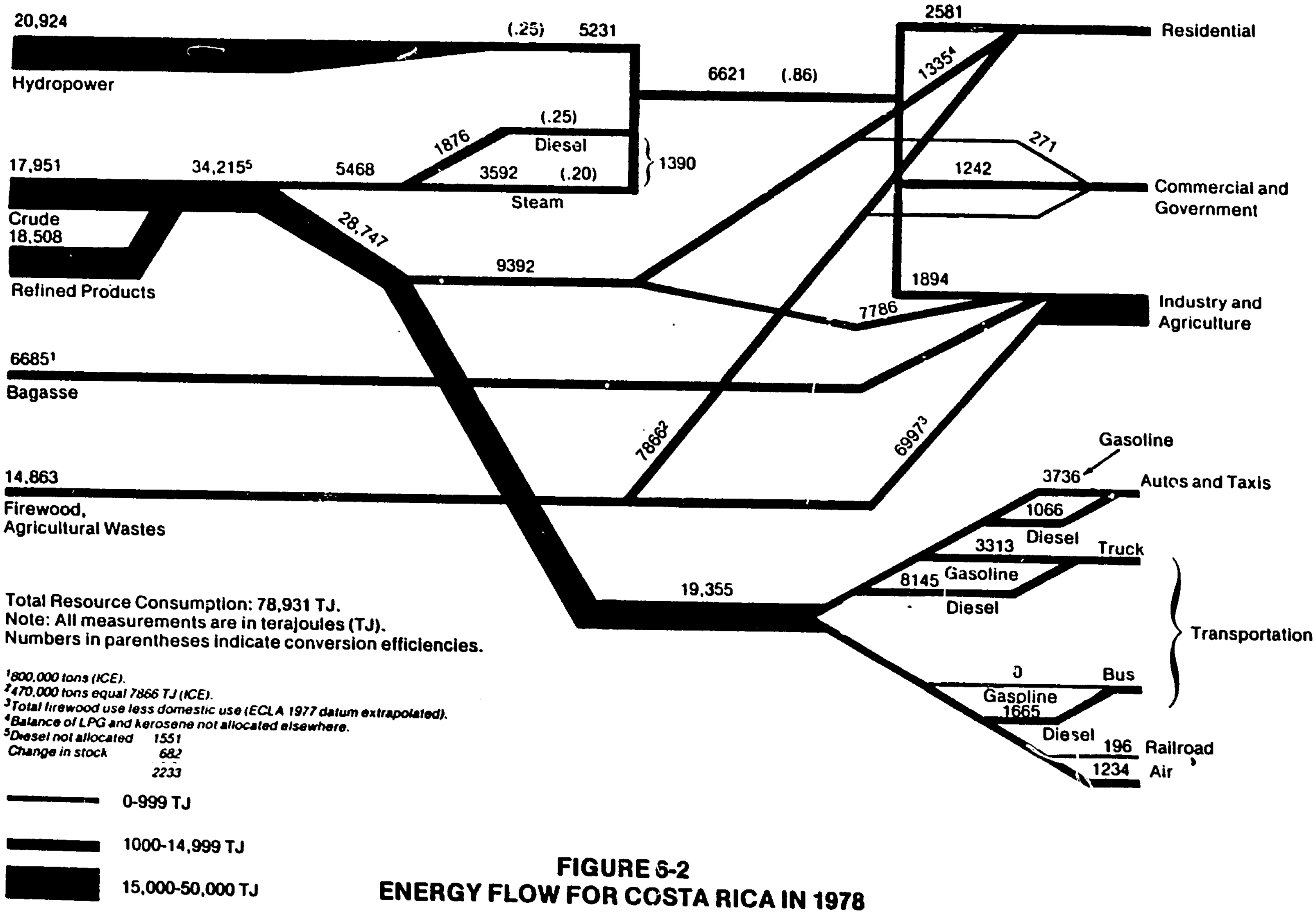


FIGURE 6-2
ENERGY FLOW FOR COSTA RICA IN 1978

because of dry weather and delays in Arenal, a major hydro project (which will add a large storage reservoir). Throughout the 1960s, hydroelectricity produced over 90 percent of Costa Rica's electricity, but from 1972 to 1976 the use of petroleum rose to about 10 to 12 percent of total generation. During the last two years, however, it jumped to 20 or 22 percent, and in 1979 it may reach 30 percent. This situation is supposed to be partly overcome in 1980 with the operation of the first stage of the Arenal project, more than a year late. Arenal is expected to make Costa Rica 98 percent reliant on hydro for its electric needs.

Installed capacity in 1978 was 459.3 MW, of which 290.5 MW was hydro and 168.8 MW was thermal (see Table 6-5). Over 99 percent of this generation was within the interconnected system. The rest of the public service electric generation serves twelve dispersed communities. The self generation sector, which has an installed capacity of 45 MW in Costa Rica, is not included in these statistics.

Electric generation in 1978 reached 1839 GWh and, for the past years, has grown at an annual rate of 8 percent (see Table 6-5). The largest growth is in the industrial sector, which consumes one-third of the total electricity sold. In 1978, industrial consumption was 21 percent higher than the previous year.

Petroleum consumption for electric generation is presented in Table 6-6. Bunker fuel (residual oil), utilized by the public utilities, is obtained from the domestic refinery, but diesel fuel is directly imported. By 1980, the petroleum consumption within the interconnected system is expected to decline by one-third, due to the completion of the first phase of the Arenal hydro project.

TABLE 6-5

COSTA RICA

ELECTRIC SECTOR DATA

	1976	1977	1978	Average Annual Growth Rate
Installed Capacity (MW)[1]	359.2	392	459.3	
Hydro	223.7	224	290.5	
Thermal	135.5	168	168.8	
Maximum Demand (MW)	304.1	328.7	358.1	
Generation (GWh)	1,576	1,677	1,839	8.0
Hydro	1,425	1,310	1,453	
Thermal	151	367	386	
Sales, Total (GWh)	1,338	1,441	1,587	8.9
Residential	638	661	717	6.0
Industrial	376	436	526	18.3
General	290	305	300	1.7
Public Lighting	35	37	45	13.4

[1]These statistics refer to the public service electric capacity including the interconnected system and isolated plants. In addition, 45 MW of thermal and hydro capacity exists in 94 plants of the private sector (industry and agriculture).

Source: Instituto Costarricense de Electricidad.

TABLE 6-6

COSTA RICA

PETROLEUM INPUTS TO ELECTRIC GENERATION

(thousand barrels)

	1977	1978
Diesel		
Interconnected System	600	554
Isolated Systems	24	30
Bunker		
Interconnected System	198	282
Total	822	866

Source: ICE.

Electricity in Costa Rica is principally supplied by the Instituto Costarricense de Electricidad (ICE). It sells a large part of its generation to four distribution companies that generate electricity on their own in a limited fashion. All thermal capacity in the country belongs to ICE, consisting of a few plants in the range of 30 to 40 MW, with others of less than 20 MW. Hydro power is generated by ICE at Rio Macho (120 MW) and Cachi (100 MW), which belong to the same river basin and are in close proximity to each other. Besides one other 30-MW site, the rest of the hydro capacity is all in units of fewer than 5000 KW, with no reservoirs. Hydro sites not belonging to ICE are also of the order of a few megawatts, on the average.

Petroleum Sector

Petroleum product consumption in Costa Rica amounted to about 5.9 million barrels in 1978 (850 thousand tons of oil equivalent), of which about one-half was imported as semi-processed crude and the other half imported as refined products (see Table 6-7). Primary suppliers include Venezuela and Curazao. Crude is delivered to Costa Rica's 10,000 barrels/day Atlantic coast refinery. The products are then transported via pipeline to the San Jose area. All importation, refinery, and commercialization activities are in the hands of the national oil company, RECOPE (Refinadora Costarricanse de Petroleo).

The growth in demand for petroleum products varies widely. Bunker fuel, used mainly in electric generation and industry, grew at slightly over 15 percent per year from 1975 to 1978; demand for diesel which is used for electric generation, industry and transportation grew nearly 14 percent per year. Gasoline demand grew at only 6.6 percent from 1975 to 1978, reflecting large diesel use by taxis, trucks, and autos. Kerosene grew at only 4.2 percent per year, while LPG, starting from a relatively low base (none was produced prior to

TABLE 6-7

COSTA RICA

PETROLEUM CONSUMPTION, 1978[1]

	Refinery Production		Direct Imports		Total Consumption	
	10^3 bbls	TJ	10^3 bbls	TJ	10^3 bbls	TJ
LPG	98.6	406	101.3	429	193.1	817
Aviation Gasoline	-	-	51.0	283	51.0	283
Gasoline	632.1	3,502	656.1	3,635	1,272.3	7,049
Kerosene	189.8	1,135	-	-	201.8	1,207
Jet Fuel	159.0	951	-	-	159.0	951
Diesel	703.7	4,324	2,286.5	14,051	2,971.0	18,256
Residual	1,140.3	7,560	-	-	1,060.5	7,031
Other	12.0	73	18.0	110	30.0	183
Total	2,935.5	17,951	3,112.9	18,508	5,938.7	35,777

[1] The figures for total consumption do not always equal the total because of changes in stocks.

Source: RECOPE.

1975 and none was imported prior to 1972) grew at the highest rate of all, 17.0 percent.

Industrial Sector

Use of commercial energy by the industrial sector (including agriculture and construction) is limited to petroleum products and electricity. Commercial quantities of coal are not produced in Costa Rica. Non-commercial energy use is extensive in agricultural processing (such as coffee processors, sugar mills, and salt manufacturers), and in the extraction of natural resources. In Costa Rica every year, 800,000 tons of bagasse are burned, with an energy equivalent of 6685 TJ.* Other agricultural wastes are also used. Systematic estimates of firewood use in industry are not available, though rough calculations indicate annual firewood use is on the order of 150 million tons of oil equivalent.**

Petroleum use in the industrial sector amounts to an estimated 364 thousand barrels of diesel (or 12 percent of total diesel consumption) and 774 thousand barrels of bunker fuel (73 percent of domestic consumption). About one-fourth of the kerosene and one-sixth of the LPG is also consumed by industry. Similar amounts of kerosene and LPG are used in the commercial sector.

Industry in Costa Rica purchased 526 GWh of electricity in 1978 or 33 percent of the total sales by electric utilities. A group of

*Instituto Costarricense de Electricidad (ICE); CEPAL cites a figure of 159 mtoe (6653 TJ) for 1976. SIECA cites bagasse use of 60-80 mtoe, or 2500-3350 TJ.

**CEPAL reports a total firewood use of 338 mtoe for 1976; of these, about 190 mtoe are used in households (using ICE's estimate of 3 tons/household and 160,000 households, 4000 cal/gr for firewood). The CEPAL total of 338 mtoe includes large losses and only 207 mtoe are estimated to be consumed at the point of final demand.

eleven companies consumed 29 percent of total electricity sold to the industrial sector, amounting to 152 GWh. These industries, however, are customers of one electric utility, and it is likely that there are other industries that are large consumers which are customers of one of the other distributors.

It is also important to note that the 526 GWh purchased by industry in 1978 excludes energy generated by individual firms such as sugar mills that burn bagasse and plantations that have their own diesel generators. A total 45 MW of capacity exists within the industrial sector, but no statistics exist on electricity generated. Because of the extensive interconnection, it is likely that a large fraction of the 45 MW is for standby, except for isolated agro-industrial facilities.

Residential Sector

Household energy use appears to be predominantly firewood, although the proportion of households using electricity and petroleum products is the highest in Central America. Information on fuel consumption in households differs widely depending on sources. On the one hand, the 1973 Census of Housing states that 67 percent of households use electric stoves. On the other hand, a 1978 SIECA report, based on a household survey, is considerably lower, with 25 percent electricity, 5 percent LPG and kerosene, and 66 percent firewood.* Part of the reason for the discrepancy is that many families supplement firewood with gas, kerosene, or electricity, using different stoves.** Total consumption of LPG and kerosene was estimated at

*ROCAP--Regional Offices for Central American Programs, Fuelwood and Alternative Energy Sources, 1979.

**Offices for Central American Programs, Fuelwood and Alternative Energy Sources, 1979.

1335 TJ or 66 percent of the total consumption of these two fuels in the country. This estimate was obtained from the difference between uses of LPG and kerosene in other sectors and total consumption (obtained from RECOPE data), and is rather high relative to the low fraction of cooking with LPG and kerosene; thus, it is likely that one-half of this amount is used for purposes other than cooking.

Total sales of electricity to the residential sector amount to 717 GWh or 45 percent of total consumption. There were 265,000 customers in 1978, or 80 percent of the total number of households.* CELADE indicates that the fraction of urban population in Costa Rica is 44 percent. Thus, the use of electricity is widespread in rural areas.**

Firewood consumption by households is approximately 470,000 tons per year, equivalent to 7866 TJ. This amount is obtained from an ICE estimate of 3 tons/household per year, and 160,000 households (at 4000 cal/gr for firewood). According to this estimate, nearly 50 percent of households use wood as a principal energy source for cooking.

Transportation Sector

The transportation sector uses all of the gasoline and an estimated 60 percent of the diesel fuel consumed in Costa Rica. The entire transportation sector, including railroads and air

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*Assuming households grow at the rate of population growth, 2.4 percent per year for the period 1973-1978.

**CELADE, Centro Latinoamerica de Demografia, "America Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985 y 2000." Boletin Demografico, 1979.

transportation, utilizes 54 percent of the total petroleum consumed in the country. Table 6-8 summarizes the fuel use by the major modes. International and intercoastal shipping, and the diesel used by a private railroad in an area of banana cultivation on the east coast, are not included in these figures. A 6-MW hydro plant powers the railroad from San Jose to the main port in the Pacific, and generates 10 x 10^6 KWh per year.

Table 6-9 shows the breakdown of diesel and gasoline use among autos, trucks, buses, and taxis. All the fuel used by buses and nearly 90 percent of the fuels used by trucks is diesel. Taxis, light trucks and jeeps are nearly 50 percent diesel-powered. The trend toward diesel is also observed in automobiles, yet the Ministry of Public Works and Transportation estimates automobiles' diesel consumption at only 5 percent of the total (in 1978). The trend toward diesel is tied to Costa Rica's pricing policy which, during the second half of 1979, had premium gasoline priced at twice that of diesel; during the first half of 1979, the difference between these two fuels was even more marked (see Table 6-10).

From the point of view of total petroleum imports, the switch to diesel is considered undesirable because it essentially does little to improve the efficiency of the fleet and, at $1/gal, does not affect demand in the same manner as $2/gal for gasoline. Another factor is that, due to the refinery structure, there is a surplus of gasoline and a shortage of diesel. Proposals exist to change the import tariffs of vehicles to favor fuel efficiency. At present, laws still favor the importation of diesel vehicles.

TABLE 6-8

COSTA RICA

CONSUMPTION OF FUELS IN THE TRANSPORTATION, 1978

(Terajoules)

	Motor Vehicles	Air Transport	Railroad
Gasoline	7,049		
Diesel	10,876		196
Jet Fuel		951	
Average Gasoline		283	
Total	17,925	1,234	196

Source: Ministry of Public Works and Transport.

TABLE 6-9

COSTA RICA

MOTOR VEHICLE FUEL USE, 1978

(Terajoules)

	Gasoline	Diesel	Total
Autos[1]	2,679	139	2,818
Pick-Up Trucks[2]	2,397	1,837	4,234
Taxis	1,057	927	1,984
Trucks	916	6,308	7,224
Buses		1,665	1,665
Total	7,049	10,876	17,925

[1]Includes station wagons.

[2]Includes jeeps.

Source: Estimate made by Ministry of Public Works and Transport.

TABLE 6-10

COSTA RICA

PRICE OF FUELS, 1977-1979

(US ¢/Gallon)

Date	Gasoline	Diesel	Kerosene	Bunker
1977	97	45	46	33
August 1978	98	45	47	33
January 1979	139	50	51	33
June 1979	181	56	64	41
August 1979	200	99	88	42

Source: Refinadora Costarricense de Petroleo.

6.4 Future Energy Use in Costa Rica

6.4.1 Electric Sector Expansion Plans

The most immediate step in the expansion of electric supply system is the Arenal hydro project which is scheduled to operate in January 1980. This 157-MW installation is over one year behind schedule because of leakage in the tunnel linking the large reservoir (Lake Arenal) with the plant, which is otherwise completed. The 174-MW Corobici plant is under construction and scheduled to be in operation in 1982. Corobici is down-river from Arenal and shares the same storage reservoir. These two plants will contribute to the interconnected system for the next few years with about 100 MW of capacity destined for what ICE calls unexpected demands (sales to Nicaragua are a strong possibility). The interconnected system is expected to be almost exclusively hydro after 1980, which will signify a savings of 40 million dollars in diesel at today's prices.

The incorporation of geothermal energy into ICE's generation capacity is scheduled for the mid 1980s with a 40-MW plant, followed by a second plant in the late 1980s. The uncertainties surrounding geothermal energy are greater than hydro, because accurate estimates of cost per kilowatt-hour cannot be made until substantial drilling is done. Under favorable conditions, geothermal would be more economical than hydro. If prospects are favorable, 80 MW of geothermal capacity are planned for the 1980s.

Besides geothermal development in Arenal and Corobici, six projects adding to 1544 MW have been studied. In addition, at least three more hydro sites have been identified which, after further analysis, could be considered more advantageous than the six projects mentioned above.

Electrical sector capacity expansion is seriously debated both within Costa Rica and the international lending institutions. Projects of the size of Boruca (760 MW), a potential site, will only be justified as part of industrial development schemes that include aluminum manufacture. Plans have been proposed either utilizing domestic bauxite or imported alumina from Africa, but the issue is generating lively debate because of cost and relative lack of ties with the domestic economy. One alternative is to continue to develop hydro sites of a 75- to 150-MW range, despite apparent economies of scale of very large projects.

6.4.2 Energy Growth Projections

Future energy requirements in Costa Rica are calculated on the basis of an overall growth rate in economic output of 6 percent; population indicators have grown at a rate of 2.2 percent and an urban-to-rural split evolving from a present 45-55 to a projected 62-38 is assumed by the year 2000.

The lack of a comprehensive energy data base precludes estimates based on detailed economic activity levels such as cement production, electric water heaters, and ton-miles of freight. Thus, a more aggregate approach has been chosen, analyzing petroleum requirements apart from electricity demands, and the growth in non-commercial energy.

Electric Sector Projections

Regarding Costa Rica, electricity demand projections prepared by the Instituto Costarricense de Electricidad for 1990 are most useful.* Costa Rica's electrical system is unlike the ones in other

*Instituto Costarricense de Electricidad, Programa de Obras de Transmision y Distribucion 1979-1982, 1978.

Central American countries since no large unsatisfied demands exist, although rural electrification continues. There are no large self-generators that cause distortions in the growth of sales by the grid, and more than 99 percent of public service electric generation belongs to the interconnected system. ICE projects an annual growth of about 7.0 percent to 1990, with the industrial sector growing at 8.62 percent, the commercial sector at 7.47 percent, and the residential sector at 5.41 percent. In preparing these projections, ICE escalated the growth in demand for each of its load centers, and incorporated new industrial loads comprising cement, aluminum, gypsum and lumber plants; but the new loads represent less than 7 percent of total electric requirements for 1990. Thus, no major industrial facilities are included in these projections, such as the controversial aluminum reduction facility that would require a major hydro plant.

A total generation of 8325 GWh (29,970 TJ) is obtained by extrapolating the ICE growth rate to the year 2000 (see Table 6-11). The underlying GNP growth rate of 6 percent per annum yields an elasticity of 1.18 for electricity generation with respect to GNP, which is lower than the historical elasticity of 1.46 for the period 1966 to 1976. The MITRE/E/DI figure is similar to the elasticity of 1.15 to 1.16 obtained in the OLADE study.*

Petroleum Demand Projections

Petroleum demand projections by the final demand sectors (excluding the electric conversion sector) are based on the 6 percent growth rate in GNP and the income and price elasticities discussed in

*OLADE, Perspectivas de la Demanda de Energia Comercial en Latino America--Periodo 1978-1990--Costa Rica, 1978.

TABLE 6-11

COSTA RICA

ELECTRICITY DEMAND PROJECTIONS

	1978	2000	Growth Rate (%) 1978-2000
Total Electricity Sales			
(GWh)	1,588	7,213	7.12
(TJ)	5,717	25,965	
Residential			
(GWh)	717	2,285	5.41
(TJ)	2,581	8,226	
Commercial			
(GWh)	345	1,683	7.47
(TJ)	1,242	6,059	
Industrial			
(GWh)	526	3,244	8.62
(TJ)	1,894	11,680	
Losses			
(GWh)	251	1,113	7.00
(TJ)	904	4,005	
Total Generation			
(GWh)	1,839	8,325	7.10
(TJ)	6,621	29,970	

[1] Growth rates originally applied only to the year 1990. Estimates applied in this study to the year 2000.

Source: ICE.

section 2.4 of Volume I. These yield growth rates for direct uses of petroleum products of 6.5 percent per year for Case I and of 4.4 percent per year for Case II. In the year 2000, demand reaches 18.8 million barrels (114,890 TJ) in Case I and 12.1 million barrels (74,132 TJ) in Case II, up from 4.7 million barrels (28,747 TJ) in 1978 (see Table 6-12). This growth is expected to come mostly from the transportation sector, which in 1978 consumed 67 percent of total direct use of petroleum, and from industry, which in 1978 consumed 27 percent of total petroleum consumption. Transportation fuel use will grow the fastest in trucks as new lands are developed further away from population centers and ports, and in urban bus transportation due to rural-to-urban migration, which causes cities to build up and trip lengths to increase. Railroads, which consumed only 1 percent of the total fuel used in transportation, will increase their demand for fuel if the government decides to upgrade the existing freight and passenger system. Railroad reform plans exist, as do plans for new railroad systems. Some changes could involve electrification of lines, like the existing railroad to the Atlantic. In any case, total diesel demand for railroads will not be significant in the overall picture of petroleum demand, and railroad electrification will reduce petroleum demand by less than 0.1 million barrels. Demand for automobile fuels will probably grow more slowly than that of trucks and buses. Fuel use per automobile is expected to decrease by the year 2000 due to availability of more efficient models. However, this will be offset by the increasing number of automobiles that GNP growth (and therefore personal income) will bring to the country. Introduction of electric vehicles has not been considered in the analysis; while possibly in existence by the end of the century, electric vehicle penetration is unlikely to be widespread. The impact of gasoline-alcohol and possibly diesel-alcohol mixtures as transportation fuels is considered in section 6.5, "Future Energy Strategies for Costa Rica."

TABLE 6-12

COSTA RICA

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

	1978	Year 2000 Case I	Year 2000 Case II
Total Direct Uses	28,747	114,890	74,132
Industry	7,786	31,117	20,100
Transport	19,355	77,354	49,890
Residential and Commercial	1,606	6,419	4,142

Source: MITRE/E/DI.

Demand for petroleum in industry will come from the expansion of manufacturing sector and of the agroindustrial sector. Little is known about present patterns of fuel use among the industrial subsectors. In general, growth will likely occur in activities in which Costa Rica has a competitive advantage in world markets, such as food processing, rather than in capital- and energy-intensive manufacturing processes.

Petroleum use in households is limited to the increases of LPG and kerosene for cooking purposes which now includes about 12 percent of households. Future growth will depend on the amount of electricity used in new households and the substitution of firewood by LPG or electricity in rural areas.

Non-Commercial Energy Projections

The growth rate of non-commercial energy depends greatly on the availability of resources and deliberate measures of biomass harvesting and utilization for energy purposes. The consumption of firewood, bagasse and other agricultural byproducts also depends on the efficiency with which they are converted, which varies widely.

For projection purposes, non-commercial energy is assumed to grow at the rate of total population growth, 2.16 percent per year.* Thus, no alterations in conversion efficiency are incorporated into the projection, which is consistent with the approach for petroleum fuels. Industry, in particular agroindustry, will possibly substitute diesel and other petroleum products with biomass resources as fuel prices increase. In addition, use of bagasse and other agricultural residues may grow faster than population, as in the late

*This assumes that firewood, charcoal and other vegetal energy forms will be available for urban areas, which is where the majority of Costa Rica's population will live by the year 2000.

1960s and early 1970s when sugar production climbed from 120 thousand tons in 1965 to over 200 thousand tons in 1975. Bagasse, however, does not influence fuel supply in the general economy, because it is used internally by major mills. The same is essentially true for other crop residues. On the other hand, there are many opportunities for reduction of total firewood use by increasing conversion efficiency and reducing transportation losses. A final argument for assuming that non-commercial energy will grow no faster than total population is that the income effects are minimal; that is, firewood use per family for cooking and heating (where needed) will not climb as a result of growth in disposable income.

In the year 2000, Costa Rica's projected use of non-commercial fuels amounts to 34,386 TJ, using CEPAL's estimate of consumption in 1978, as a basis for calculation.

6.4.3 Future Energy Resource Consumption

A final energy balance for the year 2000 in Costa Rica requires calculation of the estimated resource mix to meet an electric generation requirement of 8,325 GWh (29,970 TJ). According to information obtained from ICE and confirmed by ECLA, there is enough hydro power in the country that can be developed to generate this amount of electricity, complemented by three 40-MW geothermal plants. Assuming the latter have a plant factor of 0.65, geothermal energy could generate 680 GWh. The existing installed capacity, combined with the two projects under construction, totals 621 MW, and can generate 2720 GWh, assuming an average plant factor of 0.50. Five of the six projects that the electric utility has studied would add 784 MW to the system assuming the Boruca site is not developed. The balance of electric generation could either be obtained by developing any of nine other sites cited by ECLA, or by developing a scaled-down 250 MW site at Boruca. Table 6-13 summarizes the electric supply balance.

TABLE 6-13

COSTA RICA

ELECTRICITY SUPPLY BALANCE, YEAR 2000

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use[1] (TJ)
Hydro	1,655	7,687	27,673	11,062
Existing[2]	621	2,720	9,792	
Five ICE Sites	784	3,434	12,362	
Boruca, One Stage	250	1,533	5,519	
Geothermal	120	683	2,459	9,836
Total Generation		8,370	30,132	
Total Demand	1,775	8,325	29,970	

[1]Expressed in petroleum equivalent, utilizing a conversion factor of 0.25.

[2]Includes plants under construction.

Source: MITRE/E/DI.

A final energy balance for Costa Rica is tabulated in Table 6-14, showing current resource consumption and projected resource consumption to the year 2000.

6.5 Future Energy Strategies for Costa Rica

Substitution of Oil

The contribution of ethanol and methanol in Costa Rica amounts to 2,840 TJ, or less than 4 percent of total oil demand by the transportation sector in the year 2000 on the basis of Case I. This assumes that 25 percent of the land currently planted with sugarcane will be dedicated to ethanol production, and that 1 percent of the annual forest growth will be converted to methanol.

Conservation

The lack of a systematic data base precludes a full evaluation of the conservation potential; only general statements can be formulated. The results of reducing oil demand through 15 percent industrial conservation amount to 4,670 TJ and through 20 percent transportation conservation an additional 15,470 TJ.

Table 6-15 summarizes the impact or the contribution of oil substitution and of conservation, measured as a percentage of total projected petroleum demand. In addition, the contributions of ethanol and methanol as a percentage of current gasoline use are shown.

6.6 Recommendations to USAID for Costa Rican Energy Programs

The recommendations given here are intended as a refinement, and in some cases an expansion of the regional recommendations presented in Volume I. Where regional recommendations do not appear as national recommendations, then the regional recommendations are still valid.

TABLE 6-14

COSTA RICA

TOTAL RESOURCE USE

(Terajoules)

	1978		Year 2000			
	TJ	(%)	Case I	(%)	Case II	(%)
Hydro	20,924	27	110,692	41	110,692	48
Geothermal	0		9,836	3.6	9,836	4
Petroleum	36,459	46	114,890	43	74,132	32
Direct Uses	28,747		114,890		74,132	
Electric Generation	5,468		0		0	
Losses, Unaccounted	2,244		NA		NA	
Non-Commercial	21,488	27	34,386	13	34,386	15
Total Resources	78,931		169,804		229,046	

Source: MITRE/E/DI.

TABLE 6-15

COSTA RICA

IMPACT OF SELECTED STRATEGIES

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substitution of petroleum used in electric generation	Not applicable	---
b. Production of 10% of ethanol potential[2]	0.3%	4.0%
c. Production of 25% of ethanol potential[2]	0.6%	11.0%
d. Production of 0.5% of methanol potential[3]	0.9%	15.0%
e. Production of 1.0% of methanol potential[3]	1.8%	30.0%
f. Substitution of electricity for petroleum-based processes, vehnicl[illegible] etc.		---
II. Conservation		
a. Conservation in industry (15%)	4.0%	---
b. Conservation in transportation (20%)	13.0%	---
c. Savings in electricity use	Not applicable	---

[1]Using Case I petroleum demand as a basis.

[2]Percentage of current land devoted to sugar cane to be dedicated to energy production, or equivalent area added to cultivation.

[3]Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

Support for Integrated Planning

Costa Rica's urban and freight transportation systems offer good potential for energy conservation through improved system efficiencies. USAID should offer technical and administrative support to the Costa Rican Ministries of Planning and Industry in carrying out integrated energy/transportation planning.

Analysis of Energy Use in the Agricultural Sector

Considering that Costa Rican development plans emphasize expansion of the agricultural sector, USAID should help the Costa Rican government assess current and projected energy consumption in agriculture. The objective should be to identify options for reducing and displacing petroleum use in irrigation, food processing, packaging, transportation, and fertilization operations.

Support for Hydrocarbons Exploration and Development

There are deposits of high-quality coal in Costa Rica, and preliminary indications of petroleum and natural gas deposits. The country will need geologists, petroleum engineers, and skilled drilling crews if it is to develop these domestic resources. USAID should promote educational training programs which would allow Costa Rican students to study in the United States. Special emphasis should be placed on the skills needed for middle management and craft supervision of projects.

Support for Solar and Wind Assessments

Data on wind speeds and solar isolation are incomplete in Costa Rica, but do suggest a strong potential in some areas. USAID should offer technical and financial support in planning and implementing data collection programs to fill this information gap.

APPENDIX 6-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

The following table lists national institutions that are active in energy research. It contains short descriptions of each institution's activities.

TABLE 6.A-1

COSTA RICA

ENERGY RESEARCH AND DEVELOPMENT

Technology/Resource	Institution	Product or Activity
ALCOHOL	Corporacion Costarricense de Desarrollo	Constructing alcohol distillery in Guardia-Liberia, Cuanacaste. Projected production in 1981: 240,000 liters/day. Brazilian technology and equipment.
	University of Costa Rica	Carrying out project to develop small-scale domestic distillation using sugarcane.
BIOGAS	Universidad de Costa Rica	Conducting preliminary investiagtions in biogas utilization.
	Instituto Tecnologico de Costa Rica	Performing research on biogas production from animal wastes.
	Instituto Costarricense de Electricidad	Proposed a 6-stage program for evaluation of national biogas potential
COAL	Instituto Costarricense de Electricidad	Identified 5 geographic areas suitable for coal explorations--3 areas nominated as high priority. Proposed 3-year study to include topographic, photogeoloc, geophysical and geochemical research, plus 600-meter drilling activities in key areas. Recently discovered high-quality coal in South Atlantic region.
	Ministerio de Economia, Direccion de Geologia y Minas	Sampled coal and oil shale deposits on a limited basis.
GEOTHERMAL	Instituto Costarricense de Electricidad	Carrying out the Miravalles Geothermal Project. After completion of first phase, (1977) obtained 4.1 million dollar loan for IDB to continue exploration activities until 1980.

TABLE 6.A-1

COSTA RICA

ENERGY RESEARCH AND DEVELOPMENT (Continued)

Technology/Resource	Institution	Product or Activity
MINI-MYDRO	Instituto Costarricense de Electricidad	Identified 75 potential sites adding 40+ MW.
	Universidad de Costa Rica	Prepared master plan for energy-related research, including plans for indigenously-designed and built turbines. Completing feasibility study of 30-KW project in San Carlos.
PETROLEUM	Instituto Costarricense de Electricidad, Oficina de Geofisica	Conducts on-going program for data collection on fossil fuels.
SOLAR	Universidad Nacional	Developed solar flat-plate collectors, performed research on solar dryers for grains and conducted evaluation of potential solar technologies for Costa Rica.
	Instituto Tecnologico de Costa Rica	Performed research on solar water heaters, solar grain and wood dryers.
	Instituto Costarricense de Electricidad	Maintains 26 solar measurement stations, covering 50% of national territory. Plans to install 250 photovoltaic telephones in isolated areas by 1985.
	Instituto Meteorologico	Operates 16 solar measurement stations.
WIND	Instituto Costarricense de Electricidad	Completed preliminary study of wind potential in Costa Rica. Installed 14 monitors nationwide. Selected 5 geographic areas for further study.
	Instituto Tecnologico de Costa Rica	Collaborating with West Texas St. University to design and build prototype windmill.

TABLE 6.A-1

COSTA RICA

ENERGY RESEARCH AND DEVELOPMENT (Concluded)

Technology/Resource	Institution	Product or Activity
WOOD	Instituto Costarricense de Electricidad	Completed firewood survey in collaboration with UNDP.
	Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE)	Performed extensive research in forest utilization and management.

APPENDIX 6-B

ENERGY-RELATED INSTITUTIONS

During the MITRE/E/DI visit to Costa Rica, a number of institutions were contacted, including:

- government agencie
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in Costa Rica; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audiences
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION: Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE)

CONTACT: Santiago Fonseca Martinez, Director

LOCATION: Turrialba, Costa Rica

TELEPHONE: 56-01-22

DESCRIPTION OF INSTITUTION:

- This nonprofit, autonomous organization, created in 1973, promotes and carries out research in agriculture, forestry, and animal husbandry.

- CATIE's central facility covers 1,069 hectares of land, and on the Atlantic Coast it owns 102 hectares of farmland. Main facilities include four office buildings, a conference hall and meeting rooms, classrooms, and teaching and research labs. Greenhouses, a herbarium, two cold chambers, an arboretum, nurseries, and a meteorological station also form part of the physical plant. Other facilities include an agricultural library, dormitories, apartments, and school buildings.

- Equipment includes a motor pool of 60 vehicles, laboratory equipment, Hewlitt Packard and IBM computers, and agricultural machinery.

- The Natural Renewable Resources Division consists of thirteen professionals and thirteen support staff.

TARGET AUDIENCE: Students, farmers, universities, researchers, governments, and private organizations

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- Membership consists of Panama, Costa Rica, Nicaragua, and Honduras; each pays $50,000 annually. El Salvador has the membership proposal before their Congress, and Guatemala is negotiating membership.

- Financial collaboration with USAID; the Technical Corporation Organization of the Federal Republic of Germany; the International Development Research Center of Canada; governments of France, Switzerland, and the Netherlands; international organizations including the World Bank, OAS, FAO, UNESCO: non-profit institutions including the Rockefeller Foundation; and private organizations such as the American Cocoa Research Institute.

- Formal and informal working relationships are maintained with the International Potato Center, International Rice Research Institute, Asian Vegetable Research and Development Center, and universities.

- It coordinates programming and project development and implements with SIECA, ICAITI, INCAP, CABEI, etc.

PRODUCTS, SERVICES, CAPABILITIES:

- The Center trains, researches, and develops projects at different levels in agriculture, forestry, and animal husbandry. Many projects concentrate on appropriate low-cost and efficient technologies.

- Under the sponsorship of ROCAP, CATIE will play a major role in the project on Fuelwood and Alternative Energy Sources, formulated in 1979 which offers energy efficient and woodfuel alternative technologies for use in homes and rural communities in Central America. CATIE's effort will focus on the production of fast-growing trees and plants. Experiments will be conducted in all six countries.

- CATIE and ICAITI will both establish and strengthen relationships with public and private organizations which may act as disseminating agents for fuelwood production or energy efficient technologies.

INSTITUTION: Corporation Costarricense de Desarrollo (CODESA)

CONTACT: Marco T. Gutierrez

LOCATION: Apartado 10323
San Jose, Costa Rica

TELEPHONE: 22-44-22

DESCRIPTION OF INSTITUTION:

- Development organization for furthering economic growth in Costa Rica by strengthening and providing financial and technical support

TARGET AUDIENCE: Businessmen, federal and state governments, and general public

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- Founded in 1972
- Controlled by the government which owns 67% of the shares of stock while 33% of the shares of stock are owned by the private sector
- Administered by a board of directors, consisting of four government representatives and three private sector representatives
- Allowed to issue bonds and receive near-term deposits in national currency

PRODUCTS, SERVICES, CAPABILITIES:

- Develops new industries
- Utilizes marketing opportunities
- Stimulates production of goods currently imported
- Participates as a shareholder, with risk capital, in firms of national interest

- Finances, designs, and implements key development projects

- Sponsored joint petroleum exploration with Elf-Equitaine of France on the continental shelf of Costa Rica's Atlantic Coast

- CATSA, a subsidiary of CODESA, is developing an alcohol plant in Guardia-Liberia, Guanacaste. The project will begin distilling alcohol in 1980. By 1981/82 production should reach 240,000 liters per day. The maximum amount of gasoline imports that could be substituted by alcohol is around 15%. The technology and equipment were purchased from Brazil.

INSTITUTE:	Direccion General de Geologia, Minas y Petroleo
CONTACT:	Luis Felipe Sandoval, Director, Direccion General de Geologia, Minas, y Petroleo, Ministerio de Economia, Industria y Comercio
LOCATION:	Apartado 10216 San Jose, Costa Rica
TELEPHONE:	26-13-98
DESCRIPTION OF INSTITUTION:	• Responsible for fossil-fuel and mining activities although activities are now at a standstill awaiting passage of a new law on hydrocarbons for regulating companies prospecting and developing oil and coal reserves
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION	A branch of the Ministry of Economy, Industry and Commerce
PRODUCTS, SERVICES, CAPABILITIES:	• Plans to perform coal and oil shale explorations, sampling, evaluations, and technological investigations in the Peninsula de Nicoya, Venado de San Carlos, Fila de Carbon, Pacifico Sur y Osa, and Montanas Sur de San Jose • Intends to study coal as a substitute for bunker, coal for metallurgical applications, etc. • Evaluates data on hydrocarbons obtained from private exploration companies

INSTITUTION:	Instituto Costarricense de Electricidad (ICE)
CONTACT:	Teofilo de la Torre, Jefe Direccion Planificacion Electrica
LOCATION:	Apartado 10032 San Jose, Costa Rica
TELEPHONE:	32-72-25
DESCRIPTION OF INSTITUTION:	National Electric Utility, created in 1947, to rationally develop hydroelectric resources and coordinate electrification efforts throughout Costa Rica
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Constructs and operates facilities • Contracts both local and foreign firms • Employs about 4,000 persons excluding construction crews. Economists, engineers, geologists, chemists, and meterologists are represented on the professional staff • Finances projects through the World Bank, the IDB, the Banco Centroamericano de Integracion Economica, and ICE itself
PRODUCTS, SERVICES, CAPABILITIES:	• Has two projects on line: Arenal, a hydroelectric project with 157-MW capacity and a large reservoir, and Corobici (174 MW), now under construction.

- Boruca, a proposed project on the Atlantic Coast with 760-MW capacity (if agreed upon, is under consideration; construction will begin in the early 1980s, and the most optimistic completion date will be 1986)

- Performs studies on non-conventional energy sources including wind, solar, biomass, and hydrogen

- Investigates geothermal, mini-hydro, and coal potential, performs surveys, and publishes studies in these areas

- Encourages training of professionals in areas which offer realistic development promise such as geothermal and coal

- Provides input to the energy policy-making process

- Generates information base on energy

INSTITUTION: Instituto Tecnologico, Costa Rica

CONTACTS: Alejandro Cruz, Director, Division de Investigacion, Desarrollo y Extension Technologica; Donald B. Peterson, Division de Investigacion, Desarrollo y Extension Tecnologica

LOCATION: Apartado 159
Cartago, Costa Rica

TELEPHONE: 51-11-22

DESCRIPTION OF INSTITUTION:

- This autonomous institute offers associate's and bachelor's degrees in Construction Engineering, Industrial Production, Business Administration, Computer Science, Electronics, Forestry, Agricultural Engineering, and Agricultural Management. Technical Education, Industrial Design, and Industrial Safety will be added in 1980.

- Research, information dissemination, and extension activities operate out of the Research, Development and Extension Division (DIDET).

- Students from other Central American countries are encouraged to attend the Institute through official sponsorship.

TARGET AUDIENCE: Students, general public, farmers, researchers, businessmen, civic organizations, cooperatives, community leaders, teachers, and other universities/colleges

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- The Institute receives higher subsidies per student from the federal government than any other school.

- Construction of facilities has been financed by the IDB and expansion is presently occurring.

- The Institute responds to grant solicitations

PRODUCTS, SERVICES, CAPABILITIES:

- Divides research activities into five basic areas: woods, soils, metal-mechanics, renewable resources, and information exchange

- Focuses renewable resource work on nonconventional energy resources including solar water heaters, solar grain and wood dryers, windmills, and biogas production from animal waste

- Designs and builds alternative technology systems

- Provides information through manuals and other documentation, including NTIS publications

- Develops guidelines and technical specifications for selecting/implementing technologies

- Conducts and sponsors seminars, conferences, workshops, and exhibits (e.g., Sun Week)

INSTITUTION:	Universidad de Costa Rica
CONTACTS:	Eduardo Doryan, Colegio de Ingenieros Electricistas, Mecanicos, e Industriales, and Alvaro Umana, Coordinador General de Investigacion en Energia
LOCATION:	San Jose, Costa Rica
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Autonomous university offering undergraduate and graduate degrees in a variety of areas including electrical, mechanical chemical, civil, and industrial engineering; architecture; medicine; physics; biology; and medicine • Includes teaching, research, information and dissemination activities
TARGET AUDIENCE:	Students, general public, civic organizations, teachers, and other universities/colleges
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Supported by the federal government of Costa Rica and private funding sources.
PRODUCTS, SERVICES, CAPABILITIES:	• Conducts and sponsors seminars, workshops, conferences, and exhibits (e.g., I Seminario Nacional de Energia) • Designs and builds alternative technology systems • Developed master plan for energy-related research at the university

- Researches activities including: mini- and microhydro projects, hydrated alcohol projects, methane projects, solar crop dryers, coal gasification projects, and a hydrogen project.

- Provides individual input to energy policy-making process through use of the media

INSTITUTION:	Universidad Nacional (Heredia)
CONTACT:	Elio Ricci and S. S. Nandwani, Departamento de Fisica
LOCATION:	Heredia, Costa Rica
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Awards undergraduate degrees • Performs research as part of teaching and public service functions • Conducts energy-related workshops and seminars within the university
TARGET AUDIENCE:	Undergraduate students, farmers, researchers, community leaders, and general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Research administration is a centralized system in which one designated unit administers all research programs. • Nonprofit institution supported primarily by the federal government • Physics Department is not a separate entity; physics courses were established as part of four-year degree program in other disciplines.

PRODUCTS, SERVICES,
CAPABILITIES:

- Develops solar energy flat plate collectors, dryers for grains, and greenhouses
- Performs surveys of agricultural cooperatives to evaluate the costs of fuel and solar thermal technologies, such as solar grain dryers
- Conducts R&D, evaluation, analysis, and assessment of potential solar energy methods, techniques, and devices

Bibliography

CELADE (Centro Latinamericano de Demografia). "America Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985, y 2000," Boletin Demografico, Ano XII, No. 23. Santiago, Chile: CELADE, January 1979.

_____. Evaluacion del Censo de 1973 y Projeccion de la Poblacion por Sexo y Grupos de Edades, 1950-2000. San Jose, Costa Rica: Direccion General de Estadistica y Censos, June 1976.

CEPAL (Comision Economica para America Latina). Economic Survey of Latin America, 1978: Advance Summary. La Paz, Bolivia: United Nations, April 1979.

_____. Estudio Regional de Interconexion Electrica del Istmo Centroamericano, CEPAL/MEX,SRNET/28. Mexico: CEPAL, October 1979.

_____. Istmo Centroamericano: Consumo de Energia, 1960, 1965, y 1970 a 1976, E/CEPAL/CCE/SC.5/126. Mexico: CEPAL, November 1978.

FAO. "Explanatory Notes," 1978 FAO Production Yearbook, Volume 32. Rome: FAO, 1978 (extracts).

ICE (Instituto Costarricense de Electricidad). Direccion de Planificacion Electrica, Oficina de Estudios Especiules, Fuentes de Energia No Convencionales. Costa Rica: Instituto Costarricense de Eletricidad, August 1979.

_____. Politicos sobre el Desarollo Electrico de Costa Rica. Costa Rica: ICE, no date.

ROCAP (Regional Offices for Central American Programs). Fuelwood and Alternative Energy Sources, 596-0089. Washington, D.C.: USAID, August 1979.

SIECA (Secretaria de Integracion Economica para Centroamerica). La Situacion Energetica en Centroamerica y Perspectivas para el Futuro. Guatemala, Guatemala: SIECA, August 1978.

USAID, Costa Rica Project Paper: Science and Technology, AID/LAC/P-018, 515-0138. Washington, D.C.: Department of State, May 1979.

7.0 PANAMA

7.1 Geographic, Social, and Economic Aspects of Panama Energy Development

Geography

Panama forms the southernmost end of the isthmus of Central America. Oriented from west to east, Panama covers an area of 75,616 square kilometers, 676 kilometers in length by 50 to 182 kilometers in width. The Panama Canal, connecting the Atlantic on the north to the Pacific on the south, crosses the isthmus at approximately its halfway point.

A continental divide, the Cordillera Central, runs the length of Panama, dropping from altitudes of 5,000 to 10,000 feet above sea level at the Costa Rican and Colombia borders to low hills in the area of the canal, and beyond to the east. The Cordillera separates Panama geographically and climatically. Although the entire country is tropical, conditions to the south of the Cordillera are more moderate. Agricultural production and population are both concentrated to the southwest of the Cordillera. Population is particularly concentrated near Panama City and in areas near the Costa Rican border. The remaining areas to the north and toward the Colombian border are covered with virgin forest or swamp land. Population here is sparse, except at the port and canal cities of Cristobal and Colon, on the north coast.

The southern slopes of the Cordillera are covered by more than 300 rivers, some with extensive river basins. Some have been used effectively to generate hydroelectric power.

In 1978 the population of Panama totaled approximately 1.8 million. In that year, 52 percent of the population resided in urban areas, and was growing at 4.2 percent a year. This growth rate compares to 3.1 percent for the population generally.

In an effort to curb the urban influx, Panama has established an extensive program of health and educational improvements for the rural population. Infant mortality rates have dropped significantly: from 90 to 47 per 1000 live births over the period 1960 to 1977. The birth rate also dropped during this period from 41 to 31 annual live births per thousand population.

Economy

Gross Domestic Product in Panama totaled $2.9 billion in 1978 (1976 dollars) or $1,254 per capita, the highest in Central America.*

The 1975 sectoral composition of GDP is indicated in Table 7-1. Four sectors are significant in terms of contribution to GDP: agriculture (17 percent), manufacturing (15 percent), commerce (16 percent), and services (27 percent).

The service sectors are the most important component of the Panamanian economy, contributing 27 percent of Gross Domestic Product 1975. Included here are: Other Public and Private Services ($314 million: 1975), Canal Zone Services ($115 million: 1975), and Financial Intermediaries ($85 million: 1975).

The agricultural sector was dominated in 1977 by the production of bananas ($66 million), shrimp ($30 million) and sugar ($22

*Source: Inter-American Development Bank.

TABLE 7-1

PANAMA

S DOMESTIC PRODUCT BY SECTOR, 1970-1975

(millions of current Balboas)

	1970	1971	1972	1973	1974	1975
GROSS DOMESTIC PRODUCT (at market prices)	1,045.8	1,157.0	1,297.8	1,472.5	1,834.7	1,934.2
Agriculture	200.4	210.3	227.3	250.9	301.4	330.4
Mining	2.5	2.8	2.7	4.1	4.3	4.2
Manufacturing	166.4	185.6	207.7	224.5	266.4	287.4
Public Utilities	19.0	21.9	27.0	30.7	44.7	55.4
Transport, Storage and Communications	56.8	63.7	76.2	89.4	113.3	122.7
Commerce	146.4	163.1	183.8	210.8	299.3	312.6
Banking, Insurance and Finance	40.3	44.6	53.5	69.1	76.0	85.2
Housing	65.5	74.1	84.9	100.1	114.4	119.1
Public Administration and Defense	29.5	33.0	41.2	40.2	57.5	62.0
Other Public and Private Services	178.5	199.0	220.5	248.2	305.5	313.6
Canal Zone Services	79.3	84.0	86.0	97.0	104.4	114.6

Source: World Bank.

million). Other export commodities included fish flour ($10 million), coffee ($5 million), cacao ($2 million), and meat ($1.5 million). See Table 7-2.

The manufacturing sector is dominated by oil refining. The Texaco Company operates the country's only refinery, with a 100,000-barrels-per-day capacity, in Colon. Texaco imports all the refinery's feedstocks; in turn, about half of the production is exported. The value of exported refined products was about $118 million in 1977, excluding the refined products exported to ships.

Balance of Payments

The most important aspect of Panama's balance of payments situation is the extremely high level of external debt. In 1977, total external debts outstanding amounted to 80 percent of GDP. Avoidance of further indebtedness is required if Panama wishes to maintain sufficient import capacity to support high rates of economic growth.

The high price of oil since 1973 has done much to widen Panama's trade deficit. This problem is likely to continue in the future, and will provide an incentive to encourage export expansion in order to finance oil imports. Some expansion of exports may accompany Panama's recovery from the 1974 to 1977 recession. However, Panama's principal exports are agricultural products, such as bananas and sugar, thus developments in world markets for these commodities are of particular importance. See Table 7-3 for a breakdown of Panama's balance of payments in recent years.

Prospects for Development

The near-term prospects for growth in Panama are qualified. Despite the many beneficial aspects of its unique geographical position, Panama is constrained in its development by a large

TABLE 7-2

PANAMA

SELECTED MAJOR EXPORTS, 1970-1977

(thousands of U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977
Bananas	60,831	62,907	64,705	63,827	49,548	59,513	61,498	66,454
Coffee	1,705	1,553	2,502	2,060	2,131	2,253	3,374	5,489
Sugar	4,966	6,329	5,907	8,762	27,525	49,429	26,319	21,880
Cacao	12	0	250	296	624	848	1,339	2,115
Red Meat	2,189	1,381	3,149	1,581	1,775	1,561	3,804	1,465
Shrimp	10,168	11,953	14,631	16,707	15,182	19,010	33,517	29,984
Fish Meal	789	982	1,432	3,106	1,309	1,686	4,468	10,463
Petroleum Products[1]	21,465	25,126	19,266	21,929	52,797	94,015	38,540	43,324
Other exports[2]	6,075	4,546	9,928	18,674	37,316	39,017	44,988	40,361
Total Exports	108,201	114,777	121,770	136,961	188,207	267,332	217,847	221,535

[1] Excludes petroleum products exported for bunkering ships in Canal Zone.
[2] Includes adjustments made for balance of payments consolidation and reexports; in the 1950's a larger proportion of exports were reexports since the Colon Free Zone did not reexport significant amounts.

Note: Excludes exports of merchandise to Canal Zone and from Colon Free Zone.

Source: World Bank.

TABLE 7-3

PANAMA

BALANCE OF PAYMENTS, 1974-1977

(millions of dollars)

	1974	1975	1976	1977
Exports (goods and n.f.s.)	751.5	851.5	804.2	844.5
Imports (goods and n.f.s.)	918.4	992.1	961.0	998.2
Resource Balance	-166.9	-140.6	-156.8	-153.7
Net Factor Services and Transfers	-59.2	-25.8	-37.8	-45.6
Current Account Balance	-226.1	-166.4	-194.6	-199.3
Increase in Reserves (-)	272.0	129.9	46.3	22.4
Gross International Reserves[1]	39.3	34.4	78.9	70.9

[1] Gross international reserves data were taken from International Financial Statistics, International Monetary Fund (IMF), December 1978 and April 1979. The IMF figures may not total exactly from the World Bank data as the IMF provides gross international reserves while the World Bank provides change in net international reserves.

Source: World Bank and International Monetary Fund.

unproductive public sector and low investment levels. Panama's growth will also be hindered by the related problems of high foreign debt and the poor perfomance of state-owned agricultural enterprises. As of 1978, the total outstanding debt amounted to 80-percent of GDP. Public sector outlays peaked in 1976, with a deficit which totaled 18 percent of GDP.

However, over the long term, Panama's development outlook is favorable. Implementation of the Panama Canal Treaty offered Panama economic benefits and has helped to dispel political uncertainties which had impeded private, domestic, and foreign investment.

And there are other ways Panama can capatalize on its favorable geographic position and well-developed transportation facilities, which include a brand new airport. The government has established a free trade zone in Colon, and is considering further development of the ports of Cristobal and Balboa. In addition, Panama became a regional financial center during the 1970s. More than 85 banks have established branch offices in Panama. Clearly, the financial/service area holds strong growth potential.

Taking both the long-term growth potential and near-term constraints into account, we have assumed an annual GNP growth rate of 5.8 percent through the year 2000.

7.2 Panama Energy Resources

Table 7-4 summarizes the energy resources of Panama as of 1979. Each of the resources estimates is discussed below. The map in Figure 7-1 shows the locations of major resources in Panama.

TABLE 7-4

PANAMA

ENERGY RESOURCE SUMMARY, 1979

Hydroelectric Potential Theoretical Capacity: 2,500 MW[1] Installed Capacity: 233.6 MW (36% of total installed capacity, including former Canal Zone)
Geothermal Hot spring areas located at Cerro Pando and Agua de Salud.[3] Only surface testing has been performed to date.
Oil Reserves Proven: None.[4] Estimated: Unknown. Refining Capacity: 100,000 barrels/day[5]
Gas Reserves Proven: None.[4]
Coal No known reserves.[4]
Wind This has not been adequately evaluated. Five to ten km/hr is the annual average measured at meteorological stations.[6]
Solar Daily radiation is 341.8 to 421.2 cal/cm^2 on the average.[6]
Biomass Forests: There are 4.1 million hectares of forest and woodland.[7] Sugar: Some 41,000 hectares of sugarcane were harvested in 1978.[7]

[1] Personal communication with IRHE staff.
[2] Boletin de Estadistica Electrica - Ano 1978.
[3] Estado Actual del Reconocimiento Geotermico en la Republica de Panama, November 1977.
[4] Personal communication with Director General de Recursos Minerales.
[5] Personal communication with Texaco staff.
[6] Estadistica Panamena Ano 1976--Situacion Fisica, "Meteorologia Ano 1975."
[7] FAO Production Yearbook, 1978, Vol. 32.

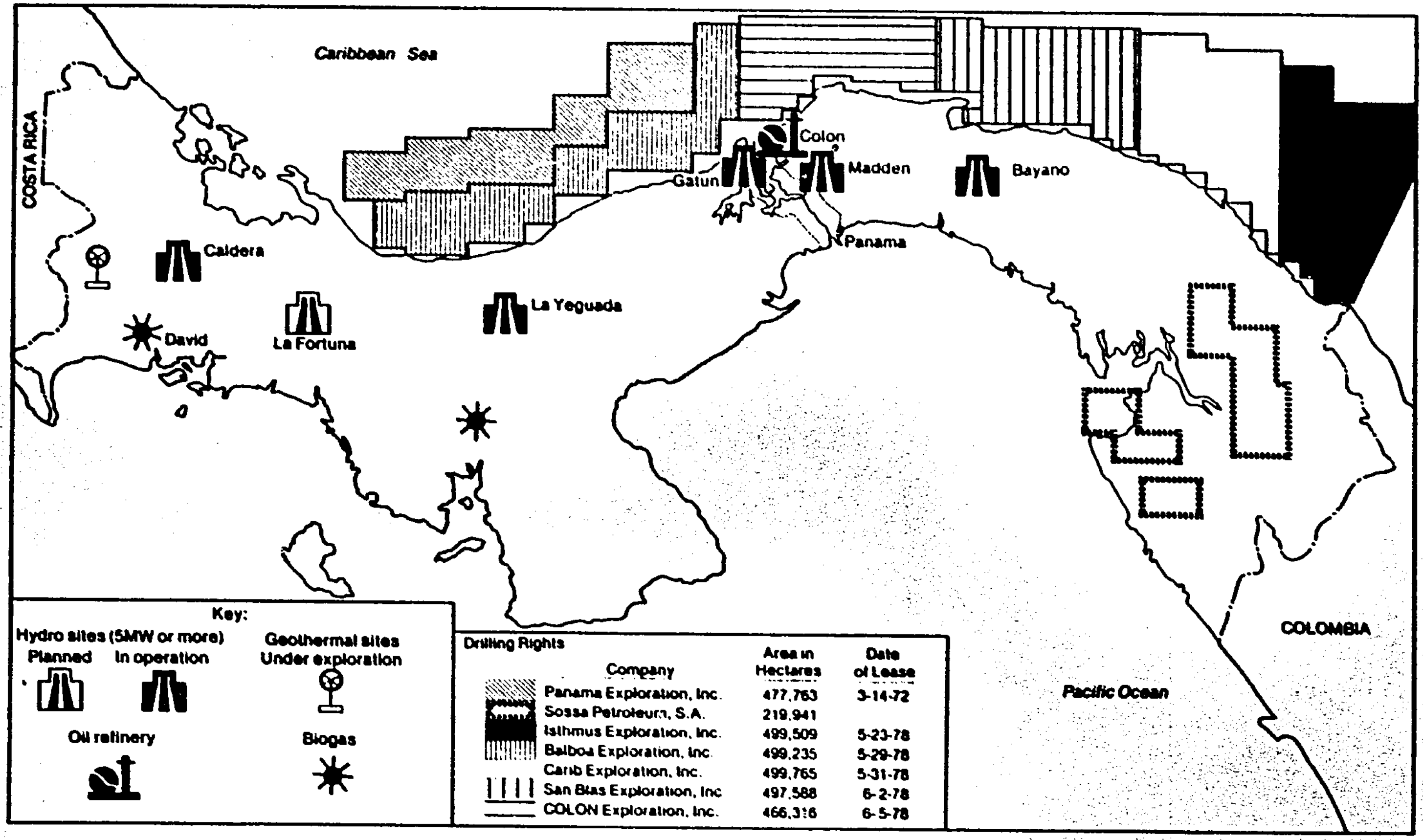


FIGURE 7-1
ENERGY RESOURCES FOR PANAMA

Hydro

Panama is just beginning to tap its extensive hydroelectric potential. Panama's electric company, Instituto de Recursos Hidraulicos y Electrificacion (IRHE), has investigated potential hydroelectric sites totalling 2500 MW. It is quite possible that the total national potential is even higher than this figure. The rivers that empty to the north into the Golfo de Los Mosquitos in the Bocas del Toro and Varaguas have not been assessed. This is the area of maximum and most constant rainfall in Panama.

At the end of 1978, Panama, including the Canal Zone, had a total of 653 MW of installed generation capacity. Of this capacity, 233 MW were hydroelectric.

Geothermal

IRHE has identified a number of sites in western Panama for possible geothermal energy development including the provinces of Chiriqui, Veraguas, Cocle, and on the island of Coiba. To date only surface testing of these sites has been performed. Based on these preliminary results, IRHE feels that the sites at Cerro Pando in Chiriqui and Agua de Salud in Veraguas are the most promising. Surface features at both sites are limited to small hot springs with moderate temperatures (less than 75°C) and small water flows.

Oil

Figure 7-1 shows the extent of crude oil drilling activities throughout Panama along with the offshore drilling right concessions. At present, onshore exploratory wells have failed to show any economically extractable quantities of oil or gas. The offshore potential for crude oil is undetermined.

The only refinery in Panama is owned and operated by the Texaco Company. This 100,000-barrel-per-day facility is located in Colon on the Caribbean coast. It serves almost all of the domestic petroleum needs of Panama plus a significant amount of petroleum product export to other countries.

Gas

There are no known natural gas reserves in Panama.

Coal

There are no known significant coal deposits in Panama. Small traces of lignite have been noted in Colon at Las Tres Hermanas, in Los Santos at Barbacho, and in Bocas del Toro. Superficial analysis has been undertaken in the first two areas where several hundred square meters of land was inspected. Deeper probing at the Colon site proved similarly disappointing. Although Bocas del Toro has not been extensively explored, mineral experts in Panama feel that coal prospects there are not promising.

Wind

Wind data is collected at seven sites throughout Panama. Data are used for meteorological purposes and are not sufficient to evaluate wind energy potential for Panama. However, average annual wind speed varies from 5 to 10 km per hour for the available sites.

Solar

Solar radiation data is available from seven meterological stations (not necessarily the same as for wind). Average daily solar radiation varies from 341.8 to 421.2 cal/cm^2 with the highest figure measured in the province of Los Santos.

Biomass

Biomass resources include wood, bagasse, and coffee waste. FAO data for 1977 indicate that 55 percent of Panama's land area is forested.

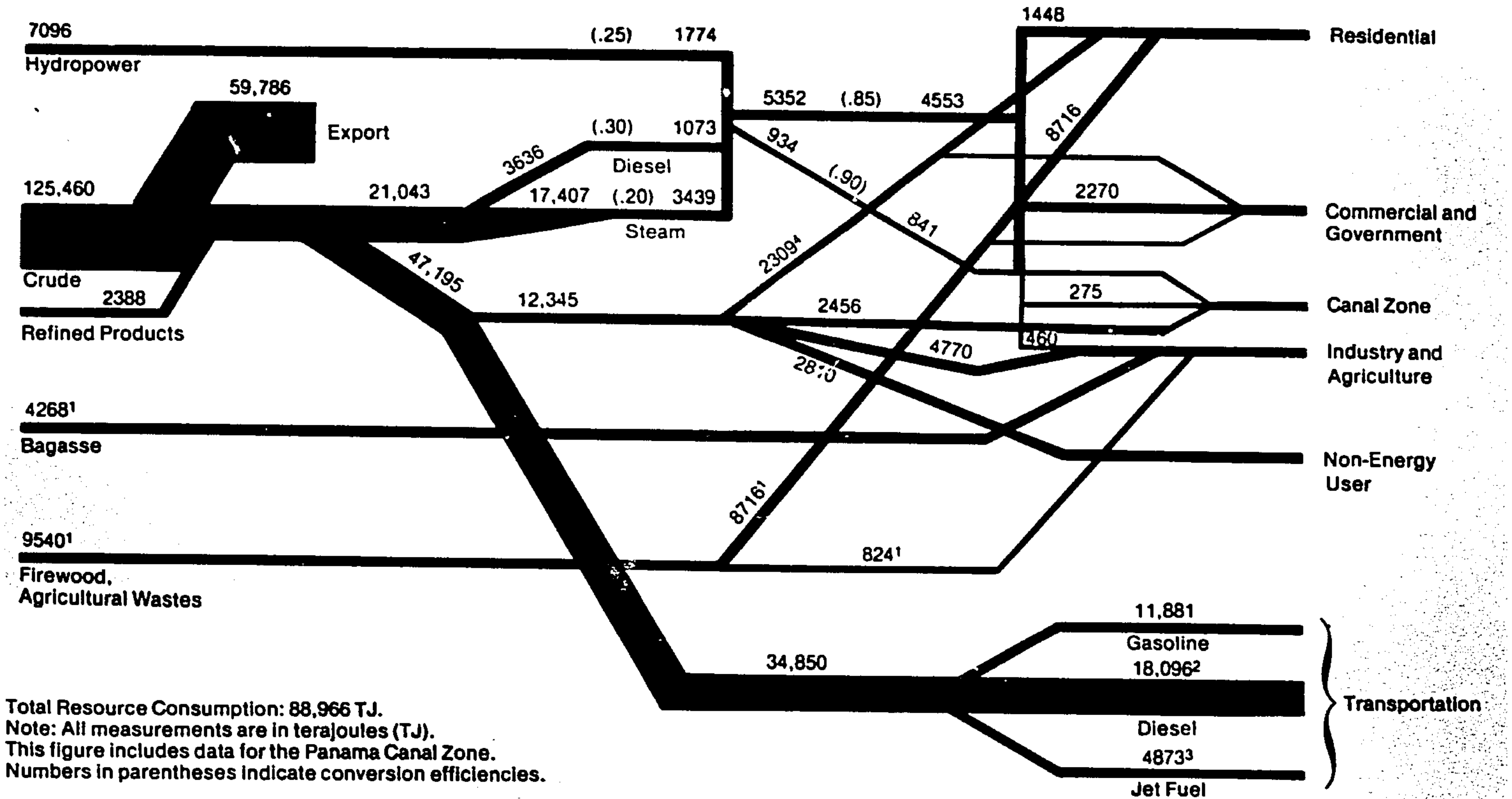
7.3 Current Energy Use in Panama

Energy resource consumption in Panama in 1977 amounted to 88,966 terajoules; 77 percent corresponds to petroleum, 16 percent to non-commercial energy and 8 percent to hydroelectricity. This total excludes 59,786 terajoules of exported petroleum products refined in the country, 80 percent of which are sales of bunker fuel to ships using the Panama Canal. Figure 7-2 depicts the flow of energy resources to all sectors of final demand for 1977. Energy use in area of the Panama Canal, which in 1977 was still under U.S. jurisdiction, is included; the electric sector in Figure 7-2 is an aggregate of Panama's electric utility sector and the Zone's own electric generation. The Zone's consumption of oil for other uses is included under a separate final demand sector. The sections that follow describe the principal features of Panama's energy system, in particular its large petroleum sector.*

Electric Sector

Historically, Panama has depended, more than any other Central American country, on thermal generation of electricity (see Table 7-5). Until 1976, hydro constituted less than ten percent of public sector installed capacity and contributed a similar share of gross electricity generation. In that year, the 150-MW Bayano plant opened; and installed hydroelectricity jumped tenfold, reaching 166.1 MW or 35.7 percent of total capacity. By the following year, hydro's

*Figure 7-2 shows a net supply of petroleum (crude and product imports minus product exports) of 68,062 terajoules; total consumption is shown as 47,195 terajoules for direct uses (excluding internal use by the refinery) and 21,043 terajoules as inputs to the electric sector, totalling 68,238 terajoules. This discrepancy arises from the conversion of barrels to terajoules for crude, diesel, gasoline, bunker, etc., and reflects that the conversion used for crude, 6120 million joules per barrel, is low in this case.



Total Resource Consumption: 88,966 TJ.
Note: All measurements are in terajoules (TJ).
This figure includes data for the Panama Canal Zone.
Numbers in parentheses indicate conversion efficiencies.

[1] *ECLA estimate.*
[2] *Derived from the ECLA breakdown between diesel used in transport and in other sectors.*
[3] *Derived from ECLA breakdown of kerosene used in transport and other sectors.*
[4] *LPG and kerosene used in households. ECLA breakdown.*

0-999 TJ
1000-14,999 TJ
15,000-50,000 TJ
50,000- TJ

FIGURE 7-2
ENERGY FLOW FOR PANAMA IN 1977

TABLE 7-5

PANAMA

ELECTRIC SECTOR DATA

	1975	1976	1977	1978	Growth Rate (%)
Total Installed Capacity					
MW	290	465	465	486	
Hydro	16	166	166	187	
Thermal	274	299	299	299	
Maximum Demand (MW)	214	242	251	253	
Generation, Gross (GWh)	1,251	1,408	1,486	1,502	
Generation, Net (GWh)	1,184	1,340	1,433	1,459	
Hydro	98	138	341	719	
Steam	964	1,026	860	580	
Diesel and Gas Turbine	189	244	285	203	
Sales, Total (GWh)	1,041	1,143	1,265	1,261	7.2
Residential	361	393	402	413	7.2
Industrial	133	129	128	142	3.7
Commercial	352	364	397	419	7.9
Government/Public Lighting	162	199	219	247	10.8
Other	14	15	15	16	11.0
Sales to Canal Zone	15	39	94	23	
Purchases from Canal Zone	30	9	17	10	

Source: IHRE.

share of gross generation was 23.0 percent. With the opening of a plant at La Estrella in 1978, installed hydroelectric capacity stood at 187.1 MW or 38.5 percent of total installed capacity, still below the regional average of 41.6 percent. Gross hydroelectric generation, however, reached 718.9 GWh, or 48.0 percent of the country's electricity output of 1,501.7 GWh in 1978.

Partially as a result of Panama's relatively greater reliance on thermal generation, the average price of electricity to consumers is the highest in the region, 5.8 cents/KWh in 1976 and 7.4 cents/KWh in 1978.*

Slow economic growth over the last six years is responsible for Panama's relatively modest annual increase in electricity consumption (7.2 percent). Hydro increased its share of generation in the same period from 9 percent to 48 percent, directly contributing to holding down petroleum consumption in the electricity generation. (See Table 7-6.)

All public service electricity generation and distribution, with the exception of the former Canal Zone, is the responsibility of the Instituto de Recursos Hidraulicos y Electrificacion (IHRE), a government utility. By late 1979, 99.6 percent of IHRE's generation occurred within its interconnected system. Individual diesel generators managed by IHRE presently serve the small remainder of isolated communities.

Private industrial electricity producers have an installed capacity of approximately 42.9 MW (see Table 7-7). A 1977 government

*IHRE (Institute de Recursos Hidraulicos oy Electriqicacion), <u>Boletin de Estadistica,</u> 1978.

TABLE 7-6

PANAMA

PETROLEUM TO ELECTRIC GENERATION[1]

ıousand barrels)

	1973	1975	1977	1978
Republic of Panama				
Diesel	371	418	460	347
Bunker	1,875	1,913	1,817	1,277
Total	2,245	2,331	2,277	1,624
Canal Zone				
Diesel			132	
Bunker			809	
Total			941	

[1]Data includes all public and private utility companies other than in Bocas del Toro province, and excludes private sector self-generators.

Sources: IHRE and Panama Canal Commission.

TABLE 7-7

PANAMA

AUTOPRODUCTORES, 1976

Installed Capacity (MW)[1]	42.9
Cement	8.1
Iron/Steel	2.3
Manufacturing	7.5
Sugar Refineries	25.0

[1]All generation is thermal (bunker, diesel, or bagasse). The cement sector and sugar refineries produce approximately half their energy requirements. The Texaco Refinery in Colon also generates its own electricity, using under 2% of its refined product output for such purposes.

Source: Direccion de Estadistica y Censo.

survey showed that net generation in the industrial sector in 1976 reached 112.7 MWh, primarily in cement production, sugar refining, food processing, and miscellaneous manufacturing.

Canal Zone Energy Production and Consumption

An assessment of energy production and consumption in Panama is complicated by the presence of the former Canal Zone, whose economic and demographic characteristics are anomalous in several respects.

The "ex-Zone" is dedicated exclusively to official and residential pursuits. The primary industry is the Panama Canal and its support activities. Within the ex-Zone, the Panama Canal Commission (formerly the Panama Canal Company) produces and distributes electricity, exchanging electricity with IRHE as necessary. Total installed capacity is 162.0 MW, of which 46.5 MW, or 28.7 percent, is hydro and the remainder thermal (see Table 7-8). In 1978, the PCC generated 663 GWh of electricity primarily for use within the Zone.

The Canal Zone electric sector is a special case. While installed hydro capacity is 46.5 MW, hydroelectric production from the Madden and Gatun hydro plants varies greatly year to year depending upon rainfall and the hydraulic requirements of the Canal. The Canal is actually a regulated watershed, and sufficient rainfall and water flow is needed to operate the Canal system and the gravity-fed locks. In dry seasons, as in 1977, priority is given to Canal use over electricity generation.

Energy consumption in the ex-Zone follows different patterns from those in neighboring Panama. The ex-Zone is a high-energy consumption enclave populated primarily by relatively high-income American citizens. No industry or agriculture exists within the area's boundaries: all energy consumption is either residential,

TABLE 7-8

PANAMA CANAL ZONE

PANAMA CANAL COMPANY INSTALLED CAPACITY, 1978

Total Installed Capacity (MW)	162
Hydro	46
Thermal	116

Source: Panama Canal Commission.

commercial (including government and Canal services), or in transportation.* Energy production and consumption are divided between a predominant military population and a civilian population employed by the PCC. (See Table 7-9.)

The PCC has made extensive efforts since 1975 to curb both electrical and petroleum consumption. As a result of a comprehensive conservation program, including an active monthly reporting system within the PCC and the Canal Zone government, total energy consumption within the Canal Zone decreased, even with workload and mechanization increases, from 1975 to 1978.

The Canal Zone's presence further complicates projections due to the temporary nature of its inhabitants' residence. The population, rather than growing, has actually decreased from a World War II high of nearly 100,000 to less than 40,000 in 1980. Further population loss is likely, to uncertain levels, unless an influx of Panamanian citizens occurs.

Petroleum Sector

Panama imports and refines more than twice its internal needs, making this sector the largest in Central America. It owes this distinction essentially to an accident of geography, the presence of the Panama Canal, which led Texaco to establish a 100,000-barrels/day refinery at Colon. Texaco sells surplus refinery output for export or, via the Canal, as fuel to transiting ships.

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*Data excludes military petroleum consumption, inasmuch as this energy is imported from the United States and consumed outside the Panamanian economy. However, petroleum usage by the Panama Canal Commission and the civilian population, along with data on all Zone electricity capacity, generation, and consumption, are included in our analysis.

TABLE 7-9

PANAMA CANAL ZONE

PANAMA CANAL COMPANY ELECTRICITY GENERATION AND DISTRIBUTION, FISCAL YEAR 1974-1978

(GWH)

	1974	1975	1976	1977	1978	(1978 %)
Gross Generation	648	631	622	559	663	(100.0%)
Hydro	258	204	339	102	300	(45.3%)
Steam	288	359	256	403	334	(50.4%)
Diesel	102	68	27	54	29	(4.4%)
Net Generation	636	615	612	544	651	-
Net Power Purchases	65	56	31	99	(21)	-
Nuclear (Army Power Barge)	39	25	28	(1)	0	-
Diesel (Army Power Barge)	26	36	13	0	0	-
IRHE	0	(5)	(10)	100	(21)	-
Total Net Power Generation and Purchase	701	671	643	643	630	-
Losses	42	49	41	46	43	-
Power Distributed and Consumed	659	622	602	597	587	(100%)
Non-Military	NA	318	303	301	295	(50%)
Panama Canal Company/ Canal Zone Government	NA	177	169	171	171	(29%)
Employees Quarters	NA	110	103	98	93	(16%)
Other	NA	31	31	32	31	(5%)
Military	NA	304	299	296	292	(50%)

Source: Panama Canal Commission.

The refinery's input of crude oil reached a high of 29.2 million barrels in 1975 before falling to 20.5 million barrels in 1977 and 16.9 million barrels in 1978. This drop reflected a drastic curtailment in the availability of Ecuadorian crude, upon which Texaco depended for most of its petroleum supplies. With rising spot market prices, the Ecuadorian government decided in 1978 to take its royalties from Texaco production in oil instead of cash, selling this oil for a profit on the spot market.

As crude imports have fallen, exports of refined products have dropped, weakening the country's foreign exchange position and diminishing the refinery's contribution to the total economy. This is particularly true for sales of fuel, primarily bunker oil, to ships passing through the Canal. These sales, which constituted an average 65 percent of exports (including sales to the Canal Zone) over the period 1972 to 1978, fell from 16.1 million barrels in 1972 to 5.0 million barrels in 1978.

Apparent domestic consumption is difficult to ascertain given the considerable "leakage" occasioned by exports, sales of bunker to ships, consumption by the Canal Zone, and sales of jet fuel to international air carriers refueling at Panama's international airport. Domestic consumption appears stable due to economic recession, the lowering of petroleum use in the electric sector following the introduction of new hydro capacity, and consumption stemming from higher gasoline, bunker, and diesel prices. (See Table 7-10.) Consumption in the Canal Zone has always been inextricably linked to the Panamanian economy and, with the implementation of the new U.S.-Panamanian Canal treaty, to the Panamanian polity as well. A balance for 1977 of the petroleum sector of Panama, including the Zone, is shown in Table 7-10.

TABLE 7-10

PANAMA

PETROLEUM BALANCE, 1977

	Imports		Refinery Output		Exports		Internal Consumption					
							Panama		Canal Zone		Total	
	10^6 bbls	TJ	10^6 bbls	TJ	10^6 bbls	TJ	10^6 bbls	TJ	10^5 bbls	TJ	10^6 bbls	TJ
Crude	20.50	125,460	-	-	-	-	-	-	-	-	-	-
Refined Products												
Gasoline	0.07	373	2.46	13,602	0.38	2,094	2.02	11,171	0.13	710	2.15	11,881
Kerosene	-	-	1.83	10,928	0.94	5,645	0.88	5,283[3]	-	-	0.88	5,283
Residual	0.02	-	10.53	69,820	7.44[1]	49,306	2.11	13,976	0.99	6,538	3.10	20,514
Diesel	0.26	1,619	4.39	26,973	0.45	2,741	3.98	24,473	0.22	1,378	4.20	25,851
LPG	0.09	396	0.36	1,503	-	-	0.45	1,899	-	-	0.45	1,899
Refinery Use	-	-	0.39	2,376	-	-	0.39	2,376	-	-	0.39	2,376
Other	-	-	0.46	2,810	-	-	0.46	2,810	-	-	0.46	2,810
		2,388		128,012		59,786	10.29	61,988	1.34	8,626	11.63	70,614

[1] Sales to ships (bunkers).
[2] Excludes use by the military; it also excludes any direct imports that may have been made by the Zone.
[3] Includes about 0.8 million barrels (4,873 TJ) of jet fuel sales to planes.

Source: Direccion de Estadistica y Censo, Instituto de Recursos Hidraulicos y Electrificacion.

In the mid-1970s, IHRE began to phase out the provision of "town gas" or piped gas manufactured from fuel oil, to customers in Panama City and Colon. By 1976, IHRE had discontinued the distribution of town gas in Panama City and consumption dropped to 53,123 cubic feet in Colon (33 percent residential and 17 percent commercial). Town gas sales in Colon continued to drop through 1978 and are due to be fully replaced by LPG in the near future. (See Table 7-11.) As demand for LPG increased and as refinery production of LPG decreased due to reduced crude imports, LPG imports have jumped considerably.

Non-commercial Sector

ECLA estimates that non-commercial fuels such as fuelwood, bagasse, and other agricultural wastes provided 13,808 TJ of energy to the Panamanian economy in 1977 or 15.5 percent of energy input. According to the 1970 census, 45 percent of the population of 600,000 people utilize fuelwood, primarily for home cooking and lighting but also for small industry. IRHE is presently completing a survey on fuelwood use in the rural sector which will provide more reliable data on fuelwood use. Preliminary results indicate that 650,000 people (39 percent of the population) continue to depend on firewood for daily energy needs.

Five sugar refineries exist which burned approximately 4,268 TJ of bagasse in 1977 (4.8 percent of total demand). Heat from the bagasse is used to assist in the refining process or, at least in the case of the government-owned refineries, to generate electricity for internal use. Inasmuch as sugar refining is relatively a large energy consumer, more efficient use of bagasse could lower present requirements for electricity and petroleum inputs.

TABLE 7-11

PANAMA

GAS CONSUMPTION, 1972-1978

(thousands of cubic feet)

Year	Total	LPG (Cylinder)	Town Gas
1972	933,631	448,030	485,601
1973	899,051	475,964	423,087
1974	898,015	511,735	386,280
1975	893,795	598,590	295,205
1976	717,082	629,356	87,226
1977	703,352	647,394	55,958
1978	738,115	689,327	48,788

Source: Direccion de Estadistica y Censo, Estadistica Panamena, 1978.

Sectoral Consumption

The largest electricity consumers are the residential and commercial sectors, reflecting the high percentage of population served by the electric utility (52.4 percent in 1978) and the service orientation of the Panamanian economy. In 1978, industry consumed only 11.3 percent of public electricity sales. However, private electricity production in the industrial sector probably came close to matching purchases from the public utility. A 1977 government survey showed private industry generation equalling 81.4 percent of the sector's purchased electricity in 1976.

Integration of the Canal Zone into the Panamanian statistical base reinforces the service bias of the figures. No industry exists in the former Zone.

The fastest growing sector in terms of electricity growth is the government sector, reflecting the expansion of government responsibilities under the military government which took power in 1968. The slowest growth took place in the industrial sector. Local manufacturers face difficulties of high wage and other input costs, competition from foreign manufacturers whose entry into the Panamanian market is facilitated by the Canal, and a small national market inhibiting economies of scale.

Total apparent domestic consumption of petroleum (including the Canal Zone and refinery consumption) reached 11.63 million barrels in 1977, or 70,614 TJ. ECLA data indicated that in 1977 51.1 percent of petroleum went to transportation, 18.8 percent went to other direct uses (such as industry, agriculture, commerce, government, and residences), and 30.1 percent went to the generation of electricity. The percentage petroleum use for transportation purposes confirms

Panama's heavy dependence upon trucks, buses, and private autos for movement of goods and people.

7.4 Future Energy Use in Panama

7.4.1 Electric Sector Expansion Plans

To meet an anticipated 7.4 percent annual growth rate between 1980 and the turn of the century, Panama is readying an extensive construction program in electricity generation capability. As in most other Central American countries, Panama is emphasizing the development of its considerable hydro resources, estimated at a minimum 2,500 MW, based on sites evaluated to date.

The major independent variable influencing Panama's electric sector expansion plans is the proposed two-billion-dollar Cerro Colorado copper project. Its inauguration is planned for 1985, but it has received criticism on environmental and financial grounds. As a result, and given the country's precarious financial overextension (a weak economy coupled with a debt-service ratio of over 50 percent), Panama is finding it difficult to enlist foreign investors.

IRHE estimates Cerro Colorado would require an average 1,510 GWh of electricity annually, with a peak load of 148.5 MW. To accommodate this demand, IRHE would have to raise its gross generation in the year 2000 by 12 percent, from 7,662 GWh to 8,549 GWh.

IRHE has defined four options for electricity generation growth over the next twenty years, two options with Cerro Colorado and two options without.* All four options assume that IRHE will expand

*IRHE, Estudio para la Expansion del Sistema Electrico de la Republica de Panama, 1979.

generating capacity at Fortuna (150 MW) in 1983 and Bayano (70 MW) in 1984. In any case, IRHE will construct hydroelectric plants on the Changuinola River (264 MW and 306 MW) and on the Teribe River (237 MW) sometime after 1986, although the exact timing will vary with the option selected.

Essentially, the two options in each category (with and without Cerro Colorado) represent greater or lesser emphasis on hydro development, and involve certain trade-offs. The options emphasizing hydro hold promise for independence from high-cost imported energy requirements in the electric sector. However, under these options, additional investments are required in site and transmission infrastructure. By scaling back hydro construction and introducing smaller thermal plants, considerable savings can be made because as these facilities are cheaper to build, require less lead-time, and can be located closer to existing transmission lines and demand centers.

Should Panama proceed with the Cerro Colorado project, it has been suggested that it seek low-sulphur Colombian anthracite for three coal-fired plants.

Geothermal potential in Panama is undetermined. Based on a MITRE/E/DI analysis of test data and a site visit, geothermal development for electricity generation appears unlikely for at least the next ten years. IRHE has no active geothermal development staff and does not currently project geothermal generation.

A major goal of Panamanian electric sector policy is to increase the scope of rural electrification. With more than half of its population currently served by electricity, the country is farther ahead towards achieving this goal than any other country in the region except Costa Rica. However, rural electrification is very expensive. Instead of integrating the small isolated systems into the national grid, IRHE plans, with AID/IDB support, to introduce minihydro and, later, possibly other alternative energy sources. In the case of minihydro, according to one IRHE official, the economies are extremely favorable--2 cents/KWh as opposed to the December 1979 cost of 16 cents/KWh for small thermal plants.

7.4.2 Energy Growth Projections

Future energy requirements in Panama are calculated on the basis of an average GNP growth rate of 5.8 percent per year through the year 2000. MITRE/E/DI assumes population growth to be 2.05 percent per year, the lowest in the region, and expects the ratio of urban population to increase from a current 56 percent of total inhabitants to 71 percent in 2000 based on CELADE's projections.

Electric Sector Projection

For purposes of this analysis, the electricity demand projections published by IHRE have been utilized. These indicate a growth rate of 7.4 percent per year through the year 2000, to a total generation of 7,662 GWh (excluding the consumption of Cerro Colorado). The needs of the Panama Canal Commission are assumed to remain constant at their current levels, bringing the total demand for Panama to 7,921 GWh in the year 2000. (See Table 7-12.) This projection is considerably lower than the one calculated by ECLA's interconnection study, even if new copper mining operations get underway. ECLA's projection implies a per-capita electricity consumption in the year 2000 of over 2,800 KWh, approaching levels currently observed in some European countries.

TABLE 7-12

PANAMA

ELECTRICITY DEMAND PROJECTIONS

	1977	2000[1]	Growth Rate (%) 1977-2000
Total Electricity Sales			
Panama			
(GWh)	1,265	6,534	7.4
(TJ)	4,553	23,524	
Canal Commission			
(GWh)	597	597	
(TJ)	2,149	2,149	
Total			
(GWh)	1,499	6,768	
(TJ)	5,394	24,365	
Losses			
Panama			
(GWh)	222	1,128	7.3
(TJ)	799	4,059	
Canal Commission			
(GWh)	26	26	
(TJ)	93	93	
Total			
(GWh)	248	1,154	
(TJ)	892	4,152	
Canal Commission			
Total Generation			
Panama			
(GWh)	1,487	7,662	7.4
(TJ)	5,352	27,583	
Canal Commission			
(GWh)	259	259	
(TJ)	934	934	
Total			
(GWh)	1,746	7,921	
(TJ)	6,286	28,517	

[1]Excludes development of Cerro Colorado.

Source: MITRE/E/DI.

Petroleum Demand Projections

The demand for petroleum products for households, transportation and industry (excluding the internal use by refineries) is escalated at a rate of 6.1 percent per year for Case I and at 4.1 percent per year for Case II. These growth rates are obtained by applying the income and price elasticities discussed previously in the report to the postulated GNP annual growth rate of 5.8 percent and by assuming a real increase in the price of oil of 5 percent per year. Under these circumstances, total consumption reaches some 30.1 million barrels for Case I and 19.5 million barrels in Case II. These projections include household and road transportation consumption in the former Canal Zone, but exclude the sales of bunker fuel to ships using the Canal. (See Table 7-13.)

Non-Commercial Fuels

For projection purposes, non-commercial energy is escalated at the rate of growth of total population, estimated to be 2.05 percent per year. By applying this growth rate we obtain a total non-commercial energy use of 22,021 TJ, using as a base the ECLA estimate of total non-commercial fuel consumption in 1977.

7.4.3 Future Energy Resource Consumption

A final energy balance for the year 2000 requires an estimation of the resource mix needed to meet electric generation demands. The electric sector supply balance is presented in Table 7-14 and shows that a very large expansion of hydro capacity, in the order of 1,200 MW, will have to take place. Sites amounting to 1,200 MW and more have been identified; their economics relative to imported coal is under consideration. However, consistent with the approach taken in this study for other countries, it is assumed that capacity expansion will be hydroelectric. The existing 415 MW of thermal capacity are

TABLE 7-13

PANAMA

PETROLEUM DEMAND PROJECTIONS, DIRECT USES

(Terajoules)

	1977	Year 2000 Case I	Year 2000 Case II
Total Direct Uses	47,195	184,226	118,922
Industry[1]	7,580	29,589	19,100
Transport	34,850	136,037	87,815
Residential	2,309	3,870	5,818
Ex Canal Zone[2]	2,456	4,730	6,189

[1]Includes non-energy uses of petroleum products (asphalts, lubricants, etc.).

[2]Includes the transportation, household and other uses in the area under jurisdiction of the United States in 1977.

Source: MITRE/E/DI.

TABLE 7-14

PANAMA

ELECTRICITY SUPPLY BALANCE, YEAR 2000[1]

	Capacity (MW)	Generation (GWh)	Generation (TJ)	Resource Use (TJ)
Hydro	1,434	6,280	22,608	90,434
Existing	234			
New Sites	1,200			
Geothermal	0	0	0	0
Thermal	815	1,650	5,940	23,760
Existing	415			
Total Generation		7,930		
Total Demand		7,921		

[1] Includes area of former Panama Canal Zone.

Source: MITRE/E/DI.

assumed to be generating electricity in 2000 also. Based on current knowledge of Panamanian geothermal resources, the MITRE/E/DI team assumes that no electricity will be generated from this resource during the next two decades. A final energy balance of Panama's resource consumption for the year 2000 is shown in Table 7-15.

7.5 Energy Strategies for Panama

Oil Substitution

Petroleum demand by the electrical sector is projected to be 3,760 TJ in the year 2000; petroleum substitution by another resource would reduce total demand by more than 11 percent. The possibility of introducing coal (imported from Colombia) has been discussed as an alternative to building hydro sites. The economics of coal versus petroleum should be investigated; a total replacement of oil would require about 720,000 tons of coal annually by the year 2000.

The potential substitution of electricity for direct petroleum use is limited because the Panamanian industrial sector is very small. Electric vehicles may be feasible earlier than in other countries in the region because of the highly urbanized nature of Panama. The same reasoning is valid for electric mass transport, either within the cities of Panama and Colon or between them; the potential exists for the electrification of the trans-isthmian Panama Railroad.

The impact of ethanol on Panama's large transportation sector would be slight, displacing less than one percent of total petroleum use, if producers allocated the equivalent of 25 percent of current yearly sugarcane production to ethanol and one percent of the yearly forest growth to methanol. Beyond the year 2000, impacts could be larger if methanol proves feasible.

TABLE 7-15

PANAMA

TOTAL RESOURCE USE, YEAR 2000

(Terajoules)

	1977	Year 2000 Case I	Year 2000 Case II
Hydro	7,096	90,434	90,434
Geothermal	0	0	0
Petroleum	68,062	207,986[1]	142,682[1]
Direct Uses	47,195	184,226	118,922
Electric Generation	21,043	23,760	23,760
Losses	(-176)	NA	NA
Non-Commercial	13,808	22,021	22,021
Total Resources		320,441	255,137

[1] Excludes some 40,000 - 50,000 TJ (7 million barrels) of bunker fuel sold to ships.

Source: MITRE/E/DI.

Conservation

The lack of a more complete data base precludes an evaluation of conservation potential; only general statements can be formulated. The results of reducing oil demand by 15 percent through conservation in industry are 4,400 TJ; a 20-percent savings in transport would free an additional 27,200 TJ (applied to Case I). Assuming that a 10-percent cut in electricity demand can be achieved, 14,600 TJ could be saved.

Table 7-16 summarizes the impact on the contribution of oil substitution and of conservation, as a percentage of total projected petroleum demand. In addition, the contributions of ethanol and methanol as a percentage of current gasoline use are also shown.

7.6 Recommendations to USAID for Panama Energy Programs

The recommendations given here are intended as a refinement, and in some cases an expansion of the regional recommendations presented in Volume I. Where regional recommendations do not appear as national recommendations, then the regional recommendations still hold.

Support for a National Energy Policy-Making Organization

Energy policy-making responsibilities and resources in Panama are currently distributed among several groups and need to be consolidated. Once this has been accomplished, USAID can be of help by providing technical training and initial staff support, program planning, and evaluation skills.

Support for Energy Conservation Planning

Energy conservation should be a prominent part of national energy planning and policy development. To encourage conservation planning, USAID should emphasize conservation-related skills in any training or staff support which is provided. USAID should explore

TABLE 7-16

PANAMA

IMPACT OF SELECTED STRATEGIE

	Percent Decline of Total Petroleum Demand[1]	Contribution as a Percentage of Current Gasoline Use
I. Oil Substitution		
a. Substitution of 50% of petroleum used in electric generation with coal or imports	5.7%	----
b. Same as (a) for 100%	11.4%	----
c. Production of 10% of ethanol potential[2]	0.15%	3%
d. Production of 25% of ethanol potential[2]	0.4%	6%
e. Production of 0.5% of methanol potential[3]	0.8%	14%
f. Production of 1.0% of methanol potential[3]	1.6%	29%
g. Substitution of electricity for petroleum-based processes, vehicles, vehicles	very small	----
II. Conservation		
a. Conservation in industry (15%)	2.1%	----
b. Conservation in transportation (20%)	13.1%	----
c. Savings in electricity use (10%)	7.0%)	

[1] Using Case I petroleum demand as a basis.

[2] Percentage of current land devoted to sugar cane to be dedicated to energy production, or equivalent area added to cultivation.

[3] Percentage of current yearly available forest resource to be used for methanol production.

Source: MITRE/E/DI.

the potential for a sharing of the successful conservation experience of the Panama Canal Commission (formerly the Panama Canal Company). The results of the Commissions's conservation program provide an example of how efficiency can be improved without sacrificing output through effective energy planning and management.

Support for Energy-Related Curriculum Development and Academic Research

As part of a strategy to help Panama develop energy-related analytical and research capabilities, USAID should encourage the academic community at the University of Panama to submit proposals for the development of energy-related curricula, e.g., courses in energy planning, resource management, energy modeling, technology assessment, financial analysis, and R&D activites.

Support for Panamanian Resource Assessment

The hydroelectric potential of northern Veraguas and parts of Bocas del Toro has not been adequately assessed. USAID should assist the government with accurate rainfall and water-gauge data collection in these areas. This data can then be synthesized into an inventory of hydro sites.

Support for Regional Cooperation

To encourage Panamanian participation in regional energy initiatives, USAID should investigate the feasibility of using one of Panama's state-owned sugar refineries to demonstrate ethanol conversion technology. The information base generated by such a project would be useful in helping other Central American countries plan and implement ethanol programs. The first step should be a comprehensive assessment of economic feasibility. Although Panama is already planning to add ethanol capacity at one of its La Victoria refineries, MITRE/E/DI site visits produced conflicting information concerning the technical readiness of the project. Analytical and management support may also be needed, since Panama recently rejected a Brazilian development proposal.

APPENDIX 7-A

ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES

The following table lists national institutions which are active in energy research. It contains short descriptions of each institution's activities.

TABLE 7.A-1

ENERGY RESEARCH AND DEVELOPMENT

PANAMA

Technology/Resource	Institution	Product or Activity
ALCOHOL	Corporacion Azucarera La Victoria	Received Brazilian technical assistance until 1978. Completed feasibility study for ethanol production, which indicates technical feasibility and near-competitive price. Expects funding from UN to provide consultant.
BIOGAS	Instituto de Recursos Hidraulicos y Electrificacion	Contracted study on the use of coffee hulls for biogas production.
	Grupo de Tecnologia Apropiada	Set up pilot biogas project using coffee hulls and another using animal waste digester.
COAL	Ministerio de Comercio e Industrias, Direccion General de Recursos Minerales	Carried out preliminary coal exploration at Colon and Los Santos. No commercially exploitable reserves found.
GEOTHERMAL	Ministerio de Comercio e Industrias, Direccion General de Recursos Minerales	Identified and inventoried geothermal resources. No current activity.
MINIHYDRO	Instituto de Recursos Hidraulicos y Electrificacion	Has on-going mini-hydro program. Sponsored by UNDP, IDB, and USAID. Identified 60 possible sites.
	Instituto Politecnico, Universidad Nacional	Initial studies on hydraulic rams.
PETROLEUM	Ministerio de Comercio e Industrias Direccion General de Recursos Minerales	Collects geologic information. Government agency for negotiation of risk contracts. Seven contracts have been signed. Drilling has yielded no commercial results.

TABLE 7.A-1 (Concluded)

ENERGY RESEARCH AND DEVELOPMENT

PANAMA

Technology/Resource	Institution	Product or Activity
SOLAR	Associacion Panamena para Energia Solar	Currently inactive.
WIND	Ministerio de Desarrollo Agricola	No activity.
WOOD	Direccion de Recursos Naturales Renovables (RENARE)	Has project for planting seedlings distributed to community groups. Initiating forest conservation/public awareness program. Has proposed law to establish communal woodlots.

APPENDIX 7-B

ENERGY-RELATED INSTITUTIONS

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During the MITRE/E/DI visit to Panama, a number of institutions were contacted, including:

- government agencies
- universities
- private energy development organizations
- volunteer groups
- community leaders

The institutions included in this study do not represent all energy-related organizations in Panama; however, we have identified major institutions in terms of capabilities and accomplishments.

Subsequent descriptions of institutions will be organized around these topics:

- general information, like the name of the organization, contact, location, and telephone number
- description of institution
- target audiences
- legal and financial setting of the institution
- products/services/capabilities

Several of the institutions may have more in common with the region as a whole than with the countries in which they are located. But a framework appeared necessary and a country breakdown of institutions lent itself best to the expertise of the contributing authors.

INSTITUTION: Comision Nacional de Energia

CONTACT: Cervantes Escalona, Chief
Asuntos Petroleros y Energeticos

LOCATION: Ministerio de Comercio e Industrias
Apartado 9658
Panama 4, Panama

TELEPHONE:

DESCRIPTION OF INSTITUTION:

- Recommends energy-related policies and practices to the President and ministers
- Consists of:
  - Minister of Commerce and Industry
  - Minister of Agricultural Development
  - Minister of Planning and Economic Policy
  - Director of IRHE
  - representatives from two universities
  - three citizens appointed by the Executive Branch

TARGET AUDIENCE: General public, government agencies

LEGAL AND FINANCIAL SETTING OF INSTITUTION:

- The Departmento de Asuntos Petroleros y Energeticos forms the Secretariat or support organization for this commission

PRODUCTS, SERVICES, CAPABILITIES:

- The Commission is not institutionalized nor does it have a budget; thus, it has been unable to give serious attention to energy-related issues

INSTITUTION:	Grupo de Tecnologia Apropiada
CONTACT:	Samuel Bern
LOCATION:	Apartado 8046 Panama 7, Panama
TELEPHONE:	61-3774
DESCRIPTION OF INSTITUTION:	• Has been incorporated as a private, nonprofit institution • Made up of professionals who volunteer to work with and advise rural groups • Develops projects and channels financial support to these groups
TARGET AUDIENCE:	Government agencies, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Projects have been financed by IHRE and USAID under the special development projects Program.
PRODUCTS, SERVICES, CAPABILITIES:	• Designing and building biogas unit which uses animal waste • Studying the feasibility of a pilot biogas project utilizing coffee wastes

INSTITUTION:	Instituto de Recursos Hidraulicos y Electrificacion (IRHE)
CONTACT:	Isaac Castillo, Director, and Jose Felix Coronado, Economist
LOCATION:	Edificio Poli, Segundo Piso Panama 5, Panama
TELEPHONE:	
DESCRIPTION OF INSTITUTE:	• Autonomous government agency with 4,200 employees • Provides 210,000 clients throughout Panama with electric power generation (installed capacity of over 450 MW) • Has sole responsibility for production, transmission, and distribution of electricity.
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	• Organized in 1960 and expanded in 1972 with the nationalization of the major electric generation company • Had operating budget of over $90.0 million in 1979 • Authorized to approve its own budget and internal regulations
PRODUCTS, SERVICES, CAPABILITIES	• Development of extensive hydroelectric capacity to reduce the ratio of thermal to total generation capacity • Interest in minihydro projects • Expansion of rural electrification network

- Staff capability in general energy development and analysis
- Collaboration with UNDP on energy balance project

INSTITUTION:	Direccion de Recursos Minerales Ministerio de Comercio e Industrias
CONTACT:	Daniel Esquivel K., Director
LOCATION:	Apartado 8515 Panama 5, Panama
TELEPHONE:	6401 73
DESCRIPTION OF INSTITUTION:	Government agency with the Ministry of Commerce and Industry
TARGET AUDIENCE:	General public, private businesses
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Government agency, created by law
PRODUCTS, SERVICES, CAPABILITIES:	• Regulates mineral exploration by private business • Serves as a repository for geological information • Analyzes data in geological and chemistry laboratories and is seeking to develop field analysis capabilities • Prepares a new hydrocarbon law • Advises Ministry of Commerce and Industry on development of minerals and fossil fuels

INSTITUTION:	Corporacion Azucarera la Victoria Ministerio de Desarrollo Agropecuario (MIDA)
CONTACT:	J.E. Falconett,
LOCATION:	Apartado 6-359 Estafeta El Dorado Panama, Panama
TELEPHONE:	2183 33, Extension 42
DESCRIPTION OF INSTITUTION:	Government-owned enterprise
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	
PRODUCTS, SERVICES, CAPABILITIES:	• Provided with a mandate to begin alcohol production from sugar cane and other agricultural products and waste • Interested in incorporating improvements in on-farm energy into its Applied Research Program

INSTITUTION:	Panama Canal Commission
CONTACT:	Frank K. Morris, Environmental Control/Energy Conservation Officer
LOCATION:	Office of Executive Planning Box M Balboa Heights, Panama
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	Public institution
TARGET AUDIENCE:	World community
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Created by treaty between the United States and Panama to manage the Panama Canal, and consisting of American and Panamanian representatives
PRODUCTS, SERVICES, CAPABILITIES:	Data collection and energy conservation efforts related to canal operation

INSTITUTION:	Universidad de Panama
CONTACT:	Hector Castillo Silva, Centro de Investigaciones de Energia, Escuela de Fisica
LOCATION:	Estafeta Universitaria Panama, Panama
TELEPHONE:	2385 95, Extension 43
DESCRIPTION OF INSTITUTION:	
TARGET AUDIENCE:	Students, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	
PRODUCTS, SERVICES, CAPABILITIES:	Very little research is performed. However, there is interest in working with the government on energy-related matters and serving as an information resource center on energy.

INSTITUTION:	Instituto Politecnico Universidad Nacional de Panama
CONTACT:	Victor Levi, Director,
LOCATION:	Panama, Panama
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	• Semi-autonomous university program concentrating on the training of engineers and professionals in technical fields • Located in six regional centers throughout the country, as well as in Panama City
TARGET AUDIENCE:	Students, general public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	National university created and supported by the national government
PRODUCTS, SERVICES, CAPABILITIES:	Investigation in low-cost, appropriate technologies relating to solar energy and energy conservation.

INSTITUTION:	Colegio San Benito
CONTACT:	John Fillis, Director
LOCATION:	Volcan, Chiriqui Panama
TELEPHONE:	
DESCRIPTION OF INSTITUTION:	Vocational school (high school students) with numerous community outreach activities
TARGET AUDIENCE:	Students, rural communities
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	Self-supporting except for $24,000 yearly from the government and USAID
PRODUCTS, SERVICES, CAPABILITIES:	• Encouragement of minihydro generators for agricultural and residential use • Solar water heater designs for use in the school

INSTITUTION:	Direccion Recursos Naturales Renovables (RENARE)
CONTACT:	Irving Diaz, Director
LOCATION:	
TELEPHONE:	52-2718
DESCRIPTION OF INSTITUTION:	
TARGET AUDIENCE:	General public
LEGAL AND FINANCIAL SETTING OF INSTITUTION:	This directorate is a division of the Ministry of Agricultural Development.
PRODUCTS, SERVICES, CAPABILITIES:	• Collaboration with U.S. Park Service on the preservation of the Canal Zone watershed, and on the training of the RENARE staff • Involvement with reforestation and biomass projects • Interest in methanol, community woodlots, and similar activities

Bibliography

CELADE (Centro Latinamericano de Demografia). "America Latina: Distribucion Relativa de la Poblacion Urbana y Rural, 1970, 1985, y 2000," Boletin Demografico, Ano XII, No. 23. Santiago, Chile: CELADE, january 1979.

CEPAL (Comision Economica para America Latina). Economic Survey of Latin America, 1978: Advance Summary, La Paz, Bolivia: United Nations, April 1979.

_____. Estudio Regionale de Interconexion Electrica del Istmo Centroamericano, CEPAL/MEX/STRNET/28. Mexico: CEPAL, October, 1979.

_____. Istmo Centroamericano: Consumo de Energia, 1960, 1975, y 1970 a 1976, E/CEPAL.SC.5/126. Mexico: CEPAL, June 1979.

Contraloria General. Panama en Cifras, Anos 1974 a 1978. Panama, Panama: Direccion de Estadistica e Censo, November 1979.

Diaz, Irving R. La Importancia Energetica de la Lena y el Carbon Vegetal en Panama. Panama, no date.

Direccion de Estadistica e Censo. Estadistica Panamena. Panama, Panama: Direccion de Estadistica e Censo, various years.

Escobar, Ismael and Mario E. Ibacachi. Contribution to the Analysis of the Development of Unconventional Energy Sources in Latin America. Washington, D.C.: Inter-American Development Bank, April 1977.

IRHE (Instituto de Recursos Hidraulicos y Electrificacion). Boletin de Estadistica Electrica. Panama, Panama: IRHE, October 1978.

IRHE, Direccion de Desarollo. Estudio para la Expansion de Sistema Electrico de la Republica de Panama. Panama, Panama: IRHE, August 1979.

_____. Informe Anual--1978. Panama, Panama: IRHE, no date.

_____. Plan Maestro para la Expansion y Majoras de los Sistema de Distribucion: Introduccion y Criterios, 1980-1984 (Pre-appraisal). Panama, Panama: IRHE, April 1979.

UNDP. Requerimentos Futuros de Fuentes No Convencionales de Energia en America Latina. Quito, Ecuador: UNDP, June 1979.

BIBLIOGRAPHY (Concluded)

USAID. Panama Project Paper: Alternative Energy Sources, Project no. 525-0207, LAC/DR: 79-15. Washington, D.C.: USAID, May 1979.

World Bank. Panama Economic Report (excerpts). Washington, D.C.: The World Bank, no date.