Report No. 3672-HA

Haiti: Issues and Options in the Energy Sector

June 1982

Report of the Joint UNDP/World Bank Energy Sector Assessment Program

ABBREVIATIONS

M	thousand
ST	short ton
B	barrel
B/D	barrels per day
Toe	tons of oil equivalent
kWh	kilowatt hour
¢	US cents
Ton	metric tonne

TABLE OF CONVERSION FACTORS

Energy Form	Unit	10^6 Btu/unit
Primary Sources:		
Hydropower	Gwh	10,195
Wood-Air dried	Mm^3	9,722
Bagasse (50% humidity)	MST	8,100
Secondary		
Electricity	Gwh	3,412
Charcoal	MT	28,173
LPG	B	3.7
Gasoline	B	4.9
Kerosene/jet fuel	B	5.4
Diesel Oil	B	5.5
Fuel Oil	B	5.8
Ton of oil equivalent	toe	39.68

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HAITI

ISSUES AND OPTIONS IN THE ENERGY SECTOR

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I. ISSUES AND RECOMMENDATIONS

1.01 Haiti is a small, open economy, with a markedly dual structure: a large agricultural sector, characterized by low productivity and dense population, and a modern, urban sector of rapid growth during the 1970's, which has a high import content. Although there has been moderate growth of the economy during the decade of about 3.6% per year, income per capita in Haiti (US$260) remains the lowest in the Western Hemisphere and three-quarters of its population live in dire poverty, with incomes per capita below US$100.

1.02 Agricultural production has been stagnant and as a result its share in GDP has decreased from 49% in 1970 to about 39% in 1979. Future productivity of the sector is threatened by a severe soil erosion problem. The pressure on land and the indiscriminate felling of trees for energy has reduced the land's protective forest covers and in many areas the land has lost its ability to retain moisture and regulate water run-off. The result is progressive desertification and periodic agricultural crisis caused by floods and droughts.

1.03 The manufacturing and construction sectors are not large enough to compensate for the poor performance in agriculture or to provide productive employment for migrants from rural areas. Most dynamic in recent years has been the assembly industry, which benefits from low-cost labor, but whose expansion depends on market conditions in the USA and Europe. The industrial sector generated 24% of GDP in 1979 and had an average growth rate in recent years of 5.6% per year; the share of the tertiary sector was 37% in GDP, and its growth rate was 3.6% per annum.

1.04 The poor performance of agriculture, the high import content of the modern sector and the progressive deterioration of the terms of trade have caused a growing deficit in the trade balance, which is only compensated in part by the inflow of foreign transfers in the form of public grants and private remittances from Haitians abroad. Medium term projections indicate that the deficit in the trade balance is likely to increase from US$ 128 million in 1980 to US$300 million by 1985. The Bank has already suggested a shift in economic policy toward agricultural and other raw material production to create the base for a backward linkage of the industrial sector and continued foreign assistance to supplement the low level of domestic savings.

Energy Sector

1.05 Haiti has an adverse energy position. The main characteristics are: (i) the weak natural energy base of the country, aggravated by the rapid depletion of its forest resources; (ii) the growing energy intensiveness of the modern sector of the economy and the high dependence of this sector on imported petroleum; (iii) the subcritical size of its energy systems, which constrains the choice of least cost solutions; and (iv) the weakness of the country's institutional structure and the scarcity of technical and economic capability to handle the problems.

1.06 It is therefore essential that the country develop effective and carefully balanced programs in supply development, demand management, institutional building, sector organization and pricing, and this report assesses these aspects of the energy sector. Haiti will continue to need external support and although in recent years bilateral and multilateral agencies have done a great deal in clarifying crucial issues and in project identification and formulation, there is a need for coordinated project implementation to enhance the effectiveness of these efforts and avoid duplication.

Energy Balance

1.07 Primary energy requirements rose by about 5.6% per year during the past decade, or 1.6 times the rate of economic growth. Per capita consumption (about 270 kg of oil equivalent in 1979) puts Haiti among the least energy-intensive economies of the world. The demand structure reflects the relatively small size of the modern urban sector. Although the demand for commercial fuels has grown at high rates during the 1970's (10% per year for oil, 16% for electricity and 15% for charcoal), these fuels supplied less than 25% of the final consumer needs in 1979. (Table 1.1). This is so because a significant portion of the industrial, artisanal and commercial sectors use bagasse and wood as the main energy source and because commercial energy is too expensive a commodity for the rural population, which depends entirely on fuelwood for is energy needs and derives an income from the production and sale of charcoal. Another indication of the market's segmentation is given by the fact that 93% of oil and electricity available for final consumption is used by industry and transport, although these sectors' share in total final energy demand is only 41%.

Table 1.1

1979: Sectoral Final Energy Consumption

Economic Sectors	Total Consumption		Sources of Energy (%)				
	1000 toe	%	Non-Commercial 1/	Charcoal	Electricity	Oil	Total
Residential	447	38.6	91.0	6.8	1.3	0.9	100.0
Industry	361	31.1	73.9	-	2.1	24.0	100.0
Transport	113	9.7	-	-	-	100.0	100.0
Others	239	20.6	84.9	12.7	0.7	1.7	100.0
TOTAL	1160	100.0	75.5	5.3	1.3	17.9	100.0

1/ Includes fuelwood and bagasse.

Source: Statistical Annex - Table 2.

1.08 Domestic energy resources provide 83% of total energy primary requirements. (Table 1.2). Wood is by far the most important source, followed by bagasse and hydropower. The energy deficit of about 17% is met by imported petroleum products. Although still modest in volumetric terms (4.8 thousand barrels per day in 1979), the cost of these imports has become a severe burden to the economy. The oil import bill was US$32 million in 1979 and is estimated at US$61 million in 1980, equal to 23 and 29%, respectively, of the country's export earnings. If past trends continue, the energy deficit would increase to 22% of total supplies by 1985 and if the gap were to be supplied by imported petroleum, the volume of these imports would reach 9 thousand barrels per day and their cost, in constant 1980 prices, would absorb at least 45% of Haiti's projected export revenue.

Table 1.2

1979: Structure of Energy Supply
(in thousand of tons of oil equivalent and %)

	Gross Supply		Conversion	Energy Sector Consumption & losses		Available for Final Consumption	
	Mtoe	%	% of Gross Supply	Mtoe	% of Gross Supply	Mtoe	%
Domestic	1132.4	83.1	-	152.2	13.4	948.3	81.8
Wood	980.0	71.9	17.2	107.5	11.0	811.4	70.0
Charcoal	-	-	-	-	-	61.1	5.3
Bagasse	104.5	7.7	100.0	40.3	-	64.2	5.5
Hydro	47.9	3.5	100.0	4.4	9.2	11.6	1.0
Imported Oil	229.8	16.9	9.1	12.6	5.5	207.5	17.9
Thermal Power	-	-	-	-	-	3.9	0.3
TOTAL	1362.2	100.0	-	164.8	12.1	1159.7	100.0

Source: Statistical Annex - Table 2.

1.09 The efficiency with which energy is transformed and used in Haiti merits special scrutiny in view of the growing constraints on domestic energy supplies and the economic burden of foreign energy imports. The estimate in Table 1.2 indicates that about 12% of primary gross supply of energy is consumed and lost in conversion processes. The most important loss occurs in charcoal production, although only 17% of wood was converted into charcoal in 1979. With progressing urbanization and exploitation of farther removed forests, the share of conversion will increase and result in accelerated depletion of the resource base. To limit this trend, urgent measures are required to establish plantations near urban centers, thus reducing the incentive for producing charcoal and to adopt better conversion methods. With respect to bagasse, the table shows that almost 40% of this fuel is lost because of inefficient handling and burning in sugarcane processing plants; similarly, it becomes evident that the losses in power transmission and distribution exceeded in 1979 the amount of electric power thermally generated.

1.10 On the other hand, fuelwood is used with very low efficiency by the final consumer. In this report, a 7% to 15% efficiency range was assumed, which is less than half of the estimated average efficiency with which fuels are used in Haiti. This indicates that considerable savings in fuelwood consumption could be achieved through the dissemination of more efficient stoves.

Development Projects

1.11 To realize a more sustainable energy position over the longer term, Haiti should follow a two-pronged approach. First, through appropriate demand management and stimulation of higher energy efficiency, increases in energy consumption should be curtailed in a manner which does not impair economic growth. Second, to the extent consistent with efficient resource allocation, indigenous energy resources should be developed. Since Haiti will not be able to support more than a limited number of projects during the next five years due to the shortage of trained people, it is important to distinguish between those which will have an immediate impact on the two crucial issues of Haiti's energy problem: depleting forest resources and increasing cost of oil imports, and those which are important for consideration in the longer-term.

PROJECTS WITH IMMEDIATE IMPACT

A. Indigenous Resource Development

Forest Resources

1.12 There is a general acknowledgement that the rapid disappearance of Haiti's forest cover involves an environmental problem of the first order that threatens the long-term productive capacity of the nation. Athough statistical information is inadequate, several studies have provided conclusive evidence of the growing imbalance between the natural growth rate of wood in existing forest areas and the domestic consumption of wood. The estimate contained in this report indicates a relationship of 1:2. Current reforestation programs are insufficient to introduce a significant change in this situation. The depletion of this resource is further aggravated by the continuing and uncontrolled expansion of agriculture into forest areas. To overcome the problem and assure a continued supply of fuelwood and charcoal, Haiti must proceed with a determined reforestation policy, including protection of remaining forests and new plantations. However, there is a justified concern that energy plantations would compete with land required for agriculture. The issue must be resolved through the definition of a land use policy and through the formulation of a strong agricultural extension program to increase the productivity of land. As a first step, a national inventory and mapping program should be completed, showing current land cover and use. It is recommended that this survey be started on a priority basis on areas suitable for fuelwood plantation development and later be expanded to cover the entire country. Further, the following actions are recommended:

(a) Identification and eventual establishment of forest plantations of fast growing species which will supply a significant portion of the nation's needs for charcoal and fuelwood. Fully implemented the program would cover between 100,000 and 300,000 ha and should be located near the major consuming centers. An immediate goal should be the establishment of a 10,000 ha

plantation near Port-au-Prince, with the objective of meeting about one-third of the capital's charcoal demand by 1990.

(b) Immediate action to sharply reduce erosion and sedimentation at Peligre and thus to protect Haiti's hydroelectric resources. Requirements include the control of grazing and cultivation, the planting of grasses on steep slopes, and reforestation of the Artibonite headwaters, in conjunction with orderly agricultural development.

(c) Identification of several blocks of partially forested land suitable for wood production which could be improved by immediate institution of basic forest management practices including fire control and elimination of illegal felling and cattle grazing. After a short period, stand improvement and planting could be initiated in these areas, with the double objective of energy production and industrial utilization of wood. The pine forest of La Selle should be considered for demonstration of these policies. The long-term objective should be to establish such forest management on approximately 100,000 ha. The Northwest Region should be included in the program.

(d) Establishment of plantation programs to identify suitable tree species and to demonstrate results for wood production and erosion control. Provisional estimates of trial plantation sizes are:

Location	Hectare
Central Plateau	200
North-West (dry sites)	100
North, or North-East (mountain sites)	100
North, or North-East (plain)	100
Cul-de-Sac	100
Southern Regions	200

Expansion of Power Generating Capacity

1.13 For planting-up purposes, electricity sales in the Port-au-Prince market have been projected by the public utility to grow at 13.1% per year during the period 1980-1986, on the basis of assumed economic growth of 4%. This compares with an actual average rate during the past decade of 16.4% in electric sales and 3.6% in GDP. Even if GDP does not grow at 4 percent, because of some industrial projects not materializing, the projections appear reasonable because demand growth is determined more by the supply capacity of the utility than by the characteristics of the market, as no more than 34% of the population in Port-au-Prince has access to electricity. The projections imply that generation requirements will double during the period and that maximum demand will increase from 54 MW in 1980 to 106 MW in 1986. For the decade as a whole, increase in generating capacity is estimated at 140 MW.

1.14 The analysis of alternative primary energy sources available for power generation indicates that the development of the hydropotential is the least cost solution for expanding generation in the interconnected system. Table 1.3 further shows that generation based on domestic lignite may not be competitive with imported coal, even if sufficient reserves can be proved to justify the installation of a steam power plant.

Table 1.3

Cost Estimate for Alternative Power Generation

Type of Plant	Size	Investment Cost	Unit Cost Estimate		
			Fuel	Capital	Total
	MW	(in 1981 US$/KW)	(¢/kWh)	(¢/kWh)	(¢/kWh)
Hydro Plants	5-32	2,200 or less	-	4.9	4.9
Diesel Units					
Bunker C fueled	7-14	800	6.2	1.9	8.1
Steam Plants					
Imported Coal-fired	30.0	1,500	3.0	3.5	6.5
Domestic Lignite-Fired					
Low Reserve Estimate	15.0	3,000	4.3	7.3	11.6
High Reserve Estimate	30.0	1,700	4.3	3.9	8.2

Source: Table 2.6

1.15 Haiti's undeveloped hydropotential is estimated at about 120 MW. The largest portion is located on the Artibonite river, downstream from the existing Peligre dam, and on an upstream tributary, the Guayamouc river. Some 100 MW, with an average aggregated generating potential of 600 GWh per year, could be developed and connected to the national grid. In addition, there are a number of mini and micro sites, some of which could be developed to supply isolated networks.

1.16 Electricite d'Haiti envisages the development of the hydropotential on the Artibonite and Guayamouc rivers during the 1980's. As a first step, its investment program for 1981-1986 establishes total expenditures at about US$250 million, allocated to the following projects:

(a) Feasibility studies for the proposed hydropower plants and construction of the largest of the four possible sites on the Artibonite (La Chapelle) and of one dam on the Guayamouc river, which not only is the least cost option for power generation but also will significantly reduce the inflow of erosion material into the Peligre Lake.

(b) A 35 MW increase in the thermal generating capacity to meet the incremental demand of the interconnected system until the hydro plants are commissioned. These plants will be diesel units, Bunker C fueled.

(c) Renovation of the distribution system, and enforcement of measures against thefts to reduce losses in the system from 28% in 1979 to at least 19% in 1986.

1.17 In addition, the following actions are recommended:

(a) Further investigation on the feasibility of developing the remaining potential on the Artibonite-Guayamouc basin, taking into account the cost of thermal capacity that has to be installed as back-up for the hydro system and comparing these costs with the coal alternative.

(b) Continue the feasibility study for the construction of a dam on the Artibonite river, upstream from Peligre, to further reduce the siltation problem of this reservoir and generate electricity. EdH should also obtain additional information on the hydrology of other upstream river basins to determine whether dams could be built in this area in the future.

(c) Initiate studies on the alternatives available for long-term expansion of the generation capacity of the system. In the 1990's, the system is likely to require a yearly increment in capacity of 15-20 MW. This would allow the commissioning of commercial size steam power plants, fueled with imported coal or imported heavy oil. The cost of these alternatives will have to be assessed in the light of relative price evolution and transport costs of these fuels.

(d) The subsidy to the isolated electric systems of the interior must be carefully monitored. A realistic cost-benefit analysis should preceed any future expansion. The development of mini-hydroplants should be encouraged whenever possible, to reduce the consumption of diesel oil in these systems.

(e) Rural electrification on a large scale should not be considered at this time, with the exception of the lower Artibonite valley, where pumping water for irrigation will achieve a significant increase in agricultural productivity.

Hydrocarbon Exploration

1.18 Past exploration efforts have not been successful. Two companies are engaged at present in exploration, following a long list of previous contractors which in total have drilled 11 wells over a total

prospective area of 20,000 km^2. Expert opinion is that prospects appear to exist at depths of more than 5,000 meters in the Artibonite and Cul-de-Sac basins and in the Les Cayes area in the southern peninsula. To accelerate exploration, the Government should request technical and financial assistance from international agencies to identify exploration projects that can attract private interest. The preparatory work for the promotion of new exploration includes:

(a) Synthesis of all geological information available from past and present exploratory activity, to better define the geological structure and help to identify drillable prospects. An exchange of information with the Dominican Republic would shed additional light on the deeper geological structure of the island, as oil has been found in the Enriquillo Graben and deep drilling is progressing.

(b) Review of the present hydrocarbon legislation and Service Contracts to bring them into line with modern petroleum operation. Model contracts and appropriate tax regimes should be adapted to local conditions. Further, the service contract with Crux International should be submitted to legal scrutiny as the company appears to have withdrawn from further activities in Haiti.

B. Demand Management

1.19 In view of the very limited resource endowment, the most immediate options available to Haiti are pricing policies and other measures to increase the efficiency of energy use, and substitute imports of high cost petroleum products by imports of cheaper and heavier oils and coal.

Pricing Policies

1.20 Pricing policies and fiscal incentives must be appropriated to the general objectives of supply development and demand management. Because of Haiti's highly skewed distribution of income, conflict between prices and purchasing power of the poor population can arise, which must be resolved.

(i) Petroleum

1.21 All oil product prices are based on border values and there are no direct subsidies. In recent years, the Government has progressively reduced its taxes on all products but gasoline to shield domestic consumers from the increase in world market prices. The taxes on gasoline were retained for conservation reasons. However, this effect has been partially eroded by substituting diesel for gasoline vehicles. Although diesel vehicles are more efficient in terms of volumetric fuel consumption, their investment cost is higher. Under current international price relationships the diesel option is economic for

intensive uses - such as public transport and freight, - but it is an expensive means of providing for private transport needs.

1.22 To avoid further distortion of the market, the Haitian Government decided in late 1981 to progressively increase taxes on transport diesel to realign over the medium term domestic relative prices for gasoline and diesel to world market ratios. Control will have to be exercised to avoid the use of the lower priced industrial diesel oil or kerosene for transport purposes.

1.23 Complementary measures to enhance conservation in the private transport sector should be envisaged, such as:

(a) Discourage the import of vehicles for private use.

(b) Eliminate all tax exemptions granted to official entities on import duties and excise tax for vehicles and fuels.

(c) Increase the annual licensing fee on automobiles, imposing a higher levy on privately-owned diesel vehicles, until the gasoline/diesel price ratio has been fully realigned.

(ii) Electricity

1.24 For appropriate electricity pricing, the tariff should reflect the incremental opportunity cost of expanding the service and generate adequate funds for financing the expansion of the system. In January 1977, the public utility adopted a new tariff structure based on the principle of marginal pricing. Some months later, it was modified to allow social pricing below a certain level of consumption for low income families and small industrial users. A fuel adjustment clause was implemented at the same time. EdH's average revenue rose from US¢ 6.5 per kWh in 1978 to an estimated US¢ 11.2 in 1981, i.e. an increase of about 20% per annum. The adequacy of the tariff structure is to be reviewed in early 1982. It is recommended that in this process consideration be given to the level of cross subsidization among categories of consumers and between Port-au-Prince and the provinces, and that marginal costs be assessed in the light of the new investments.

1.25 The present financial situation of the electric utility is comfortable although the rates of return were only 4.4% and 5.5% in 1979 and 1980, lower than the respective 7% and 7.5% rates of return established as targets by the government and the electric corporation in consultation with IDA. Internal cash generation has provided 54% of the total construction expenditures of EdH in the last fiscal year. Financial forecasts show that for EdH to earn 8% on its revalued assets during 1981-1986, its average revenue per kWh need to be raised by about 10% per year. The corresponding revenues would enable EdH to contribute internally about 35% toward its investment program during that period.

(iii) Fuelwood

1.26 For consumers/harvesters wood appears to be a free good, but a zero price does not reflect the economic cost of depletion of the forest resources. The only tax in the production of charcoal is a levy of about US$1.65 per ton, imposed when cutting green trees. This is too low to finance effective forest management or to encourage the establishment of plantations. There is no doubt that the cost of wood plantations will result in a much higher price for wood. Therefore, the price of charcoal will have to be increased through higher taxation. Compensatory measures will have to be found to allow the poorest segments of the population in deforested areas to continue purchasing their required needs.

Demand Management Projects

1.27 Reduction of losses and thefts in power distribution: In 1979, these losses exceeded the amount of electricity generated in thermal units. Thefts represent a high portion of the 28% of energy lost. Investment in the renovation of the distribution system of Port-au-Prince is therefore well justified and the law against illegal connections must be fully enforced.

1.28 Energy audits in large industrial establishments are required to assess immediately attainable energy savings, by increasing the efficiency of energy use in existing equipment; these audits should cover steam generation and distribution equipment, electricity use in machinery and lighting, etc.

1.29 Technology changes: The cement factory has proposed an expansion of its productive capacity, conversion of its manufacturing process to the dry technology, and replacement of residual oil for imported coal as the main energy source. The dry technology reduces energy input per unit of output by almost 50% and the substitution for coal could lead to important foreign exchange savings. Given the significant impact of this project on Haiti's energy balance, the project should be evaluated as soon as possible.

1.30 There are a number of industrial groups that have a good growth potential. These should be evaluated to assess retrofitting possibilities and installation of new efficient equipment.

1.31 Mass transport system: Major measures in this area would be to increase the number of buses in the Port-au-Prince area and introduce interurban services, implement traffic regulations to reduce congestion in flow and curtail the import of vehicles for private use.

1.32 Efficient Stoves: The introduction of an efficient stove design appropriate to local conditions could reduce the energy intake for cooking by as much as half of the required in the traditional 3-stone fireplace. A preliminary analysis indicates that even if the dissemination is fully subsidized and only a 5% increase in fuel efficiency is achieved, the program would have a positive return relative

to the cost of new wood plantations. A survey should also be carried out on the type of equipment most commonly used by the commercial and artisenal sectors, to assess the technical modifications required to improve their efficiency.

C. Institutional Development

1.33 Haiti's energy situation will continue to deteriorate unless the Government recognizes the urgency of the issues and commits itself to decisive action on the above recommendations. It is felt that the implementation of the energy program is constrained more by shortcomings in the decision making/implementation process than by the availability of resources. In other words, there is a possibility for Haiti to obtain larger amounts of financial and technical foreign assistance, but, at the present, the country lacks the ability to effectively and productively utilize the additional resources that could be made available to it. To improve this situation, the Government must agree on and define its energy objectives. It should decide upon a strategy and on the programs to carry out that strategy. An implementation schedule should be set, and the agency responsible for each program should be designated. Finally, these agencies should be given the necessary legal authority and a minimum of financial support to execute their responsibilities.

1.34 To assist the Government in the planning and implementation process, the mission recommends the creation of an Advisory Committee, which would be made up of the heads of the agencies in charge of energy programs, of technical public and private experts, and representatives of interested international aid agencies. Furthermore, it is suggested that an Energy Statistical Unit be established to provide the quantitative framework for the decision-making process.

1.35 The technical and managerial capability of the individual agencies must be strengthened, particularly the Forestry Service and the Division of Energy Resources. At a first step, it is suggested that an Economic Evaluation Unit be set-up to help select those projects with the highest socio-economic returns and to advise the technical departments of the Ministries on organizational schemes for project development. Whenever possible, the private sector should be encouraged to participate in project execution and operation. Special attention should be given to the utilization of communal and cooperative organizations in rural areas. In addition, the individual services should contract a few high level outside experts and managers to allow immediate execution of priority projects and provide for on-the-job training of present staff.

OTHER PROJECTS

A. Indigenous Resource Development

Agricultural Waste Products and Solar Water Heating

1.36 Haiti's large agricultural sector offers opportunities for converting agro-industrial waste products into usable forms of energy. It

is suggested to direct efforts towards the identification of specific localized projects. This requires assessment of the volumes and geographic location of potential materials, such as those derived from coffee, cotton, sugar cane, vetiver, and solid urban waste; evaluation of energy end-uses, choice of most appropriate technology and economic and financial analysis.

1.37 Large consumers of hot water should be made aware of the economic advantages of solar water heating systems. They have proven to be competitive in many countries in applications that range from hot water for households, hotels and hospitals, to pre-heating of low-medium temperature process water in industries. These systems can be installed in new buildings or retrofitted into existing ones. They can be used alone or in combination with electric or fossil-fueled heaters. It is suggested that the Government should evaluate potential savings of commercial energy that can be achieved through the diffusion of this technology and provide the private sector with the required technical assistance.

Lignite: Maissade and Camp Perrin

1.38 Lignite is found near the town of Maissade in the Central Plateau and in two locations in the Southwest peninsula. Maissade is by far the most important field, although the quality of its lignite (high ash and sulphur content) makes it suitable only for industrial use. Camp Perrin is a very small field, but its lignite has the right quality for use as cooking fuel.

1.39 The structure of Maissade has been determined by two geological surveys which indicate the existence of several small deposits in which lignite seams with a thickness of 1-2.5 meters are buried at depth of up to 20 meters. Only one of these deposits has been evaluated; proven reserves are 750 thousand tons and the ratio of lignite to overburden is 1:10.5. A preliminary cost estimate for capital intensive open cast mining of this deposit indicates that lignite could be recovered at about US$36/ton. Taking into account its calorific value (2,500 kcal/kg), Maissade lignite would only be competitive with coal should the landed price of this product exceed US$100/ton. 1/ (The current landed cost for imported coal is estimated at US$ 70/ton.) The intensive exploitation of the deposit for power generation can therefore not be justified under present economic conditions.

1.40 However, further exploration is necessary to determine the extension of the deposits, the depth of the seams, their thickness and

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1/ Based on relative calorific values of coal and lignite. This figure does not include the capital cost differential between lignite fueled and coal fueled power plants.

the quality of the coal. 1/ This involves the following action: (a) topographic mapping of the area; (b) synthesis of the results from the previous exploratory campaigns; (c) intensive exploration of deposits already detected and further extensive exploration of the rest of the field. A detailed feasibility study of the mining project should be made once the new information has been compiled. It should include the evaluation of alternative industrial uses for the lignite.

1.41 The survey on Camp Perrin indicated that the deposit could contain at best some 100,000 tons. The Ministry of Mines and Natural Resources intends to assess whether this lignite could be mined as a cottage industry to provide a fuel for household cooking. Despite the probable size of the deposit, it could provide for the household requirements of the cities of the region.

Other Renewable Resources

1.42 Several public institutions in Haiti are engaged in research on renewable energy technologies. In view of the scarcity of technical and managerial resources, it is suggested that the range of programs be narrowed, by selecting those that might have the highest impact on the rural sector, reducing deforestation and increasing the productivity of agriculture, such as solar crop dryers and cookers, wind water-pumping, and mini-hydroplants. The strategy should include research and development to adapt these technologies to local conditions, build-up of domestic capability in repair, maintenance and construction of hardware, extension of their use and training.

B. Demand Management

1.43 Higher efficiency in Bagasse use: Only one industrial plant cogenerates steam and electricity from bagasse to satisfy the energy requirements in its sugar cane processing facility. There are two other industrial plants in operation that use bagasse to generate heat, but which purchase diesel oil for power generation. It is therefore recommended that the industry be studied to determine whether it is feasible to increase electric generation from bagasse and supply a surplus to the national grid. It would require investment in power generation equipment and in bagasse handling facilities.

1.44 Residential and Commercial Sectors: A national educational campaign informing the public on the energy problem and indicating saving opportunities would be helpful in obtaining the cooperation of the population in the demand management program.

1/ The German aid agency has in principle agreed to finance the second phase exploration of Maissade.

1.45 The prevailing method of producing charcoal in Haiti is in traditional earth mounds. There are no obvious gains to be expected from introducing modern charcoal making processes, because few areas have the wood concentrations to warrant substantial investment in new equipment. More efficient methods, including the recovery of pyrolytic oils, should be considered in future energy plantations, and in areas where forest management programs have been established.

INVESTMENT REQUIREMENTS AND FOREIGN ASSISTANCE

1.46 The public energy investment requirements for the next five years were conservatively estimated at about US$300 million, 82% of which (US$248 million) correspond to the power development program; 11% (US$33.4 million) to forestry projects; 2.0% (US$6.2 million) to other resource assessment and development; and 5% (US$15.5 million) to demand management and institutional building.

1.47 Public finances already depend heavily on foreign resources and a significant portion of domestic resources are earmarked as counterpart funds. The increased investment effort involves important decisions in scarce resource allocation and, therefore, coordination of objectives between Government and foreign aid institutions becomes crucial.

II. PROSPECTS FOR DEVELOPING INDIGENOUS ENERGY RESOURCES

Resource Overview

2.01 Haiti has a very limited resource base. At present, only wood and hydroelectricity are being produced. About one-third of the nation's hydropotential has already been developed; the rest consists of a number of small sites with an aggregate potential of 110 MW which is planned to be developed during the present decade for connection to the integrated system. Some isolated centers can be supplied with energy from a number of micro hydro sites. Although the country has not yet been fully evaluated, there are modest prospects for discovering significant accumulations of oil and gas. Small lignite deposits have been found, but they are costly to exploit because of their size and the overburden of unproductive material that covers them. There appear to be no high temperature geothermal prospects.

2.02 As neither fossil fuels nor hydroelectric power can greatly increase their share in the long term supply of energy, there is no reason to expect a major change in the nation's heavy dependence on wood. But the potential supply of wood is rapidly being depleted. Large areas of Haiti have been deforested in recent decades and few timber reserves are left. The clearing of land for agricultural purpose and the felling of trees for fuelwood and charcoal are the main causes.

2.03 However, the necessity for re-establishing Haiti's forest cover goes far beyond energy reasons. Deforestation has caused soil erosion which is so serious that the long term productive capacity of the land is threatened. In many areas, the land has reduced its ability to retain moisture and regulate water run-off; the result is desertification and loss of agricultural productivity on which depends the livelihood of three quarters of the Haitian population.

2.04 The first section of this chapter describes the present disequilibrium between wood growth and depletion and proposes a strategy to reverse the situation. The second part analyzes the prospects for fossil and hydropower energy development. The last section describes alternative energy technologies that have a potential to supply small scale energy needs.

A. Forest Resources

1. Identification of the Problem

1.1 Deforestation

2.05 Statistics on the rate of deforestation are inadequate, and would, in any case, be difficult to collect because deforestation is not through systematic clearcutting but through a rapid degradation of the forest by partial cutting and the destruction of forest regeneration by agriculture and grazing.

2.06 DARNDR 1/ has started preparing some maps which show the rapid rate of disappearance of pine forests. Another indication of the rate of deforestation is provided by statistics in the UNDP report on the Plateau Central, 2/ which show the change in forest area between 1956 and 1977. The authors include several qualifications with their tabulations, but all trends are consistent and negative. Total forest area was reduced by 59% during the period studied; in the case of dense pine stands the reduction was 99%. All sources agree that an environmental problem of the first order is involved.

1.2 Inventory

2.07 There is no systematic forest inventory for Haiti, but all official statistics confirm the general impression that there is little forest left. A recent report 3/, gives the total forest area of Haiti in 1978 as 243,000 ha, or 9% of total land area; the same source states that 926,500 ha or 35% of Haiti should properly be covered by forest, presumably a reference to the large areas of degraded forest, deforested woodland and land under cultivation, but unsuitable for this purpose. If we describe these areas as "open, degraded woodland" and assume that they cover 683,500 ha (926,500 ha minus 243,000 ha) then the basic forestry statistics of the following table result:

Table 2.1

DISTRIBUTION OF FOREST AREA (1978)

Forest Type	Area (ha)
Coniferous	73,000
Broad-leaved	150,000
Mangrove	20,000
Open degraded woodland	683,500

2.08 The figures in the above table are only rough estimates. They exclude the well-developed culture of fruit trees, such as mangoes, in the good agricultural areas, though this is unimportant in the context of an energy survey because, while these "orchards" yield some wood, their primary purpose is food production. On balance, however, the table probably over-estimates the size of the forest area, because it is based on estimates for 1978, and deforestation continues at a rapid pace: land is being cleared for agriculture, mangrove stands are being removed for shoreline development, and charcoal makers are moving from one region to another, following the disappearing forest. (For example, many charcoal

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1/ Ministry of Agriculture and Rural Development.
2/ Report "Projet de Mise en Valeur du Plateau Central, "UNDP", September 1980.
3/ DARNDR, 1980.

producers currently in the Northwest have arrived in recent years from the Gonaive area).

2.09 In this report, it is assumed that the forest area is shrinking at an annual rate of 5%. This could well be an underestimate; in 1976, FAO estimated that Haiti's forests would disappear in ten years and UNDP indicated in its study a 59% reduction between 1956 and 1977, which is equivalent to an annual decline of slightly less than 7%. This rate of deforestation is extremely high and can be compared with the current decline in forest area in Nepal and in several provinces of Thailand.

1.3 Growth Rates

2.10 National forest inventory figures giving standing volume per acre are unavailable but a growth rate of 1 m^3/ha/yr is assumed for degraded, open woodland; this value has some basis in estimates for open woodland in the southern Sudan. A growth rate of 5 m^3/ha/yr is assigned to the closed, natural forest, and 10 m^3/ha/yr is accepted for plantations. The last figure does not imply that growth rates as high as 30 or 35 m^3/ha/yr could not be achieved on intensively managed plantations of fast-growing species: this is entirely possible; rather it is an estimate which makes allowance for some failures of plantations and for some plantations on poor, dry sites.

2.11 A number of domestic and foreign organizations have initiated reforestation and forest protection programs in Haiti. (See Annex 2). Although the scope of these individual projects is small relative to the magnitude of the energy problem, their experience is of high value, because they evidence the constraints to rapid reforestation, such as lack of trained staff, lack of coordination among Government institutions, difficulties with planning and land tenure, and the attitude of the population toward these programs. These programs also include small scale tree-planting in homestead gardens, backyard woodlots and marginal land, for which free tree seedlings are given out.

1.4 Projected Balance of Wood to 1985

2.12 The data on wood consumption, forest areas, growth rates and present reforestation programs discussed above, have been combined in the following table:

Table 2.2

Wood Balance: 1980-85

	Growth Rate	Forest Area (ha)			Growth (1000 m^3)	
	$(m^3/ha)/yr$	1978	1980	1985	1980	1985
Closed Forests, including Mangrove Forest 1/	5	243,000	218,700	158,075	1,094	790
Open, Degraded Woodland 2/	1	683,500	707,800	768,425	708	768
Plantation 3/	10	no estimate	1,500	6,000	15	60
Total Growth					1,817	1,618
Consumption 4/					4,000	5,105
Difference 5/					2,183	3,487

Notes:

1/ Assumed a 5% annual decline in closed forest area from 1978 base.
2/ Degraded woodland increase assumed to equal decrease of closed forest area.
3/ Assumes no major new programs in plantations.
4/ Consumption projected at 5% annual growth.
5/ Indicates resource base disappearing. Wood is being 'mined': unstable situation.

2.13 This table confirms that Haiti is far from a balance between growth and depletion, that the forests are disappearing at a rapid rate, and the continuation of present trends will ultimately lead to a collapse of supply as the resource base is fully depleted. Current plantation programs are insufficient to introduce a significant change in this situation. To solve the problem, reforestation must proceed together with a determined effort to reduce the growth in demand for fuelwood, by introducing more efficient stoves and by providing energy alternatives. The approaches available to deal with the problem include the following:

2. Reforestation Strategies

2.1 Wood Plantations

2.14 Two basic types of plantations should form part of a national strategy to overcome the developing wood shortage: intensively managed, highly productive energy plantations and traditional forestry plantation, often in conjunction with agri-forestry projects.

2.15 The traditional forestry plantations are an essential part of the solution. They should be established on land that is primarily suited for forestry, rather than for agriculture. The emphasis should be on native species, for reasons described in the discussion of the HACHO

project; the Northwest Region would be a prime candidate for such plantations. The need for such plantations is well recognized in the programs of the Department of Agriculture, of HACHO and USAID; the immediate requirement is to greatly increase the current level of effort. The most effective approach would be to strengthen existing programs. Protection from illegal cutting and grazing is a pre-requisite for success.

2.16 In addition, a series of energy plantations should be established within 50 km of population centers, beginning with the Port-au-Prince area. The production of wood for charcoal or fuelwood should be the prime objective and all other considerations, such as creation of employment and environmental protection should be secondary. The following principles should be followed:

(a) Selection of good sites to ensure high production. Conflict with agriculture is inevitable and must be resolved.

(b) Use of fast growing exotic species.

(c) Separate nurseries for each plantation and centralized seed production.

2.17 There are several reasons why initial plantations on terrain near Port-au-Prince are recommended: (a) proximity to consuming center reduces the advantages of charcoal conversion and this diminishes losses; (b) the consumer would have access to a cheaper fuel; (c) start-up costs (except possibly land acquisition) will be lower because some of the infrastructure is already in place, and growth will be higher than on many of the distant sites; (d) successful plantation near Port-au-Prince will be a most effective demonstration area; and (e) the chances of success will be greater because qualified personnel, required for nurseries, seed production and for future management will inevitably gravitate to Port-au-Prince.

2.18 It is always a difficult decision to plant trees on land that could be used to produce food. Therefore, the decision must be based on a careful economic analysis of the costs and benefits associated with the use of land and energy plantations. The effective production of wood [1/] plus the reduction in negative externalties associated with depletion of forest areas should be imputed as benefits to the projects. The cost estimates should include foregone agricultural production. In making this choice one should consider the fact that agricultural crops can be

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1/ Experiences in several countries indicate that yields of 10 to 30 m^3/ha/yr can be achieved, at costs that range up to US$20 per cubic meter. Thus, on a thermal equivalent basis, fuelwood could be produced in the range of US$1 to 2.2 per million Btu, which compares with a cost for imported oil of about US$5 per million Btu.

planted between the rows of trees during the first years of each rotation. Good land for afforestation is still available in Haiti, even on relatively level terrain, within 50 km of Port-au-Prince. Specific references to this were made at HACHO and at Operation Double Harvest. The Government of Haiti is rightly concerned that the best land in the plains be reserved for agriculture. However, it was agreed that some higher grounds and low hills adjacent to, or within the plains (such as the Plain de Cul-de-Sac) would be available for afforestation. The concept of energy plantations on relatively good land will become far more attractive if a successful plantation were established and could be demonstrated.

2.2 Treatment and Protection of Existing Forests

2.19 It is usually less difficult and expensive to improve an existing not totally degraded forest than to establish a new one. The risk of failure is greatly reduced and the results are more predictable. One of the most cost effective measures that could be taken in Haiti would be enforced protection from grazing, cultivation and illegal felling. In areas with adequate rainfall this would be enough to ensure the establishment of a productive forest. Productivity could then be further increased by silvicultural treatments including selective cutting, thinning and weeding. IDA is currently processing a project for stand improvement in the pine forests in the southeastern region of Haiti.

2.3 Erosion Control

2.20 The control of erosion is one of the most critical needs in Haiti; erosion control is a priority with objectives that go far beyond the production of energy. Soil erosion 1/ threatens the long-term productive capacity of land and, therefore, must be controlled if there is to be any hope of restoring an energy balance through wood production.

2.21 One of the critical areas involves the Peligre Reservoir which has already lost one-fourth of its useful capacity due to sedimentation resulting from deforestation of the Artibonite watershed. The result is an environmental problem with direct and immediate impact on energy (electricity) supply. The problem is officially recognized, but progress in controlling grazing or in afforestation is inadequate. Documents in the Ministry of Planning show that progress with tree planting has fallen far short of official targets. Afforestation has to be part of the solution for Peligre, but the immediate requirements are control of grazing and cultivation, the planting of grasses on steep slopes and structures to restrict erosion in the most critical areas.

1/ According to FAO estimates, the country loses some 15 million cubic meters of soil yearly, corresponding to 6,000 ha of land.

2.22 A serious component of the erosion problem is that there are large areas of poor agricultural land under cultivation, particularly on upper mountain slopes. This land should ultimately revert to forest cover. The main reason for afforestation of these areas is the restoration and protection of the environment and, in particular, the control of erosion. Reforestation of these areas should not have to be justified on the basis of economic wood production or of an energy balance; these considerations are secondary when compared to the threat to the long-term productive capacity of the land. The dilemma is that these essential measures cannot be undertaken unless the food currently produced on sub-marginal lands can somehow be replaced.

3. Recommended Action

2.23 Haiti's forests have been dangerously depleted to supply wood and charcoal for domestic and commercial needs. Continuing, uncontrolled expansion of agriculture into the forest has significantly contributed to forest destruction. To a lesser extent, forest exploitation for lumber and construction needs has added to the problem. The net effect has been to reduce the forest growth to below national needs. The loss of forest cover, coupled with over-grazing and poor farming practices is seriously depleting soil fertility and has created major erosion problems. The following immediate action is recommended.

(a) Identification for an eventual establishment of forest plantations of fast growing species which will supply a significant portion of the nation's needs for charcoal and fuelwood. Fully implemented, the program would cover between 100,000 and 300,000 ha and should be located within close proximity of major consuming centers. An immediate goal should be the establishment of a 10,000 ha plantation near Port-au-Prince, with the objective of meeting approximately one-third of Port-au-Prince's charcoal demand by 1990.

(b) Immediate action to sharply reduce erosion and sedimentation at Peligre and thus to protect Haiti's hydroelectric resources. 1/ Requirements include the control of grazing and cultivation, the planting of grasses on steep slopes, and reforestation of the Artibonite headwaters, in conjunction with orderly agricultural development.

(c) Identification of several blocks of partially forested land suitable for wood production which could be improved by immediate institution of basic forest management practices including fire control, elimination of illegal

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1/ See also Paras 2.58-2.60.

felling, and cattle grazing. After a short period, stand improvement and planting could be initiated in these areas. Approximately 1,000 ha should be considered for demonstration of these practices. The long-term objective should be to establish such forest management on approximately 100,000 ha. The Northwest Region should be included in this program. The management project for the pine forest of La Selle will demonstrate the results that can be expected from such actions.

(d) Establishment of plantation programs to identify suitable tree species and to demonstrate results for wood production and erosion control. Provisional estimates of trial plantation sizes are:

Location	Ha.
Central Plateau	200
North-west (dry sites)	100
North or North-East (mountain sites)	100
North or North-East (plain)	100
Cul-de-Sac	100
Southern Regions	200

2.24 Haiti's national development requires the establishment of a land use policy which will reduce the conflict between forestry and agriculture. The first step should be completion of a national inventory and mapping program to show current land cover and use. The cost of a useful national survey would be near $500,000.

2.25 It is recommended that this survey be started on a priority basis on areas suitable for fuelwood plantation development and later be expanded to cover the entire country.

B. Fossil Energy Resources

1. Oil and Gas Prospects

2.26 The main prospects for hydrocarbons lie within the two grabens which are known as the Artibonite basin and Cul-de-Sac basin in the west, and in the Les Cayes area in the southern peninsula. Drilling to date has not been sufficiently deep to test the complete sedimentary section. A more detailed review of the geology and geophysics is required to assess the prospects in the deeper, possibly pre-evaporite section, with further deep drilling to 5,000 meters plus, both on and offshore. Indications are that the deeper and yet untested sections in

the Cul-de-Sac and Artibonite basins could have potential for hydrocarbons. 1/

1.1 Status of Exploration

2.27 Petroleum exploration started in the 1940s and resulted in the drilling of four dry holes by ARCO between 1944 and 1947. Jurinet-1 (8,804 ft) and Maissade-1 (9,010 ft) were located on the Central Plateau, Saint Marc-1 (4,099 ft) in the same structural setting but near the shore, and finally, Cul-de-Sac-1 (8,064 ft) in the Port-au-Prince depresssion near the airstrip. Oil shows were reported from Oligo-Miocene strata. Subsequently, John Mecom (U.S.) drilled four wells between 1955 and 1957, with a total footage of 21,889 ft. Three wells were located on the La Gonave Island anticlinal feature (3,138; 8,002 and 6,977 ft, respectively) and the last one, a shallow Cul-de-Sac-1 (3,772 ft), near the capital city. All wells were dry. More recently in 1972, a well-known promoter, Wendell Phillips, managed to obtain exploration rights covering the entire territory, but he was forced out in 1976 after failing to complete any drilling.

2.28 In June 1976, the newly created Institut National de Recherches Minieres (INAREM) signed a service contract for the exploration of four blocks with CRUX International (a subsidiary of Southern Cross, U.S.). Following a marine seismic survey, three offshore wells were drilled in 1977 by Reading & Bates. These are Cul-de-Sac-1 (9,658 ft), Les Arcadins-1 (6,428 ft) and Artibonite-1 (6,604 ft). All were dry and there is no mention of oil shows. Crux relinquished its northern block along the Atlantic coast and that of Les Cayes. A similar contract signed the same year with a Venezuelan company named HIDECA for five distinct blocks, was rescinded. In July 1976, Anschutz Petroleum Corporation of Denver, U.S.A., signed a service contract for two areas. Block A covers a huge area of the Central Plateau where ARCO drilled two dry holes which had oil shows and Block B covers the Western half of the southern peninsula and a large offshore section around it. The contractors will have to drill two 12,000 ft wells to preserve its holding rights after completing a minimum of 400 kms of seismic lines on each block. Until now, Anschutz has completed the seismic survey of Block A and is carrying out the work on Block B.

2.29 As indicated on the Map, more than 50% of the territory has been contracted for exploration. In addition to the contracts with Crux and Anschutz, the Government had planned to enter into a 50/50 joint venture with Crux for a block located in the northern part of the southern peninsula. This company, however, apparently wants to withdraw from further activities in Haiti. Information on how the government proposes

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1/ This is the expert opinion of Mr. Daniels of Exploration Consultants, Ltd., who visited Haiti in November 1980 as part of a follow-up mission for the World Bank Caribbean Petroleum Exploration Promotion Project.

to explore the small block southwest of the Artibonite valley (indicated by C on the Map), was not obtained.

1.2 Recommended Strategy for Exploration

2.30 The exploration effort made until now is insufficient to establish Haiti's hydrocarbon potential. A total of 11 wells have been drilled with a total footage of some 75 thousand feet. This is very small for a total prospective area of 20,000 km^2. To speed up exploratory activities, the following is recommended:

(a) Synthesis of all geological information available from past and present exploratory activity, to better define the geological structure and help to identify drillable prospects. An exchange of information with the Dominican Republic would shed light on the deeper geological structure of the island, as oil has been found in the Enriquillo Graben and deep drilling is progressing;

(b) Review of present legislation and service contracts to bring them into line with modern petroleum agreements in future arrangements;

(c) The service contracts with Crux International should be submitted to legal scrutiny amd terminated if the company does not wish to continue operations in Haiti.

(d) Given the high risk of oil exploration and the shortages of investment funds, the Government should proceed carefully in evaluating joint venture arrangements. Direct involvement in exploration can only be justified in areas of proven good hydrocarbon potential; and

(e) For promoting exploration, the Government should request technical and financial assistance from international public institutions to identify and prepare exploration projects that can attract private interests.

2. Lignite

2.1 Resources

2.31 The most important deposits of lignite are located near the town of Maissade in the Central Plateau region. The reserves proven up to now amount to only 750 thousand tonnes (MT), but it can be reasonably expected that further exploration would prove additional reserves. It is not certain, however, whether this field contains sufficient resources to fuel a full commercial sized power plant. Preliminary estimates of the field's potential vary from 1.5 to 7 million tonnes. In the southern peninsula, surveys have indicated the presence of lignite at Camp Perrin and L'Asile. Only the first has been classified as a small field (100 MT), which

could be exploited manually and serve to produce a fuel for household consumption. (See Map for location).

2.32 The Maissade field was studied by two recent exploratory campaigns. The first, in 1976 by SOFREMINES 1/, established the extension of the field over an area of 7 km2. The second, in 1980 by the German Geological Institute 2/, obtained information on its structure.

2.33 The central area of the field was tested with 7 deep drillings, which revealed that lignite is not distributed uniformly, but rather confined to narrow deposits, which extend in a direction NW-SE, similar to the general orientation of the Central Plateau and that of the river flows. Several small deposits, parallel to each other were detected. Within these deposits, the thickness of the lignite seams remains approximately constant, (1.5-2.5 meters) while in the intermediate area they become very thin (less than 1 meter). It also became apparent that today's rivers follow the fossil lignite beds and that, in consequence, the lignite deposits have been heavily fragmented by erosion.

2.34 The deep drillings have indicated that the lignite appears stratified in layers at different depths. The deepest of the series, immediately overlaying the base rock, has no economic interest. Above it, at least three seams have been identified. It has not been possible to fully correlate them, because tectonic alterations have caused abrupt lateral changes in the facies. Apparently, the second lignite horizon (B) from above is the most important; its thickness reaches up to 2.5 meters. The seams are separated from each other by layers of sterile material (mainly clays) that vary from 6 to 14 meters in thickness. The distance of the seams to the surface depends on the degree of erosion, (in some areas seam B is 20 meters deep). The area has not been topographically mapped and, therefore, it is not possible to fully estimate the volume of overburden that has to be removed to reach a mineable lignite seam. Preliminary evaluation indicates for Block 5 that the ratio is 1 ton of lignite to 10.5 m3 of sterile material.

2.35 In the Ravine de Sable, reserves have been estimated on the basis of the extension of seam B over a length of 1,500 meters and a width of 200 meters. With an average thickness of the seam of 1.9 meters (it varies from 1.5 to 2.5 meters), and a apecific weight of 1.3, reserves in the order of 750 thousand tons were assessed.

1/ Report SOFREMINES/SOFRELEC: "UNDP Long Term Pre-investment Study of the Power Sector", Volume II, Lignite, 1976.

2/ Report on "Recherches Preliminaires a l'Exploitation Des Lignites Maissade/Haiti", 1980 by Saarberg Interplan GmbH and the Federal Institute of Geology and Raw Materials (BGR).

2.36 The chemical analysis of the lignite samples from the various seams indicates little difference in quality. Their values are as follows:

Table 2.3

	Range	Average in Block 5
Water content (crude lignite)	17-41%	
Water content (pure lignite)	26-30%	42.5%
Ash content (crude)	25-57%	35-40%
Combustion value 1/	2000-3600 kcal/kg	
Calorific value 2/	1700-3300 kcal/kg	2500 kcal/kg
Sulphur content (crude lignite)	5-7%	5.5%

1/ Obtained from samples of deep drillings.

2/ Estimated on the basis of a 5.5% of hydrogen content. (superior calorific value)

2.37 Under atmospheric conditions the lignite crumbles into fine particulates. It has a large mineral component, mostly clay, which is intimately mixed with it and therefore cannot be removed. The high sulphur content is in part due to the presence of pyrites in the clay and in the lignite itself, where it forms grains and sometimes larger agglomerates. Technologically, it would be possible to remove at least part of the pyrites, and thus reduce the sulphur content. These characteristics make it best suited for use in steam boilers for power generation or industrial plants. It cannot be used as a cooking fuel, unless chemically treated and agglomerated.

2.1.1 Camp Perrin

2.38 This deposit is located near the city of Les Cayes in the southern peninsula. Its origin is traced back to the miocene, when Camp Perrin and L'Asile were part of a large enclosure filled with detric sediments, which was later compressed and fragmented. Camp Perrin is a restricted area (10 kms. long by 2 kms. wide) of complex structure, with heavy folding. The surface survey, carried out by Sofremines in 1976, indicated only one small zone (Delinois) in the Bras Gauche Ravine has some interest. In general, the lignite horizons are less than 30 cms. thick; at Delinois, however, 8 seams with a total thickness of 8.96 meters were detected. The Ministry of Mines and Energy has decided to continue the geologic exploration to assess recoverable reserves and at the end of 1980 transferred the drilling equipment used in Maissade to Camp Perrin.

2.39 The quality of the lignite is somewhat better than that of Maissade. The values of the samples taken by SOFREMINES average:

Table 2.4

Calorific Value (Superior-dry)	3,260 kcal/kg
Humidity (crude lignite)	25.4%
Ashes	45.1%
Volatile Material	29.2%
Sulphur	1.1%

2.2 Mining Project

2.2.1 Maissade

2.40 Saarberg Interplan, as part of the study financed by GTZ, made a preliminary assessement of the technical problems and the cost of exploiting these deposits on an industrial scale.

2.41 Open cast mining was chosen as the alternative under which maximum recovery of lignite can be achieved. This implies that huge quantities of sterile material (about 7.6 million m^3 in Block 5) will have to be removed to uncover the lignite seams. This is not only costly but also poses environmental problems: top soil has to be recovered, drainage of the area has to be insured, and land will have to be reclaimed in exploited zones. Mining operations are restricted to only the dry season, because the average annual precipitation of 2000 mm is concentrated in 100-150 days, during which time the ground becomes unworkable.

2.42 The consultant's economic analysis is based on an annual lignite production assumption of 66,000 tons (based on the fuel requirements for an 8 MW power plant). To bring forward such a volume in only 180 working days, a highly mechanized and automated work plan was chosen for the removal of the overburden and the extraction of lignite. Under this set-up, the mining operations would generate employment for only 111 people, of which 54 would be specialized workers and 39 non-specialized labor.

2.43 The study provides a preliminary estimate on the unit cost of lignite mined under these conditions at US$36.13 per ton. This figure comprises all fixed 1/ and variable costs associated with the project, assuming a 5% interest rate on capital investment and a 10% interest on working capital (see Table 15). To place this cost in perspective, the following comparisons wil alternative fuels are made:

1/ Assets were depreciated over normal life and not over the estimated duration of the project.

Table 2.5

	Cost Comparison Cost per Unit US$/unit	Calorific Value kcal/unit	Cost US$106 kcal
Coal 1/	60/ton	7,000/kg	8.57
Coal 1/	70/ton	7,000/kg	10.00
Fuel Oil	30/bbl	1,436 x 103/bbl	20.90
Lignite	36.13/ton	2,500/kg	14.45

1/ Given the difficulty in assessing delivered costs for small cargos of coal, transport and handling costs were estimated in the first case as US$15 and in the second as US$25/ton.

2.44 The above table indicates that the Maissade lignite would only be competitive with coal if the landed price of this coal was greater than US$100/ton. Furthermore, the mining cost so estimated does not include off-site investments that would have to be made for exploiting the field. The most significant is the construction of about 30 kms of roads with several bridges to connect the field with the town of Maissade and with Hinche, where highway RN3 ends. Assuming an average construction cost of US$300,000/km, the investment would amount to at least US$9 million, part of which would have to be allocated to the mining project.

2.3 Use for Power Generation

2.45 The quality of Maissade lignite makes it best suited for industrial use. The following economic analysis shows that is use for power generation does not seem justified under present economic conditions.

2.46 First, the size of the deposit imposes severe restrictions on the dimensions of the steam power plant. Given the structure of the field, it is impossible to assess ultimate recoverable reserves, before the deposits have been totally evaluated. The following estimates assume the existence of 2 million tons, which would be enough to fuel a 15 MW plant over 20 years. 1/

2.47 Although investment figures in coal fired power plants vary significantly from site to site, it can be safely assumed that the investment cost used by the consultant is on the low side (US$1425/kW)

1/ Assuming a specific thermal consumption of 3,000 kcal/kWh and operations during 5,500 hours per year, 6.6 tons of lignite would be required per year and per KW installed. 15 MW over 20 years would use 1,980 thousand tons of lignite.

for a plant in the range of 10-15 MW. A recent appraisal for a 29 MW coal fired plant in Mauritius, coming on stream by 1984-85, estimates investment at US$1500/kW. Given the economies of scale, it is more likely that the investment cost for a 15 MW lignite-fueled steam power plant at Maissade would be around US$3,000/kW of installed capacity. Thus, at 12% interest over 20 years operation, the investment cost would be about 7.3¢/kWh. This compares to a coal power plant of about 30 MW operating over 25 years, with a unit capital cost of about 3.5¢/kWh, or with a diesel unit cost of about 1.9¢/kWh. Comparison can also be made with the hydropower development, which has an investment cost of US$2200/kW and a unit cost of about 4.9¢/kWh (See Table 2.6).

2.48 In addition to these economic considerations, there is a technical factor that makes the feasibility of a small lignite-fired power plant at Maissade uncertain. Small boilers (below 30 MW) are designed with chaingrate strokers to burn (+) 6 mm coal having ash content of less than 25% or so. Maissade lignite has an ash content in the range of 35-40%.

2.49 A larger sized plant could be envisaged if reserves prove to be larger or if the plant is supplemented with imported coal. In the latter case, the plant could be located at the mine or near Port-au-Prince, depending on the relative transport costs over a distance of 160 kms. However, the comparison of fuel costs is similarly unfavorable. The lignite alternative has a fuel cost of about 4.34¢/kWh 1/, which compares to a coal cost of 3.0¢/kWh 2/ (at US$70/ton).

2.50 It is not expected that the discovery of additional deposits at Maissade and the increase in recoverable reserves would substantially reduce the mining cost, because in each of these deposits the thickness of the lignite seams and the overburden are likely to be similar to that of the already evaluated Block 5.

2.51 It is difficult to assess at this stage the foreign cost component of the mining project. However, it can be estimated that unless the domestic share in the cost of lignite is at least 40%, Haiti's foreign exchange balance would be burdened more by the project than by importing coal for fueling a small sized power plant over 20 years at present prices.

1/ Assuming a specific thermal consumption of 3,000 kcal/kWh, an average calorific value for lignite of 2,500 kcal/kg, and a mined cost of US$36.13/ton.

2/ Estimated on a calorific value for coal of 7,000 kcal/kg and a landed price of US$70/ton.

Table 2.6

Cost Estimate for Alternative Power Generation

Type of Plant	Size MW	Life Years	1981 Investment Cost (US/kW)	Unit Cost Estimate Fuel (¢/kWh)	Capital 1/ (¢/kWh)	Total (¢/kWh)
Feasible Hydro 2/	5-32	40	2,200 or less	-	4.9	4.9
Diesel Units 3/	7-14	25	800	6.2	1.9	8.1
Imported Coal: Steam 4/	30.0	25	1,800	3.0	3.5	6.5
Steam Domestic Lignite-Fired 5/						
Low Reserve Estimate	15.0	20	3,000	4.3	7.3	11.6
High Reserve Estimate	30.0	25	1,700	4.3	3.9	8.2

1/ Estimated at 12% interest, over life of plant, operating 5,500 hours per year. Sizes refer to installed capacity.

2/ Six possible sites on the Artibonite and Guayamouc river. Investment represents highest cost development being considered. Source: Table 16 of Statistical Appendix.

3/ These plants operate on Bunker C fuel. Fuel costs are estimated for a 10% diesel oil + 90% fuel oil mix and an average efficiency of 2,600 kcal/kWh. Assumed prices are: diesel, US$47/bbl and fuel oil, US$37.8/bbl.

4/ Estimated investment cost for similar plant being built in Mauritius. Fuel cost estimated at a landed cost for coal of US$70/ton.

5/ Ultimate recoverable lignite reserves at Maissade are uncertain. The first alternative assumes that exploration will detect 2 million tons of lignite, while the high alternative is based on a 6 million tons reserves estimate. Fuel cost is based on an estimated mining cost of US$36.16/ton.

2.4 Recommended Strategy for Exploration

2.52 In spite of the marginality of Haiti's lignite deposits, their potential should be fully assessed. In the case of Maissade, the present estimate of reserves is solely based on a detailed survey of the "Ravine de Sable" sector (Block 5), located in the center of the field. Other deposits have been detected towards the Canot river in the north and towards the Haut Piege river in the west and south. Thus, further exploration is necessary to determine the extension of these deposits, the

depth of the seams, their thickness and the quality of the coal. 1/ This involves the following actions: (a) topographic mapping of the area; (b) synthesis of the results from the previous exploratory campaigns; (c) intensive exploration of the deposits already detected in the neighborhood of Ravine de Sable; and (d) further extensive exploration of the rest of the field.

2.53 A detailed pre-feasibility study of the mining project should be made once the new information has been completely compiled. This study should explore alternatives uses for the lignite, including the possibility of attracting to the area industries that could use this fuel directly in their processes. This would allow consideration of more labor intensive mining plans, thus reducing the foreign cost component of the project. The study should also evaluate the economic feasibility of reducing the sulphur content of this lignite, which could then be used as a cooking fuel.

2.54 The information on the structure of Camp Perrin is insufficient to assess the feasibility of recovering these reserves, which appear to be very small. However, the higher quality of this lignite justifies further drilling of the Delinois sector and an extensive survey of the rest of the field. If the lignite can be mined manually and serve to produce a substitute for charcoal in household uses, even small quantities of lignite could ease the pressure on Haiti's scarce wood resources.

C. Hydropotential and Power Expansion Program

1. Inventory 2/

2.55 Haiti's undeveloped hydropotential is estimated at about 120 MW, which compares with an expected increase in maximum demand of 140 MW during this decade. This potential can be grouped in three categories: (a) conventional sites 3/ that are economically feasible for addition to the interconnected power system; (b) high cost conventional sites; and (c) micro-hydro sites, both of which could eventually supply isolated networks (see Table 16).

1/ The German Government has indicated in principle its interest in financing a second exploratory phase of Maissade.

2/ The inventory was made in 1976 by Lalonde Girouard-Letendre et Ass. Ltee., and is contained in the report "Projet d'Inventaire des Ressources Hydrauliques d'Haiti". It was financed by CIDA.

3/ Conventional sites are those where the water fall is artificially created by a dam. The feasibilility limit was established at a development cost of US$6,500 per kW installed at 1976 prices.

2.56 The first group consists of four favorable sites for building dams on the Artibonite river, downstream from the existing Peligre station and two dams on an upstream tributary, the Guayamouc river. About 100 MW with an average generating capacity of 600 Gwh per year appear to be feasible. The downstream plants on the Artibonite will be operated as run-of-the river stations and benefit from the regulatory capacity of the Peligre lake. Their firm capacity is now estimated at 43 MW and will depend on the efforts to avoid further siltation of this reservoir. The two dams on the Guayamouc river should contribute to the reduction of the problem. These plants, with an investment cost of less than US$2,200/kW, are to be developed during the 1980's.

2.57 The second group is composed of eight possible sites, with a total capacity of 10 MW. Their investment cost ranges from US$6,000-10,000/kW and are therefore uneconomic at this time.

2.58 Finally, a series of micro plants could be installed in many mountain streams with a limited water flow but high water head. As indicated in Table 16, preliminary investment estimates suggest that some of these sites can be economically developed and two, Caracol and Saut Mathurine have been incorporated into the development program. Their development should be coordinated with the rural electrification programs.

2. Sedimentation of Peligre

2.59 The siltation study of the Peligre reservoir has revealed that the erosion process seems to accelerate and that, if no measures are taken, the lake's present useful capacity of 374 million cubic meters will have disappeared completely by the year 2016. Although the filling up of the reservoir does not reduce substantially the total energy produced at Peligre and at the four stations planned downstream, it would cause considerable loss in firm capacity, from a potential of about 60 MW at present storage capacity to 21 MW by 2016. This decrease in primary energy production has to be compensated by the introduction of an equivalent thermal reserve capacity in the interconnected system. The present value of the loss of the Peligre sedimentation to the power system has been estimated at US$16 million or at 4.4¢ per cubic meter of sediment that enters the lake. This relative low cost estimate assumes that all secondary energy generated on the Artibonite can be fully used by the system.

2.60 The most economic, but partial, solution to the problem is to construct the dams at the two identified sites on the Guayamouc river, which would serve to generate electric power and to reduce the sedimentation of the Peligre Lake by 38% 1/. A new reservoir at the

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1/ Other solutions were discarded because of its high cost. Dredging the lake is estimated to cost US$0.50/$m^3$ and dams at the entry of the

upper Guayamouc would slow down the loss in the storage capacity of Peligre (by the year 2016 remaining capacity would be 118 million m3), and increase the regulated flow of the Guayamouc - Artibonite system and the firm capacity of its plants by approximately 11.3 MW.

2.61 Other possible sites for dam construction on the upper Artibonite basin are being investigated. Two possible closures have been evaluated, one on the Artibonite river, limiting with Dominican Republic, and the other on the Macassie river. Preliminary results indicate that on the first site, a dam could be built at an investment cost of US$48.8 million, which would serve a power plant of 9.4 MW and be capable of retaining 156 million cubic meters of sediments. The water flow on the Macassie river, however, is not significant enough to justify the construction of a dam. If politically feasible, a joint development effort with Dominican Republic of the Artibonite should be envisaged as soon as possible.

3. Power Development Strategy

3.1 Expansion 1980-1990

2.62 The development of the hydropotential on the Artibonite and Guayamouc rivers has been retained in EdH's investment program for 1981-1990 as the least cost solution for expanding generating capacity. This is reflected in Table 2.6.

2.63 The evaluation of the Guayamouc project has shown that the proposed dam not only will significantly reduce the inflow of erosion material into the Peligre Lake, but is economically justified on the basis of power generation. The most promising site on the Artibonite is La Chapelle, where the installed capacity could attain 28 MW at a cost of about US$2,000 per kW. Thus, these two projects will be given priority.

2.64 EdH has requested and obtained a loan from IDB for carrying out a feasibility study of La Chapelle. If the results are favorable, IDB may consider to finance its construction. Similarly, IDB has included in its 1982 lending program the necessary funds for the study of the second project on the Artibonite at La Verrette. IDA is to assist in the evaluation of the Guayamouc project and may eventually finance its construction.

2.65 Because of the long lead times of hydro power projects, none of these plants can be commissioned within the next five years. Thus incremental demand for power will have to be met through an increase of thermal capacity by about 35 MW, to be installed either in existing stations or at new locations in Port-au-Prince. These additions will consist of diesel units, fueled with Bunker C.

2.66 Fuel consumption will increase accordingly during this period. Diesel oil requirements should decrease in Port-au-Prince, through the installation Bunker C fueled units. The saving, however, will be compensated by increased consumption in the isolated systems of the provinces. EdH estimates that its fuel bill will increase to US$33 million in 1985/86 representing 50% of its operational costs, assuming a 3% p.a. increase in real prices, or about 10% p.a. in nominal terms.

2.67 To minimize the investment and fuel costs, the 1981-86 program also addresses the inefficiency of the present system, caused by losses and thefts. Investments in the order of US$8.5 million are planned for renovating the distribution system and it is expected that as a result losses should decrease from 28% in 1979 to 19% in 1986 and even further if thefts are reduced.

2.68 If the necessary funds can be found to carry out the proposed hydro development plan, Guayamouc and La Chapelle are to start operations in 1986, La Verrette in 1988 and the other two plants on the Artibonite in 1990, if their cost is competitive. This development would make available a total capacity of 100 MW with an average generation of 600 Gwh per year to meet the market's requirements under normal hydrological conditions. However, due to the cyclical recurrence of very dry seasons, the hydro capacity has to be backed by additional spare thermal capacity. It is estimated that about 70 MW of reserve capacity will have to be added to the interconnected system during the period 1986-1990.

2.69 Little information is available on the expansion programs in the provinces. As formerly indicated, a number of small and micro developments are possible, and these could help to supply existing isolated systems. Some of them appear to be economically feasible. These systems are of limited size. Therefore, an industrial policy leading to the establishment of major electric consumers in the interior should be carefully coordinated with EdH.

2.70 Rural electrification on a large scale should not be considered at this time, with the exception of the lower Artibonite valley, where pumping water for irrigation will achieve a significant increase in agricultural productivity. For future irrigation projects the use of windmills and photovoltaic cells for water pumping could be evaluated.

3.2 Long-term Generation Alternatives

2.71 Given the limitations of Haiti's hydro potential, the future expansion of the system will have to be based on thermal plants. During the 1980's, maximum demand will be growing at some 8-10 MW per year, while at the end of the decade the additional capacity required will be of the order of some 15-20 MW per year, if growth continues at the present pace. At that time, the commissioning of larger steam or diesel plants could be envisaged. The choice between imported coal or heavy fuel oil depends on the future price relationship of these fuels, on their relative transport costs, and on the plants capital cost ratio.

2.72 High hopes were placed in 1976 on the utilization of Maissade lignite reserves for electricity generation. However, as indicated in Paras. 2.45-2.51, the development of the field for power generation does not appear economic under present conditions. But these conditions could change: a cheaper mining method could be found or alternative fuel prices may increase faster than expected.

D. Alternative Energy Options

1. Geothermal Potential

2.73 OLADE's 1/ preliminary reconnaissance work has indicated that high temperature sources do not exist in Haiti. Low enthalpy geothermal systems seem to be present in the northwestern region of the Cul-de-Sac plain, at the extremity of a major fault system, and at the thermal springs near Gonaives and Los Posos in the Central Plateau and at Dame Marie in the southern peninsula. It is doubtful if low enthalpy resources can be exploited for power purposes or industrial uses under current economic and technical conditions. OLADE has formulated a second stage exploration project to determine the potential of the various sites and possible uses, but the organization has not yet been able to fund the project.

2. Agricultural Waste Products

2.74 Agro-industrial waste derived from coffee plantations and processing, cotton ginning, essential oil processing (for cosmetics), sugar refining, rice, corn, sorghum and other cereal plantations, etc. are potential materials from which energy can be derived. Significant progress has been made worldwide in direct combustion and in processing these residues into pellets for use in industrial boilers, as agglomerates for household consumption, or for gas generation through pyrolysis or fermentation, etc.

2.75 Since 1976, the MMRE has carried out experiments on the technical aspects of small-scale briquetting and anaerobic fermentation to provide an alternative energy source for the rural population and a means to substitute for charcoal production as an economic livelihood. The following illustrates the research that has been carried out.

2.76 Briquettes are being produced from several materials, such as vetiver roots, cotton waste and sawdust. These are chopped into fine particles, homogenously mixed and bound together to achieve cohesion. Sodium silicate, a waste product from soap factories, has been found to be an excellent binder which dries quickly and produces a resistant briquette. The paste is then casted and compressed into forms. Finally, the briquettes must be dried.

1/ Latin American Energy Organization.

2.77 The trials have shown that, when used in an appropriate stove, the briquette heats quicker than charcoal, but burns out faster. Combustion is slower and without smoke if sufficient cotton waste is used as a component. On the average, a one-pound briquette sustains combustion for 20 minutes, and it is assumed that about 200 briquettes replace one 30 kg sac of average quality charcoal. According to this proportion, the present market value of a briquette would be about US$0.02 or US$40 per ton, based on a price for charcoal of US$4 per 30 kg sac in Port-au-Prince.

2.78 The Ministry has not evaluated if it is possible to produce this fuel at present price levels. But given the growing scarcity of fuelwood and rising charcoal prices, the project merits more careful evaluation. The technology used at the laboratory is simple and labor intensive and attempts to demonstrate that briquettes could be produced manually by groups of peasants as an alternative activity to charcoal production. But there are also no obstacles to produce them with more mechanized means in an industrial undertaking. Transport is an important cost element to be taken into account when selecting the site for a pilot plant. Cotton is produced in the Gonaives plain; wood waste at Morne La Selle and Port-au-Prince. The capital is also the largest market for charcoal and therefore offers the best place to introduce a new product. 1/

2.79 As a complementary alternative, the Energy Division evaluates the production of lignite agglomerates. Because of the brittleness of the mined lignite and its sulphur and ash content, it cannot be used directly as a stove fuel. But if adequately treated, it can be agglomerated together with agro-industrial waste to form an excellent fuel.

2.80 The process developed consists of: (a) elimination of impurities associated with the mined coal (limestone and clay); (b) desulfurization by means of a lime solution, followed by drying and washing; (c) activation of burning properties by addition of sodium chloride, potash, carbonized vegetable waste (cotton is excellent), or molasses; and (d) addition of starch as binding agent; then the agglomerates have to be cast and dried to avoid crumbling during transport and permit smokeless combustion.

2.81 Both the briquette and the lignite agglomerates burn badly in the 3-stone fireplace, because of the high heat loss resulting from the free circulation of air. A simple, closed cylinder stove has been found to provide excellent results. Here the air enters at the bottom, crosses the fuel placed on a grid and exhausts at the top. A similar design would also improve efficiency of charcoal burning. The Ministry estimates that these stoves could be produced in Haiti at a price of about US$5.00 per unit.

1/ The Energy Laboratory is successfully selling its small briquette production to bakeries in Port-au-Prince.

2.82 Another possible way of recycling agricultural waste is anaerobic fermentation. This process has the advantage that besides a clean energy form, an excellent fertilizer is obtained. With some assistance from OLADE, the research group at the Energy Division is studying alternative designs, including the Guatemalan, Chinese, and Mexican prototypes of biodigesters. The drawbacks for the dissemination of this technology is that some technical skills are required to construct, operate and maintain these digesters. Most importantly, they must be refilled with exact proportions of animal and vegetal waste to achieve proper operation. The Ministry has even considered the alternative of the establishment of a commercial service, where empty vessels would be refilled with waste products and sent out to the customers, in a manner similar to the present LPG service. The mission feels that such a project should be carefully screened, because of the energy consumed in transport. Currently, demonstration units are proposed for selected farms, slaughter houses and possibly hotels located in areas where technical personnel can be made available.

2.83 The recycling of urban waste could also be evaluated. There is a semi-private enterprise that uses part of Port-au-Prince's waste to produce compost. Pyrolysis of urban waste is becoming commercially feasible in developed countries where a large portion of waste consists of non-biodegradable material. In the case of Haiti, the fermentation process is probably more advantageous because of the predominantly organic composition of the waste and the need for fertilizers.

3. Solar Energy

2.84 Given Haiti's geographic location, average solar radiation is good (Table 21). Both the Technology Center of the Ministry of Planning and the Energy Division of MMRE are studying alternative uses for solar energy. Direct uses include water heating, crop drying, desalination and solar cookers. A large unit for potable water production was set up at La Gonave island. Solar water heaters have become competitive in many countries for applications in residential, commercial and institutional buildings. It is suggested that DMRE evaluate potential savings of oil and electricity and assess measures to promote the introduction of water heaters in the market. The potential of solar crop driers is seriously limited because of the low income level of the agricultural producers. However, by accelerating drying time, the technology improves product quality, permits large scale commercialization of food crops and fruits and, in general, achieves savings in the order of 10 to 20% in post harvest losses. Solar cookers are expensive and require substantial changes in cooking habits. However, given the scarcity of fuelwood, research on these cookers should be included in the energy program.

2.85 The conversion of solar energy into electricity via photovoltaic cells and solar ponds can become a feasible alternative for special needs in the future. However, their widespread application in Haiti should not be considered at present.

4. Wind Power Energy

2.86 Windpower has traditionally played an important role in coastal navigation and even today a large part of the merchandise transport is carried in sailing boats. A few windmills are in operation in various parts of Haiti for water pumping and electricity generation. Inadequate choice of location and lack of maintenance have been the causes for many shut-downs. It appears that some areas of Haiti, mainly in the Northern plain and the coastal zones, have wind regimes that permit small-scale utilization, such as water pumping and electricity generation for lighting and radio communication. 1/

2.87 A 1978 survey 2/ indicated that the existing data on wind patterns is insufficient to serve as a basis for windmill development program. It suggested that as a first step, a wind resource assessment network be set up, equipped with simple and sturdy measurements instruments, to register the chronological wind pattern by day and night at the most promising locations. WMO has offered its assistance to organize such a campaign.

2.88 The survey further suggested the installation of a few pilot windmills in the coastal areas where exploitable winds are recognized to exist, and where their use for water pumping and electricity generation can be demonstrated. Their design should take into account that Haiti is located in a hurricane zone.

2.89 The proposed program has not been implemented. Apparently some measurement instruments and pilot mills have been set up at the Gonave island, with the assistance of USAID. The Ministry of Mines and Energy Resources has only recently incorporated windmills in its research program with the objective of studying a simplified design that could be produced in Haiti. The German government is considering financing the construction of four windmills and evaluating operations during a one-year period.

5. Conclusions

2.90 Given the restrictions on primary energy resources, evaluation of these non-conventional energy forms should be firmly pursued. To achieve practical results, the present program carried out by MMRE should be reoriented from academic research to project identification and implementations. It is suggested that the following strategy be followed:

1/ Only average wind velocity statistics are available for a few locations in Haiti. Table 22 shows that highest values were measured in Port-de-Paix on the north coast and at higher altitudes around Port-au-Prince.

2/ Made by an expert from the World Meteorological Organization (MWO).

(a) Organic Wastes: Agricultural residues and municipal solid wastes.

(i) Resource assessment: Identify amounts of material available at specific locations, determine composition and evaluate present use.

(ii) Energy end-users: Determine the potential market at the site, characteristic of consumers and their requirements.

(iii) Optimal Match: Evaluate various conversion technologies and define best suited for resource and energy needs. Evaluate economic and financial feasibility of specific project.

(iv) Assess possible organizational set-up and promote private participation, including cooperative ownership of project. Determine financial assistance for implementation.

(b) Solar Energy

(i) Solar Water Heaters: Identify potential use for stand-alone or hybrid-mode systems (operating with with other electrical or fossil fuel hot water systems), in (i) commercial, institutional and residential sectors (hot water or pre-heating of water in hotels, laundries, hospitals and homes) and (ii) industrial uses: low to medium temperature process water, primarily as pre-heaters.

(ii) Solar crop dryers: Survey the most important crops and assess post harvest losses; identify crops which have the highest economic potential for crop drying. Develop a design to meet the specific drying requirements of the particular crops.

(iii) Solar Cookers: Assess the cooking needs and patterns of the rural population and evaluate potential savings of fuelwood. Choose proper cooker design and adapt to local conditions. Field-test the design and evaluate reaction. Formulate a diffusion strategy.

(c) Wind Energy

(i) Resource assessment: Statistical data on wind regimes should be augmented; priority should be given to areas where the potential appears to be the highest;

(ii) Field- test and install a limited number of windmills in areas where there exists a need for water pumping and/or small electric power. Equip some with instrumentation for additional data collection and extrapolate;

(iii) Research and development on windmill designs to match use and wind regimes. Diffusion.

2.91 The long term strategy for the development of renewable resources in Haiti should also include the build-up of domestic capability in repair, maintenance and construction of hardware, extension of their use and training.

III. DEMAND MANAGEMENT STRATEGIES

3.01 Total primary energy consumption is estimated at 1.4 million tons of oil equivalent for 1979. This puts Haiti among the countries of lowest per capita consumption (270 kg of oil equivalent per person) in the world. The other significant characteristic in Haiti is the duality of the energy market, in which the use of commercial fuels is restricted to the urban, modern sector of the economy, while the large majority of the people depend on fuelwood and other agricultural waste products for their energy needs.

Aggregate Demand: Past Trends and Projections

3.02 During the past decade, the average rate of growth in primary energy consumption was 5.6%, which compares with an annual 3.6% increase in GDP. However, the shift in economic activity away from agriculture, growing urbanization and expansion of the transport network has led to a high demand increase for commercial fuels. On the average, the rate exceeded 10% for oil, 16% for electricity and 15% for charcoal.

3.03 Assuming that the historical relationship between energy and GDP growth rates (1.6) is maintained in the future, and that the economy grows at 3.5% per year, the following projection results:

Table 3.1

	000's tons of oil equiv.			Av. annual growth rates	
	1979	1985	1990	1979-85	1985-90
Total Energy	1364	1891	2484	5.6	5.6
Domestic	1133	1475	1937	4.5	5.6
Wood	980	1313	1676	5.0	5.0
Hydro	48	57	156	2.9	22.3
Bagasse	105	105	105	.0	.0
Imports	231	416	547	10.3	5.6

3.04 This is a rather optimistic outlook because it assumes accelerated development of the hydropotential, allows for an increase in fuelwood supply although forest resources are dwindling, and does not take into account that increasing urbanization may well accelerate the growth rate of demand for commercial fuels. The table shows that under these conditions, the projected energy deficit would rise from 17% in 1979 to about 22% in 1985, remaining at that value during the rest of the decade. If the gap is met by imported oil, the volume would increase from 4.9 Mb/d in 1979 to 9 Mb/d in 1985, and the cost of these imports would reach US$140 million (in 1981 prices), which is equivalent to 45% of Haiti's projected export revenue for 1985 in 1980 prices. This compares with US$32 million or 23% of merchandise exports in 1979; and US$61 million estimated in 1980, equivalent to 29% of export revenue. Import requirements would be considerably larger, should the projected

investments for hydropower development not become available or wood resources not be able to sustain a 5% growth in demand.

Advantages of Demand Management Policy

3.05 The Mission considers that the Haitian energy system has a margin of demand compressibility which would not constrain economic growth. Although the present data on energy consumption is insufficient to permit a full analysis of the energy saving potential, the results obtained in other countries with similar conditions to those of Haiti indicate that savings of the order of 20% might be achievable over a period of five years.

3.06 The advantages to be gained from a demand management policy leading to higher efficiency in energy use and reduction of waste are important; among others, a decrease in oil import requirements and capital investment in the power sector, which would release resources for other development objectives; industries could diminish their production costs and make their products more competitive in international markets; the poorest segments of the rural population would benefit from a more ample supply of fuelwood, etc.

3.07 Demand management basically strives to change consumption patterns. To be successful, the policy requires the full and voluntary participation of the population. It has to provide information to make the public aware of the energy problem and of saving opportunities. Technical assistance must be made available to individual consumer groups to help them in establishing better housekeeping practices and implementing retrofitting projects. Finally, economic incentives have to be created to induce producers and consumers of energy to follow the policy.

A. Energy Pricing: Present Levels and Recommended Actions

3.08 Energy pricing decisions in the energy sector must be taken in an integrated framework, in which linkages among energy subsectors and with the rest of the economy must be explicitly recognized. In Haiti, the energy pricing policy must take into account that the development of incremental supplies and the demand management strategy requires adequate economic inventives. At the same time, it must consider the low level of income of the vast majority of the people. Thus, investment and pricing decisions in energy cannot be isolated from economic development policies.

3.09 The present practice of setting energy prices does not serve an explicit energy policy, but responds to general economic considerations and to budgetary requirements. The Ministry of Commerce and Industry, through its Service de la Direction des Prix, fixes the prices for oil products, sets a maximum price on charcoal and participates in determining electricity tariffs. 1/ Taxes are set by the Ministry of Finance and

1/ The "Law Protecting National Industry" (June 14, 1960) authorizes the Ministry to "prevent illegal price increases, to control the cost of imported and domestic goods, and to fix the prices to the public."

Economic Affairs, collected and controlled by the National Bank and channeled to the budget.

1. Wood and Charcoal

3.10 In many areas wood is basically free of charge; its market price does not reflect the economic cost of depletion of forest resources and the consequent effects on the environment, or the negative externalities associated with the use of this resource.

3.11 In other areas, fuelwood has a price. Conway 1/ indicates that in 1979, one decimeter of wood could be bought in Fonds Parisien (deforested zone in Cul-de-Sac) at US$0.04 (or US$40/m3), while the same amount bought 6 dm3 of unidentified wood or 3 dm3 of logwood in the Port-de-Paix area (Northwest). The price of charcoal has risen substantially in recent years (see Table 11). Differences in retail prices at major markets are due to competition, shortages and charcoal quality. Transportation costs are a major factor and largely account for regional differences. In 1980, the prices for charcoal were approximately: Miragoane, US$1.50 per 30 kg sack; Cap Haitien, US$2.0; Port-au-Prince, US$4.0.

3.12 The only tax incurred in the production of charcoal is a tax of 20 cents per m3 of wood levied on each tree cut down, which is roughly equivalent to US$1.65 per ton of charcoal. Wood from the natural forest is, therefore, provided almost free of charge. This is a major disincentive to forest management and the establishment of plantations. Investors in reforestation will lose if competitors are allowed free access to standing timber.

3.13 There is no doubt that the cost of wood from plantations will be higher than the cost of wood currently extracted from the natural forest. Energy plantations will, therefore, require that the taxes imposed on charcoal producers operating in the natural forests be substantially increased. The conflict between the price for wood and charcoal and the purchasing capacity of the poorer population will have to be resolved through selective subsidies.

3.14 The growing scarcity of wood affects mainly the poorer rural and urban population. As shown in Table 3.2, the cost of cooking in deforested areas probably exceeds the cost of middle-income households in Port-au-Prince, which can afford to buy an LPG or kerosene stove. Consideration should therefore be given to the alternative of subsidizing the acquisition cost of more efficient stoves to this segment of the population.

1/ F. Conway: Study of the Fuelwood Situation in Haiti. USAID mission to Haiti 1979.

Table 3.2

Comparison of End-Use Price for Cooking Fuels
(1980 prices)

	Cost		End-Use Efficiency	Cost of Energy Used
	US$/unit	US$/10⁶ Btu	%	US$/10⁶ Btu
Fuelwood - wooded area	6.67/m3	0.686	7	9.80
- deforested area	40m3	4.11	7	58.78
Charcoal	2.00-4.00/30kg	2.37-4.73	20	11.85-23.65
Kerosene	1.24/gal	10.02	30	33.39
LPG	1.33/gal	15.10	70	21.57

2. Petroleum Products

3.15 LPG, gasoline, diesel and kerosene are subject to price control. Prices are fixed in parity with the average postings at Aruba and Curazao, plus freight, insurance, wharfage, taxes, marketing and distribution margins.

3.16 Since 1974-75, the policy has been to hold down consumer prices to quench inflation (see Tables 12 and 17). Automatic transfer of price increases in the international market has been substituted by periodically negotiated price revisions. Taxes have been gradually reduced and the companies' margins have been frozen in real terms.

3.17 The present price structure for controlled products is as follows:

Table 3.3

Petroleum Product Prices 1/
(US$/gal)

	Gasoline	Diesel	Kerosene	LPG
Cif Price	1.04	1.00	1.09	1.27
Taxes	0.87	-	-	0.02
Marketing Margin	0.14	0.10	0.08	n.a.
Dealers Margin	0.10	0.07	0.07	0.04
Retail Price2/	2.15	1.17	1.24	1.33

1/ Estimated as of May 1981. For full information as of August 1980, see Table 13.

2/ These are the retail levels for Port-au-Prince. A small transport element is included in the prices in other regions.

3.18 There are two forms of taxation: import duty and excise tax. As of August 1980, import duty was levied on gasoline (33% of landed cost), LPG and lubricants. Consumption tax is applied on gasoline (22¢/gal); on LPG, fuel oil and asphalt (2¢/gal); and on lubricants (3¢/gal). Taxes on kerosene and diesel were completely removed between 1976 and 1979. About 16% of gasoline sales are exempted from taxes, and represent the consumption of government institutions and international organizations.

3.19 Due to the country's critical foreign exchange shortage, the government increased taxes on gasoline in March 1981. Import duty was increased to 60% of cif value and excise tax to 25¢/gal. This measure reverses drastically the past trends, when State revenue from taxes on petroleum products decreased from US$20.2 million in FY75/76 to about US$2.8 million in FY78/79.

3.20 The marketing margins have been a long standing issue in price negotiations. Companies 1/ have complained that the average margin allowed does not reflect increasing operating costs and working capital requirements, nor provides an incentive for new investment. Furthermore, the policy favors those companies with a larger share in the gasoline market because the margin on this fuel has been consistently higher than on the other products. In August 1980, the margin differential between gasoline and diesel was reduced from 17¢/gal to 4¢/gal, by lowering the margin on gasoline and increasing that on diesel. However, the decision resulted in a 2¢/gal decrease in the average marketing margin. As a result, one company decided to cut back deliveries to the market.

3.21 The policy to retain only taxes on gasoline created a domestic relative price structure that increasingly differed from world market structure (Table 18) and which contributed to changes in the composition of Haiti's car fleet. Data on sales of automotive fuels indicates that 50% of the volume sold in 1979 consisted of diesel oil. This cannot be explained only by an increase in the number of public transport and freight vehicles, where substitution for diesel is appropriate; it also represents a substantial increase of diesel vehicles in the private car fleet, which accounted for two-thirds of the automotive fleet in 1978.

3.22 Above a certain level, prices for automotive fuels become an efficient deterrent to non-essential uses of the private automobile. However, the conservation effect gets lost when fuel prices decrease relative to other goods or when a substitute is available at a lower cost. In general, real petroleum product prices have declined between 1974 and 1979 (see Table 17).

3.23 To avoid further distorsion of the market, the Haitian Government decided in late 1981 to progressively increase taxes on transport diesel to realign over the medium term domestic relative prices for gasoline and diesel to world market ratios. Control will have to be

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1/ Shell, Esso and Texaco.

exercised to avoid the use of the lower priced industrial diesel oil or kerosene for transport purposes.

3.24 Complementary measures to enhance conservation in the private transport sector should be envisaged, such as:

(a) Discourage the import of vehicles for private use in general and, in particular of diesel cars.

(b) Eliminate all tax exemptions granted to official entities on import duties and excise tax for vehicles and fuels.

(c) Increase the annual licensing fee on automobiles, imposing a higher levy on privately-owned diesel vehicles, until the gasoline/diesel ratio has been fully aligned.

3. Electric Tariff Structure

3.25 The rates for power were substantially increased in January 1977 and a new rate structure established. This new rate structure has had little effect on the characteristics of the load and though no specific studies have been conducted, it is EdH's feeling that the price elasticity of consumption has continued to be around zero.

3.26 The present rate structure divides consumers into three classes as follows: residential, commercial, and governments; industrial; and public lighting. Residential and commercial clients who have a monthly consumption of less than 30 kWh benefit from a lower tariff than those in the 31-200 kWh range, and another block is established for consumers who use more than 200 kWh a month. Industry has the most sophisticated rate structure which includes differentiation according to the voltage and demand for the fixed charge of the supply, and peak and off-peak hours for the energy price. Public street lighting has a flat rate and so has electricity for irrigation purposes. The rate structure and its evolution during the 1978/80 period can be seen in Table 14.

3.27 The tariffs are composed of two elements: the first one being a base rate which covers capital costs, operation and maintenance, the second part being essentially connected with fuel price increases. This implies a fuel adjustment clause which is automatically applied every three months.

3.28 The rate structure proposed by the consultants and adopted by EdH in 1977 differed considerably from the rates calculated by Sofrelec in 1976 based on the principle of marginal costing. Two examples should illustrate this statement. The relation between the highest and lowest tariffs for low voltage consumers, per monthly kWh billed, was in theory established at four to one. The current relation for these sales is 1.3 to 1. As for high tension clients, the study proposed a US$2 fixed charge per kW of maximum demand. The tariff applied since July 1980 is US$0.77 per kW.

3.29 The basic low tension rate which is common to residential and commercial consumers, according to the last adjustment of July 1981, starts with a unit price of electricity of US¢9.8 per kWh for the modest consumers, and increases to a level of US¢13.1 for those consumers requiring more than 200 kWh/month. The low tension rate for small industrial consumers has been kept relatively low, as an incentive for the establishment of assembly industries which create jobs in the Port-au-Prince area. Its level (US¢8.78) is similar to that of the energy supplies at high tension. It is debatable whether this cross subsidy is effectively promoting industrial development, for the availability of power supply is surely more important than the price at which it is sold in a country where the minimum wage is on the order of US$3.00 per day. The same reasoning can be applied to the power systems in the province. If the other conditions required for industrial localization are given, EdH should endeavour to supply the power requirements of the new concerns, which would also improve the load factor of the isolated systems.

3.30 On the other hand about 43% of EdH's consumers are classified in the social rate (for consumption up to 30 kWh per month) they represent only 2.5% of total sales and 3.5% of EdH's total revenue. Because the minimum charge is US$2.85, this group barely covers amortization of the capital cost of the house connection and meter, let alone cost of the network, generating plant and operating cost. However, because this group uses on the average only 20 kWh/m, the effective rate is US¢14.2/kWh, or almost as much as the highest block of residential consumers. A similar cross subsidization occurs between Port-au-Prince and the provinces. In these isolated systems, the average revenue does not even cover the cost of diesel oil used to generate the requirements. Although this subsidy does not yet pose an undue financial burden, EdH will have to monitor carefully the revenue-versus-cost situation. The forthcoming updating tariff study will provide information to assess an acceptable balance in future cross-subsidization.

3.1 EdH's Financial Situation

3.31 Until 1975, when the first contacts were established with IDA, EdH's financial condition was weak because of inadequate rates, non-payment of power bills by the public sector and excessive reliance on short-term debt. This situation was reflected in modest capital investments during the 1971/75 period, which were financed by Government transfers and overdrafts at the National Bank. Operating efficiency was also very poor and losses reached some 42% of gross generation. In early 1977, EdH implemented new tariffs but due to strong consumer dissatisfaction with the electric supply situation (affected by a severe drought which rendered the hydro station at Peligre practically inoperative), the Government reduced the rates in March and they were not restored to their original level until July of that same year. One major problem with EdH's income has always been the arrears in payments from the public sector to the utility. This situation has fluctuated during the last five years but is still serious. The rates of return on revalued fixed

assets established during the negotiations of the first and second power projects financed by IDA were never fully attained, and therefore EdH could run into difficulties in the self-financing of the investments connected with its expansion programs, should this trend continue.

3.32 The present financial situation is confortable though the rate of return barely reached 4.4% and 5% in fiscal year 1979 and 1980. Operating revenues for FY1979/80 have been estimated at some US$19 million. The operating expenses and depreciation amount to some US$14 million of which about US$5 million correspond to fuel cost. The net internal cash generation after debt service is US$6.2 million which is about 54% of the total construction expenditures for the same period. Nevertheless, because of the accelerated expansion program proposed, a revision of base rates (over and above the quarterly adjustments in the fuel surcharge) is being envisaged.

B. Other Supply and Demand Management Actions

3.33 The revision of the flow of energy throughout the economy permits identification of priority areas for other management actions. The following sections analyze this flow at the supply and conversion level, and at each sector of consumption.

1. Energy Supply and Conversion

3.34 The energy balance shows that domestic resources provide the bulk of primary energy requirements: fuelwood provides approximately 72%, bagasse 7.7%, hydropower 3.5%. The rest of the needs are supplied by imported petroleum products.

1.1 Wood Production

3.35 Because wood is gathered in all parts of the country mostly as a free good, it is easier to quantify production through consumption estimates. Wood is consumed as fuelwood or charcoal. In the rural, wood producing areas, drywood is used directly as fuel; charcoal dominates in urban areas and in deforested zones, where transportation cost is a major consideration.

3.36 The most reliable estimate on wood consumption is probably that of Earl 1/, which indicates that the annual consumption of charcoal and fuelwood is equivalent to 4 million m3. This estimate is reasonable but not precise and will be accepted only in the absence of better data. It compares with an estimate of 5 million m3, made by the Ministry of Agriculture, Natural Resources and Rural Development (DARNDR). It is higher than the firewood consumption of 0.319 m3 per person found in household surveys in Fonds Parisien, (Cul-de-Sac region) "a figure which should be considered conservative"2/ and is lower than the often cited

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1/ D.E. Earl, 1976. Reboisement et lutte contre l'erosion, Haiti, UNDP.

2/ F.J. Conway, 1979. A Study on the Fuelwood Situation in Haiti, USAID

official figures of 10 million m3, questioned by Voltaire.[1/]

3.37 Statistics on charcoal provide some information on consumption in Port-au-Prince. In the fiscal year 1977/78, charcoal consumption in the capital was 37,000 tonnes, which represented a 72.4% increase over 1973/74, or 14.6% per year. It has been estimated that about half of charcoal production is consumed in the interior.

3.38 Wood is collected in almost all areas in Haiti. The largest charcoal producing areas are the Northwest, in the triangle Anse-Rouge-Port de Paix-Mole St. Nicholas and the Cotes de Fer area in the southern peninsula. The resources on the island of La Gonave, formerly an important producer, seem to have been depleted. The northwest is estimated to produce about 50% of the charcoal volume consumed in Port-au-Prince.

3.39 Charcoal is produced mostly from green wood. In public lands, the most common tree used is the Bayahonde, which grows even in arid areas and has the capacity to regenerate itself. Others are the medium sized Bois Cabrit; the Candelon; and the Bois Gaiac, which has almost completely disappeared.

3.40 The wood harvesting and charcoal production is performed by individuals who have no other economic alternative, often as a part time job for peasants and as a full time job for those who do not have a piece of land to cultivate. These individuals tend to move from one area to another as resources become depleted. The growing population pressure and the scarcity of wood have increased competition at the production level, and it is estimated that the average earnings of a charcoal producer for a 6-day working week is between US$1.40-2.00 (in 1979).

3.41 Various studies have shown that the distribution of charcoal is also very competitive. A major cost element in the price of charcoal to the final consumer is transport, which is made by truck or by sailing boats.

3.42 The present free and uncontrolled access to public forest contributes significantly to the deforestation process. Trees are cut before maturity, regrowth is destroyed and even roots are extracted for charcoal production. Furthermore, the tax system, which only imposes a levy on green trees that are cut down, induces charcoal producers to set whole forests on fire to kill harvestable trees. Forest management could substantially reduce this waste, by opening up mature forests and protecting regrowth in exploited areas.

1/ K. Voltaire, 1979. Charcoal in Haiti, USAID, Haiti.

1.2 Conversion to Charcoal

3.43 When charcoal is produced from wood, much energy is lost. The gains are that one has produced a fuel which weighs far less than wood per unit of energy, occupies less volume, burns with a clean flame, and is usually consumed in more efficient stoves. Charcoal weighs about half as much as the original, air-dry wood and its yield in weight is usually 20% to 30% of the dry weight of wood used. If we accept energy values of 7.0 kcal for charcoal and 3.5 kcal for dry wood, then the production of charcoal would represent a loss of between 27% and 52% of potential energy contained in wood. The loss will be reduced if pyrolytic oils are utilized and it is partly compensated for by lower transportation costs and more efficient consumption. However, the existence of this loss in energy value offers some opportunities for energy saving, particularly for energy plantations in locations where transportation is not a major fctor, and where the burning of wood or the production of oils can be considered.

3.44 The prevailing method of producing charcoal in Haiti is with traditional earth mounds. In theory this method is less efficient (i.e., produces less charcoal from a given quantity of wood) than kilns in which the rate of burning can be controlled. For example, a USAID report 1/ cites a study of charcoal making in Africa in which the traditional method is said to produce "barely half of the volume of charcoal which might be obtained by more efficient methods." The evidence for the efficiency of new methods, however, is not nearly as convincing in the case of Haiti. For example, there is an agreement on the high level of the charcoal makers, who represent somewhat of a guild, pursuing a traditional occupation and who, in view of the scarcity of wood, must have ample incentive to minimize waste. A FAO study in Haiti 2/ presents results of tests in which the traditional method yielded more charcoal per unit of wood than steel kilns and underground kilns. This result may not be conclusive. The performance statistics observed are somewhat erratic and technical and other difficulties were encountered.

3.45 A gain in efficiency in the production of charcoal is possible by producing pyrolytic oils, which can be a by-product of charcoal production, but are lost in the traditional production methods. Pyrolytic oils are a potentially important source of energy for cooking and industrial applications, including electrical power generation. According to Chiang, the weight of oil produced by a continuous pyrolytic converter is approximately equal to 75% to 85% of the weight of charcoal produced and each ton of oil contains about 25 million Btu. His report offers a detailed feasibility study of pyrolytic converters. The

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1/ Chiang, T.I., et al: "Pyrolytic conversion of agricultural and forestry wastes in Ghana." USAID, Washington, D.C., 1976.

2/ Cited in Earl, D.E., "Reboisement et lutte contre l'erosion" - Haiti, 1970.

procedure is not free of problems: there may be adverse affects on the quality of charcoal produced, and the oils themselves are somewhat corrosive and polymerize on exposure to air. Nevertheless, the potential source of energy involved is so important that it deserves detailed further study. Modern charcoal producing methods should therefore be considered in energy plantations and in the natural forest areas subject to management programs. These will offer the concentration of wood supply, the infrastructure and the possibility for training and supervision to justify investments in new methods and equipment.

3.46 In countries where there are ample forest resources, a simpler and in some circumstances more efficient approach would be to produce electricity or steam by burning wood directly. The feasibility of this approach is shown in an analysis recently completed for the Dominican Republic by the MITRE Corporation. 1/ The method proposed appears promising; however, the immediate priority in Haiti should be to establish plantations, to introduce protection and forest management and thereby to produce the wood which is the pre-requisite for successful application of these new technologies.

1.3 Electric Power Generation and Distribution

3.47 The production, transport and distribution of electric power in Haiti is handled by Electricite d'Haiti (EdH), an autonomous government-owned agency which has had a country-wide legal monopoly as a public utility since 1971.

3.48 EdH operates the main interconnected system which is served by the Dr. Francois Duvalier (Peligre) hydroelectric power plant on the Artibonite River. This plant was built in 1971 at the foot of the Peligre dam constructed in the mid-1950's for the purpose of regulating the waters for irrigation and flood control. This generating station has a rated capacity of 47.1 MW and an effective capacity of 44 MW, consisting of three 15.7 MW units linked to the capital of Haiti by a single 2 circuit 115 kV line, and through a 69 kV sub-transmission ring to three diesel power plants located in Port-au-Prince, which have a total effective capacity of some 38 MW. With the exception of three small hydropower plants located at Drouet (2.5 MW), Jacmel (.8 MW) and Belladere (30 kW), the remaining capacity consists of 17.1 MW of light diesel groups, which operate with low load factors in isolated systems serving provincial towns and villages. (see Table 9).

3.49 In FY 1979/80, the interconnected system generated 279 Gwh. Losses and thefts in distribution and the station's own requirements add up to 28% of gross generation. The present system operation allows for 79% of total production to be supplied by hydro generation. Due to the fact that reservoir operation is conditioned by the irrigation and flood

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1/ Trehan, R.K., 1980. Potential for energy farms in the Dominican Republic.

control requirements, the guaranteed hydro capacity varies substantially during the different parts of the year, dropping from 44 MW during the wet season, to 21.6 MW during the dry season. During the wet season,the hydro plant is operated on a run of the river basis, and the variations in demand are compensated by both the heavy and light diesels. During the dry season, and for the purpose of maintaining an adequate flow in the river so as to cover the irrigation needs, the reservoir is drawn down and the hydro is operated as a semi-base plant, for it has no re-regulating reservoirs downstream.

3.50 Apart from the utility's system, there are a number of industries which autogenerate their own needs by using locally produced agricultural waste, such as bagasse, or by burning oil derivatives which they import directly. The major auto producers of electric energy are CdH's cement factory (13 MW), HASCO's sugar mill (2.2 MW), a flour mill (1 MW) and a bauxite extraction concern (.5 MW). Some of these have cogeneration systems (steam and electricity). There are also numerous small standby diesel and gasoline fueled plants, which were installed in the past by consumers, due to the poor reliability of public utility service.

3.51 The present quality of service in the Port-au-Prince area shows a great improvement when compared with the situation in 1976, when IDA commenced its involvement in Haiti's power sector. At that time, the thermal back up of the Peligre hydro generating facility was insufficient, and the risk of power shortages because of a dry year was serious. In the dry year of 1977, numerous blackouts occurred and rationing of power supply had to be imposed.

3.52 IDA's First Power Project, which basically covered the installation of additional diesel engine capacity (21 MW), and a substantial improvement in the transmission and distribution system in Port-au-Prince, has helped solve the situation and allowed for a rapid growth of sales. We have here a case in which the load growth is basically induced by the increase of an adequate supply.

3.53 As the hydro generation is limited to a single plant, the increase in consumption for the next five years will have to be satisfied by adding thermal capacity with the consequent increase in fuel consumption. It is suggested that in the investment program priority be given to the reduction of the system's technical losses as well as to the losses in transmission and distribution.

1.4 Bagasse

3.54 It has been estimated that around 85,000 ha are under sugar cane production in Haiti. Cane from only about 19,000 ha is converted into raw sugar in industrial mills and the rest is processed in artisanal establishments producing rough sugar (rapadou) or alcohol (clairin), or is used directly for human and animal consumption. Yields are extremely low by the standards of most cane growing countries, and vary from 80 tonnes per ha in Les Cayes during the best years to 10 to 15 tonnes per

ha in the Central Plateau. If a conservative estimate of 25 tons per ha is assumed, total sugar cane production in Haiti can be estimated at more than 2 million tonnes per year.

3.55 The bagasse content in sugar cane can vary between 25% to 37%. Thus, the total amount of residue potentially available exceeds 500 thousand tonnes per year. With a humidity factor of 50%, the calorific value of this bagasse can be estimated at 4.05 thousand Btu/lb, and the total energy potential that could be derived from this source is equal to about 350 to 400 GWh per year.

3.56 At present, less than one-half of this potential is being utilized. There are three modern sugar mills in operation, the most important of which is HASCO which produces about 62% of total industrial sugar production. This mill is the only one that cogenerates steam and electricity from bagasse, but satisfies only its own internal energy requirements. The other two plants burn bagasse for steam generation, but use diesel for electricity generation.

3.57 There is little information on the artisanal processors of sugar cane (guildives) which process about half of the sugarcane production and are scattered all over the country. There are indications that these establishments only satisfy part of their energy needs with bagasse, and purchase large quantities of fuelwood. Apparently, the unused tonnage of bagasse is allowed to decompose and eventually is recycled to the fields as fertilizer. The reason for this inefficiency is that these guildives date back to colonial times and use a technology adapted to conditions of the past.

3.58 The potential of bagasse as an important source of energy is being slowly recognized. While the calorific value of bagasse contained in a tonne of sugar cane was estimated in the energy balance at 2.2 million Btu, the energy requirements in a modern, average-sized plant can be calculated at 1.4 million Btu per ton of cane processed. Therefore, the industry could make available to the economy a surplus energy of 0.8 million Btu per ton of cane. With sugar cane production of 2 million tons per year and assuming a conversion efficiency of 10,000 Btu/kWh, the industry could theoretically generate 160 Gwh of excess electricity per year. This is equal to 80% of the power generation of Haiti's interconnected system.

3.59 This issue deserves explicit study, regarding collection and seasonality of bagasse production, progressive phase-out of artisanal guildives and capital investment in modern sugar plants to improve the efficiency with which bagasse is handled and burned.

1.5 Petroleum

3.60 Haiti imports all its petroleum requirements in the form of finished products, which is a sensible strategy given the size of the market (4.9 M b/d in 1979) and the surplus capacity in the Caribbean refineries. The bulk petroleum products are imported and distributed by

Shell, Esso and Texaco. Shell imports, mostly from Curacao, its own requirements and those of Esso and Reynolds Bauxite Co.; Texaco brings its products from Trinidad. Occasional purchases are made from other Caribbean refineries, such as those in Jamaica and Venezuela. LPG is imported by Tropigas, and distributed by this company and Gas d'Haiti. Lubricants are imported by all companies from the Caribbean, USA and Europe.

3.61 There is no significant loss of energy at the supply level. However, import costs could be reduced by changing the qualitative composition of imports towards more heavy fuels. In 1979, the imported volume of 1.8 million barrels was composed of 26% light products (LPG and gasoline), 46% middle distillates (kerosene and diesel) and 28% heavy products (fuel oil, asphalt and lubricants).

3.62 The Haitian Government has applied for inclusion in the Mexican-Venezuelan oil facility, under which crude oil supplies are guaranteed to countries of the region and a low interest credit is granted on 30% of the f.o.b. value of imports. In a surplus market, such a fixed arrangement must be carefully monitored to achieve the expected cost savings.

2. Energy Efficiency in Final Consumption

3.63 To provide an initial understanding of the pattern of consumption and to identify priority areas for a demand management strategy, the following estimate of energy consumption by economic sectors was developed. It attempts to measure energy demand at the input level and at the level of effective use. The difference originates from the relative efficiency with which energy is used by each individual sector.

Table 3.4

1979 Energy Consumption Structure

	Consumer Input		Effective Use By Consumer		Efficency Ratio
	Mtoe	%	Mtoe	%	(2:1)
Industry	360	31.1	108	50.3	0.30
Transport					
Road	89	7.7	20	9.4	0.23
Air	24	2.0	5	2.2	0.21
Commerce & Services	240	20.6	40	18.6	0.17
Households	447	38.6	42	19.5	0.09
Total	1160	100.0	215	100.0	0.19

Source: Statistical Annex - Tables 3 - 4.

3.64 The table illustrates the importance of the modern sector of the economy in total energy consumption, including most of industry and transport and a significant part of the tertiary sector. It further indicates that its efficiency ratio in energy use is at least twice the ratio of the traditional sector. For the economy as a whole, the estimate indicates that less than one-fifth of the energy made available to the final consumer is effectively used.

2.1 Traditional Sector

3.65 According to DARNDR, consumption of wood for energy is about 95% of total wood consumption. However, in the long run, one can expect a substantial increase in the demand for housing and for fence-posts if grazing controls are introduced. Strong arguments to divert wood available for the production of energy to other uses are, therefore, inevitable in the future. This prospect is important in considering a strategy for achieving an energy balance. The expected new demand for wood practically eliminates the risk that there will be no market for wood resulting from reforestation programs.

3.66 Other economic considerations stress the need to make the most efficient use possible the of available wood supply. On one hand, the growing scarcity of wood has considerably increased the cost of energy to the rural population, thus further reducing their already very low income level. On the other hand, wood plantations have a significant investment cost. Assuming present fuelwood consumption at 4 million m3 of solid wood content, it can be estimated that a 10% gain in efficiency in the use of this resource would be equivalent to planting 40,000 ha of new forests with an average growth rate of 10 m^3/year. At a cost of about US$1,000 per ha for the establishment and maintenance of plantations (not including land acquisition and harvesting cost), a policy directed to this saving objective would achieve a saving exceeding US$40 million.

2.1.1 Efficient Stoves

3.67 It has been demonstrated in countries similar to Haiti, for example in Guatemala, that through the introduction of "Lorena" stoves, energy savings for cooking could be as large as 50% of the amount of energy used in the traditional 3-stone fireplace. These stoves are made of sand and clay, that is, local materials available everywhere, requiring no investment except time and involving designs that allow much leeway for incorporating local preferences and the use of almost any fuel. The method for constructing Lorena stoves and for implementing their introduction in the rural environment have been described by Evans, from the Aprovecho Institute. 1/

1/ I. Evans: Lorena Owner-bult Stoves; a construction manual. Published by the Appropriate Technology Project of Volunteers in Asia, 1979.

3.68 It should be recognized, however, that the dissemination of Lorena stoves takes time. The program should review the work already done in Haiti and in other countries and promote the build-up of a local manufacturing capacity for cheap stoves and even consider the alternative of introducing portable metal stoves. As formerly indicated, the MMRE has designed such a metal stove which burns briquettes, but could be used for firewood burning if adequately isolated by double walls. However, the cost of these, estimated at about US$5 per unit, may exceed the purchasing power of the majority of the Haitian rural population that lives in absolute poverty. Therefore, consideration should be given to a one time subsidy. Assuming the existence of about 750 thousand rural households, this subsidy would amount to about US$4 million. It would achieve a positive return relative to wood plantations if only 5% of the fuelwood used in households is saved.

3.69 The traditional sector also comprises a large number of small industrial, artisan and commercial establishments that use fuelwood and charcoal in a rather inefficient way. A survey of this sector would help to assess the type of equipment most commonly used in this sector and provide information on the technical modifications required to improve consumption efficency.

2.2 Modern Sector

3.70 Imported oil and electricity provide the bulk of this sector's energy requirement. The following highlights the ways in which the different sectors make use of these fuels.

2.2.1 Aggregate Demand for Oil and Electricity

3.71 Oil demand is dominated by a few relatively large users. The main trends since 1973 have been: (a) total consumption has grown at an average annual rate of 10.9%; (b) gasoline demand increased to 1978 on the average by 10.1% per year, but seems to be levelling off since then; (c) diesel oil shows sustained growth of 10.3% per year; (d) fuel oil consumption has not increased since 1976; and (e) LPG and kerosene demand has grown at a higher than average rate, reflecting perhaps substitution for charcoal and fuelwood mainly in the service and small industry sectors.

3.72 Electricity sales have grown on the average by 16.4% during the 1970's; the pattern was somewhat erratic, largely due to shortages of generating capacity. Residential and industrial use of energy has grown substantially in the Port-au-Prince area, while commercial, public lighting and other sales have remained relatively small. In the other towns of Haiti that have access to electric public service, and where total sales amount to only 9% of EdH's operation in 1979, the increase in consumption has been even faster in recent years, reflecting the very low initial stage of electrification (see Table 10).

3.73 Existing power services are limited to the Port-au-Prince area and to eighteen smaller towns of the interior. They supply 7% of the

population of Haiti, which means that those with access to electricity are a small and privileged group. More than 80% of all clients served through the public systems are located in Port-au-Prince. These were billed a total of 197 GWh, or 91% of total sales, during FY1979/80.

2.2.2 Sectoral Distribution of Consumption

3.74 For 1979, the sales of oil products and electricity can be allocated to the various economic sectors as follows:

Table 3.5

Economic Sector	Petroleum Products 1/ 000's Bbls	%	Electricity GWH	%
Industry	604	38.4	100.6	51.0
Transport	858	56.0	-	-
Residential-Commercial	70	4.6	80.2	40.7
Others	-	-	16.3	8.3
Total	1,532	100.0	197.1	100.0

1/ Excludes oil input to power generation and consumption of non-energy products.

Source: Statistical Annex - Table 8 - 10.

a. Industrial Sector

3.75 The modern industrial sector uses at least 35% of total oil imports and more than 50% of power generation. Only a few energy intensive industries exist, such as cement, bauxite mining and steel mill. The first two, together with the public electric utility, consume 80% of fuel oil imports. About 70% of diesel oil consumption takes place in only 18 industries. The rest of the sector is composed of a large number of small factories. However, industries such as food processing, tobacco, chemicals and textiles are rapidly growing and offer opportunities for installing new and more efficient equipment.

3.76 Most industrial consumers are located in the Port-au-Prince area. The demand for electricity in the transformation industries produces a rather unusual load curve weekdays, as the morning peak is about 20% higher than the evening peak. This situation, which is also induced by the functioning of air conditioners during the hot mid-day hours, results in an exceptionally high daily load factor for the Port-au-Prince power supply system.

3.77 In a survey carried out by E. Cecelski in 1980 1/, it was found that the sector in general has a clear perception of their energy costs and interest in improving energy efficiency. However, the lack of trained energy managers and the non-existence of energy auditing services have limited the actual implementation of measures to only the largest industries.

3.78 The energy intensive industries have already implemented improved housekeeping practices and are considering major capital investments in more energy efficient processes. For example, Ciment d'Haiti has installed a sophisticated control center that monitors temperatures and operation of kilns and crushers. The firm is currently receiving assistance from a Swiss company to reduce energy costs. Also, Reynolds Bauxite has introduced changes in the specifications, increasing the humidity content in the ore. 2/ However, the company apparently will cease its activities in Haiti, and can therefore be excluded from the conservation program.

3.79 Major investments for process change and interfuel substitution are now being considered by the cement factory. The plant uses the wet process technology and increased its capacity in 1975 from 85 thousand tonnes to 300 MT per year to supply the growing domestic demand and to export a surplus. The plant uses fuel oil for heat generation and diesel fuel for electricity production.

3.80 To cope with the projected rapid increase in the domestic demand for cement (to about 500 MT in 1984), the company has proposed to expand its productive capacity, to convert to the dry process technology and to substitute for imported coal. The first stage of the expansion plan proposes the construction of a new kiln with a capacity of 500 MT/year, and an investment of US$31.5 million in 1980 prices, including coal handling facilities. The second stage envisages the conversion of the largest existing kiln to the dry process, requiring an additional investment of US$30-35 million. Several issues, mainly related to the monopoly position of CdH and financing, have delayed the decision.

3.81 A realistic market study on cement should be made before final decision is taken. Should expansion be warranted, the choice of the dry-process technology is correct because it reduces energy requirements by about 50%. However, the substitution of fuel oil by coal merits a thorough analysis because of the uncertainty about the evolution of the relative prices of these fuels in international markets and because the cost of transporting small cargoes of coal might offset this fuel's price advantage at the source.

1/ E. Cecelski: "Prospects for Energy Conservation in a Low Income Developing Country: the case of Haiti", Institute for Energy Analysis, Oak Ridge Ass. Universities.

2/ Apparently, the company has a tax incentive to export ore of higher humidity content.

3.82 Acierie d'Haiti has already purchased an electric arc furnace, which is the least energy intensive method for steel making from scrap. However, this project was not carefully evaluated and perhaps should not have implemented. In general, electric intensive industries should not be encouraged in Haiti, due to the lack of low cost primary energy resources.

b. Transport

3.83 Transport is the most important user of petroleum products and the fastest growing. Gasoline and diesel provide each about half of the requirements for road transportation, which represents about 80% of this sector's total demand; aviation requirements make-up the difference. Sales of marine bunkers are not statistically reflected and appear to be small. The international ships purchase their fuel at the Caribbean refineries and a large part of domestic shipping still takes place in sailing boats.

3.84 During the 1970's considerable investments were made in road infrastructure, both inter-urban and in the cities, mainly in Port-au-Prince. Although improvement of road conditions reduces the energy used per kilometer, it also creates an incentive for increasing the number of vehicles and the number of kilometers travelled. Between 1971 and 1978, the automotive fleet of Haiti increased on the average by 12% per year to 24.8 thousand in 1978, two-thirds of which were private cars, 20% public service and 12% exonerated vehicles. The government has attempted to restrict car imports and to orient the composition of the fleet through taxation.

3.85 Import duty on vehicles is based on size and value. Units valued at more than US$5000 require special permits. Imports of used cars have been prohibited. Diesel fueled vehicles are given a tax advantage. As a result, many Japanese and diesel fueled cars have been imported during the last 3-4 years, but the tax has not lowered the growth rate in the number of imports. Its effectiveness could be enhanced by raising it significantly, by attuning it to fuel efficiency and by more rigorous enforcement. Currently, government and international organizations are exonerated from import duty and their car purchases have increased substantially (25% per year). Also, it appears that the effectiveness of the duty is eroded through under-invoicing and other practices.

3.86 As a result of this policy, gasoline consumption growth has decreased from an average of 11% per year between 1973-78 to about 4-5% in recent years, while diesel has taken up the trend and supplied in 1979 about 50% of this market's requirements. The sales volume of both fuels appears to be growing now at about 8% per year. To achieve a more moderate trend in the future, the recommendations on road traffic and public transport development, as suggested on the 1977 national transport study, should be implemented together with the proposed pricing policy.

3.87 The most important component of aviation fuels is jet fuel sold to international companies, and its growth rate reflects the expansion of tourism. Aviation gasoline is mostly used by Haiti's military institutions.

c. Residential and Commercial Sectors

3.88 It is difficult to assess the effective use of energy in this sector. With respect to oil products, it appears that LPG and kerosene have only marginally penetrated the urban household market. Even in the middle class homes in Port-au-Prince, charcoal stoves are used alongside LPG and electric ones. Kerosene is an important fuel for lighting in both urban and rural area. Electricity and LPG are used for water heating in hotels and private homes. Air conditioning and the use of other electric appliances is expanding as a result of tourism and a growing middle class.

3.89 It is obvious that the construction industry should be guided to adapt the design of new houses and commercial buildings to the local climatic conditions, thus reducing the long term expansion of energy demand for air conditioning, lighting and water heating. Retrofitting of existing hotels, hospitals and homes with solar water heaters should prove an attractive investment under present conditions.

3. Projections

3.90 The foregoing description of the energy flow through the system evidences that there is a real potential for achieving energy savings, that the pressure on forest resources can be diminished and that the energy deficit can be maintained within affordable levels. In Table 19 a preliminary projection of petroleum imports to the year 1985 is made, assuming an average growth in non-substitutable demand of 8% per year, the conversion to coal of the heat requirements of the cement factory and the termination of Reynolds operations in Haiti. Total oil imports would increase to about 6 Mb/d by 1985 instead of the 9 Mb/d projected without conservation. Coal imports for producing 500 MT/y of clinker with the dry technology are estimated at about 61 thousand tons. Thus, total fuel imports by 1985 could be reduced to about US$96 million in constant 1981 prices, instead of the formerly estimated US$140 million. 1/

3.91 Electricity sales have been maintained as forecasted by EdH for planting-up purposes. These projections are based on elaborate econometric models, assume a 4% annual increase in GDP, and a 13.8% growth in electricity sales. Industry is expected to grow at the highest rate (15.1% per year), to 55% of total electric sales by 1985. The renovation of the distribution system and the control of illegal connections are to reduce the losses of the system to 19% at the end of

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1/ Projections were made on an average price for oil products of US$43/bbl and US$70/ton of coal.

the period (Table 20). This forecast seems to be high given the uncertainties of Haiti's future growth and the expansion of the assembly industry, to which industrial power consumption is closely linked. However, it has to be recalled that in the Port-au-Prince power system, normal demand growth is determined more by the supply capacity of the utility than by the characteristics of the market. As no more than 25% of the urban population has access to electricity, demand will follow the investment available to connect potential customers to the network.

3.92 4. Recommended Demand Management Actions

(i) The introduction of efficient stoves requires changes in cooking habits. It is therefore advisable to initiate the program by selecting a few urban and rural areas in which to demonstrate the advantages of possible alternatives, appraise the receptivity of the population and the obstacles that have to be overcome and train personnel to carry out the future program.

(ii) In the industrial sector, the proposed projects of large capital investments in interfuel substitution (Ciment d'Haiti) and electric intensive industries (Acierie d'Haiti) should be reviewed by experienced consultants to determine whether their scope and timing are in Haiti's best interest. In general, an energy audit service should be established to help identify energy saving opportunities and assist enterprises in the set up of retrofitting projects. As a first step in the program, a survey of existing industries must be carried out, gathering information on their specific energy consumption and cost structure. The survey would permit to select an initial group of plants in which the effectiveness of the program can be demonstrated. As energy managers do not exist in Haiti, foreign technical assistance would be required to provide the initial service and to train local personnel.

(iii) It has been shown that the transport sector uses 50% of imported petroleum products. Thus, a more moderate growth of oil consumption in the sector must be achieved through a coordinated transportation policy. Consideration should be given to the following aspects: Mass transit systems offer the best opportunity to achieve a reduction in the growth rate of automotive fuels. The private sector provides a competitive and efficient service. It should be given assistance to renovate and expand their fleet. The use of the private automobile should be limited through curtailment of car imports, the imposition of an annual licensing fee and other price disincentives. Interurban transport modes should take into consideration that maritime transport is the most energy efficient mode, and therefore should be encouraged; of special interest is the maintenance of the sailing vessel fleet. Future road

construction should open up Haiti's interior rather than substitute for coastal navigation.

(iv) In the commerical sector, energy audits can also provide valuable assistance to reduce energy consumption for lighting, air conditioning and water heating. Special attention should be given to assessing the feasibility of retrofitting hotels with solar water heaters, investigating the foreign exchange savings that would result from the import of solar kits. The residential sector, in particular, needs to be addressed through an education campaign, stressing good housekeeping practices such as cooking with pressure cookers, turning off unnecessary lights, etc.

IV. INSTITUTIONAL ISSUES

4.01 Haiti's energy situation will continue to deteriorate unless the Government recognizes the urgency of the issues and commits itself to decisive action. It is felt that the implementation of the energy program is constrained more by shortcomings in the decision making/implementation process than by the availability of resources. In other words, there is a possibility for Haiti to obtain larger amounts of financial and technical foreign assistance; but, at the present, the country lacks the ability to effectively and productively utilize the additional resources that could be made available to it. To improve this situation, the government must agree on and define its economic objectives and insert its energy strategy within a global framework. It should decide upon a policy to implement its energy programs, engaging to the fullest the human resources available in Haiti. This implies encouraging the participation of the private sector in energy related activities, through a clear definition of objectives and legal mechanisms.

4.02 The institutional capability in planning and implementation should be strengthened. At present, there is a lack of coordination among institutions involved in energy decision making; authority is often dispersed and responsibility is diluted; individual services are technically weak and little attention is given to economic and financial evaluation of programs and projects; finally, budgetary allocation does not reflect priority of programs and, therefore, basic services are inadequately staffed, lack minimum equipment and cannot afford training.

1. Present Institutional Organization

4.03 Currently, the State exercises its administrative and regulatory authority over the sector through a number of institutions. The most important are the following:

(a) Secretairerie d'Etat du Plan: This Planning Ministry was established in 1978 to replace the former Planning and Development Council (CONADEP). It performs an oversight function of the public sector investment program and serves as liaison for foreign technical and financial assistance. The annual budget merely reflects the proposals submitted by the individual ministries and institutes. No attempt is made to consolidate all energy related projects into a single program; nor does the Ministry have a quantitative framework to evaluate the effects of energy related decisions on economic development.

(b) Department des Mines et des Ressources Energetiques (DMRE): In 1978, this Ministry replaced the Institute of Mineral Resources (INAREM). It has the responsibility to promote the development of new energy and mineral

resources. It is structured into five divisions: Geology, Energy Resources, Programming, Mines and Quarries and a Technology Laboratory. The Division of Energy Resources has no overview of the sector and does not participate in the decisions relating to energy pricing, electric power, forestry, oil imports or energy use. It is headed by a geologist and has a staff of about 20 young professionals. Its activities are oriented mainly towards technology research; and, little consideration has been given to the economic and financial aspects of the individual projects. Its budget depends heavily on foreign funding. Its investment budget for FY1980/81 amounts to the equivalent of US$1.9 million, 80% of which was to be obtained from external sources. A large portion of programmed funds do not become available in time and, as a result, only about 20% of the scheduled working program has been effectively accomplished in the past. The Division of Energy Resources is organized into the following activities:

(i) Conventional Energy: nominally surveys the activities of private operators carrying out petroleum exploration and participates in the evaluation of the lignite deposits.

(ii) Synthetic Fuels: engages in basic research on charcoal alternatives, such as straw briquettes and lignite agglomerates. It also has evaluated improved stoves for wood, charcoal and synthetic fuels burning for cooking. Its future plans include research on fermentation processes to produce liquid fuels from sugar cane, sorghum, cassava and other vegetal sources.

(iii) Bioenergy: investigates biodigester prototypes for the production of gas from animal and vegetal waste. The research has shown that biodigesters require rather exact proportions of inputs and vigilance in operation and maintenance, thus limiting the widespread use of this technology in Haiti.

(iv) Solar, Geothermal and Windpower: experiments with various designs of solar artifacts and windmills for construction and use in Haiti. It also participates with OLADE1/ in geothermal assessment.

1/ Latin American Energy Organization.

(v) Hydrogeology: evaluates Haiti's underground water resources.

(c) Department of Agriculture, Natural Resources and Rural Development (DARNDR): The Division of Natural Resources is responsible for the protection of forest resources; it regulates and taxes charcoal production and undertakes reforestation. The Bureau Forestier is extremely weak, with only two graduate foresters. Its investment budget for 1980/81 amounts to US$2.9 million and also depends on foreign assistance for more than 80%. The Bank has proposed a pilot forestry project, which includes assistance for the institutional build-up of this office and for the introduction of forestry courses at the Ecole Moyenne d'Agriculture, which is part of the Faculte d'Agronomie et de Medicine Veterinaire at Damien (near Port-au-Port).

(d) Office of Science and Technology: reports to the Ministry of Planning. Its technology center is funded by USAID and engages in the research of new energy technologies, such as solar applications. It duplicates, to some extent, the activities carried out by DMRE.

(e) Institut de Developpement Agricole et Industriel: reports to the Ministry of Commerce and Industry and funds some energy related projects, among which enhanced efficiency in buring bagasse is included. The funds allocated for the study of the utilization of sugar cane sub-products amounts to US$33,000 in FY 1980/81, and are provided by OAS.

(f) Electricite d'Haiti: is an autonomous Government agency, responsible for power supply in Haiti. It was established in 1971 to take over the Government-owned Peligre hydro plant and the privately-owned Compagnie d'Eclairage Electrique of Port-au-Prince and Cap Haitien, whose concessions had expired. In 1974, it was also entrusted with the operations of the various isolated power facilities in the provinces.

Investment in the power sector also depends heavily on foreign resources. International agencies such as IDA, IDB, EEC, and national aid agencies such as the Canadian International Development Agency and the Kreditanstalt fuer Wiederaufbau, provide more than 60% of the required funds.

Since IDA's First Power Project was started in 1976, investment in the power sector has increased substantially with regard to the 1971/75 level. Nevertheless, EdH's performance has been hampered by institutional, technical

and human resources problems. Continuous training programs and adequate renumeration to retain qualified personnel are required to continue improving the capability of this corporation. In addition, foreign technical and financial assistance should continue to be provided during EdH's expansion program.

(g) Other Institutions: There are a group of agencies that affect energy use through their policies in other areas. Thus, the Ministry of Commerce and Industry sets the prices of wage goods, and is concerned with the effects on inflation. Its Direction des Prix is currently being reorganized to enable a closer follow-up of domestic and foreign price trends, including oil prices. This Ministry negotiates with the private oil companies the landed price of fuels and the commercialization margins. The lack of an adequate information basis has caused delays in price readjustments in the past. Similarly, the Ministry of Finance sets vehicle and fuel import taxes and grants government exemptions, while the Ministry of Foreign Affairs grants similar exemptions to the international agencies.

The National Statistical Institute, dependent on the Ministry of Planning, is the only agency that collects basic statistical information, including energy data.

2. Institutional Changes

(a) Advisory Commission: It is suggested that an advisory commission be established and convened on a regular basis to improve coordination in decision making and provide a forum in which energy implicatons of investment and pricing decisions can be discussed. This commission should be integrated with the heads of the agencies in charge of energy programs, technical experts drawn from both public and private sectors, and representatives of interested international aid agencies.

(b) Statistical Energy Unit: It is suggested that a Statistical Energy Unit be organized within the DMRE or the Ministry of Planning to improve the quantitative framework within which decisions are taken. This unit should be responsible for building a centralized energy data base and for developing regular channels of communication to obtain, synthesize and provide information on market variables to all concerned with energy matters. This unit would also have the responsibility to make surveys on specific energy consumption of the various economic sectors to serve as basis for the demand management strategy. Such a service would have to be created from scratch and would require

adequate training of at least three professionals and the assistance of an outside consultant for six months.

(c) Economic Evaluation Unit: Similarly, to avoid duplication and facilitate optimum allocation of resources, a centralized Economic Evaluation Unit should be created which would be responsible for gathering information on ongoing energy projects and research programs. The unit should identify projects and explore the interest of the private sector in their implementation. In an initial stage, this unit should be established within the Ministry of Planning and work in close cooperation with DMRE and the Forestry Service.

(d) The Forestry Service must be strengthened and reorganized. A minimum target is to increase its strength by five professionals and 10 technicians. The added staffing would permit the Service to place more emphasis on forest protection, management and silviculture and to initiate a limited research program on fuelwood species, including the Bayahonde species.

(e) The Division of Energy Resources should coordinate its research program on non-conventional energy source with the other research institutes to optimize scarce resources and to concentrate efforts in a few areas where significant results can be expected over the short term. It is further suggested that part of the activities of the Division be reoriented towards the demand management program. An initial group, composed of engineers, economists and sociologists should be made available as the national counterpart of the external consultants that would design the energy audit and the rural "efficient stove" programs and implement them in the first phase.

3. Training

Continued training of personnel in technical areas and in economic project analysis should be given first priority in annual working programs.

4. Operating Budgets

Annual budgets should be carefully designed to cover staffing, transport, offices and field costs required to execute expanded work load. This is particularly important in the case of the Forest Service.

5. Legal Aspects

(a) Laws and regulations must be brought into line with national goals. Individual services must be granted the necessary authority to implement programs and to enforce

the laws. In the case of Forestry, the Service must be given the authority to protect certain areas from illegal felling and grazing, and forestry and charcoal taxes must be revised to discourage indiscriminate harvesting in natural resources.

(b) Present laws and regulations for the private sector should be reviewed in order to enhance private participation in energy projects. Special attention should be given to the promotion of communal and cooperative participation.

V. INVESTMENT REQUIREMENTS AND FOREIGN ASSISTANCE

5.01 The coordination of objectives between Government and foreign aid institutions, and within each of these groups, is crucial for the efficient allocation of resources to the development of Haiti. The Central Government's finances depend heavily on foreign resources. The 1981 investment budget estimates that 65.2% of total resources would originate abroad. As most foreign assistance projects require counterpart funds, these projects also tie down a significant portion of domestic resources. Thus, boths group should be equally interested in avoiding duplication and in strict choice of projects.

5.02 For the energy sector, capital and technical assistance requirements for the next five years are conservatively estimated at about US$300 million (see Table below). The pace of actual implementation of the proposed programs will depend on the rate at which the absorptive capacity of local institutions can be expanded, on the capability to generate counterpart funds and on the availability of foreign resources.

5.03 The largest scale investment projects are on the supply side of the energy system. The power sector will absorb more than 80% of the total estimated requirements. This is largely due to the continued asistance to EdH which, in the past, has substantially improved its absorptive capacity. The much needed programs in reforestation and forest plantations will require a somewhat longer lead time because of the weakness of the forest extension service, the reduced number of technical personnel, and the difficult choices involved in land allocation and pricing. Investments that were included in the hydrocarbon sector cover only preparatory work and institutional development, while actual geological surveys and exploratory drilling are expected to be carried out by the private sector. Also there will be growing requirements for small scale programs for the development of micro hydro sites, recycling of agricultural waste of energy, and new, non-conventional energy technologies.

Haiti: Public Sector Investment Requirements in the Energy Sector

	1981-1986 (Million US$)
Supply Development:	
Forest Resources	
Trial Plantation 800 ha.	1.2
Trial Wood Management 1,000 ha.	1.2
Pine Forest Management	1.5
Land Use Survey	0.5
Plantation 20,000 ha.	20.0
Forest Management	9.0
Electric Sector Development Program	247.5
Hydrocarbon Exploration Promotion	3.0
Agricultural Waste Products and Solar Heating	5.0
Demand Management:	
Energy audits & retrofitting fund	3.0
Mass Transit System (200 buses)	4.0
Efficient Stoves Program	5.0
Public Campaign	0.5
Institutional Development and Training (100 man/month)	3.0
TOTAL	304.4

Source: Mission's estimate.

5.04 Haiti's weak institutions and limited financial and human resources require that external assistance be coordinated at the level of the participating agencies to improve the quality of external assistance. In the power sector, such an arrangement has permitted the orderly planning of investments and has enhanced the operating efficiency of the public corporation. Similar arrangements should be set up in other subsectors and, in particular, for the forest program.

5.05 In the case of technology research, resource assessment and training, regional cooperation could play an important role in disseminating knowledge and reducing the waste of resources. This has been recognized in the meeting of the Caribbean Group for Cooperation in Economic Development (CGCED). The establishment of common services, the pooling of technology, regional studies and technical assistance were recommended. Such a cooperative effort would be cost effective, especially for the small countries of the region such as Haiti.

TABLE 1

HAITI: 1979 ENERGY BALANCE
(in original units)

	Fuelwood ($M\ m^3$) 3/	Bagasse (MST) 4/	Hydro (Gwh)	Charcoal (MT) 3/	LPG (MB) 5/	Gasoline (MB)	Middle Distillates (MB)	Fuel Oil (MB)	Electricity (Gwh)
Supply									
Domestic Production	4,000	512	(187)						187
Imports					30	435	827	424	
Total Supply	4,000	512	187		30	435	827	424	187
Conversion									
Public Power Service 1/							(121)		64
Station Consumption									(2)
Statistical Differences							(18)	(26)	
Charcoal 2/	(688)			86					
Losses in Production									
Electric Distribution Losses									(68)
Other Losses		128							
Available For Final Demand	3,312	384		86		435	688	398	181
Industry	1,000	384				49	157	398	91
Transport									
Road						349	332		
Air						37	140		
Commerce and Services	1,000			43	15		29		20
Households	2,000			43	15		30		70

1/ Reported as actual fuel consumption by EdH for FY78/79; difference with sales to EdH reported by oil companies are allocated to statiscal differences and stock.

2/ Assuming a yield of 1 ton of charcoal per 8 m^3 of wood.

3/ Final consumption of fuelwood allocated 25% each to industry, commerce and services and 50% to households. Volume refers to solid wood content, not stacked wood. Charcoal allocated 50% each to commerce and households.

4/ Industrial sugar production was 71.7 MT, guildives assumed to process similar amount of cane. Assumed 7% average sugar content and 25% bagasse in cane. Guildives use only 50% of bagasse available.

5/ LPG and kerosene allocated 50-50% to commerce and households.

TABLE 2

HAITI: NATIONAL ENERGY BALANCE - 1979
(thousand tons of oil equivalent)

Source / Category	Energy Sources														
	Primary				Secondary										
	Wood	Bagasse	Hydro	Total Primary	Charcoal	LPG	Gasoline	Kerosene/ Jet	Diesel Oil	Fuel Oil	Total Second	Electricity	Consumption Energy Sector	Statistical Adjustments	Total
1. Production	980.0	104.5	47.9	1132.4	-	-	-	-	-	-	-	-	-	-	1132.4
2. Imports	-	-	-	-	-	2.2	53.7	25.3	86.6	62.0	-	-	-	-	229.8
3. Gross Supply	980.0	104.5	47.9	1132.4	-	2.2	53.7	25.3	86.6	62.0	229.8	-	-	-	1362.2
4. Losses		40.3	-	40.3	-	-	-	-	-	-	-	-	-	-	40.3
5. Net Supply	980.0	64.2	47.9	1092.1	-	2.2	53.7	25.3	86.6	62.0	229.8	-	-	-	1321.9
6. Transformation	(168.6)		(47.9)	-	61.1	-	-	-	(18.5)	(3.8)	-	21.4	118.6	37.7	-
6.1 Public - Hydropower	-	-	(47.9)	-	-	-	-	-	-	-	-	16.0	-	31.9	-
6.2 Public - Thermal Power	-	-	-	-	-	-	-	-	(18.5)	(3.8)	-	5.4	11.1	5.8	-
6.3 Charcoal Makers	(168.6)	-	-	-	61.1	-	-	-	-	-	-	-	107.5	-	-
7. Transmission & Distribution Losses	-	-	-	-	-	-	-	-	-	-	-	5.9	-	-	-
8. Consumption	811.4	64.2	-	875.6	61.1	2.2	53.7	25.3	68.1	58.2	268.6	15.5	-	-	1159.7
8.1 Industry	202.0	64.2	-	266.2	-	-	6.1	-	22.1	58.2	86.4	7.8	-	-	360.4
8.2 Transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	43.2	-	46.0	-	89.2	-	-	-	89.2
Air	-	-	-	-	-	-	4.4	19.1	-	-	23.5	-	-	-	23.5
8.3 Commerce & Service	203.0	-	-	203.0	30.5	1.1	-	3.1	-	-	34.7	1.7	-	-	239.4
8.4 Households	406.4	-	-	406.4	30.6	1.1	-	3.1	-	-	34.8	6.0	-	-	447.2

TABLE 3

HAITI: PRIMARY ENERGY CONSUMPTION

Energy Form	Unit	Conversion Factor 10^6 Btu/unit	Energy Consumption Units 1979	Energy Consumption Units 1973	Energy Consumption Mtoe 4/ 1979	Energy Consumption Mtoe 4/ 1973	Structure (%) 1979	Structure (%) 1973	Average Annual Growth %
DOMESTIC					1,133	857	83.1	87.1	4.8
Hydropower 1/	GWh	10,195	187	109	48	28	3.5	2.8	9.4
Fuelwood 2/	Mm^3	9,722	4,000	2,985	980	731	71.9	74.3	5.0
Bagasse 3/	MST	8,100	512	479	105	98	7.7	10.0	1.2
IMPORTED									
Petroleum	MB		1,716	940	231	127	16.9	12.9	10.5
LPG		3,700	30	10	2	1			
Gasolines		4,900	435	248	54	31			
Middle Distillates		5,400	827	444	112	60			
Fuel Oil		5,800	424	238	62	35			
TOTAL					1,363	984	100.0	100.0	5.6
Population (millions)					5	4.5			1.7
Per Capita Consumption (toe/capita)					0.273	0.219			3.7

1/ Hydropower as generated by Peligre in FY1978/79. For 1973 it was assumed that hydropower's share in total generation was 79%. Conversion factor assumes equivalent thermal efficiency.

2/ Estimates on annual wood consumption vary from 4 to 15 million cubic meters. In this report, m^3 refers to solid wood content, not stacked wood. Heat value for air dried wood is measured: 3.5 kcal/g and 700 kg/m^3 of wood.

3/ Estimated based on industrial sugar production: 67 MT in 1973 and 71.7 MT in 1979. Average sugar content was assumed 7%, and bagasse 25% of sugar cane. Cane used for alcohol production and non-industrial sugar plants was assumed to be of similar magnitude as industrial sugar production. ST stands for short-ton.

4/ Mtoe: (thousand tons of oil equivalent) = 39.68×10^9Btu.

Table 4

Haiti: 1979 Final Energy Utilization 1/
(in thousands of tons of oil equivalent)

	Fuelwood	Bagasse	Charcoal	LPG	Gasoline	Middle Distillates	Fuel Oil	Electricity	TOTAL	Relative Share
Industry	30.43	21.20			1.21	6.63	40.72	7.81	108.00	50.3
Transport										
Road					8.62	11.50			20.12	9.4
Air					0.92	3.81			4.73	2.2
Commerce & Services	30.43		6.11	0.99		0.93		1.54	40.00	18.6
Households	28.40		6.10	0.99		0.93		5.40	41.82	19.5
Total	89.26	21.20	12.21	1.98	10.75	23.80	40.72	14.75	214.67	100.0
Relative Share	41.6	9.9	5.7	0.9	5.0	11.1	18.9	6.9	100.0	

1/ Takes into account approximate efficiencies of energy utilization. Data taken from last section of Table 2. Conversion at following factors:

Commodity	Sector	Efficiency
Fuelwood	Industry, commerce and services	15%
	Households	7%
Bagasse	Industry	33%
Charcoal		
	Commerce, services and households	20%
LPG	Commerce, services and households	70%
Gasoline	All sectors	20%
Diesel	Industry	30%
	Transport	25%
Kerosene	Transport	20%
	Commerce, households	30%
Fuel oil	Industry	70%
Electricity	Industry	100%
	Other sectors	90%

TABLE 5

Haiti: Value of Petroleum Imports
(in thousand Gourdes)

	(1) Petroleum Imports MG	MUS$	(2) Total Imports MG	(3) Total Exports MG	(4) Share of Oil Imports (1/2) %	(5) Imports in Exports (1/3) %
72/73	21,083		383,329	256,544	5.5	8.2
73/74	61,677		556,623	356,666	11.1	17.3
74/75	64,188		712,578	405,894	9.0	15.8
75/76	84,210		1,005,319	587,669	8.4	14.3
76/77	116,970	23,394	1,041,210	716,549	11.2	16.3
77/78	121,517	24,303	1,103,431	794,739	11.0	15.3
78/79		25,000 e/				
1979		32,000 e/				
1980		61,000 e/				

e/ Estimated.

Source: Le Commerce Exterieur d'Haiti - Bulletin Annuel - Departement des Finances et des Affaires Economiques.

TABLE 6

HAITI: Petroleum Consumption
(000 barrels per year)

	1973	1974	1975	1976	1977	1978	1979	1980 1/	Average Annual Growth Rate (%) 1973-1979	1979/1980
LPG	10	11	12	16	18	22	24	30	17.1	25.0
Aviation Gasoline	21	20	19	27	30	34	37	23	12.2	(37.8)
Jet-Fuel	56	84	61	75	89	96	140	126	12.9	(10.0)
Motor Gasoline	227	241	264	301	333	382	398	391	10.7	(1.8)
Kerosene	29	38	26	34	42	60	46	46	10.4	(0.0)
Diesel	359	359	418	501	556	579	625	620	10.9	(0.8)
Fuel Oil	238	319	252	456	425	469	424	412	11.4	(2.8)
Lubricants	22	25	21	22	23	24	25	35	1.4	40.0
Asphalt	4	7	14	62	35	29	47	12	48.9	(74.5)
Others	2	2	1	2	2	2	2	-	-	
Total	968	1,106	1,088	1,496	1,553	1,697	1,768	1,695	11.4	(4.1)

1/ Government estimate.

Source: Oil Companies.

TABLE 7

HAITI: Structure of Petroleum Consumption by Fuel Type

	1973	1974	1975	1976	1977	1978	1979	1980
LPG	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.8
Aviation Gasoline	2.2	1.8	1.7	1.8	1.9	2.0	2.1	1.4
Jet Fuel	5.8	7.6	5.6	5.0	5.7	5.7	7.9	7.4
Motor Gasoline	23.5	21.8	24.3	20.1	21.4	22.5	22.5	23.1
Kerosene	3.0	3.4	2.4	2.3	2.7	3.5	2.6	2.7
Diesel	37.1	32.5	38.4	33.5	35.8	34.1	35.3	36.6
Fuel Oil	24.6	28.8	23.2	30.5	27.4	27.6	24.0	24.3
Speciality Products	2.8	3.1	3.3	5.7	3.9	3.3	4.2	2.7

TABLE 8

HAITI: Petroleum Consumption by Economic Sectors

(1000 barrels per year)

Sector	1978 Volume	1978 %	1979 Volume	1979 %
Industry 1/	786	46.3	766	43.3
Gasoline	47	2.8	49	2.7
Middle Distillates	270	15.9	293	16.6
Bauxite	-		28	
Electricité d'Haiti	123		136	
Others 2/	147		101	
Fuel Oil	469	27.6	424	24.0
Bauxite	27		25	
Cement	287		277	
Electricité d'Haiti	25		26	
Others 3/	130		96	
Transport	774	45.6	858	48.5
Domestic	678	40.0	718	40.6
Road Transport	644	38.0	681	38.5
Gasoline	335		349	
Diesel	309		332	
Aviation Gasoline	34	2.0	37	2.1
International Jet Fuel	96	5.6	140	7.9
Residential & Commercial	82	4.8	70	4.0
LPG	22		24	
Kerosene	60		46	
Speciality Products	55	3.3	74	4.2
Total	1,697	100.0	1,768	100.0

Source: Oil Companies and Mission estimates.

1/ Includes industry as well as the service sector.

2/ Includes consumption for power generation in industrial establishments and in the service sector, such as potable water company, hotel industry and others.

3/ Obtained as a residual.

Table 9

Haiti: Power Generating Facilities

	Capacity MW Nominal	Effective
Interconnected System:		
Hydro		
Peligre	47.1	44 wet/21.6 dry
Thermal		
Diesel Oil	25.1	20.0
Bunker C 1/	21.0	18.0
Total Port-au-Prince	93.2	82.0 (wet years) 59.6 (dry years)
Provinces:		
Hydro	3.2	2.3
Thermal (Diesel)	19.4	17.0
Total Haiti:	115.8	101.3 (wet years) 78.9 (dry years)

1/ An additional 21 MW will become operational in 1981.

TABLE 10

Historical Power Data
(1971-1980)

Fiscal year	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979	1979-1980
SALES (GWh)									
Residential	19.9	24.3	28.2	31.8	41.9	58.7[1]	64.8[1]	75.3[1]	69.5
Commercial	12.9	12.7	10.6	9.9	11.6				10.7
Industrial	17.9	26.3	36.9	45.3	56.3	60.0	81.0	90.9	100.6
Public lighting	2.7	3.3	4.8	6.0	7.0	6.5	6.3	6.8	7.1
Others	5.1	5.6	5.9	6.5	6.4	6.7	7.9	8.2	9.2
TOTAL	58.5	72.2	86.4	99.5	123.2	131.9	160,0	181.2	197.1
Losses (GWh)	32.9	35.6	42.6	48.3	40.6	41.0	56.9	67.7	79.5
Generation (GWh) net	91.4	107.8	129.0	147.8	163.8	172.9	216.9	248.9	276.6
Maximum demand (MW)[2]	21.4	24.9	27.9	32.4	35.3	37.2	43.5	51.0	54.0
Number of consumers (1 000)	27.7	30.1	32.6	39.4	43.2	47.9	53.9	59.8	61.9
GROWTH DATA (%/a)									
Residential	-	22.1	16.0	12.8	31.8	9.7	10.4	16.2	6.5
Commercial	-	-1.6	-16.5	-6.6	17.2				
Industrial	-	46.9	40.3	22.8	24.3	6.6	35.0	12.2	10.7
Public lighting	-	22.2	45.5	25.0	16.7	-7.1	-3.1	7.9	4.4
Others	-	9.8	5.4	10.2	-1.5	4.7	17.9	3.8	12.2
TOTAL	-	23.4	19.7	15.2	23.8	7.1	21.3	13.3	8.8
Losses	-	8.2	19.7	13.4	-15.9	1.0	38.8	19.0	17.4
Generation	-	17.9	19.7	14.6	10.8	5.6	25.4	14.8	11.1
Maximum demand	-	16.4	12.0	16.1	9.0	5.4	16.9	17.2	5.9
Consumers	-	8.7	8.3	20.9	9.6	10.9	12.5	10.9	3.5

Source: HQI, LGL, LMBDS/Facturation E.d.H.

1 No breakdown for those years.

2 Maximum demand for the calendar year.

TABLE 11

HAITI: Charcoal Prices, Port-au-Prince

1. Price Evolution

	US$/ton
1973-74	51
1974-75	58
1975-76	53
1976-77	64
1977-78	73
1978-79	87

2. Cost Break-down for charcoal from the Northwest, transported by truck to Port-au-Prince (1979).

	US$/ton	%
To Producer	40.00	46
Government Tax	1.65	
Charcoal Bags	6.65	
Transport & Loading	20.00	23
Distributor's Profit	18.70	22
Total	87.00	

Source: Charcoal in Haiti, Karl Voltaire, 1979.

TABLE 12

HAITI: Evolution of Retail Prices
for Products Subject to Government Control

(US$/gallon)

DATE	GASOLINE	DIESEL	KEROSENE	LPG (US$/25 lbs.)
January 9, 1974	.84	.50	.52	
February 8, 1974	.94	.63	.65	
March 18, 1974	.94	.63	.65	
May 1, 1975	.92	.60	.65	
March 5, 1976	.94	.63	.64	
March 2, 1977	.97	.65	.64	
April 23, 1977	.97	.65	.58	
June 1, 1977	.97	.65	.58	
March 1, 1979	1.06	.65	.62	
April 17, 1979	1.06	.65	.62	- 5.35
June 1, 1979	1.29	.72	.70	5.35
June 7, 1979	1.29	.72	.75	5.35
August 8, 1979	1.58	.80	.90	- 5.60
September 2, 1979	1.58	.85	1.05	5.60
February 20, 1980	1.85	1.07	1.20	- 7.52
August - 1980	1.85	1.17	1.24	7.52
March - 1981	2.15	1.17		n.a.

TABLE 13

HAITI: Petroleum Products - Price Structure as of August 1980.

(US$/gal.)

	Gasoline	Kerosene	Diesel	Fuel Oil	LPG 1/
Average Postings in Caribbean	0.986	1.032	0.940	0.555	NA
Freight, Insurance & Wharfage	0.057	0.058	0.060	0.09	NA
Price cif	1.043	1.090	1.000	0.647	NA
Import Duty	0.344	-	-	-	0.057
Excise Tax	0.220	-	-	0.020	0.021
Marketing Margin	0.143	0.080	0.100	0.083	NA
Dealers Margin	0.100	0.070	0.070	NA	0.042
Final Consumers Price	1.850	1.240	1.170	0.750	1.330

1/ Prices are fixed in weight - an equivalent of 527 galons per ton was assumed for conversion. LPG consists mostly of propane and is sold in containers of 100, 25, and 10 pounds.

TABLE 14

HAITI

Electricite d'Haiti

Evolution of Electicity Tariffs 1978-1981
(Monthly Billing in US¢/kWh)

	1978		1980		1981	
	Basic Rate	Fuel Surch.	Basic Rate	Fuel Surch.	Basic Rate	Fuel Surch.
1. Residential/Commercial and Government						
First 30 kWh	5.5	0.17	7.79	1.68	7.79	2.01
31-200 kWh	6.6	0.20	9.32	1.94	9.32	2.32
in excess of 200	7.3	0.22	10.38	2.19	10.38	2.63
2. Industrial						
- Low Tension and less than 45 KW	5.0	0.15	7.08	1.42	7.08	1.70
Fixed charge US$1/KW						
- Middle Tension and more than 45 KW						
Fixed charge US$1.1/ KW						
Peak hours (7 a.m.-7 p.m.)	5.5	0.17	7.79	1.68	7.79	2.01
Off peak and Sundays	2.3	0.08	3.66	0.77	3.66	0.93
- High Tension						
69 kV and 115 kV						
Fixed charge US$0.77/KW						
Peak hours	5.0	0.15	7.08	1.42	7.08	1.70
Off peak	2.3	0.07	3.34	0.65	3.30	0.77
3. Public Lighting	8.8	0.26	12.41	2.58	12.51	3.09
4. Irrigation	3.8		n.a.			

Source: Electricite d'Haiti

TABLE 15

HAITI: Maissade Lignite - Preliminary Mining Costs

(Thousand US$)

Item	Installed Investment Cost	Annual Charge 1/	Unit Cost (US$) 11/
Equipment:			
-Sterile Material Removal 2/	3,900.00	355.8	5.39
-Lignite extraction 3/	1,690.00	277.9	4.21
On-Site Infrastructure 4/	1,845.05	155.8	2.36
Spare Part Stocks 5/	1,346.00	134.6*	2.04
Personnel Costs 6/		537.0	8.14
Operating & Maintenance Costs 7/		436.2	6.61
Preliminary Clearing Costs 8/	1,763.00	176.3*	2.67
Working Capital 9/	944.00	94.4*	1.43
Sub-Total	11,488.05	2,168.0	32.85
Contingencies 10/	-	216.8	3.28
	11,488.05	2,384.8	36.13

1/ Includes Depreciation (over Life of Asset) and 5% interest, unless marked with asterix.
2/ Alternative of excavator on caterpillar with auto-mobile transport bucket.
3/ Composed of 2 excavators with shovel, 5 trucks, 2 nivelators and other fixed and mobil equipment.
4/ Includes buildings for offices, living quarters, workshops and deposits, as well as on site roads and canalization.
5/ Assumed 20% of value of equipment 10% interest charge.
6/ Total number of jobs: 111, divided in seven categories.
7/ Maintenance is calculated as percentage of investment.
8/ First year of operation will serve to uncover main lignite seams. Costs were capitalized at 10% interest.
9/ Represents approximately 3 months operations, capitalized at 10% interest.
10/ Estimated at 10% of total costs.
11/ Based on an annual production of 66,000 tons of lignite.

Source: Saarberg Interplan GmbH.

TABLE 16

HAITI: Hydro Potential

Sites	Capacity (MW) 1/ Firm	Capacity (MW) 1/ Installed	Generation (GWh) Average	Investment 2/ Total MUS$ 1981	Investment 2/ Unit US$/kW
1. **Interconnection Feasible 1980-90**					
Artibonite 108.1 La Verrette	16.0	32.0	212	63	1,980
Artibonite 139.9 La Chapelle	13.1	28.6	169	58	2,035
Artibonite 166.0	6.5	13.0	79	25	1,941
Artibonite 176.7	7.4	14.9	84	25	1,690
Guayamouc 1	3.0	8.9	43	17	1,920
Guayamouc 2	1.7	5.3	30	11	2,160
Sub-Total	43.2	102.7	617	199	1,938
2. Other Conventional Sites					
Grande Anse (four sites)		5.7			5,400-7,600
Des Trois Rivieres (two sites)		2.5			8,000-9,550
Riviere Grise (one site)		0.7			9,100
La Theme		1.3			8,520
Sub-Total		10.2			
3. Micro-Plants					
Saute D'Eau (Mirebalais)		0.7			1,700
Pichon (Belle Anse)		1.2			620
Deluze-Lanzac (Montrouis)		1.2			620
Gobe (St. Marc)		0.2			2,080
Petite Riviere		0.1			2,450
Caracol (Grande Riviere du Nord)		0.3			1,840
Samana (Hinche)		0.8			1,370
Saut du Barril (P.R. Nippes)		0.4			1,860
Gosseline (Jacmel)		0.2			3,780
Monance (Leogane)		1.1			890
Bassin Bleu (Jacmel)		0.1			5,170
Voldrogue (Jeremie)		0.2			1,920
Sub-Total		6.5			

1/ Firm Capacity is guaranteed 93% of time. Installed capacity as available at least 35% of time.
2/ Investment costs refer only to generating facilities. They do not include financing and transmission facilities.

Sources: Group I - EdH: Programme d'Investissement 1981-1990 - Consultants HQI-LGL-LMBDS-1981 and Etude d' Optimisation Barrages Art-1, 3, 4, Sept 1981 (in this study the effect of the Guayamouc dams on Artibonite has been taken into account.
Group II - III - Project d'Inventaire des Ressources Hydrauliques - LGL - 1976.

Table 17

Haiti: Oil Product Retail Prices at Constant 1974 Prices
(US$/gallon)

	Cost of Living Index a/		Gasoline	Diesel	Kerosene
	%/year	Accumulated			
1974	-	-	0.94	0.63	0.65
1975	18.5	18.5	0.78	0.51	0.55
1976	3.2	22.3	0.77	0.52	0.52
1977	5.0	28.4	0.73	0.51	0.45
1978	2.3	31.4	0.74	0.49	0.44
1979	18.8	56.1	1.01	0.54	0.67
1980	12.0 e/	74.8	1.05	0.67	0.71

a/ At the end of the year, based on Port-au-Prince. Estimated IBRD - 1981 Economic Memorandum on Haiti.

e/ Preliminary estimate.

TABLE 18

HAITI: PRICE DIFFERENTIAL BETWEEN GASOLINE AND DIESEL OIL AT DOMESTIC RETAIL AND LANDED PRICE LEVELS

(US¢/gallon)

	Domestic Retail Prices			Calculated Landed Prices		
	Gasoline	Diesel Oil	Differential	Gasoline	Diesel Oil	Differential
1978	97.0	65.0	32.0	42.5	39.3	3.2
1979	158.0	80.0	78.0	74.0	69.8	4.2
1980	185.0	117.0	68.0	99.5	96.6	2.9
1981	215.0	117.0	98.0	99.4	92.6	6.8

Source: Domestic Retail Prices - Table 12

Border prices as calculated by World Bank for third quarter of each year.

Table 19

Oil Demand Projection 1979-85 Under Conservation
Volume (MB)

Products	1979	1985	Average Growth Rate (%) 1973-79	1979-85
LPG	24	56	18	15
Aviation Gasoline	37	42	12	2
Jet Fuel	140	199	12	6
Motor Gasoline 1/	398	495	12	6
Kerosene	46	94	10	8
Diesel	625	776	10	3.7
Road Transport 4/	332	498	-	7
Power Generation 3/	136	124	-	(1.5)
Others 1/	157	154	-	3
Fuel Oil	424	462	11	0.7
Power Generation 3/	26	360	-	55
Cement Factory 2/	277	-	-	-
Others 1/	121	102	-	1
Non-Energy Products	74	79	-	1
Total	1768	2203	11	3.7
Adjusted for Cement and Bauxite Consumption	1389	2203		8.0

1/ Projection made on 1979 base less consumption of Reynolds Bauxite, which will cease its activities in Haiti.

2/ Assumes that the Cement factory has been converted to coal by 1985.

3/ As estimated by EdH for FY 1984/85.

4/ Diesel growth for road transport takes into account expansion of mass transport and freight requirements.

Table 20

Haiti: Electricity Projections to 1986

	1980	1986	Annual Average Growth Rate
Sales (GWh)	197.4	428.9	13.8
Residential-Commercial	80.2	169.3	13.3
Industrial	100.9	235.1	15.1
Other	16.3	24.5	7.0
Losses (%)	27.3	19.0	
(GWh)	74.0	100.6	
Required Generation (GWh)	271.4	529.5	11.8
Maximum Demand (MW)	54.0	106.0	11.9

Source: EdH. Development Program

TABLE 21

HAITI: AVERAGE MONTHLY RADIATION AS MEASURED AT DAMIEN 1/

(kWh/m^3 per day)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
1962	-	-	-	-	-	-	-	-	-	-	(4.28)	4.34	-
1963	4.71	5.55	6.06	6.41	6.36	6.40	6.51	6.56	5.91	4.74	4.87	4.42	5.71
1964	4.87	5.38	6.13	6.63	6.34	6.56	6.42	6.32	6.00	5.43	4.83	4.62	5.79
1965	4.73	5.31	5.89	6.26	5.33	6.13	6.01	-	-	5.24	4.40	4.21	-
1966	4.21	5.04	5.71	6.40	5.75	6.05	6.07	5.48	5.43	4.28	3.89	3.89	5.18
1963/1966	4.63	5.32	5.94	6.42	5.94	6.28	6.26	6.12	5.78	4.92	4.49	4.28	5.54

1/ Damien near Port-au-Prince (18° 36', 72° 17', 18 m) Eppley pyranometer.

TABLE 22

HAITI: AVERAGE WIND VELOCITIES
(km/h)

Location Altitude	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Desronville (2 m)	7.84	8.32	9.57	10.91	8.25	6.45	6.80	6.13	5.79	5.4	6.77	7.99	7.49
Port-au-Prince (45 m)	10.1	10.9	11.9	11.4	11.0	12.0	11.7	10.8	10.3	9.1	8.5	9.1	10.6
Damien (0.5 m above ground)	3.33	4.10	4.33	3.90	4.37	5.18	5.40	4.60	4.19	3.86	2.67	3.10	4.0
Damien (2 m above ground)	5.01	5.77	5.70	5.12	5.56	7.50	7.32	5.76	5.43	4.89	3.24	4.29	5.4
Damien (14 m above ground)	8.3	9.4	9.7	8.6	10.3	12.0	10.8	10.1	9.2	7.6	6.4	7.1	9.1
Above for period 1965/68													
Rochasse (pres de Jeremie)	5.9	7.1	5.8	6.3	5.2	6.0	4.5	6.3	6.2	6.9	7.5	6.0	6.2
Des Cois (Plateau Central)	4.3	4.3	7.0	3.3	4.9	3.5	-	4.4	3.7	3.3	4.3	4.6	4.3
Bois Clehors (Artibonite)	6.0	6.0	6.7	7.3	6.6	5.7	5.8	6.1	8.7	4.9	6.0	4.5	6.2
Kenscoff (Morne du Refuge)	12.1	10.3	7.9	10.4	10.5	11.7	12.7	14.0	10.7	10.3	6.8	11.7	10.8
Port de Paix	14.5	18.6	17.3	18.4	17.5	14.6	21.6	16.7	13.1	10.5	15.1	15.6	16.1
Cavaillon	10.9	10.9	9.4	8.8	8.4	8.5	9.0	8.5	8.1	8.0	9.4	9.5	9.1
Above for Year 1954													

INDIVIDUAL FORESTRY PROGRAMS

1. The Department of Agriculture

The Department of Agriculture, Natural Resources and Rural Development (DARNDR) is involved in several reforestation and forest protection programs, including consideration of a fuelwood plantation project in the Northwest and of a pilot plantation project near Port-au-Prince. Its official forestry-related priorities, as recognized in the 1980/81 Annual Plan at the Ministry of Planning, are the reforestation of the Peligre basin, the building of erosion control structures, the management and protection of the Limbe basin, and several smaller reforestation programs. The total area planted to date is probably between 500 and 700 ha. In general the results achieved have fallen far short of objectives. In the Annual Budgetary Plan reasons given for not reaching the objective included lack of trained staff, lack of coordination, difficulties with planning and with land tenure.

2. HACHO

HACHO is an organization of local communities, which coordinates projects supported by various aid-giving organizations; one of its programs is a bilateral agri-forestry project, financed by the Federal Republic of Germany under the "Food for Work" program. The project became active in late 1977 and the intention is to continue it as long as the necessary cooperation is maintained.

The current total budget of the forestry component is merged with other programs and is not clearly identified. However, one good measure of the level of activity is the current annual operating budget for forestry, which amounts to about $280,000. Approximately $20,000 of this is reserved for vehicles, maintenance of a depot at Gonaive and purchase of tools, while $260,000 is to be paid out as 130,000 "daily rations" of approximately $2 each for work on forestry activities.

The forestry project has three objectives: (a) reforestation; (b) stand improvement; and (c) support of charcoal makers' cooperatives. The forestry program is being implemented in the northwestern regions of Haiti, starting with agri-forestry projects east of Gonaive (Mas Rouge) and then continuing westward at a series of locations reaching to the tip of the Northwest Peninsula. Technical details are as follows:

(a) Reforestation: To date one million trees have been planted, including replacements of mortality. Roughly half of these have been set out in closed plantations, mostly on poor, dry

sites. The other half has been distributed for agri-forestry plantations. The total area planted to date is approximately 800 ha and it is expected that planting in the next few years will proceed at the rate of 400 ha per year. The project emphasizes the planting of native species, including mahogany, which grows very slowly, two species of Gaiac, Frene and Chene. Exotics, including eucalypts, Casuaria, Neem, Leucaena and pines (P. oocarpa and P. occidentalis) have also been planted but appeared less successful. Leucaena grew poorly on dry soils and was not appreciated by the population because it was unknown; eucalypts and pines failed because the necessary seed treatment and nursery procedures could not be implemented without constant supervision, which was not available. The forester explained that the attitude of the population must be considered in selecting species for plantations; native trees are "respected" by the rural population. For example, a mahogany will not be cut for charcoal, but will be allowed to grow until it is large enough to yield lumber; if exotic trees die, the failure is blamed on the species; if a plantation of native trees fails, the attitude is: "It will grow next year".

(b) Stand improvement: Stand improvement projects, northwest of Gonaive, are intended to increase wood production in existing stand, composed largely of bayahonde. So far, 80 ha have been treated. The main procedure is to cut cactus plants to reduce competition; the usual payment is one "daily ration" for clearing 100 square meters. Attempts to plant additional trees in the treated areas have had little success, because of damage by grazing.

(c) Cooperatives: At Ti Riviere, in the Northwest Region the project supports three cooperatives of charcoal producers. The goals are to eliminate the middleman in marketing, to provide credits to allow producers to ride out periods of low prices and the long-term objective of involving charcoal producers in systematic forest management.

3. Operation Double Harvest

Operation Double Harvest is a non-government, non-profit organization which manages a 70 ha farm on fertile land near Port-au-Prince. The operation is managed by Mr. Aart Van Wingerten who has a background of success in the nursery and florist business. The operation appears efficient and is impressive; the attitude towards innovation is aggressive with a strong tendency to immediate action and practical trials, rather than long-term research.

Most of the 70 hectares are under agricultural crops: tomatoes, beans, peanuts, sunflowers and others; ornamental plants ae being raised for export. Perhaps two hectares have been planted with fast-growing species, in particular, Laucaena but also Neem and Acacia; the results have been excellent. Recently a cattle herd has been started with the plan that up to 40% of its feed be Leucaena foliage.

There are several reasons why some links or cooperation with Operation Double Harvest should be considered in any major forestry project, in particular, if this should involve establishment of plantations near Port-au-Prince:

- It is a successful demonstration of plantations of fast-growing species.

- The existing plantations have a large capacity for Leucaena seed production. Seed has already been exported. "Plus trees" have been identified for the collection of future seed supplies.

- Procedures for the mass production of nursery operation could be rapidly expanded. Seed treatment methods have been tested; experience has been gained on the best age for outplanting, and plants are efficiently produced. The standard approach is to grow seedlings on peat plugs arranged in styrofoam blocks. The best planting medium has proved to be imported peat, but local materials were also found to give acceptable results.

The future of USAID involve strong support for Operation Double Harvest.

4. USAID

The USAID program is potentially highly relevant to any program in forestry and energy; it is comprehensive and includes such topics as energy assessment, energy technology, training and education, energy plantations and reforestation. Forestry and energy related programs could involve an $8 million budget, spread over five years; however, funding for the major share of the program has not yet been approved. The USAID program has been considerably reduced and now does only refer to the "Outreach Program", with the basic objective to plant trees. It involves support for "Operation Double Harvest" (which is described separately) experimental plantation (400 ha) spread throughout Haiti, nurseries, the selection of seed trees, seed production and demonstrations. It also involves the support of local agri-forestry projects to advance the growing of trees for income;all channels, public and private groups will be utilized.

5. CIDA

The Canadian International Development Agency (CIDA) supported a large project, known as DRIPP for the integrated rural development of an area on the South Peninsula. Its objectives included agricultural development, health, education and public works, including irrigation. Erosion control measures were taken, and some trees were planted in connection with agricultural development. This program was cancelled in 1981.

The project, however, is significant because it highlights an institutional problem which will be encountered in any forestry or environmental program: the different Ministries in Haiti are all on an equal basis and tend to compete, rather than to accept one Ministry in a

coordinating role. In addition, the administrative subdivisions of Haiti differ from Ministry to Ministry, which is a further obstacle to coordination. The DRIPP project attempted to overcome these problems by establishing a regional development authority with representation of all Ministries involved. Another relevant problem which was being dealt with, although with little success, is the unclear definition of land ownership and the lack of a cadastre.

TERMS OF SERVICE CONTRACTS

1. Date of Contract:

Crux (International) Ltd.	June 21, 1976
Anschutz Overseas Corp.	July 13, 1979

2. Coverage:

Crux (International) Ltd.

Zone I. Bay of Port-au-Prince and Cul-de-Sac (2,368 Km^2)
Zone II. Plaine du Nord (1,541 km^2)
Zone III. Artibonite Basin (1,241 Km^2)
Zone IV. Basin of Les Cayes (1,217 km^2)

Anschutz Overseas Corp.

Zone A. Plateau Central - defined by geographical coordinates
Zone B. Southwest Peninsula - defined by geographical coordinates.

Both contracts cover all petroleum operations, from exploration, development, production, and marketing of oil. Companies have first option for the development of natural gas or the establishment of a refinery.

3. Duration:

25 years after commercial production is established. Contracts may be renewed for 10 additional years.
Contracts may be renegotiated 7 years after pay-out or 10 years after commercial production, whichever is longer, to adjust them to new economic conditions.

4. Working Commitments:

No minimum financial commitments. Physical commitments are as follows:

Crux (International) Ltd.

Geological and geophysical work: No minimum established. Contract establishes Zone I as first target, followed by any other area. Surveys were made in 1976-1977.

Exploratory drilling: Minimum one well during first year. Three wells were drilled in 1977.

Anschutz Overseas Corp.

Geological and geophysical work: Minimum commitment of 400 km of seismic lines within first 16 months. Additional work to month 22.
Company to the end of 1980 had accomplished 400 km of seismic on Block A and proceeded to Block B.

Exploratory Drilling: Commitment: one well to 12,000 ft to be initiated before month 28 (November 1981). One additional well by month 40 (Nov. 1982).

5. Relinquishment:

Crux (International) Ltd.: After four years, the company must relinquish assigned blocks according to the number of wells drilled. With three wells the company had to relinquish one block.

Anschutz Overseas Corp.: no term is set for relinquishment.

Both companies may abandon any area at any time without penalty.

6. Disposition of Crude Oil: In case of commercial production, companies are free to market production without being committed to supply domestic requirements. The Government has the right to purchase oil at competitive international prices.

7. Financial Provisions:

The contracts provide for a 60/40 split of net profits between Government and oil companies. This derives from a direct 20% participation, plus a 50% income tax on the companies' 80% share in profits.

For the recovery of pre-production costs and operation expenditures 40% of gross revenues are set aside until all investment costs have been recovered. Contracts do not specify a depreciation schedule.

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