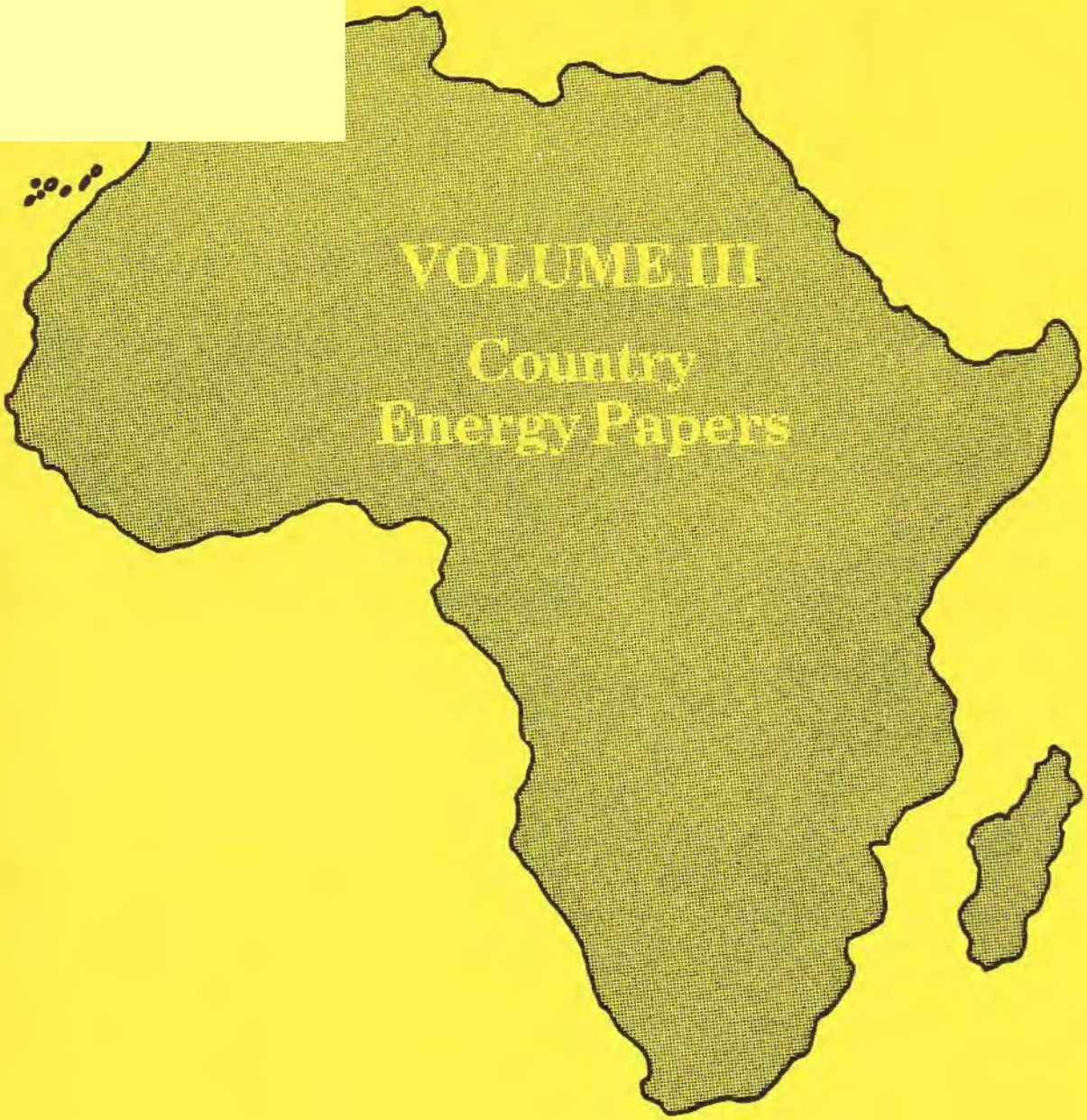
Proceedings of Workshop on Energy, Forestry and Environment



Bureau for Africa
Agency for International Development

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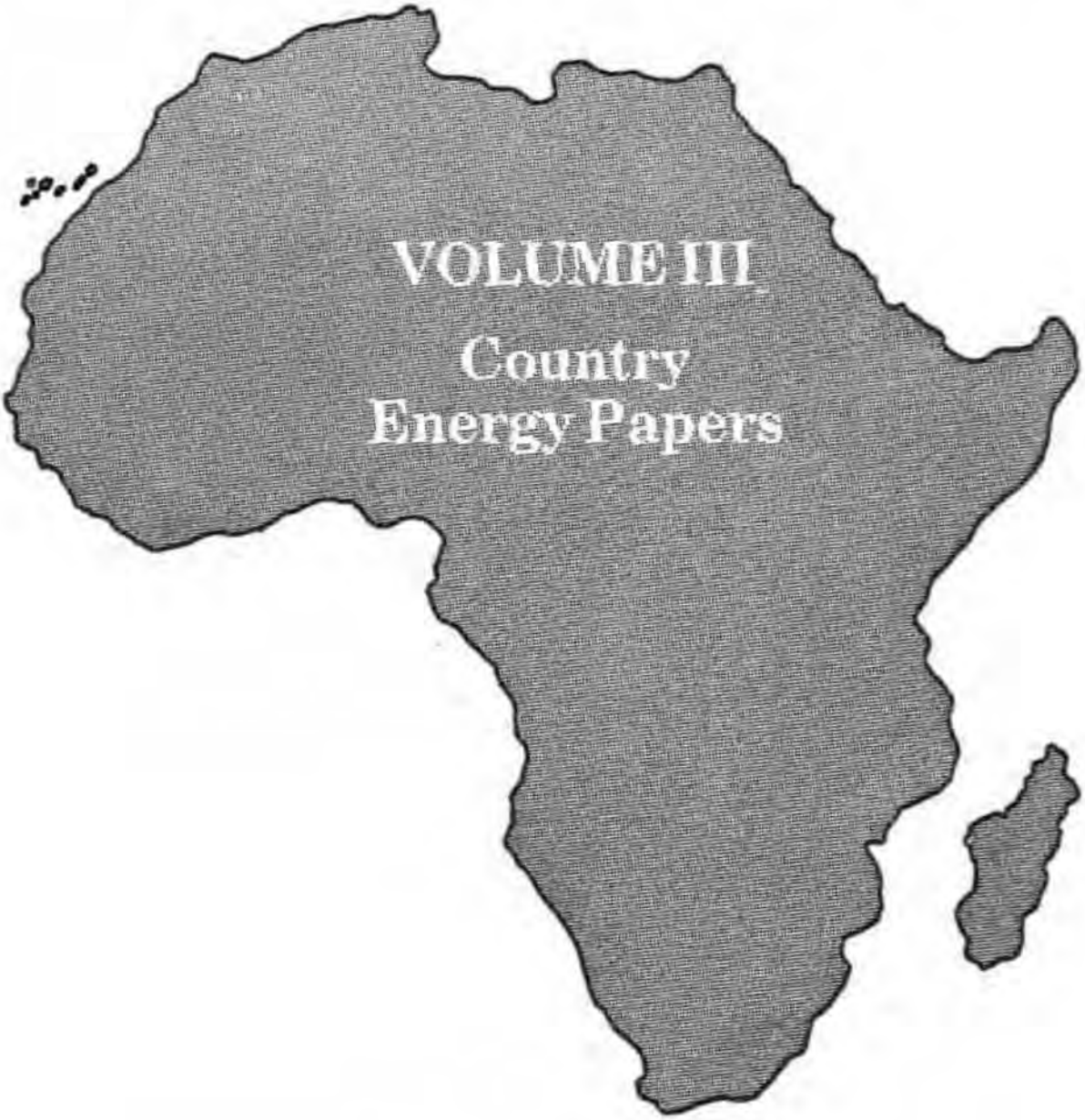

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Volume: I Workshop Summary

Volume I includes the Workshop Report as prepared by the participants, a strategy for action and recommendations to the Assistant Administrator of the Bureau for Africa for implementing the strategy. In addition, there is information on the history of the Bureau for Africa's energy, forestry and environment programs.

Volume II: Discussion Papers/Case Studies

Volume II includes the 41 discussion papers and case studies which were prepared for the workshop.

Volume III: Country Energy Papers

Volume III includes the energy profiles of 21 African countries. The papers were prepared by energy, forestry and environmental officers of AID field offices.

This document was prepared under A.I.D. Contract No. AFR-0135-C-00-1087-00 by Development Assistance Corporation. The views necessarily and interpretations expressed are those of the authors and do not reflect the official position of the Agency for International Development.

VOLUME III: COUNTRY ENERGY PAPERS

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INTRODUCTION

The Workshop on Energy, Forestry and Environment was held in Nairobi, Kenya during December 6-11, 1981. In order to encourage the participants to look objectively at the energy situation in their respective countries, each Mission was asked to prepare a "mini" energy assessment. A comprehensive outline of what to look for was cabled to all African AID missions by AFR/DR. In effect, the participants were being asked to think the through the entire energy assessment process.

The outline called for a review of the existing energy sources, in conventional and traditional terms. It then asked what the possibilities were for augmenting these energy sources with resources (both conventional and renewable) from within the country. In addition, energy consumption patterns, government energy policy and the involvement of the private sector were addressed.

At the Workshop, the participants were organized into four discussion groups based on regional and ecological similarities. Each participant was given the energy papers of his/her colleagues within the group. A leader helped each of the four groups focus on key energy, resource management and forestry issues. Consensus statements were drafted by each group which were incorporated into a Workshop Report (see Volume I, page 39).

This volume includes the country energy papers which were prepared for the Workshop by 21 USAID Missions. The quality and comprehensiveness of these papers vary from country to country depending on the energy data and information available to the Mission personnel.

BOTSWANA

I. Introduction

Botswana is a landlocked, semi-arid country with an area of 582,000 square kilometers and a population estimated at 800,000. Much of the country is relatively featureless with gentle undulations, occasional rocky outcrops and a mean altitude above sea level of 1,000 meters. Eighty percent of the land is covered with Kgalagadi sand, supporting savannah-type thorn bush vegetation. Rainfall is erratic, averaging 700 millimeters in the extreme north to 200 millimeters in the extreme southwest. In the Northwest the Okavango River drains inland from Angola to form an extensive swamp, while in the central Northeast lies a large area of calcrete plains bordering the Makgadikgadi Pans. The eastern margin of the country, adjacent to the Limpopo drainage system, has a somewhat less harsh climate and more fertile soils than elsewhere and it is here that the bulk of Botswana's population is concentrated.

Energy resources used in Botswana reflect the economic and social structure of the country with 80% of the people living in rural areas and an average rural income of approximately $388 per year. The majority of the people use wood for heating and cooking and either candles or kerosene for lighting. It was estimated that half of the energy consumed in Botswana in 1975 came from wood collected in the vicinity of major villages.

Most electricity consumption is by towns and mining operations. The Botswana Power Corporation (BPC) is the major supplier using both oil and coal-fired generators. The BPC's total generating capacity of some 80 megawatts reflects the small size of the economy.

Exclusive of electricity generation, oil is used by the railway, by some 5,000 water boreholes and by vehicles. Botswana produces no pertroleum or natural gas and has virtually no potential for hydroelectric power. National supplies of firewood are under heavy pressure around all sizeable villages, with demand increasing as these villages continue to grow. On the other hand, the country has vast supplies of coal and the climate is ideally suited to the use of solar energy.

II. Source of Energy

A. Conventional Energy

The main sources of conventional energy in Botswana are coal and petroleum products. There are almost unlimited reserves of coal (estimated at 17 billion tons) but for various reasons (i.e. Development, Transportation/Distribution) the country cannot rely on this reserve to meet all the present requirements for energy. Nevertheless, the production of coal is on the increase and does provide a very significant proportion of total domestic energy consumption, both through the generation of electricity and in some industrial processes

associated with the mines. Total primary sources of energy produced or imported into the country in 1980 had an energy equivalent of 4055 million kilowatt hours. Almost 60% of this was domestic coal production with the remaining 40% coming from imports of petroleum products.

Petroleum products are wholly imported in refined form, largely from the Republic of South Africa and any disruption of imports through either political or economic means would have a drastic effect on the economy. Since 1974-1975, Botswana's imports of petroleum products have grown at an average annual rate of 16% while the annual growth rate of the gross domestic product for 1979-1985 is forecast at 10%. The percentage of total imports of petrol-fuels increased from 4.6% of the import budget in 1972 to 11.32% in 1978 and is considerably higher today despite a greater domestic electricity production from coal. Table I illustrates total petroleum and coal imports.

TABLE I

Imported Sources	Quantity	
Liquid Petroleum	2,267	Tons
Petrol and aviation fuel	48,783,000	Liters
Diesel and gas oil	94,704,000	Liters
Kerosene	5,620,000	Liters
Fuel oil	1,094,000	Liters
Coal	14,178	Tons

SOURCES: MMRWA Planning unit, 1981

B. Traditional/Renewable Energy

The basic fuel of the majority of the people is wood which is primarily used for cooking and heating. In some areas people have to travel considerable distances to collect wood, as firewood is fast becoming a scarce commodity. In towns and villages wood is brought in from the countryside and sold at markedly high prices. The data on firewood consumption are incomplete, but estimates indicate that each person in the rural areas uses an average of about 1/2 to 3/4 ton of wood per year -- one of Africa's highest wood consumption rates. Deforestation is clearly a prime factor contributing to the increasing threat of desertification in Botswana's more populated areas, which are located just short distances from the Kalahari Desert.

Other forms of renewable energy include solar-powered water heating, water pumping by windmills and solar electricity generation for small loads in rural areas. The total number of kilowatt hours supplied is extremely low but further development is steadily advancing.

III. Energy Consumption

Data on energy consumption by both the industrial and agricultural sectors is extremely sketchy. It is known, however, that the majority of electricity produced in the country is consumed by the mining sector and by the towns. In the agricultural sector, most energy consumption is through traditional means such as animal draught power but tractor power has been increasing steadily over the past five years.

IV. Energy Resources

Large deposits of low-grade coal have been discovered in Botswana, estimated at approximately 17 billion tons. In order to minimize dependence on imported oil, the Government has initiated plans to substitute domestically produced coal for imported oil in the generation of electricity. An expanded power station is in the planning stage and it is anticipated that Botswana will eventually generate nearly 100% of its growing demand for electric power using local coal.

As stated earlier, the principal source of energy for the majority of the people is wood. It may be possible to substitute for wood in some situations, either by cheap solar devices or local coal. However, there are potential difficulties of cost, air pollution and acceptability. More promising is the development of efficient stoves for burning wood and the establishment of woodlots outside villages.

In response to the above situation, USAID and the Government of Botswana, have embarked on a Renewable Energy Technology Project to introduce renewable energy technologies (RET's) at the village level. The $4.7 million project will research, develop and put into use RET's which can reduce Botswana's dependence on vulnerable supplies of increasingly expensive fossil fuels. Village-level RET's will focus primarily on the improved use of wood or its substitution. (e.g. solar ovens, wood stoves, windmills, solar earthen batch water heaters, thatch insulation). In addition, RET's will encourage reforestation through other USAID/B activities such as the Rural Sector Grant which is providing funds to the Brigades to promote reforestation. As wood continues to become an increasingly scarce resource, it is evident that there is an urgent need to reduce wood use and increase wood production if severe environmental degradation is to be avoided.

V. Government Energy Policy

The Government of Botswana's objectives for the energy sector are:

- To minimize dependence on imported oil, due to the unreliability of supply and rising price. This will be done by substituting domestic coal for oil in electricity genera-tion and industrial use, by substituting wind or solar power for diesel in water pumping, and by encouraging conservation

in the use of petroleum products.

- To safeguard essential oil supplies by maintaining adequate reserves and developing contingency plans to cope with any interruption to normal supplies.

- To provide electricity to meet the demands of the new mines and industries needed to fulfill major production and employment goals. This will be done through the completion of existing projects and by adopting a long term programto provide a flexible abundant power supply for the late 1980s and beyond.

- To minimize the costs of electricity to industrial and private users. This implies both minimizing the production costs of electricity and ensuring that the conditions of its supply are not onerous.

- To avoid subsidizing private urban electricity consumers. The present element of intra-urban cross-subsidy will be retained because it favors low-income consumers who use electricity mainly for lighting.

- To increase the energy available to the majority of rural people, and to reduce the time and ecological damage involved in firewood collection. This will involve support for organizations which can implement programs of extension and marketing of solar energy and of more efficient wood and coal stoves, as well as woodlot programs.

- To minimize fossil energy consumption by designing buildings that require less heating and cooling, by substituting solar energy for electricity in water heating where this is economical and by investigating heating and cooling systems, using coal, for government buildings.

Oil import policy is the responsibility of the Ministry of Commerce and Industry, while electricity and other energy matters are generally the responsibility of the Ministry of Mineral Resources and Water Affairs (MMRWA). The Botswana Renewable Energy Coordination Committee has recently been organized, chaired by MRWA, to bring together different governmental and parastatal units to discuss energy policy.

Major efforts will be required to safeguard and develop supplies of firewood, to develop the national coal resources and to introduce the more extensive use of solar and wind power. Government and parastatal development expenditure on energy is expected to total P123.6 million ($139.6) over the next five years. These expenditures are summarized below:

Parastatal (BPC)	P Million
Generation and transmission	108.4
Other BPC capital expenditure	4.2
Government	
Rural Power supplies	1.3
Utilization of solar energy	1.0
Expansion of electrical department	2.4
Oil Storage	6.3
	123.6

This picture is not complete, as it excludes projects for woodlots and windmills. It also ignores expenditure by non-governmental organizations which are important for development of rural energy sources. Recently, a new petroleum and exploration law was enacted and ESSO is now in final negotiations for exploratory rights in large area of the Kalahari desert.

VI. Private Sector Involvement

Private sector and Non-Government Organizations (NGO's) are very active in the energy field. There are several small sources of solar water heaters within the country. Small solar businesses, are manufacturing batch and thermosyphon types of active and passive solar water heaters. Commercial solar water heating systems are in evidence in Gaborones, on Botswana Housing Corporation (BHC)-owned houses, on private residences and institutions (a convent) and prominently atop dormitories of the national university.

I. The Impact of Geography, Economics and Demography

Burundi is a relatively least developed country with roughly the same size and population as Maryland. It is overwhelmingly rural (less than 5 percent of the population of 4,022,000 people lived in agglomeration of village size or larger in 1979), with nationwide average population density of 161 people per square kilometer in 1979. Ngozi, Muramvya and the rural portion of Bujumbura provinces average densities between 246 and 286 people per square kilometer. Burundi has a per capita income of 180 dollars in current prices. Inflation has reduced average per capita consumption of kerosene for lamps from one liter a year per person in 1972 to half that level in 1980. The World Bank statistics indicate that Burundi has the 2nd lowest per capita consumption of energy measured in kilograms of coal equivalent.

Burundi is more than 1,400 kilometers from Dar es Salaam and 2,000 kilometers by road through Uganda to the port of Mombasa. Much of Burundi is a shield-shaped plateau gradually rising to the Zaire Nile divide and then dropping sharply down to the escarpment of the Western rift to Lake Tanganyika. The average daytime temperature on the crest is 17° to 19°C with nights often below 11°C and occasionally dropping to near zero. It is wetter on the crest with 1,600 mm rainfall a year compared to 800 to 1,000 mm in the Ruzizi plains near Bujumbura.

The heavy population density has resulted in marginal lands, some sloping more than 45°, coming under permanent cultivation thus encouraging erosion. Interplanting of small fields, harvested over time, reduces the period during which the soil is bare. Cultivation and clean weeding with hoes can cause devastating erosion problems.

II. The Modern Sector

A. Petroleum, Oil and Lubricants

Burundi imports all its petroleum and must continue to do so. Imports are mostly diesel fuel and gasoline for transportation, thus limiting the chances of substituting other forms of energy. Diesel and gasoline accounted for 62 percent of petroleum imports for 1973 and 77 percent in 1979. Diesel fuel imports increased 223 percent between 1973 and 1979. The results are summarized below:

	1973	1976	1978	1979	1980
Total Petroleum Imports (MT)	22,144	24,180	27,300	30,385	35,501
Francs Bu(million)	176.9	442.7	644.3	1,287.8	2,294

Although Burundi had only 1.3 vehicles per thousand people in 1979, the GRB assumes that growth petroleum requirements will increase about 8 percent a year.

Burundi can store about four months' supply of petroleum products. Supplies may be interrupted by transportation bottlenecks at the port of Dar es Salaam or civil unrest problems in Uganda.

In 1979, petroleum imports amounted to $14.4 million, or nearly 14 percent of export earnings, and accounted for about half of the price increase in imported goods. In 1980, the value of petroleum imports was $25.6 million, and 39.1 percent of export earnings (Burundi's exports fluctuate widely from year to year depending on the coffee crop and prices). The impact of petroleum price increases has been disastrous upon rural development programs and sustained growth in Burundi is dependent on improving productivity of food and export crops (56 percent of GDP at factor cost). It is clear that the rising fuel and transportation costs involved in improved distribution of agricultural inputs and collection and marketing of crops has resulted in a far lower internal rate of return to development projects than when they were planned. The cost of fuel is a major reason behind smallholder tea projects becoming uneconomical as well as soaring recurrent costs of future agricultural production programs.

B. Electricity

Bujumbura accounts for 95 percent of Burundi's electricity consumption. Gitega and Bururi towns consume most of the remainder of electricity. During the past five years electricity usage has grown by 9 percent and a growth rate of 8 percent a year is projected for the next decade.

The Ruzizi hydroelectric station in Zaire supplies Bujumbura with peak power of 8.5 megawatts via a 115 kilometer high tension line. The city has a backup diesel generator dating from the 1950s which can only supply peak power of 2 megawatts. Bujumbura suffers from periodic brownouts and breakdowns of electricity. It will continue to do so until the Chinese-built Mugere hydroelectric station comes fully on stream in 1982 (total power at 8 megawatts, with a guarantee of 2.3 megawatts in the dry season). Gitega has an old diesel generator which was used until the West German built hydroelectric station (1.3 megawatts peak production) came on stream in 1980. Bururi Town has a 100 kilowatt diesel generator which will soon be replaced by a hydroelectric generator.

Because of Burundi's geography and climate, the GRB has deliberately launched a program to use hydroelectric plants within Burundi to supply the country's electricity needs for urban areas. Work must begin on a network of hydro generators

producing peaks of 6.0 to 18 megawatts. Consequently the GRB has proposed the Rwegura project (18 megawatts guaranteed power) in northwestern Burundi to supply Bujumbura, Ngozi and Kayanza using a 700 kilometer long high tension line. Ruzizi II in Zaire will also supply hydroelectric power. Neither project will be completed before 1987 and the regional Akagera dam will be later still.

The GRB has a program to install micro-hydroelectric plants with power of less of 100 kilowatts which supply water as well as electricity. These will be financed by private funds (i.e. the missions) or the Government, at an estimated cost of $110,000 to $168,000 each, and will supply local Government centers, schools and clinics. Another program for plants of 250 to 300 kilowatts peak load is planned for Muyinga, Kirundo and Bururi.

C. Other Urban Fuel Requirements: Peat

Artisanal industries, commercial enterprises and institutions have traditionally relied on charcoal. Charcoal meets most urban daily fuel requirements. Estimated total wood/charcoal usage in Burundi vary considerably, but the GRB estimates consumption at one stere* per person per year or roughly four million steres annually (estimates vary considerably according to source). If we assume that rural fuel consumption is 0.5 steres of wood per person per year, then all urban usage including light industry institutions and households require about 2,000,000 steres a year. (Burundi charcoal making methods require 7 kilos of wood to make one of charcoal). The price of charcoal increased sevenfold between 1970 and 1980 and threefold from about 8 FBu/kg retail price in 1976 to 23 FBu/kg today.

Burundi has substantial peat reserves. The urban domestic market should be the major target group for conversion to peat. In the GRB's view substituting peat for charcoal will give time for plantations to mature. Peat is an incomplete solution and temporary palliative to the overall energy problem.

Beginning in 1978 with the AID project, Alternative Energy: Peat I ($490,000), AID has financed experimentation with peat production and usage. A European Development Fund activity opened up the Kisozi bog soon after the CRS program began. Production reached 4,000 tons in 1980 and about 6,000 tons in 1981. Primary uses for peat include bakeries, light industry, institutions and the Burundi army. We estimate that the peat produced during the 1981 season will be completely used by

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* A cubic meter of stacked logs.

March/April 1982 (well before production starts in May) because its price is attractive compared to charcoal. In the Peat II Project Paper, it was assumed that about 136,400 MT of peat would be produced between 1980 and 1985. The quantity of peat will be the energy equivalent of clean cutting 9,500 hectares of forest, or cropping 45,700 hectares. Projected demand may be as much as 52,100 MT in the last year of the project, assuming the requirements of 7,000 MT for institutions, 5,300 MT for industries, 12,800 MT for commercial/artisanal use and 27,000 MT for urban domestic needs (or 60 percent of the urban household market). The project evaluation now under way will probably indicate that urban domestic usage was over estimated while institutional/industrial/commercial requirements were under estimated.

III. Rural Fuel Requirements

The dominant fuel of rural Burundi is wood. It is used inside the house for cooking and for heating at higher altitudes where it has the additional benefit of driving insects away and preserving food such as maize hung from the roof. Women in Burundi are responsible for gathering fuel and preparing food, in addition to food crop production. Men make charcoal and work on peat bogs, in nurseries and on afforestation programs. In the most densely populated parts of Burundi, wood is no longer regarded as a "free good". In the lightly populated province of Bururi, field interviews indicate that women, as well as men, are interested in planting their own seedlings to produce firewood (and poles for construction).

While usage estimates vary considerably, rural fuel usage is probably half a stere per person per year. Burundi will need about 200,000 cubic meters of saw wood by 1990 and about 1,230.000 cubic meters for firewood.

Although Burundi was almost entirely covered in forest during the 17th century, in late January 1981 the GRB estimated that total forest cover had been reduced to 88,000 hectares. The IBRD estimated the total forest cover at 90,000 hectares in 1978/1979 or 3 percent of Burundi's total area. There was then about 40,000 hectares of tropical highland forest, 20,000 hectares of savannah woodlands, 25,000 hectares of existing forest plantations and the remaining 5,000 hectares was in new plantation. Even with current reforestation programs, it is estimated that tree cover will be reduced to about 40 percent of present area by 1986.

Even if the lowest wood consumption estimates are used, the ecologists are greatly concerned about its implication. If corrective action is not taken, Burundi's remaining forests will disappear entirely in another decade or less. This will not only be disastrous for the rural population who depend on wood for fuel, but also for the ecology of the land itself. Without the protection supplied by forests and woodlands in the form of ground cover, soil erosion and run off will accelerate as well as the

degeneration of watersheds. Erosion also causes silt fill and other problems with hydroelectric installations, thus necessitating actions to maintain cover in order to reap full benefit from the capital investment.

The GRB has long recognized the seriousness of its forestry resource problems. Thus the Second (1973-1977) and Third (1978-1982) Five Year Plans list an improved forestry sector as one of their goals, along with improved soil and water conservation. In an extensive publicity campaign, 1979 was the "Year of the Tree" and 1980 was the "Year of Soil Conservation". The most urgent priority is stopping the degradation of the natural forest and its eventual disappearance. The next priority is producing wood, predominantly firewood. The third priority is tree planting for erosion control and watershed protection along the crest.

The GRB should reach its goal of 240,000 hectares of new plantations of quick growing species in 25 to 30 years, if its current annual planting rate by donors and by the Ministry of Agriculture's Department of Water and Forests are sustained. Since trees require 5 to 8 years to reach exploitable size, it probably will not meet fuel requirements unless peat is substituted promptly for charcoal in a substantial portion of the "modern sector" and in urban areas. Most of the donor supported programs are for increasing saw timber production rather than improving firewood availability. This has left the GRB to use its own scarce development resources for fuelwood development programs for the most part, especially the seedling distribution and extension programs which farmers to plant trees on their homesteads as well as to develop community plantations.

Forestry research programs have concentrated almost entirely on timber production rather than fuelwood. Although the forestry programs use mostly exotic species, growth trials have been conducted on indigenous trees regarding saw wood potential. It should be noted that most Leucacena species do not grow well at altitudes over 800 meters and are therefore not successful in most of Burundi. Callitris, the old standby for high altitudes (above 1,800 meters and steep, rocky slopes) is excellent for erosion control but is slow growing. Currently, the standby for individual woodlots and small communal plantations are Eucalyptus species.

The most ambitious donor project, and the only existing one with a fuel component, is the $8.8 million IBRD-led forestry program that began in May 1979. It includes support from an IDA loan, French technical assistance, UNDP training grant and additional funds from the European Economic Community (Special Action Account). It includes establishing two plantations (5,000 hectares of pine in the south and 2,000 hectares of eucalyptus in the north); 30 communal seedling nurseries; technical assistance to the Department of Water and Forests; and financing research and study on energy needs and sources including new techniques for charcoal production and cooking stoves. Additional donor projects include:

- The European Development Fund's 3,200 hectares plantation for saw timber, begun in 1978;

- The Belgian-implemented, Saudi financed 12,000 hectare plantation of pine, eucalyptus and Callitris in southern Burundi;

- A three year UNDP/FAO forestry training program for eight team foresters and 85 forestry technicians.

The forthcoming IDA-led Ngozi III rural development project includes $2.4 million for forestry and erosion control. It will have 4,300 hectares of plantation for firewood, coal, communal plantations and planting of private and individual woodlots for farmers. The proposed Kirimiro project has $1.5 million for forestry and erosion control (1,200 hectares of protection plantation, 600 hectares fuelwood and pole plantation, 200 hectares of saw timber, 400 hectares for rehabilitation of communal plantations, 300 hectares of new communal woodlots and 250 hectares of project woodlots).

Another planned firewood project is AID's proposed Bururi Forest Project (see below).

IV. GRB Strategy and Program Implementation

Energy and fuelwood have been a major concern of the GRB for some time. Part of this is because of the seriousness of the forestry/erosion/fuelwood conundrum, and the remainder caused by being landlocked, totally without petrocarbons, and dependent on external hydroelectric sources. Energy problems and requirements are discussed as a whole from petroleum products hydroelectricity, peat and wood. The GRB realizes that solar, wind, and biogas resources will be unable to meet substantial requirements for some time to come, although a small appropriate technology energy research unit has been set up in the University of Burundi's Faculty of Science. Peat is, at present, a temporary aid (it is not renewable), and, if used properly, will give fuelwood programs the necessary lead time.

Petroleum products will be used primarily for transportation, while hydroelectric installations of all sizes and types must be relied upon for electricity generation. Widespread rural electrification is out of the question, due to cost, but small to micro-scale hydroelectric turbines must be increasingly relied upon to supply provincial and communal centers, hospitals, clinics and other services, even agricultural research stations (where possible). Public works programs are evaluated in terms of their energy requirements.

Energy programs are implemented by several GRB agencies. Hydroelectricity and diesel generators fall under the General Directorate of Energy (Ministry of Public Works, Energy and Mines). The trinational Energy Commission of the Great Lakes (now part of

CEPGL) handles regional programs and installations such as Ruzizi I and II. Peat, as a non-renewable resource, has its development agencies report to the General Directorate of Mines. Firewood and forestry are the responsibility of the Ministry of Agriculture's Department of Water and Forests, except for the large rural development projects which come under regional development societies (the forthcoming Kirimiro and Ngozi III projects). Some timber production programs have been spun off into a National Wood Office. The new Director General of conservation of natural resources in the Presidency is the former Director of the Department of Water and Forests. He still maintains a major interest in the Bururi Forest project along with other energy and conservation policies.

V. AID Strategy

AID's strategy in Burundi, as presented in the FY 1983 CDSS, is to help solve the land/food/population dilemma faced by the rural poor possessing a small resource base. The U.S. is a relatively minor donor of economic assistance, and has a few carefully selected projects within three strategy objectives:

- Increasing food availability to the rural poor, particularly densely populated areas;
- Reducing the rate of loss of arable land to soil erosion and increasing the availability of alternative energy sources to the rural and ruban poor; and
- Improving the delivery of health and family planning services.

Within the soil conservation/afforestation and energy strategy objective, AID has the following bilateral projects:

- Alternative Energy: Peat II (695-0103) (1980) is the second phase of a long term program to increase Burundi's use of peat as fuel and reduce the strain on dwindling forest resources (LOP $8.0 million).
- Bururi Forest (proposed for FY 1982) combines preserving one of two high altitude antural forests with fire and construction wood production (LOP $1,144,000).

Regional programs include various regionally financed energy sector training programs and proposed forestry/natural resources training programs; participation in CDA (ex. CADA) programs, particularly for forestry extension training.

I. Background

Cameroon has often been described as a microcosm of Africa. Within its 475,000 square kilometers (about the size of France) can be found tropical rainforests, coastal mangrove swamps, mountainous highlands, savannah grasslands and Sahelian regions. Its population of approximately 8,600,000 is ethnically diverse with more than 200 different tribes speaking 24 major African languages. As a confederation of previous French and English dependencies, Cameroon is officially a bilingual country. The French language and influence predominate, however. The major religious groups are Muslims, Christians and Animist. Although primarily agricultural, Cameroon is also developing coastal port facilities, minerals, natural gas, oil and hydroelectric power.

II. Energy Resources

A. Petroleum

Recent discoveries and development of off-shore oil resources are presently providing great impetus to the growth and development of Cameroon's economy. As late as 1977/78 the mining and petroleum sector accounted for less than one percent of the GDP. With an estimated production of three million tons in 1980/81, the sector now accounts for slightly more than nine percent. Nor is the end in sight. The most conservative estimates for petroleum production for 1985 place the level at five million tons.

The implications for Cameroons's future development are, of course, profound. At present prices and with the most conservative of production estimates, the revenues accruing to the GURC from its 40 percent share in oil operations should be approaching 500 million dollars annually by the end of 1984. This figure represents more than one-half of the GURC;s total revenues for the fiscal year just completed. A refinery has been built to supply domestic requirements of approximately 700,000 tons of refined petroleum products per year. The refinery's eventual total capacity is 2 million tons which will allow Cameroon to export refined petroleum products to neighboring West African nations.

PROVEN RESERVES OF OIL AND OIL PRODUCTION

Proven reserves as of 1/1/81 in 10^6 barrels	Estimated oil production (000 barrels/day)			
	1977	1978	1979	1980
200	-	12	34	57

B. Natural Gas

In order to exploit Cameroon's 150 billion cubic meters of

known natural gas reserves, a study is currently underway to determine the feasibility of building a plant which could begin liquifying natural gas, mostly for export, by 1987. If expectations are realized, liquified natural gas exports could make a significant contribution to the GDP by the end of the decade.

C. Electricity

Electrical energy accounts for less than two percent of the GDP. Capacity has grown slowly for years owing to the large initial output of the dam at Edea on the Sanaga. That structure was completed in the mid 1950s. Its capacity was so large that it continues to supply well over half the nation's total demand for electricity. The situation is in the midst of change, however. The dam at Edea expanded its production from 240 to 260 megawatts between 1977 and 1980. The newly completed dam at Song-Loulou, also on the Sanaga, will initially generate an additional 192 megawatts. This figure will be doubled to 384 megawatts after 1983. The Lagdo dam, situated on the Benue close to Garoua in the North Province, will add an additional 72 megawatts of generating capacity when completed in 1983.

ELECTRIC POWER CAPACITY (MW)

	1980	1981	1982	1983	1984
Hydroelectric power stations	265	457	553	625	721
Thermal (diesel) power stations	54	72	92	102	114
TOTAL	319	529	645	727	835

Overall, a total of 83 percent of Cameroon's electric power is generated from hydroelectric sources. Both the remaining potential and requirements for the future are vast. At 115 billion kilowatt hours, only one percent of which is presently in use, the country's estimated potential for hydroelectric power is second only to that of Zaire on the African continent. Systematic prospecting for sources and sites of hydropower is underway and a completed study is expected in 1983. Demand is certain to increase significantly in the future as well, as industry expands and rural communities - only two percent of which presently receive electricity - are added to the national grid.

D. Forestry

The Cameroonian forest covers between 15 and 20 million hectares of land and is located, for the most part, in the southern region of the country.

EXPORTS OF WOOD (IN 000 TONS)

1976	1977	1978	1979
551.1	578.1	564.5	564..0

According to Ministry of Mines and Energy officials, the major source of energy for Cameroon is wood (70%), followed by oil (20%) and hydroelectricity (10%). The exportation of wood products from Cameroon in 1979 provided 11 percent of the total value of exports. Although Cameroon's forestry resources are significant, the arid Sahelian zone in the North of Cameroon is beginning the early stages of the fuelwood crisis that so many African countries have already experienced. As a result of population growth, the need for agricultural land and fuelwood is increasing. This has caused shortages of fuelwood, especially in densely populated settlements. Now people in rural areas of the North Province's Sahelian region spend more time on fuel collection at the cost of productive activities.

In recognition of the importance of forestry resources to economic development, Cameroon has sought to assure continued supplies of forestry products for industry and fuelwood. In the North Province, reforestation activities are underway with assistance from the regional Sahel Vert program. A major project to expand the contribution of the forestry sector to the national economy through the establishment of plantations and the strengthening of the government agencies responsible for forestry regeneration is being developed with the IBRD. This proposed project will include up to 20 pilot village wood lots for the production of fuelwood and building poles. Private voluntary organizations have also undertaken development of projects to address the fuelwood shortage problem in the North Province.

The Ministry of Mines and Energy is responsible for identifying activities to be undertaken and formulating energy plans and policies. Other institutions such as the University of Yaounde (National Superior Polytechnical School), General Delegation for Scientific and Technical Research (Institute for Geological and Mineral Research) and the National Center for Studies and Experimentation of Agricultural Machinery are responsible for research and field testing of new energy sources such as biomass, micro-hydropower, wind and solar energy. Of the aforementioned, micro-hydropower and solar energy are being given the greatest attention as potential power sources for isolated users of electrical energy. A recently completed AID-assisted report on household consumer energy in the North Province confirmed that kerosene is the fuel of choice among the urban population. It is expected that the percent of Cameroon's energy coming from wood will continue to decline as the proportion of the population living in urban centers increases.

On balance, then, it would appear that energy availability, both at present and within the foreseeable future, will not be a constraint to the country's development objectives.

GAMBIA

I. Background

The Gambia is a country of 600,000 people and is the smallest independent state in Africa. It has a land mass of 4,300 square miles (11,000 square kilometers) making the density of population the fourth highest in Africa. The Gambia is part of the Sahel zone with over 70% of the population living in the rural areas. Its conventional energy is derived primarily from fuelwood and groundnut hulls. The country has no fossil fuel deposits, and all oil and gas are imported. Most of the commercial energy is utilized in the urban areas for the production of electricity and the operation of vehicles and machinery. Present electrical power generation capacity is 12.6 megawatts.

II. Fuelwood and Reforestation

Fuelwood: Recent statistics show that fuelwood accounts for 84% of the total primary energy consumption of the country (i.e., 320,000 tons of oil equivalent). Average per capita consumption of this energy source is 1.5 m^3 per year. The cost of fuelwood per kilogram is 0.003 dalasis (0.0150 US$)*. This is the opportunity cost on collecting fuelwood in the rural areas. The market price is 0.05 D/kg ($0.025) in the provinces and 0.1 D/kg ($0.05) in the urban area. This makes the total value of fuelwood production of 27 million dalasis ($13.5m) or 7% of the total GDP.

Over 50% of the total fuelwood was consumed in the form of charcoal (production of charcoal is now banned in The Gambia). Charcoal was produced mainly for urban consumption -- cooking, ironing, gold and silver smithing. The charcoal consumed in the rural area, mainly for silver smithing, was minimal. Traditionally, energy for cooking in the rural areas has always been in the form of firewood. Price of charcoal also limits its use in the rural area. A bag of 50 kg costs D5.00 ($2.50). This is beyond the earning capacity of the rural populace.

The method of charcoal production (open kiln) in The Gambia was proven very inefficient. Not only was the energy loss in the conversion process from wood to charcoal, but environmental degradation and deforestation was accelerated by the felling of trees. This prompted the Government of The Gambia to take measures in order to reduce the per-capita wood consumption. The charcoal ban and the introduction of more efficient stoves were among the measures taken.

Gambia's extensive reliance on wood, coupled with drought prior to 1981 and an increasing population, caused some concern. A reforestation program was initiated in the Banjul Declaration of 1977. The present estimates indicate that by the year 2000 the demand for wood cannot be met by replanting trees.

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* 1 dalasis = US $.50

A search for alternative sources of energy must be initiated.

Reforestation: The Forestry Department had embarked on schemes to increase the supply of fuelwood by reforestation through large-scale plantations, village woodlots and the National Tree Planting Festival.

Plantations: The main species used in plantations in the Gambia is Gmelina arborea which was introduced in the early 1950's when the first seed was brought from Sierra Leone. At the end of 1980, there were 1204 hectares of established plantations mostly consisting of Gmelina arborea.

Wood Lots: A pilot village wood lot project started in 1980 with the establishment of two one-hectare wood lots of Gmelina by each of two villages, Kembuji in the Western Division and Illiasa in North Bank Division. It is planned to extend the number of villages by two each year over the five year life of the USAID-funded Forestry Project. The Forestry Department provides advice and guidance, fence posts, barbed wire, staples and the necessary planting stock. The villagers provide the necessary labor inputs. Control of the management of the wood lot and ultimate disposal of the products lies entirely in the hands of the villagers.

National Tree Planting Festival: This festival, which takes place annually during the second week of July, was started in July 1978. There have been three festivals "to foster a national consciousness of the value and importance of forest cover, to maintain and improve the environment; both rural and urban, by a tree-planting campaign carried out by the people of The Gambia."

The main species provided are: e.g. Gmelina arborea; Azadirachta indica and Anacardium occidentale. Tree seeds and seedlings for the first three campaigns have had to be supplied without the use of nurseries, as there are presently no tree nurseries in The Gambia. Thus Gmelina arborea root/shoot cuttings were taken from the plantations, Azadirachta indica were obtained up where available and cashew nuts were provided for direct seeding.

III. Alternative Sources of Energy

Gambia has shown a great effort to create alternative energy sources particularly from groundnut shells. This energy source accounts for 3.7% of the total energy balance (i.e., 14,000 tons of oil equivalent). It is primarily used in the industrial power supply G.P.M.B. oil mill) as well as in the household. The pilot plant has a capacity of 6 tons/h. The shells make up 30% of the groundnut weight. The calorific value is approximately 4000 k cal/kg compared to fresh wood of 2000 k cal/kg. The results of this project have been very promising and can give a substantial input to solve the fuelwood problem.

Biogas production from cow dung has potential in The Gambia. It is estimated that there are 293,000 head of cattle head in the country. One cow gives an average of 10 kg of dung a day. Approximately 20 kgs of dung produce $2m^3$ of gas a day. With so many cattle in the Gambia biogas is both a short term and long term solution to the fuelwood problem.

Solar energy utilization has hardly been investigated. However, some measurements pertinent to solar energy potential have been carried out by the Department of Hydrometeorological Services. The Gambia receives over 3,000 hours of sunshine per year, mostly via direct radiation, except in August when the radiation flux is less than 400 Langleys per day. A significant use is already made of solar energy in the production and processing of agricultural products. For example, over 130,000 MT of groundnuts and over 70,000 tons of cereal, mainly millet, sorghum and rice are dried yearly by stacking or spreading them in the sun before thrashing; and up to 20,000 tons of marine products caught locally, of which 50 percent are exported, are usually sun-dried. Plans for economic and social development call for increased output of smoked or dried fish.

IV. Oil Imports

The Government of The Gambia imports 100% of its petroleum needs, primarily from Venezuela. Oil exploration attempts to produce oil domestically have met with little success.

Importation of petroleum products is left to the private sector with the government providing foreign exchange and price control. There is no subsidy in the price of petrol, however, LPG is duty free.

Shell Corporation has been the dominant importer and distributor of all petroleum products. However, in October 1981, Gambia Utility Corporation imported 7,500 MT of gas oil. The storage facility provided by Shell is the only fuel installation in The Gambia.

The petrol retail trading is predominately in the hands of service station dealers who work on a commission set up by the Ministry of Finance and Trade. It is expected that the private ownership may phase out fuel importation due mainly to government price control. It is likely that future role of distributors (service stations) will remain in the private sector.

V. Energy Policy

The Energy situation in the country has necessitated The Gambia to formulate an Energy Master Plan as a guideline for the efficient development and management of its energy resources. The Plan defines an investment program for resource development and energy conservation, energy pricing, taxation and other related policies.

A. Objectives of the Plan

1. To make projections of a supply/demand energy balance for the periods 1981-90 and, tentatively, 1990-2000, in order to evaluate:

   a. future energy availabilities and needs of the economy;

   b. options for reconciling the two; and

   c. the budgetary and balance of payments impact of the energy sector under the projected conditions.

2. To formulate energy pricing policies aimed at:

   a. stimulating more efficient energy use, using conservation and substitution of domestically produced energy for imported energy;

   b. stimulating the production and use of indigenous energy resources;

   c. strengthening the financial structure of energy enterprises in the public sector; and

   d. ensuring that the basic energy needs of the poor are affordable.

3. To evaluate development options and define investment priorities for the energy sector for the period 1981-1990.

4. To analyze alternative sources of energy in connection with the Plan of Action to combat desertification with emphasis being placed on rural energy.

5. To analyze and make recommendations on the institutional, administrative and managerial issues related to energy planning.

6. To analyze and make recommendations regarding contingency planning for petroleum and other fuel shortfalls.

7. To review, analyze and make recommendations on health and safety factors relating to existing and planned petroleum product usage and storage; and

8. To train qualified Gambian nationals in energy planning and analysis.

GUINEA

I. Introduction

Guinea, with an area of almost 246,000 km², is well endowed with arable land, water and mineral resources. Its terrain is varied, and its broad range of eco-climatic zones permits diversified farming in addition to livestock raising, forestry and fishing (see figures 1 and 2).

Before independence in 1958, the country was a major exporter of bananas, coffee, pineapples and palm oil and was practically self-sufficient in basic foodstuffs. Since then, Guinea's choice of agricultural development strategy has not sustained these production levels. Consequently, despite vast potential, agricultural exports have all but vanished and Guinea is a net importer of its own food -- rice.

With respect to mineral resources, bauxite reserves are estimated at 29 percent of known world reserves. Bauxite and aluminum exports are Guinea's major source of foreign exchange. Considerable high-grade iron ore deposits have been identified and geological propects for uranium and offshore oil are good.

The three major rivers in West Africa originate in Guinea: the Gambia, the Senegal, and the Niger. These and numerous other sources provide significant potential for hydroelectric power.

Guinea's ample endowment of natural resources nothwithstanding, overall economic performance has been disappointing. Real growth of GNP from 1958-1973 was estimated at 2.5 percent. Guinea has a population of more than 5.5 million, of which 85 percent is rural. Domestic food production is not keeping pace with population, which is growing at an annual rate of 2.9 percent. Despite revenues from mineral exports, food and energy importation is placing a large and growing burden on the struggling economy: oil imports almost tripled between 1976 and 1979 (See Table 1). Increased use of marginal lands (and reduced fallow periods) is leading to serious deforestation, soil erosion, and silting of major tributaries.

TABLE I

Fuel Imports ($ millions)

1976	1977	1978	1979	1980	1981
13.1	17.9	26.0	36	N/A	N/A

Source: World Bank Study, 1980, and unpublished sources.

II. Conventional Energy and Power Resources

A. Statistical Overview

Although data for the energy sector are incomplete, it is estimated that firewood and charcoal provide 65 percent of the

approximately one million tons of crude oil equivalent (TOE) energy consumed as primary energy by households, transport and state-run industry. Increased use of firewood, the most important fuel source for most of the Guinean population including urban households, is leading to significant depletion of forests, particularly in the savannah region of the north. Total power generation in Guinea in 1978 was about 150 GWh 1/; approximately 88 percent was hydrogenerated and the balance was thermic (diesel) generated. In 1979, Guinean imports of petroleum products (40% of total imports from all sectors) reached $36 million. 2/ From 1979 to 1985, it is anticipated that electrical consumption will grow by 12 percent per annum. (See figure 3.)

B. Hydroelectric

Guinea's most abundant energy resource with potential for substituting for imported fuels is hydroelectric power. Power potential of these resources is estimated to amount to at least 6000 NW with an average output of about 35,000 GWh (3 million TOE). Not all of this potential may be economic to realize. Forty (40) MW of hydro-potential have so far been developed with average energy production of about 245 GWh (21,000 TOE). Feasibility studies have been financed and the GOG has approached foreign aid donors for the financing of the 750 MW Konkoure hydroelectric project. Funding requirements for this undertaking are estimated at close to 2 billion dollars.

C. Mini-Micro Hydro Generators

There are 65 sites in Middle Guinea alone that are suitable for the installation of mini or micro hydro-generators. With only 3 to 4 percent of Guinea's rural population served by electricity, it is easy to see why the GOG is extremely interested in developing this potential. Cost per installed kilowatt at 1980 prices was estimated at $3,000. Many studies have been conducted or are planned. A ten volume study of hydroelectric sites in the Fouta Djallon was completed by a Czechoslovakian study team. The World Bank has sent and VITA will be sending experts to plan additional feasibility studies.

D. Thermal

Thermal electric production in the public sector is estimated

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1/ GWh: gigawatt, one million kilowatt hours (KWh).

2/ An additional $35 million was imported directly by two (2) mixed enterprises.

at 25 MW with 10 MW supplementing Conakry's grid and the balance spread among seven urban centers up-country. Mixed enterprises generate approximately 70 MW at three bauxite mining sites.

III. Non-Conventional Energy

A. Windpower

Wind speeds in Guinea have been measured at 11 locations in Guinea. Wind speeds are low; analysis of these data indicate wind energy potential is very small. Nonetheless, a Savonius wind machine has been installed and two wind-powered water pumps are slated for installation.

B. Solar

Sunshine duration is measured at 12 stations; four stations are equipped to measure total insolation. Complete data are lacking, but preliminary analysis indicate this resource as considerably less than neighboring Senegal and Mali.

C. Biogas

Biogas is being tested at the Foulaya National Research Institute and there is considerable interest in biogas experimentation at state collective farms. Funding and technical problems do not dampen Guinean enthusiasm for biogas, but replicability is questionable.

D. Ethanol

Good supplies of starch and/or sugar wastes exist (oranges, mangos, and pineapples). It is estimated that 400,000 liters of ethanol could be produced from orange wastes alone. (There is a 20% waste factor at the orange peel oil refinery plant). However, use of land for energy farming will compete with land use for essential food crops, limiting larger scale ethanol production.

E. Agricultural/Forestry Wastes

Coconut shells, sawdust, rice hulls and rice straw are being used in a limited manner in lower Guinea. Briquetting or other processing may be feasible and is under study.

F. Geothermal

Two (2) geothermal sources exist in Northern Guinea with temperatures at about 60 degrees centigrade. The GOG is seeking financing for the visit of a geothermal expert in order to determine potential of these two sources.

G. Ocean Thermal

The GOG is interested in exploiting this resource along its three hundred kilometers of Atlantic coastline. Three monitoring stations have been installed; two more are planned. The Oceanographic Institute in Conakry which is responsible for such studies was financed and built by the Soviet Union.

H. Animal Power

Guinea has emphasized farm mechanization in order to achieve rapid agricultural progress. Draft animals are not numerous. Increased use of animal power has economic benefits for small farmers and will be systematically explored by USAID and other donors.

IV. Forestry and the Environment

A. Background

The Fouta Djallon plateau is the source of the three great West African rivers. A deteriorating ecological balance could have disastrous implications for the ten African nations whose agriculture depends on their flow. Given low agricultural yields and high population growth, more and more marginal land is being put into production. Arable land is becoming less available and there has been a corresponding decrease in the traditional fallow period. Brush-burning for livestock grazing is widespread. Soil erosion and silting in most of the tributaries in Middle Guinea is widely evident.

Between 1960 and 1977, approximately 30 percent of the Guinean forest cover was destroyed principally as a result of slash-and-burn agriculture. It is estimated that more than 1000 hectares of trees must be planted annually in a typical 500 km^2 area in order to offset the 6000 tons of wood harvested annually from a site of identical size.

Fuelwood costs between $.05 and $.75 per kilogram; annual consumption is put at 1,100,000 tons. Charcoal costs $.06 per kilogram. Fuelwood costs alone can consume as much as 20% of a Conakry family's income. Rural families pay less but spend much time and energy gathering increasingly scarce firewood, particularly in Middle Guinea.

While at present only one institution is experimenting with improved woodstoves, government interest is high. The GOG is seeking assistance from UNICEF and the FAO for a 21-month improved woodstove project. A VITA proposal recommends the introduction of adaptation and testing of improved stoves in Middle Guinea.

B. GOG Policy

The GOG clearly recognizes its major, international role in protecting its forest resources. (The Five-Year Plan earmarked the largest share of the national budget, 21 percent, for investment in Agriculture, Water and Forestry). Numerous decrees and proclamations have been issued: tree planting is required at births and weddings; five hectares of trees must be planted before permission is granted for visits to Mecca; only deadwood can be harvested; charcoal is produced only under license; brush-burning is punishable by death. Despite these decrees, enforcement is lax; the deforestation problem grows.

V. Donor Assistance

Table II shows donor assistance to the development of Guinea's energy sector:

TABLE II

Donors		Amount ($ MM)	Project
(i)	IDA	$ 28.5	To improve electrical distribution in Conakry.
(ii)	African Development Fund	2.3	Pre-investment study for elec./water supply to eight towns.
(iii)	W. Germany	14.4	Rehab. of Conakry's elec/prod dist.
(iv)	Caisse Centrale de Cooperation Economique (CCCE), France	4.5	Feasibility study of Konkoure Dam.
(v)	Various	Approx. 1.0	Mini hydroelectric power studies.

Donor assistance includes the FAO's five-year, $5 million Watershed Management Project which covers a 500 km² area of the Kokoulo River Basin which traverses the Pita/Labe region in Middle Guinea. The USAID Community Forestry AIP, signed August 1981 for $460,000 will coordinate with FAO and work with two arrondissements in the Pita region as well.

VI. Summary

Guinea does not have the financial resources to exploit the potential of its sizeable hydroelectric and forestry resources. Moreover, it faces increasingly large foreign exchange costs for

fuel importation. Further neglect of the deforestation could threaten not only Guinea, but its many neighbors.

Donor assistance and GOG effort are increasing as are the number of projects aimed at increasing farm yields, developing small hydropower plants, increasing reforestation and improving environmental education.

Although increasing in magnitude, the Guinean energy development program remains inadequate to meet even short-term needs. Much work remains; larger (and costlier) programs must be mounted and donor coordination must improve to avoid costly overlap and ensure efficient implementation.

KENYA

I. Background

Kenya is suffering both from rapidly increasing prices for imported oil on which it is heavily dependent, and from increasingly severe pressures on its biomass resources. The country has one of the fastest growing populations in the world, the overall growth rate of about 4% being even higher in two of its most populous and largely rural provinces. With over 83% of the country's land area being arid or only marginally productive, the land frontier is rapidly closing in. The energy crisis affects both urban dwellers in term of higher prices and occasional fuel shortages, and has far reaching effects in rural areas through loss of arable land and consequently decreasing food production.

This paper summarizes the issues, problems, and potential of Kenya to face and resolve its energy crisis, and the current status of GOK and donor efforts. Summary statements are supplemented with references to more complete studies and reports.

II. Sources of Energy

A. Conventional Energy

Sources of conventional energy used in various sectors are petroleum (imported), coal and coke (imported), and hydropower (imported and domestic). Of the total amount of 3,561,100 tons of oil equivalent produced in or imported to Kenya in 1980, 41% consisted of hydropower generated in Kenya, 8.7% was imported hydropower from Uganda, 0.5% from imported coke and coal, and the balance of 49.8% was imported petroleum. Table I shows relative amounts of these sources for 1976 thru 1980.

B. Traditional/Renewable Energy

Fuelwood and charcoal are the primary sources of energy for the population living in rural areas (total rural population is estimated at 13 million) and more than 50% of the population living in urban areas (population approximately 4 million).

Estimates of charcoal production range from 170,000 - 310,000 tons in 1975 to 1,100,000 tons in 1981. Most charcoal is produced in primitive earth kilns by people living in rural areas who either scavenge or bootleg the wood supply, with little effort at replenishment.

III. Energy Consumption

A. Sectoral Patterns in Use of Commercial Energy

Table II shows conventional energy demand by sectors. Transportation alone consumes 53% of fuel used in Kenya, one-half by private autos and one-third by air travel. Industries use 21% of the fuel, 11% is used in thermal

generation of electricity, 9% in agriculture, and the remainder of 6% is used in buildings, residences, and for construction.

Forty-five percent of electrical power is used by industry, and 48% is used in buildings and residences. The remaining 7% is used for energy production, agriculture and construction.

Conventional energy provides approximately 20 to 30% of all energy consumed in Kenya. Conventional energy from petroleum, coal and electricity increased by 2% in 1979 and by 4% in 1980. Petroleum product consumption increased by 5.6% in 1980 -- faster than the increase in the Gross Domestic Product.

B. Balance of Payments

The new oil bill for commercial energy consumption rose from Kenya Pounds 33.9 million in 1976 to Kenya Pounds 68.8 million in 1979 to over Kenya Pounds 116 million in 1980. As of 1979, the cost of oil amounted to 18.1% of the value of total exports, rising from 1.1% in 1972.*

C. Biomass Resources

The population of Kenya consumes a great deal of fuelwood for its domestic needs. Fuelwood provides, directly or indirectly (through charcoal), approximately 80 to 90% of all the domestic energy consumed in the country but the average consumption per head of fuelwood (including charcoal) is not known with any degree of reliability. Estimates of average per capita consumption range from 0.8 m^3 to 1.5 m^3. Even if the lower estimate is used it would represent an annual consumption of at least 13 million m^3 for fuelwood and charcoal. It is not clear where all this fuelwood is coming from, but a substantial amount must come from forest land, whether gazetted or not; the rest must come from scrubland, farmland, scattered trees and shrubs. Since annual consumption far outstrips wood regeneration, fuelwood consumption is clearly leading to significant deforestation. The dimensions of the phenomenon, however, are only dimly known, The Ministry of Environment and Natural Resources (MENR) survey of 1979/1980 found acute scarcity in Kitui, Turkana, Machakos, and parts of Kakamega Districts and in much of Nyanza Province. Crop residues and manure are widely used in these areas to substitute for fuelwood; richer families are able to afford kerosene. Rapid loss of forest cover is noticeable in areas peripheral to Nairobi which furnishes the capital with charcoal.

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* One Kenya Pound = U.S. $2.00

IV. Energy Resources

A. Potential of Conventional Energy Resources

1. Hydroelectric Power

The development of hydroelectric power is the responsibility of the Ministry of Energy. The Tana River Basin is the main source of hydroelectricity. At present, five generating stations with installed capacity of 335 MW are in operation and the construction of one more (Kiambere Valley) generating station with a power potential of 130 MW is expected to commence soon and come into operation in 1987. The Master Water Plan estimates the total potential at a little more than 3,000 MW sufficient to meet Kenya's requirements up to the year 2000. The Tana River accounts for 1,230 MW and the Athi/Sabaki Rivers for 370 MW.

Expansion of mini-hydropower potential is being conducted in Western Kenya, supported by Finland. In total, this potential is estimated at 1,200 MW of which 750 MW can be economically harnessed at current market prices.

2. Fossil Fuels

The GOK is encouraging the exploration for oil believed to exist off the coast and possibly in the Rift Valley near the Sudan border. Kenya has no known coal deposits.

3. Nuclear

Although preliminary indications of finding uranium in southeast Kenya are promising, development of nuclear power is not being considered at present.

B. Potential of Alternative Energy Resources

1. Geothermal

This is the most important new source of energy in Kenya for the immediate future. The maximum and minimum potential has been estimated at 1400 MW and 170 MW respectively over a 25 year period for the Olkaria region along, where one 15 MW plant is already in operation and another 15 MW plant is expected to be in operation in 1982. Exploration on two other geothermal fields -- Eburru and Lake Bogoria -- will begin soon.

2. Alcohol

Two plants are under construction. One at Kisumu will be operational by mid-1982, the other at Muhoroni will be operational by 1983/4. The design capacity of each of

these molasses-based plants is 60,000 liters/day. The proposed Riana Ethanol Project, which will use sugar cane juice directly to produce 150,000 liters/day, is expected on line by 1984/5. However, construction costs for the two plants at Kisumu and Muhoroni are exceedingly high and the economic viability of these plants has been subject to considerable discussion.

3. Solar

Solar radiation data indicates average insolation rates of up to 30 to 45 watts per square centimeter. Drying of agricultural commodities and salt production are both practiced. The second most widespread application is in commercial water heating. Flat plate collectors of varying sizes and qualities are being manufactured and/or assembled locally and are priced approximately K.Shs. 2,000 per square meter. GOK is actively seeking to install solar water heating in hospitals, schools, clinics, etc., especially in isolated areas. There is potential for solar water desalination units to provide water for some areas. Also, GOK is interested in applied photovoltaic devices when costs become competitive with alternative energy sources.

4. Wind

Used in Kenya for the past 100 years, wind power technologies have met with little success because of (1) data on prevailing winds are insufficient for design purposes, (2) mill design and component materials have not been adequately field tested and changed as required, and (3) costs are prohibitively high. Government does plan to gather more reliable data on prevailing winds and to promote development of cheap but reliable local hardware.

5. Biogas

Biogas technology was first used 30 years ago. Manufacture of biogas digesters began in 1958; results have been disappointing. However, estimates of potential for biogas range from (a) sufficient energy to completely replace the use of firewood plus 5840×10^{10} kcal to spare, to (b) sufficient energy to replace half the use of firewood.

6. Solid Wastes

Large quantities of waste materials are available for conversion into usable sources of energy. Examples are coffee husks, sugar bagasse, rice husks, sawdust, and maize cobs. A new Kenya Planters Cooperative Union annually converts 20,000 tons of coffee husks into 7,000

tons of charcoal briquettes, but the selling price is presently over twice that of wood charcoal. (KSh 2.75 vs. KSh 1.00 per kilo). Because of its greater convenience in use, however, "Kahawa Coal" is popular with the urban expatriate community.

7. Fuelwood Energy

Kenya's natural and man-made forests total 2.35 million hectares. Gazetted forests (with officially marked boundaries) total 1.57 million hectares, the remaining 0.78 million hectares are ungazetted. Indigenous forest produces very little biomass for sawmilling and pulpwood production compared to exotic tree plantations. (Industrial plantations produce up to 150 times more wood than natural forests.)

Natural forest areas are being depleted, first to make more land available for agriculture, and second, because in many areas wood is being taken faster than new growth is achieved. Numerous studies on fuelwood supply and demand conclude that existing and planned production of fuelwood from forests and woodlands is inadequate to meet present demand on a sustained yield basis. Estimates of the rate of depletion indicate that at least half of the remaining "wood cover" would be stripped over the next three decades, and possibly as early as the coming decade. The need for fuelwood conservation has been recognized and several groups and individuals are beginning to develop, and trying to distribute the use of improved cookstoves.

C. Monitoring Environmental Effects

AID assistance through the Environmental Training and Management Project (a regional project) has enabled GOK to produce a series of district environmental profiles which can be used in monitoring the environmental status, especially the effects of deforestation. A siltation model is also being developed under this project.

V. Private Sector Involvement

At present, importation, refining, and distribution activities (except a pipeline) of petroleum products are owned and managed by the multinational oil companies. However, the Government has recently established the National Oil Corporation of Kenya which will be responsible for procuring and refining 50% of the crude oil. The government sets controlled prices.

Generally, the private sector operates production and distribution of charcoal subject to government control of prices.

In the private sector, relatively large businesses appear to have an interest in conserving energy if it will save money. Firestone has been instrumental in introducing energy-efficient measures at its plant. Major hotels seem interested in using flow restrictors to save hot water. A parastatal pyrethrum processing board in Nakuru has added new steam valves, instrumentation, insulation on steam pipes, and installed a sawdust burning boiler to complement the existing oil boiler. Further initiatives to save energy in the commercial sector are possible but management must deal with tariffs and restrictions for imports of conservation and solar water heating equipment, lack of expertise to retrofit existing equipment, lack of trained staff (competent engineers are often fully occupied -- and indeed overworked -- simply keeping the plant functioning), and the demands of other parts of their operation.

Private Voluntary Organizations (PVOs) are very active in renewable energy activities. Thirty-six PVOs are involved in the fuelwood area. Most are doing tree planting; others are developing seedling nurseries; some are involved in information dissemination. Eighteen groups are working on solar, 21 on wind, and 14 on biogas. These groups are also involved in other conservation such as improving cookstove insulation and efficiency.

VI. Donor Involvement

Several donors are active in Kenya. Donor participation includes assistance in power generation, transportation, distribution, rural electrification, fossil fuels, geothermal, energy planning, and renewable energy including forestry/fuelwood. Donors include World Bank, EEC, Denmark, United Kingdom, Sweden, Canada, FRG, several UN organizations, AFDB, France and USAID. Donor response is more than adequate at present. GOK is constrained by a limited capability to absorb the present assistance.

VII. GOK Strategy and Policies

Planning and Coordination: In 1979 Government established the Ministry of Energy (MOE) charged with energy planning and providing advice on energy policy. Besides policies on pricing, production, and distribution of conventional fuels and electricity, MOE has the task of developing consistent and workable strategies to increase use of renewable sources of energy.

Petroleum: Government controls the prices charged by multinational oil companies. Since June 1980, petroleum prices have been raised four times. Motor fuel prices have increased approximately 50 percent. However, one-half of the increases merely reflect costs that have been passed on to consumers. Kerosene prices, kept relatively low for the benefit of the Kenyans, are subsidized by petrol prices. Government also plans to increase the efficiency of the Mombasa refinery in order to increase crude oil requirements. Refined petroleum products are re-exported to neighboring countries and Government plans to increase Kenya's role in this activity which has been an important source of foreign exchange.

Education: Government has also started a radio and television campaign to educate the public on conservation measures such as economical driving habits -- but the effort is spotty and needs improvement by seeking a wider audience on issues relevant to their daily lives (such as improved cookstoves).

Government has considered but not implemented conservation measures such as a ban on Sunday driving, and shortened lunch periods to reduce lunchtime commuting.

Import tariffs on coal and coke are lower than that for petroleum. Charcoal prices, also set by government, are lower than prices for kerosene. Duties on larger luxury automobile have recently been raised in further effort to discourage use of high fuel-consuming vehicles.

Hydropower: Government intends to maximize the utilization of Kenya's hydropower potential and has constructed, and plans to construct several more, large hydroelectric generating plants. Development of small scale hydropower sources is now under study.

Renewable Resources: Government has been changing its focus in recent years from industrial plantations for sawmilling and pulp production to fuelwood related projects. The Rural Afforestation Extension Service of the Ministry of Environment and Natural Resources (MENR) was established in 1971 to work in all forestry activities outside gazetted forests. However, still over 70% of the MENR budget is for maintenance and development of industrial forest plantations.

The Ministry of Agriculture (MOA) offers extension services to the division and location levels, to run nurseries and encourage tree planting for erosion control, and for increasing wood production to satisfy the needs of the tobacco and tea industries. This effort is not well organized.

The Ministry of Energy (MOE) is attempting to establish policies for promoting renewable energy use. Part of this task involves coordinating the efforts of MENR and MOA. MOE has begun by trying to coordinate the establishment of six fuelwood agroforestry extension centers variously located in different climatic zones. Much effort at coordination will be needed if these centers are to be successful.

MOE also plans to encourage the use of more efficient cookstoves and charcoal kilns, and to develop applications to utilize biogas, solar, wind and solid wastes. Again, MOE has hardly begun and much effort will be required before a workable coordination mechanism for the many pilot projects becomes effective.

VIII. USAID Activities

USAID, through the Renewable Energy Development Project, is assisting the MOE by (1) conducting initial planning and surveys, (2) providing staff support for institution-building and (3) providing staff assistance and finances for an Energy Development Fund. This assistance is to help MOE develop relevant policies in conservation and renewable energies, and to promote demonstration and extension programs.

Based on MOE's present and projected capabilities, the magnitude of its responsibilities and on the need to establish in the field viable renewable energy applications, Mission believes that future involvement in energy assistance is possible. Many donors are already involved in development of conventional energy resources. With AID expertise in renewables and GOK's need for developing renewable energy resources, it is possible that future assistance would be in this area, in particular for fuelwood.

TABLE I

PRODUCTION AND CONSUMPTION
OF PRIMARY COMMERCIAL ENERGY IN KENYA

Source of Energy	1976	1977	1978	1979	1980
Coal & Coke Imports ('000 tons) oil equipment	44.9	43.8	34.8	11.3	16.9
Imported petroleum oil on '000 tons	2446.7	2556.5	2369.2	2471.5	3075.5
Consumption of petroleum products in Kenya in '000 tons oil equivalent	1563.5	1607.8	1659.9	1669.3	1768.2
Hydroelectricity (GWH) Domestic	1080	1085	1357	1543	1461
Imported	242	272	217	160	315

Source: Economic Survey, 1981

TABLE II

DEMAND FOR COMMERCIAL ENERGY BY SECTOR IN 1979

	Fuels	Electricity
Transportation	53%	-
Industry	21%	45%
Energy Production	11%	4%
Agriculture	9%	2%
Buildings & Residences	5%	48%
Construction	1%	1%
TOTAL	100%	100%

Source: Schipper et.al., Energy Conservation in Kenya: Progress, Potentials, Problems.

LESOTHO

I. Overview

Lesotho is a small landlocked enclave within the Republic of South Africa with a total area of 30,350 km² and 3,548 km² of arable land. The climate has a moderate to minimal rainfall. The country has a strip of "lowlands" along the western border. These lowlands are rolling hills, foothills and plateau upon which two-thirds of the country's 1.2 million live. The remaining one-third of the population live in the rugged Maluti, Central and Drakensberg Mountains, and along the Senqu (Orange) River Valley. The terrain in the mountain is mostly rangeland covered with grasses and scrub brush except where over grazing has completely removed the vegetation and erosion exposes bedrock. The lowland valleys contain growths of trees and support farms with both fields and pastures. In recent years, migration pressures and population growth have resulted in heavy cutting of trees and small brush in the lowlands which has increased erosion under the infrequent but torrential rains. Lesotho has no known commercially viable sources of conventional fossil fuels such as coal or oil. A very thin seam of coal and low grade uranium ore deposits have not been deemed worth mining at present. Due to the terrain, small-scale hydroelectric installations are a possibility. The Taiwanese Government is building two small hydroelectric plants for Lesotho.

II. Sources of Energy

A. Conventional

As shown in Table I, the sources of energy imported into Lesotho are shown to have increased three-fold in half a decade.

TABLE I

C.I.F. Value of imports by Major Commodity for the Period 1974-1978: Mineral fuels, lubricants and related materials (000's of Rands; R1=$1.30 in 1980)

1974	1975	1976	1977	1978
5,381	7,131	11,742	17,636	17,901

Listed by commodities, the pattern is shown in Table II:

TABLE II

	1978 C.I.F. Value (000's)	Consumption 1978/79	Consumption 1980/81 (liters)
Coal	R 455	-	-
Petrol	6,057	4,543,751	27,532,656
Aviation Petrol	216	56,724	1,191,213
Paraffin Oil	4,748	102,042	15,792,529
Diesel Oil	2,890	4,609,823	19,612,001
Lubricating Oils, Greases	544	-	-
Petroleum Jelly	568	-	-
Other Coal Products	566	-	-
Domestic Gas	383	82,373	216,629 kg
Electricity	1,474	84,000,000	99,000,000 KWHR
	R17,901,000		

Firewood imports were listed as R266,000 in 1978 and R1,329,000 in 1979, although this rise may be due to accounting procedure changes.

The rise in imported liquid fuels is shown as:

TABLE III

Annual Sales (Million of Rands)	1977	1979
Petrol	4.7	6.0
Paraffin Oil	4.5	4.7
Diesel Oil	2.3	2.9

The rise in fuel costs is seen in the Retail Price Index as exceeding any other category of purchases.

TABLE IV
Low Income Households
Retail Price Index & Percentage Changes, Oct. 1972=100%

Commodity Group	1975	1979
Food and Drink	156%	285%
Rent and Home	138%	188%
Fuel, Light & Heat	184%	506%
Clothing	127%	164%
Transport	112%	318%

The average all-electric household in the capital city, Maseru, used about 27 kilowatt-hours per day in 1978 or 97 megajoule (MJ) per day. This is 3.5×10^4 MJ/year. In

contrast, an average Lesotho household uses about 90,000 BTU per day for cooking, lighting and heating which is equivalent to 95 MJ per day or 3.5×10^4 MJ per year. Thus, based upon the 1976 de facto number of household in Lesotho, 240,308, total national household energy consumption is about 8.5×10^9 MJ. These numbers are subject to closer scrutiny in light of "non-official" informal economic activities such as beer brewing. The traditional fuels, firewood, small shrubs, grasses and field stubble, and dung are under pressure from increasing population growth and increasing herd size. There is no charcoal production.

B. Renewable

The Lesotho Woodlot Project data on tree planting show a total of 2,976 hectares planted in 1981. The desired annual rate is 550 hectares, although that has not always been met. The trees are valued at about 8,000 Rand per hectare but the wood is used more for construction material than as fuelwood. There are many trees planted by the public on Tree Planting Day each year and other ongoing programs such as through the soil conservation division of the Ministry of Agriculture. In contrast, it is frequently noted that there are large numbers of recently felled trees along river banks and public lands, leading to the observation that the total tree population is either steady or declining.

Since the terrain varies enormously from the lowlands to the mountains, it is difficult to obtain meaningful figures for the biomass potential of the country. Ranging from 50 kg/ha on severely eroded land to a measured 546 kg/10 m x 10 m woodlot in the mountains 'Malefiloane region (54,000 kg/ha), the average estimated biomass potential may be around 5,000 kg/ha in the mountain rangelands. The lowlands estimate is at least three times that. Mr. Marc Best reports an annual firewood consumption of 1.5×10^3 kg for households in 'Malefiloane. At a measured 23.26 MJ/kg, this is 3.5×10^4 MJ/year equivalent to the urban household in Maseru. He also reports the combustion of 1.35×10^3 kg of dung/household. At an average calorific value of 13 MJ/kg, this represents 1.7×10^4 MJ/year/household. In the same area, a typical household would also burn about 27 liters of paraffin oil per year. At 38 MJ/litre, this is an additional 1×10^4 MJ/year, making the household total energy consumption 5.3×10^4 MJ/year. Since this village area is at an altitude of 2680 meters and ranges from a June temperature of 5°C to a December temperature of 17°C, it represents the colder end of the climatic spectrum of Lesotho. Mr. Best interviewed the villagers and found that 73% of the women reported that collecting wood is a problem and 80% responded that the collection of wood has become worse. The average walking distance from the village to the wood collecting areas was found to be 3.5 km. Thirteen hours and 50 minutes was spent weekly in the collecting of wood amounting to an average of 95.2 kg. Within these villages,

the collection of fuel follows a seasonal pattern. Much of the cooking is done with three-legged cast iron pots above the fire. Little of the potential heat from the fuel heats the contents of the pot, but when cooking fire is indoors it contributes to space heating. The distribution of energy in this village is approximately 68% for cooking, 30% for heating and only 2% for lighting. The per capita annual fuel consumptions were found to be 6.7×10^3 MJ of wood, 3.4×10^3 MJ of dung and 0.2 MJ of paraffin. At 5.2 persons per household, this is 5.3×10^4 MJ/year.

Although the prices of bundles of wood varies from 30 cents to 1 Rand, at an average of 50 cents per bundle of wood which has a mass of 21 kg, this is about 500 MJ per bundle or an energy price of 1 Rand per 1000 MJ. People have expressed concern on the reduction of wood supplies as they are either paying more for wood or are spending more time in fuelwood collection. The supply of dung has remained constant or has slightly increased with increasing herds, although families without cattle are a severe disadvantage. Fuel efficient stoves and village woodlots can play a large role in this area.

III. Energy Policies and Priorities

Energy is addressed in the Third Five-Year Development Plan, but no separate official Lesotho Energy Policy exists. The Ministry of Water, Energy and Mining commissioned a German team to help formulate policy two years ago, but this has not yet been implemented. Policies are being created piecemeal by other Ministries to deal with their internal decision making processes. The Ministry of Cooperatives and Rural Development is participating in the Renewable Energy Technology (RET) Project (USAID-funded) and is drawing up a rudimentary energy policy.

Lesotho has an active program of economic development which encourages all businesses, including the multinationals, to invest in the country with tax reliefs. Many of the larger commercial establishments account for the bulk of the formal sector energy consumption. For example, out of the nominal 30 MW imported electricity, three resort hotels use about 2 MW, or 7% of the national total. Since many of the commercial establishments can pass on the energy costs to consumers, they are not highly motivated to initiate energy conservation or use alternative energy sources unless pushed by outside forces. Because Lesotho is an enclave within the Republic of South Africa and on the energy trade routes for coal and liquid fuels, and is attached to the R.S.A. electrical grid, the prices for these energy sources are among the lowest on the African continent. For example, electricity is sold at 4 to 5 U.S. cents per kilowatt hour, petrol is available for 63 U.S. cents per liter (U.S. $2.38 per gallon), and coal is U.S. $4 per kilogram bag (or U.S. $73 per ton). Thus, with ample and cheap energy supplies, Lesotho has not perceived any major needs to introduce energy conservation or energy alternatives until recent years as R.S.A. prices rose.

The energy priorities in the next five years are to encourage large-scale hydroelectric with smaller installations. Taking a demonstrated electrical demand growth rate of around 15% per year, both large-scale and mini-hydro plants are planned.

Subsidies on energy appear only on paraffin and diesel for agriculture. The "Common Fuel Fund", jointly administered by Botswana, Lesotho and Swaziland, raises funds from taxes on petrol and diesel sales.

At present, policies for conservation include restricted hours of sale of petrol and diesel and a 90 Km/hr speed limit.

IV. The Role of the Private Sector

Several private companies were formed to deal with the manufacturing and installation of solar water heaters. The financial history of these has not been outstanding and problems with installation and maintenance have increased. In certain instances, people have remarked that "solar water heaters don't work, because I know someone who has one on their house and it's not in operation". A priority for the RET Project is to identify these faulty units and train artisans or repair crews to perform retrofit services. (Certain heaters properly installed and maintained have given flawless service.)

There is a potential role for the cooperatives and credit unions to help promote and finance energy systems and to encourage small-scale entrepreneurial efforts. The RET Project is collaborating with the cooperatives in this area as well as with the Basotho Enterprises Development Corporation (BEDCO), a parastatal which encourages medium-scale businesses.

BEDCO is examining the possible production of kits for solar cookers and the possibilities of concentrating on solar collectors for commercial and institutional water heating in conjunction with the RET Project. One of the major constraints to implementing small businesses is the lack of entrepreneurial skills and the lack of start-up capital. Short-term loans to entrepreneurs closely coupled with business advice is desperately needed.

V. The Role of New Technologies

The potential for several technologies such as producer gas and small-scale Stirling engines and biogas need further evaluation, especially in comparison to draft animal power. Price reductions on producer gas and Stirling engines may help reduce the demand on imported fuels for both stationary and mobile power sources. Since the draft animal is part of the Lesotho "cattle culture", its total replacement by mechanized traction even at the small-scale levels seems remote, although mechanical power sources introduced for other purposes may be accepted.

The use of small engines or other mechanical systems with renewable fuel sources may appear attractive based upon capital costs and overall efficiency numbers, compared to draft animals. However, it must be stated that mechanical aptitude and the concept of routine maintenance is sorely lacking, as demonstrated by about half of the Lesotho tractor fleet being out of service at any one time. Still, under an established repair and maintenance scheme, these small power sources may have possibilities for Lesotho which should be investigated further in concert with forestry biomass production.

TABLE V

Technology	Fuel	$/kw	Overall Efficiency 1/	Scale 2/ kw	End Use 3/	Status
Draft animal	cattle feed	240	3.5%	0.1-0.5	M,S	Available
Producer gas engines	dry biomass	200	12-21%	2	M,S	Available
Stirling engines	dry biomass	350	4-4%	0.1-0.5	M,S	Under Development
Biogas	animal manure & crop residues	150[4]	7%	0.1-0.5	S	Available
Photovoltaic	sunlight	7K-50K	-	0.1	S	Under Development
Water Pump-windmills	wind	4K-10K	-	0.2	S	Available

1 raw material to mechanical output
2 practical minimum size
3 M=mobile, S=stationary
4 excludes digestor costs

Lesotho Government involvement with renewable energy planning policy is mandated through the Ministry of Water, Energy and Mining and the Central Planning and Development Office. The Ministry of Agriculture (MINAG) has a Home Economics Unit which has been teaching the construction of mud stoves, solar dryers, and other renewable energy systems. MINAG also is looking into a biogas program. A Ministry official has returned from overseas training program in biogas. The OPEC Fund has provided $250,000 for a biogas and solar energy development scheme. The Anglo De Beers Forest Services have been establishing woodlots since 1973, with 2000 hectares planted to date. The Ministry of Cooperatives and Rural Development oversees the RET Project which has fuel efficient stoves, solar heater building design, pedal power, solar greenhouses and growholes, and building insulation and weatherization as major components, with research and demonstration in biogas and

micro-hydroelectric. The RET Project is collaborating with the Ministry of Works and with several private architectural firms in providing design guidelines for solar heated buildings.

A possible role of USAID and other donors is to 1) assist in energy conservation and building retrofit equipment; 2) help expand the existing woodlots program and start village woodlots; 3) provide photovoltaic purchase assistance for remote clinics and schools; 4) assist in providing or purchasing small mechanical energy sources such as producer gas and Stirling (both biomass and direct solar); and 5) provide financial assistance as small business starter loans coupled with expert business advice for construction and maintenance of energy systems. The development of human resources ranges from the needs of the village energy technician, through the small-scale manufacturer, to the national energy policy planners. This total energy related package mentioned above may require 3 to 5 million dollars per year for 10 years to assist Lesotho in becoming more energy independent. Another possible role is to assist in the forestry program which could use 10 foresters, one in each district, plus three assistants each. Gully and erosion control plantings can provide local village energy sources. This would cost about 2 million dollars over a 5 year period. This should be looked at in terms of regional cooperative programs including SADCC.

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LIBERIA

I. Sources of Energy

Liberia imports all of its fossil fuel through five multinational commercial distributors of oil and oil products. The government-owned Liberia Petroleum Refining and Distributing Company has the capacity of 15,000 Bbl/day; the refinery is now working at full capacity. Plans are underway to expand capacity and to develop contracts with other parties for refined products. Fifty percent of the refinery's output is fuel oil, most of which is used by the iron ore companies. Twenty-one percent is diesel fuel, 14 percent is gasoline, eight percent is jet fuel, three percent fuel gas, while less than one percent is produced in the form of asphalt and LPG. Less than half of one percent of its product consists of intermediaries (kerosene and naptha).

Petroleum imports are becoming a major foreign exchange cost, rising from $5.5 million and 6.3 percent of total imports in 1970 to $118 million, or 20 percent of imports in 1980. Liberia's 1981 oil bill is expected to exceed $130 million. Its monthly payments to the oil financing facility average $11 million and this has become a major foreign exchange problem.

The Liberian Electricity Corporation (LEC), a government-owned corporation, generates and distributes electricity to several communities in Liberia. The LEC operates a power grid within the Monrovia area consisting of 11 MW diesel, 64 MW gas turbine and 64 MW hydro installation (Mt. Coffee Hydroelectric Facility). In 1980 it added a 26 MW marine diesel generator and added two 13-MW units in 1981. The LEC also operates nine stations in towns in the interior which are separate from the Monrovia system. The diesel generators in these towns range in capacity between 300 KW and 2 MW. Smaller towns reportedly have small diesel set in the 10-1000 KW range, owned and operated by private entrepreneurs. Demand strains supply at all facilities.

A major constraint to effective year-round use of hydropower is the lack of storage for the dry season (Mt. Coffee Facility has no reservoir) which lasts six months of the year. Plans are underway for a major hydro project along the St. Paul River in Central Liberia, which will increase hydroelectric capacity by 414 MW by 1990, with storage. This is to be accomplished in several phases.

Liberia has a considerable supply of firewood for domestic consumption. Approximately 43 percent (4.8 million hectares) of the country is heavily forested. Although in areas near urban centers firewood is a market commodity with availability relatively unassured, wood is collected by family members and used for cooking over open fires in rural areas. In urban areas, charcoal (made in the interior and transported daily to urban markets by pickups and trucks) is the favored residential fuel for cooking and water heating.

A German study indicates that Liberia's forest reserves can provide up to 3.4 million cubic meters of wood annually; this is equivalent to over 600 GWH of electricity annually. The country has ongoing reforestation programs and this theoretically assures the wood resource as an energy reserve.

II. Consumption of Energy

The consumer list for petroleum products is headed by the mining concessions (mostly for electricity generation) which consume 62 percent of total in the form of fuel oil and diesel, followed by land transport at 15 percent (gasoline), commercial electricity generation of 11 percent (diesel and fuel oil), air transport at nine percent (jet fuel), and the refinery itself uses three percent in the form of fuel gas.

Monrovia's demand for electricity (both petro and hydrogenerated) is such that installed capacity is becoming strained. Illegal hookups and non-payment of electricity bills causes LEC to operate at considerable annual loss.

As a result of escalating prices of petroleum products and electricity, there has been a shift to more traditional sources of energy (charcoal) in urban low-income households. In Monrovia, the average per capita use of wood is 0.4 m^3/annum of which 48 percent is in the form of charcoal. In rural towns, up to 5.5 m^3 of wood per year is used per capita. Of this figure only 0.15 percent is in the form of charcoal. The cost of firewood, charcoal and kerosene for a typical family of five is about $280 per annum, which means that 20 percent of a typical family's budget is spent on energy.

III. Energy Resources

Apart from hydroelectric potential, of which Liberia has a considerable amount, the country has no other conventional resources; there are no known oil deposits or coal. Alternative energy sources are being investigated (wind, solar, biomass) but are not yet being developed.

The country's forest resources are approximately 4.8 million hectares. From this, 3.4 million m^3 of wood could be harvested. Currently the annual use of wood is 236,000 m^3.

Liberia's forest reserves are ample and its offtake is currently limited to logging concessions, shifting agriculture and firewood cutting. Timber concessions operate under agreements which require them to replant logged-over areas. The Forestry Development Authority (FDA) monitors offtake and reforestation. Under the shifting agriculture system which prevails in Liberia, only two percent of all arable land is under cultivation at any given time. The rest lies fallow for up to 12 years in rotation cycle or is virgin land. Fuelwood conservation therefore has not yet become a perceived need; nor is there a movement afoot to improve cook

stoves to make them more fuel efficient. There is a potential problem if wood is to be used in any major way for combustion or lumber since much of the thin tropical soil's fertility is incorporated in the standing crop. If this is not recycled, soil fertility will decrease and deforestation could become a problem.

IV. Government Energy Policy

Liberia's new government is planning programs to benefit the rural farming population and the urban poor. The most pressing immediate issue is the financial stability of the Government. It is concerned with large and rapid development projects. In the energy sector, projects include offshore oil exploration (under IBRD funding), major hydropower development on the St. Paul River and additional studies on the Mano and Cavalla Rivers, and major wood combustion for electricity generation. There are also attempts to collect and analyze data on fossil resources and to develop fuel storage and supply strategies.

In 1978 the Government created the National Energy Commission which has as its operational base the Bureau of Hydrocarbons in the Ministry of Lands, Mines and Energy (Natural Resources). With the encouragement of this commission, government is becoming more sensitized to renewable and alternative energy issues. The Forestry Development Authority (FDA) is experimenting with medium-scale technologies for charcoal production; the University of Liberia's Engineering School is constructing simple flat-plate solar collectors; the Chinese have displayed examples of their micro-hydro technologies and the Germans are being encouraged to participate in a demonstration of wood to wood-waste combustion for electrification in one of their timber concessions.

The cost of the monthly oil import bill and the foreign exchange contortions through which government has to go each month to pay these bills are such that development of expanded hydroelectric generating capacity is one of the most urgent priorities of government.

Unfortunately, there has been little energy planning in most ministries of government. The previous tendency was for the midterm plan to be the sum of the major projects underway. The Ministry of Planning is hoping to change that, but their first priority is to get a second four-year plan financed and implemented. Another institutional problem inherited from the past is the lack of data; this is particularly critical in the energy sector where there is very little information on many of the country's renewable energy resources. This is coupled with a shortage of Liberians trained in several of the fields necessary for planning and implementing these plans.

The newly formed National Energy Commission has as its main task the production of a National Energy Plan. In order to assist this effort, USAID has recently signed a project agreement with the GOL

to make a long term advisor available to work on a National Energy Assessment and help prepare the National Energy Plan.

V. Private Sector Involvement

In the conventional energy sector, private oil companies handle the commercial distribution of refined products from the Government-owned refinery (Shell, Texaco, Mobil, BP and AGIP). The refinery is managed on behalf of Government by a private (US) refinery management company. Since the prices are officially fixed there is little competition among distributors/marketers. The Government-owned LEC generates and distributes electric power throughout the country, except in the three iron ore mining concessions which generate their own electricity from fuel bought from the Government Refinery. A private company (not US) is carrying offshore oil explorations on the Liberian continental shelf under the World Bank funded oil exploration loan.

In the traditional energy sector, private individuals, companies and cooperatives are responsible for making and distributing charcoal, while market women retail the coal in the traditional markets. These are all small-scale undertakings. Firewood production, distribution and marketing are also in private hands. The world's largest rubber plantation (Firestone) is a major source for Monrovia firewood, as they regularly cull old/diseased Hevea trees which are then cut up and sold as cordwood to private distributors and sales outlets. The traditional energy generation process is about as efficient as it can be from a commercial point of view.

Traditional energy use, however, is inefficient and there is considerable scope for private entrepreneurs to develop and market more fuel-efficient wood and charcoal stoves. There are no political or institutional constraints.

VI. Donor Efforts

Germany	Rural Electrification Study Bomi Hills Ctr. (Forestry/Timber) Demonstration Project on Wood Combustion Technical Assistance to Forestry Development Authority Monrovia Power Grid Extension
Netherlands	Wood Processing Industry
European Development Fund	Mano River Union Hydroelectric study UPDEA Electricity Production Training
European Investment Bank	Power Loan to LEC to expand fuel-generated capacity

USAID	LOFA County Mini-Hydro Pilot Project Energy Assessment and Planning Advisor
IBRD	Fourth power loan (LEC-expand fuel generated capacity) Forestry Loan (IDA-Forest Development Authority) Petroleum Development Study
African Development Bank	Feasibility Study for St. Paul Hydroelectric Projects Reforestation Loan
Saudi Fund	Power Loan (LEC-Expand fuel generated capacity)
Badea	Power Loan (LEC-Expand fuel generated capacity)
UNDP	Water Resources Policy, Management, Legislation (TA)

VII. Conclusion

In view of the rising cost of imported oil to meet Liberia's energy needs, and the consequent drain of the nation's foreign exchange, Liberia should place major emphasis on the development of hydroelectric power and on new and renewable energy technologies as part of its rural and urban development programs. A quick review of the energy sector reveals the following:

A. There is no integration of Liberian energy activities into the overall national development planning efforts. This means that non-industrial (rural) areas remain comparatively disadvantaged in energy development.

B. There has never been a complete inventory of Liberia's energy resources, taking into account their potentials, possible development and utilization, as well as the needed manpower in the energy sector. Liberia is largely unaware of the country's energy resource potentials. Therefore alternative energy resource use is low and the necessary technology has not been developed.

C. Liberia relies heavily on imported crude oil (and some refined product) for its energy needs. This constitutes a heavy drain on scarce foreign exchange and affects domestic savings.

D. Liberia has considerable scope for introducing conservation activities, but the population remains unsensitized.

E. Liberia has considerable hydroelectric energy generating

potential, but the public investment cost of major schemes are unaffordably high. Mini-hydro technology is now being tested and many prove cost effective and replicable elsewhere. Wood, charcoal, wind, solar and biomass all present potential sources of additional energy. Their technologies must be developed and utilized.

TABLE I
LIBERIA'S OIL IMPORTS

YEAR	TOTAL CRUDE IN BARRELS	PERCENT INCREASE	COST IN US $M	PERCENT INCREASE
1975	1,498,712	-	48.3	-
1976	1,559,850	4.6	59.5	18.8
1977*	-	-	68.8	15.6
1978	2,904,808	46.6	84.6	29.7
1979	3,807,558	23.7	116.0	37.1
1980	4,927,500	22.7	118.0	1.7

* Refinery not operating because of breakdown/repairs.

TABLE II
LIBERIA'S PETROLEUM IMPORTS FOR 1979

PRODUCT	IMPORT (BARRELS)
Premium Gasoline	159,680
Regular Gasoline	-
Gas Oil	704,101
Jet Fuel	73,331
Asphalt	2,424
Fuel Oil	115,818

TABLE III
ENERGY DEMAND
(000 of Bbl of Crude Oil Equivalent) Annual

DEMAND CATEGORY	TOTAL ENERGY	PERCENT
Direct Heat		
-Industrial	1,905.0*	28.81
-Domestic	2,139.0	32.4
Transport		
-Road	541.4	8.2
-Ship	31.0	.5
-Air	319.7	4.8
Electricity Gen.		
-LEC-Petro	382.8	5.8
-LEC-Hydro	705.5	10.7
-Private	452.0	6.8
Other		
-Naptha	16.4	.2
-Asphalt	19.1	.3
Refinery	95.4	1.4
TOTAL	6,607.3	100.0

* Data on industrial wood use not available; this figure should be larger.

MALI

I. Sources of Energy

A. Conventional Energy

Mali's modern sector is fueled mainly by imported petroleum. No coal is imported and no electricity generated elsewhere is imported. The hydraulic generating capacity at three locations amounts to 50 Kw.

B. Traditional/Renewable Energy

The main sources of traditional energy other than human is biomass in the form of fuelwood and charcoal. The sun has been a renewable energy resource which will probably grow in importance if proper technologies are introduced in the future.

There has been little attempt to produce fuelwood in plantations. Most fuelwood is gathered or cut in the natural forests by either women or by professional cutters. There also exists a small class of professionals who process wood into charcoal. The production of biomass in plantations centers mainly on industrial scale activities using exotic species in the vicinity of Bamako. The total area planted probably does not exceed 2000 ha.

II. Energy Consumption

All petroleum products are imported. For 1979, 182,765 metric tons were consumed (See Table I). Almost all petroleum products are consumed in the urban areas. (See Table II for a breakdown of energy consumption in Bamako). Greatest use of petroleum products is in the transport sector, 69% for 1979. It should be noted also that very little of imported petroleum goes for agricultural activities. The main source of energy for agriculture remains human. The impact of oil imports can be seen in Table III. It has of course, a devastating effect on the balance of payments.

TABLE I
Consumption of Petroleum

Year	MT	% Increase
1973	118,533	-
1974	121,848	2.8
1975	130,085	6.7
1976	140,394	7.9
1977	150,549	7.2
1978	167,980	11.6
1979*	182,765	8.8
1980*	189,410	3.6

* projection
Source: Ministry of Industrial Development

TABLE II
Energy Consumption by Sector in Bamako

	Wood	Electricity	Petroleum Products
Domestic	89%	36.6%	8%
Artisanal	5%	N/A	N/A
Industry	5%	63.4%	21%
Collectivities	1%	N/A	N/A
Transport	N/A	N/A	71%

TABLE III
Volume and Cost of Imported Petroleum Products by Year

Year	Volume M^3	Cost (billions MF)	% of total imports
1974	N/A	7.6	8.8%
1975	147,765	8.6	11.5%
1976	160,614	10.5	14.3%
1977	173,684	14.0	17.9%
1978	187,665	17.0	N/A
1979*	211,760	23.0	N/A
1980*	224,480	35.0	N/A

* estimates
Source: Ministry of Industrial Development

Energy consumption varies from urban to rural environments in Mali. However in both cases domestic energy (for cooking) is supplied overwhelmingly by wood. More wood is consumed by urban dwellers per capita because they have less access to agricultural wastes. Generally one can estimate per capita consumption at between 0.8 and 1.3 m^3 per year. The Forestry Service estimates fuelwood consumption for 1977 to be 539,818 steres. This is an increase of nearly 150% over 1973 consumption.

The overwhelming use of wood for cooking has been the major factor leading to deforestation. The increased unavailability of wood in some areas has lead to fewer cooked meals and the use of dung as fuel. Available data is insufficient to calculate the rate of deforestation, but it is considerable.

III. Energy Resources

A. Conventional Energy

Mali has very little in terms of indigenous conventional energy resources although there is some hydroelectric potential and oil exploration is continuing.

1. Hydroelectric. Present generating capacity amounts to 50 Kw with plans for an additional 250-325 Kw and potential for another 145 Kw. Unfortunately the potential sites,

although they may be technically good sites, are generally far from population centers and industries. In addition some of the sites are on relatively flat land which means that large areas must be flooded to provide power. Although Mali is actively pursuing a hydroelectric policy the future possibilities after the Manantali dam is built are uncertain.

2. Petroleum Products. French and American oil companies are exploring for oil, especially in the northern areas of Mali. Although Mali has not yet produced any oil, rising oil prices and the continued interest of oil companies may mean that some oil may be produced. To date all petroleum products have been imported. Oil shale resources have been known to exist in western Mali since 1945 and in Nara since 1960. They have never been exploited. An estimated 10 billion tons exist with a 10% oil content.

3. Uranium. Good prospects for uranium discovery appear in two sites in Mali and intensive research is being undertaken by the Japanese and French. Uranium, however, should probably not be considered an energy resource for Mali in the short run but as a source of export earnings.

4. Coal. There do not appear to be any significant reserves of coal in Mali.

B. Traditional/Renewable Energy

Mali's traditional nonhuman energy source is wood. Wood accounts for approximately 90% of rural Mali's nonhuman energy consumption. Although deforestation is a major problem the biomass potential in Mali is fairly good. Solar and wind energy are of some potential also.

1. Wind. Limited data exists on the wind regimes in Mali. The northern areas look the most promising but are also the least populated except along the Niger river. In these areas some potential for irrigation and perhaps the production of electricity exists.

2. Solar. The solar energy resource in Mali appears to be very large given the semiarid and arid conditions. However reliable measurements of insolation are not available. These measurements, when available, may show that the percentage of diffuse radiation is relatively high due to dust and other particles in the atmosphere. If this is the case, the potential for using concentrating solar energy systems, which only use direct radiation, may be limited.

3. Biomass. It is extremely difficult to estimate the biomass resource of Mali. The World Bank has estimated that 43% or about 533,200 km^2 of Mali is in rainfall zones where natural forest productivity is estimated at between 50 and 200 $m^2/km/year$. Whatever the resource, it is a clearly diminishing one by most accounts.

   The major causes of deforestation seem to be herding, clearing for agriculture and cutting to satisfy domestic cooking needs. Of these three, the third has the largest effect.

   Natural regeneration cannot keep up with the deforestation rates. Present planting rates do not make up the difference. Hence there is a great awareness on the part of both the GRM and villagers of the need to address this situation. Programs involving improved cookstoves and charcoal conversion processes are being highly promoted and although fairly recent, seem to be gathering momentum.

   The investigation and development of alternative energy technologies, although still in its infancy, is being actively pursued by the GRM. After an unsuccessful experiment with windpower in the late 1950s, several organizations are developing local wind machines and about 50 have been installed. A program of solar water heater production was started several years ago and continues albeit cautiously. Research and development have started on solar drying, solar distillation, biogas and other alternative technologies. A significant number of photovotaic solar pumps have been installed and photovoltaics as a power source for hospitals has also been promoted.

IV. Government Energy Policy

Unfortunately the GRM does not yet have a comprehensive energy policy. Energy matters are being handled in a piecemeal fashion; a parastatal handles electricity; the National Direction of Mines handles oil, coal and gas; the National Direction of Hydraulics and Energy handles hydropower and solar energy; and the Rural Engineering Department handles biomass. However, the new five-year plan calls for the setting up of a National Direction for Energy which would have the mandate for substantial energy planning and coordination.

At this point most broad energy issues are dealt with by the Ministry of Industrial Development. The priorities that they express in conjunction with the Ministry of Plan include the development of hydroelectric power, continued support for petroleum research and the development of renewable energy resources; especially solar. It must be stressed, however, that the GRM is

interested in any kind of outside support for energy activities. In this regard the GRM's relationship with the multinationals is improving and will probably continue to do so.

GRM policy regarding fuelwood and reforestation has undergone a major change in the last few years and appears to be more coherent than the energy policy. In brief, the GRM is prepared to deviate from its long-standing policy of the protection of the natural resource base by the fining of people for illegal hunting, fishing and cutting, and the controlling of these activities through permits. The GRM has realized that in some instances this has been counterproductive and now wishes to create one tree nursery within every county in the country and implement village level forestation activities. This coupled with industrial plantations around the major urban centers is hoped to counteract the deforestation process while the forestry service continues activities oriented towards the preservation of the environment.

In addition, a Forestry Fund has been set up. This allows the Forestry Service to keep its revenues from the sale of the wood and charcoal produced under its auspices and revenues from the sale of permits. Previously these funds were sent back to the National Treasury but now can be used for reforestation efforts.

V. Private Sector Involvement

The involvement of the private sector in the energy sector is extremely limited. In terms of conventional energy, the involvement seems constrained to petroleum exploration by multinationals and the presence of some oil distribution companies who are constrained to sell at the government-set price. At the other end of the scale, private sector artisanal entrepreneurs are involved in the distribution of fuelwood and charcoal and the fabrication of charcoal stoves.

Given Mali's financial constraints, lack of resources and weak technological infrastructure, it is hard to say whether a larger role for the private sector would contribute to a more effective approach to energy problems. Certainly the electricity utility, a parastatal, could be made more efficient and perhaps private involvement could achieve it. If some promising renewable energy technologies are developed, the private sector should be involved in their production. Private entrepreneurs have already expressed a great interest in energy devices but practically no proven devices capable of in-country manufacturers have been developed.

There are political and institutional constraints to private sector involvement. After independence, Mali moved towards the public sector and many state enterprises were created. Although the GRM is moving away from dependence on state enterprises this shift institutionally as well as politically is liable to be cautious.

VI. Mali's Approach to the Energy Problem

The energy crisis in Mali is so severe and the financial situation such that the GRM is forced to continually look to the donors for financing of a whole array of energy projects. The donor community is helping the GRM address its energy problems at all levels. In addition donors are involved heavily in conventional energy, including petroleum exploration and hydroelectric power.

The GRM is making a step towards increasing the effectiveness of its own response by the proposal to set up a new coordinating and planning body. Although opinions vary about the adequacy of the donor response in most energy areas, it meets the ability of the GRM to absorb it. The forestry sector, however, stands out as one area where the donor response has been timid and GRM capacity to absorb assistance has not been reached.

MAURITANIA

I. Background

Mauritania's energy position is weak because of a narrow energy resource base with a heavy dependence on imported petroleum products and rapidly depleting forestry reserves for meeting energy demands. A long-range investment plan for the sector has yet to be prepared and there remain some deficiencies in energy pricing.

Mauritania is the Sahel country most severely affected by drought and environmental degradation. The 400,000 square miles of territory and its 1.6 million people have suffered the effects of diminishing rainfall, crop dessication, soil erosion, and the loss of valuable pasture and agricultural land. Deforestation has been particularly severe.

In times of drought, herders stripped trees for forage when nothing else was available for their animals. An expanding urban population is increasing demands for more fuel. Trees are being exploited for charcoal production without being replaced through reforestation. As more ground cover and protective tree species disappear, soil erosion accelerates and resource productivity declines dramatically. Many sand dunes, which less than a generation ago were stabilized by growth of trees and other vegetation, have been denuded of all protective covering and are moving into agriculturally productive zones.

II. Energy Resources

Forests covering 1,500 square kilometers in the south (or 1.3% of the national territory) are the most important known domestic energy source. Drought and growing over-exploitation have reduced the area along the Senegal river formerly devoted to Gonakier *Acacia nilotica* trees (ideal for producing charcoal) by almost a third from 20,204 hectares before 1970. Protection and reforestation activities will be needed to assure the adequacy and durability of continued charcoal production.

The biomass potential is difficult to tap because of the wide expanse of the country's territory. The total cultivated area is about 140,000 hectares and the goats, sheep, camels and other animals number about 4.0 million UBT. Wind energy is potentially significant since the wind velocity along the coast and in a few interior regions often exceeds five meters per second, but a couple of trials during the 1950's failed because of improper maintenance. Three stations are now performing an evaluation of wind energy potential in Aleg, Mederdra and Keur Massene in the southern part of the country and an aerogenerator has been set up in the national coastal park, with a rated power of one kilowatt. With 3,000 hours of sunlight per year, the potential for solar energy is great and is being tested in several sites. A one-kilowatt solar pump, a Rankihe thermodynamic system with a capacity of 50 cubic meters per day, has been installed at Chinguetti. A 12 kw pump, financed by a grant of $500,000 from the European Development Fund, has also been

installed to provide irrigation for a rice field of 22 hectares, located along the Senegal river. This pump has a capacity of 200 cubic meters per day.

There has also been installed at N'Taket a one peak kilowatt photovoltaic-powered pump with a capacity of 25-30 cubic meters per day. During the early 1960's, a desalinization plant was installed in Nouakchott, but the technology was not well adapted, and the plant was abandoned when an abundant fresh water source was found by Chinese experts in 1962, some 40 kilometers east. A UNDP-funded feasibility study is evaluating the prospects of small solar stills to help solve the water supply problem for fishermen along the sea coast.

Hydropower potential exists along the Senegal river, some 500 kilometers away from the major load center. Mauritania is considering participating in the Manantali dam scheme - on the Mali frontier - but serious questions need to be resolved about its timing and economic viability. Minor hydrocarbon shows have been encountered on- and offshore, but more exploration is needed to assess the country's potential.

The World Bank is assisting the Mauritanian government's efforts to induce multinational firms to participate in intensified hydrocarbon exploration and such efforts have already led to a couple of contract signings and other expressions of serious interest on the part of multinational firms. The other area where private enterprise is significantly involved is in the production and distribution of wood and charcoal with several hundred private entrepreneurs.

III. Energy Consumption

Overall energy consumption was estimated at 320,000 tons of oil equivalent in 1979 or 207 kilograms per capita. Imported petroleum products account for 40% of overall energy consumption and wood and charcoal for 60%. Electricity use, some 106 kwh in 1979, is equivalent to about 16% of final energy use. Generation is based entirely on small diesel units with an installed capacity totalling about 60 Mw, of which about 25% is captive.

The domestic consumption of petroleum products was about 137,000 tons in 1980. Demand increased during the period 1971-1977 by about 3.5% per annum. In 1978-1979, demand fell by nearly 15% per annum because of the closure of a copper mine and Mauritania's withdrawal from the Western Sahara war, but in 1980, demand resumed its growth at 5.6% per annum. Gas oil is by far the most important product, accounting in 1979 for over 70% of petroleum product consumption. Among end-users of petroleum products, transportation accounts for 48%, mining and industry 31%, power generation 19% and residential/commercial use 2%. While the cost of petroleum product imports averaged $20-25 million per year over the 1975-1978 period, this cost jumped to $37 million in 1979 and perhaps $56 million in 1980 (or 25% of Mauritania's export earnings).

The total removals of wood during 1980 for such uses as cooking wood, charcoal, timber poles, housing, fencing and nets was about 730,000 tons. Some 700,000 tons was used for cooking purposes alone, divided into 300,000 tons of firewood and 79,000 tons of charcoal (the wood equivalent of 395,000 tons).

IV. Future Prospects and Governmental Policies

Energy-related investment for the 1981-85 period is expected to amount to $75 million, mostly financed by foreign aid. About 80% of the investments will be in the power sector where projects underway include the installation of 32 MW of additional diesel-based generating capacity (financed by French assistance) in Nouakchott and new units at the Guelbs iron mines (partially financed by the World Bank). These investments together with other increases in energy consumption could boost the cost of imported petroleum to over $100 million annually by 1985. The main demand stimulant is the new units at the Guelbs iron mines. While the purity of the iron in the present mines is 65%, in the new mines it is only 35%. The consumption of fuel at the mines will accordingly more than triple from the present 37,000 tons annually to 124,000 tons. The ability of Mauritania to meet this much higher petroleum import bill is contingent upon a more favorable movement in iron ore export prices than has occurred during the last several years and on such other developments as much more intensive exploitation and local benefits from fisheries. The dilemma for Mauritania's economy is that iron ore exploitation presently yields 85% of the country's foreign exchange export earnings and constitutes 13% of the country's GDP; the loss of iron ore production would therefore be serious for the economy.

The GIRM is acutely aware of the environmental and energy problems facing the country. In August 1980, the GIRM Council of Ministers approved and fully endorsed a national strategy for desertification control which deals with three related sectors: forestry and ecology, agriculture and water management, and livestock and pastoralism. Actions to improve the efficiency of woodstoves and charcoal production and the effective management of forest resources are included in the proposed steps to implement this strategy. The GIRM appeal for donor support has been particularly insistent on broad action programs consistent with an integrated approach to questions of resource management which will affect traditional fuel sources.

The prospects for meeting local cooking needs are brighter. The consumption of wood for cooking purposes is calculated to rise to 1.35 million tons by 2,000. On the other hand, rational production from Mauritania's forests could yield more than three million tons of wood presently on a sustainable basis. If the planned measures of protection and reforestation are implemented successfully, exhaustion of Mauritania's forests will be prevented and sufficient wood made available for all of Mauritania's cooking fuel and other consumption needs for many years to come. A major corollary benefit would be maintenance of a significant defensive barrier

against soil erosion and creeping sand encroachment. UNSO and USAID are the lead donors in the on going efforts at forest regeneration, costing several million dollars.

A principal feature of these activities is localized training activities to promote local participation in resource management and to involve lower-level personnel of the Environment Protection Service to re-orient the staff from a repressive role to one of outreach and extension.

A planning unit is to be established and energy studies launched so that the government will be in a position to elaborate and implement the national resource management strategy and to develop appropriate energy policies.

The Directorate of Mines and Geology of the Ministry of Mines and Energy is in charge of hydrocarbon exploration and supply while that Ministry's Energy Unit is in charge of renewable energy and energy planning. The Environment Protection Service of the Ministry of Rural Development is responsible for forestry and pasture management and the Ministry of Water and Housing supervises the State Power and Water Utility Company, SONELEC, a parastatal organization. The policy making process has been hampered by a poor data base, insufficient staffing of the agencies in charge and inadequate communication among concerned ministries.

Fuel prices in the aggregate reflect total costs, although there is a proliferation of preferential prices for government entities, fishing vessels and several other favored users. For example, the retail prices of kerosene and gas oil are 30% and 17% less, respectively, than the gasoline retail preice even though their CIF import prices are higher than that of gasoline. Electricity tariffs were raised in November to the equivalent of 22 to 26¢ per kwh in a major step to stem the massive losses which had reached $2.5 million in 1980. The costs of wood and charcoal (17¢ per kilogram for the latter are also officially controlled at artificially low levels.

When the GIRM completes its recently initiated comprehensive studies complementing the national resource management strategy and the formulation of energy policies and development priorities, a long-range investment plan for the energy and forestry sectors can be prepared. Environmental degradation has already proceeded so far and the local energy deficit become so great that substantial donor assistance will be needed to help Mauritania achieve the goals of this long-range investment plan.

NIGER

I. Energy Sources

In Niger, firewood accounts for 85% of the rural and urban energy sources and is used mainly fr cooking and heating. Butane gas is next; 250 tons of gas were imported in 1972 and 500 tons in 1979. The total amount of gas used is relatively small and much of what is used is for commercial and industrial purposes. Kerosene, electricity and charcoal are also used in small quantities for cooking.

Most of the firewood gatherers are individual merchants who buy firewood from farmers and laborers. There are very few collective activities in regards to firewood gathering. All of the commercial firewood is transported by trucks, camels, and donkeys.

The GON Forest Service has very little control over the sale of firewood. Merchants are supposed to buy permits at 35 FCFA/stere which is way out of line with regards to what a stere sells for on the open market (approximately 5,000 FCFA in Niamey). This price is rising at approximately 6% per year.

II. Firewood Consumption and Deforestation

Total fuelwood consumption for 1980 was 3.9 million cubic meters (1.8 million tons). This figure greatly exceeds the exploitable average annual increment of exploitable natural forest which is 2.0 million cubic meters per year (.4 m^3/hectare/year x 5 million hectares).

Estimates of between 60,000 (CILSS 1981) and 80,000 (Lanly 1980) hectares of firewood capital are lost each year through cutting. A combination of overcutting, overgrazing, drought and other ecological disturbances (termites, rodents, etc.) have resulted in a severe decrease of the country's biomass in certain regions. The USAID Forestry Land Use and Planning Project (683-0230) is currently studying deforestation by comparing aerial photos from as early as 1955 with photos taken in 1979. Certain areas that show once to have been uniform areas of dense vegetation and trees are now severely degraded "brouse tigree", composed mainly of Combretum-type species. We feel that overgrazing is a more important factor in soil degradation than wood cutting. It is forbidden to cut live wood for selling purposes, and although this law is not strictly adhered to, there is not much evidence of live trees being cut in the particular forest that we studied. There was, however, much evidence of heavy grazing pressure and termite activity which seems to have "opened" the forest to the patchy vegetative type which is now present.

Very little study has been done in Niger with regards to biomass loss or exact causes of this loss from an ecological standpoint. The present weight of firewood (biomass forest resources) is estimated at approximately 3,024,000,000 kg. (average 1440 kg/hectare x 2,100,000 natural forests).

Land clearance for agriculture can be a problem and is also a function of the methods used to clear and plant. Much of the agriculture carried out in the northern pastoral zone causes very little physical-mechanical disturbance of the soil (little or no tillage). This type of planting has little effect on the habitat even in relatively dry years. More intensive cultivation on marginal lands does, however, seem to reduce habitat potential and increases the chances of desertification (especially if this is done in a particularly dry year).

Agriculture can in some cases be of benefit to the habitat as it cuts down on overgrazing (an effect that is evident in most of the National Forests where agriculture is forbidden).

III. Natural Regeneration and Plantation Versus Utilization

According to a recent CILSS report the total projected firewood potential of Niger (plantations and natural) by the year 2,000 will be approximately 5,802,500 steres/year, and the total firewood needs will be 14,510,000 steres/year. These figures are approximate however, and recent production-oriented sampling in areas previously thought of as "useless brush" are showing a much higher potential than the 0.5-1.5 steres/hectare/year generally accepted for natural vegetation production. Example: The area around Niamey has been cited as being "completely wiped out" through overcutting, overgrazing, etc. Recent trials in a National Forest only 22 kms from Niamey have shown as many as 30 steres/hectare of Combretum which is the main firewood species for Niamey. A fenced plot of Combretum was cut in 1974 and grew to maturity within 4 years. These vast stands of "useless brush" could provide alot more than 0.5-1.5 steres/ha/year if managed properly on a selective coppice sustained-yield rotation with some site improvement work done where the deterioration is worse. If nothing is done with these forests they will continue to deteriorate beyond the point of repair, but fenced-in plots indicate that with proper protection they can still be salvaged.

Figures for production yields on dry and irrigated plantation are not available. The irrigated plantation installed by the 1st Phase of the World Bank Forestry Project are costing more than $6,000/hectare. Plantations in general do not seem to be succeeding in Niger and have actually done more harm than good in areas where National Forests have been bulldozed to plant fast growing exotics.

IV. Fuelwood Conservation

Experiments are being carried out in Niger with solar cookers and solar hot water heaters. The hot water heaters seem to be more successful than the solar cookers which are clumsy and not adapted to the Nigerien kitchen.

Woodstoves are being experimented with and have shown themselves to work although certain technical, social, and economic problems

still remain to be resolved. The Church World Service has been working with the Women's Association of Niger to produce, distribute, and evaluate the performance of several models of woodstoves which have worked already in Niger and in Upper Volta. The 2nd Phase of the World Bank Forestry Project will also be studying the social and economic factors relevant to woodstove development.

V. Role of GON Regarding Fuelwood and Reforestation

The GON's policy regarding fuelwood and reforestation is very loose ended. The Director of the Nigerien Forest Service depends on reports and advice from CILSS and other donors in formulating policy. The USAID Forestry Land Use and Planning Project will produce a 20 year plan for the Forest Service. In the meantime however, the main objectives of the GON Forest Service are the following:

A. Increase fuelwood supply by managing natural forests, planting irrigated plantations of fast growing exotics, and planting rainfed plantations of fast growing exotics.

B. Encourage the local populations to plant trees in village woodlots and mini-nurseries run by family units or individuals.

C. Improve the quality of the Forest Service with more and better personnel through long-term education, recycling schools, seminars, etc.

The GON Forest Service has always been hampered by political and institutional constraints. This situation is gradually changing and the President recently delivered several major speeches on desertification and deforestation.

VI. Role of the Donor Community in Fuelwood and Reforestation

The following are a list of the ongoing forestry projects in Niger:

A. World Bank Forestry Project: 1st Phase, 1978-1981, $4.5 million; The 2nd Phase (1982, approximately $16 million). The program consists of irrigated tree plantations, rainfed tree plantations, education, research, extension work, fire and erosion control.

B. USAID Forestry Land Use and Planning Project (683-0230), 1980-1984 for approximately $4 million. The program has four main sections of activity; model sites (research and applied forestry techniques applicable to the rest of Niger), human resources (education, recycling programs, extension, seminars, etc.), resource inventory (aerial photography, mapping, Landsat imagery), and the creation of a documentation center.

C. UNSO-Greenbelt, around Niamey, 1981-1983, $184,500.

D. D.D.A. (Swiss) Management of ronier in the Dallol Maouri - 1981-1983 for $900,000.

E. D.D.A. Management around wells in pastoral zone - 1981-1983 for $736-000.

F. F.A.C. Acacia Albida Project in Dosso - 1981-1985 for $400,000.

G. C.A.R.E. Reforestation in the arrondissement of Bouza - 1976-1981 for $725,000. Program is to stabilize sand dunes, fix river banks in Bouza, and create Windbreaks in Majjia Valley. (Note: The windbreak activity has been cited as one of the most successful forestry projects in the Sahel. The final analysis is that 6% of land was taken out of production for the windbreaks and a net gain of 23% in the production of millet was recorded on land between the windbreaks versus land without windbreaks. See Report by Els-Bogneheau, 1980, Majjia Valley Windbreak Study).

H. C.R.D.I.: Village Woodlots in Zinder, - 1981-1983 for $141,200.00.

I. F.E.D.: - 1973-1981, "3M" Development Project in Zinder, for $142,000. Program is village woodlots, live fencing, windbreaks and rainfed plantations.

J. C.A.R.E. Small gardens and live fencing project at Balleyara for $120,000.00. Program is to diversify agriculture in small gardens and protect gardens with the fencing.

The USAID Forestry Land Use and Planning Project is doing an evaluation of all past and ongoing forestry related projects. The results of this evaluation show very few projects have succeeded due to lack of attention to socioeconomic factors and poor practice of basic Sahelian forestry techniques. Village woodlots show little promise in Niger, and work with families and individuals has proven to be better suited to Nigerien ways. Irrigated plantations are too costly, and to take land out of agriculture for dryland plantations or to plow up natural vegetation in favor of rainfed plantations has failed more often than not. In general, donors seem to place too much emphasis on costly fast growing exotic species plantations and too little emphasis on the potential that exists in the natural forests.

RWANDA*

I. Introduction

The two major sources of energy currently supplying Rwanda's needs are hydroelectric power and fuelwood. The former supplies a very limited market, including industries, the administrative and service sector, and a relatively small number of urban consumers. The degree of market concentration for electricity is illustrated by the number subscribers - approximately 4,500 out of a total country population of 5 million. Although the distribution network has been considerably extended in the past 3 years, and further extensions are planned, the dispersed settlement pattern in conjunction with low rural incomes will prevent widespread domestic use of electric power for many years to come.

Forecasts of electrical energy requirements indicate that there will be an adequate margin between supply and demand if the new power stations - Mukungwa, Ruzizi II and eventually, Rusumo, come into production as scheduled. The future supply and demand balance could be upset by large-scale industrial development arising from the exploitation of methane gas in Lake Kivu. According to present Government policy, the proposed heavy industries will be obliged to fulfill their energy requirements by the use of hydroelectric power. If this policy is maintained and enforced, demand forecasts will have to be revised and a strategy developed to satisfy the increased requirements.

A far more widely used source of energy is fuelwood, which is employed by over 90% of the population, mainly for cooking but also for heating in high altitudes. According to recent surveys supplies of fuelwood are rapidly diminishing, despite efforts by the Government and agricultural projects to engage in reforestation. While these efforts may prevent a deterioration in the situation, it is not likely to undergo a dramatic improvement since a growing population is requiring more and more land to cultivate food crops.

Dwindling fuelwood supplies in Bugesera will have a particularly marked effect on the supply of charcoal, which is produced in that region. It is planned to market peat as a substitute for charcoal, which is presently used by approximately 95% of the population of Kigali, in addition to consumers in other urban areas.

Two potential new energy sources, methane gas and peat, are at relatively early stages of development and many uncertainties exist regarding their exploitation and use. Three peat marshes are presently being exploited in Rwanda on a small scale. Two of these marshes are drainable and the technology for extracting the peat is fairly straightforward. The peat produced is used industrially for pyrethrum drying and cement production. A third marsh, Busoro, in

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* Adapted from a paper prepared for AID/Rwanda by Mary Reintsma, August 1981.

southern Rwanda is not drainable and the Ministry of Natural Resources is presently undertaking experiments to find the most appropriate technology for extraction of the peat. The Ministry intends to establish a Peat Office to administer the commercialization of peat for domestic use and a consumer education program is underway to facilitate this.

II. Imported Fuels

The economic viability of developing Rwanda's internal energy resources depends partially on the availability and costs of alternative imported fuels. The rapidly increasing bill for imports, particularly gasoline, diesel and kerosene, is already placing a considerable burden on the meager national budget, and the situation threatens to deteriorate.

In absolute terms, the costs of imports of these fuels has risen almost 300% in the past five years; 10 million in 1976 to $28 million in 1980. The bill for gasoline and diesel imports alone has risen by 2,500% over the past ten years; $1 million in 1970, to $25 million in 1980.

Of even more significance than the absolute increase in the cost of fuel imports is the relative increase vis-a-vis export earnings. For instance, in 1976, 12.0% of export earnings went to purchase imported fuels, while in 1980 the corresponding figure was 37.5%. The pertinent data is summarized in Table I.

TABLE
Imported Fuels *
Total Value as % of Total Imports and Exports

Year	Tons	Value (million RWF)	% of Total Imports	% of Total Exports
1976	34,071	948.9	10.1	12.0
1977	32,585	947.9	8.9	9.4
1978	37,911	1,210.5	7.2	14.9
1979	38,323	1,705.6	9.4	15.3
1980	43,049	2,535.6	11.5	37.5

* includes gasoline, diesel and kerosene; no aviation fuels
Sources: Ministry of Finance
Ministry of Plan, Statistics Bulletin No. 60.

III. Fuelwood and Charcoal

A. Introduction

In Rwanda, wood is the most widely used source of energy for domestic purposes. Its primary use is for cooking, although it is also used for heating in high altitudes.

B. Supply and Demand

The supply of fuelwood in 1977 was estimated as between 100-130,000 hectares of natural forest, and 25-26,000 hectares of planted woodlots. 1/ The forested area is mainly comprised of the Gishwati and Nyungwe natural forests which, according to MINAGRI statistics, declined in area from 162,000 hectares in 1957 to 130,000 hectares in 1977, i.e. 1600 hectares per annum.

A third area of natural woodland is located in Bugesera in southern Rwanda. This has been a major charcoal producing area, supplying Kigali and other urban markets. However, in two of the three Bugesera communes the wooded area has been almost completely destroyed and in the third it is rapidly becoming depleted.

Of the planted woodlands, the vast majority, amounting to 60 to 70% of the total area, is owned by communes. A further 15 to 20% belongs to individuals or private groups, 10% is state land, and 2% is roadside planting. The commune woodlands are made up of approximately 5,000 lots, of which 2,300 are smaller than two hectares and only about 500 are over 10 hectares.

The rapid diminution in the area of wooded land, particularly in Bugesera and the Nyungwe and Gishwati forests indicates that the demand for wood far exceeds the supply available through natural regeneration. This contention is supported by recent estimates that demand per person (1 m^3) is equal to the natural regeneration rate of .1 hectare, while actual forested area is .04 hectare per person. In other words, the forested area is equal to only 40% of the area which would be required to fulfill the demand by natural regeneration.

C. Charcoal

A relatively large component of the total demand for wood is derived from the Kigali charcoal market. It has been estimated that the annual consumption of charcoal in Kigali is 63,000 sacks (of approx. 50-60 kg.) for which 780 hectares must be deforested. Most of this wood comes from the Bugesera reserve. According to a recent survey, 95% of Kigali households use charcoal for cooking. There is also a fairly high industrial demand for charcoal to be used in processes such as firing bricks and tiles and in traditional forges. It is preferable to fuelwood because of its higher calorific value and because it produces less smoke and cinders.

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1 WB study - 100,000 ha forest and 26,000 planted woodlots.
MINAGRI - 130,000 ha forest, 25,000 planted.

The deforestation of the Bugesera region to provide charcoal for Kigali and other urban markets was exacerbated by immigration into the region and consequent burning of large tracts to clear land, eradicate tse-tse flies, and generate new growth for livestock grazing. The rate of influx of settlers into the region is reflected in the change of population density from 20 persons per km^2 in 1960 to 120 persons per km^2 in 1978.

D. GOR Policy

In recent years, the government has attempted to implement a forestry management policy which takes into account the state, communal and private woodlots, as well as the natural forests. At the National level the administrative responsibility for forestry development lies with the Department of Water and Forests in the Ministry of Agriculture, while at the commune level agronomists are responsible for the technical aspects of forestry resource development and the bourgmaster has administrative authority over commune woodlots.

In the natural forests there has been a drive to replant areas between the actual boundaries of the forested area and the official boundaries. Both in the natural forests and in the state woodlands, guards are employed by the government to control cutting activities.

E. Contribution of Aid Agencies

Many of the organised forestry activities are being undertaken by foreign aid projects. The first such project was the Swiss-financed Pilot Forestry project in Kibuye. Started in 1967, this project incorporated training, research, extension work and reforestation in Kibuye prefecture and on the borders of the Nyungwe forest. By early 1980, 2,250 hectares had been reforested.

The FAO Agricultural Intensification Project in Gikongoro aims to replant 750 hectares per annum; 1268 were planted between 1977-1979.

A large reforestation program was implemented by the Nyabisindu agro-pastoral project, financed by Germany. Between 1975 and 1978 a total of 4,200 hectares were planted, of which 145 were fruit trees.

The BGM project in Bugesera planted approximately 870 hectares between 1977-1979.

Future projects include: reforestation of the Gishwati forest with 5,000 hectares of pine and 5,000 hectares of eucalyptus, financed by the World Bank: reforestation of 5,000 hectares

in Kigali prefecture and 3,000 hectares in Butare, also financed by the World Bank: reforestation of 1,000 hectares, bordering on Nyungwe, financed by Belgium; and projects on the Zaire-Nile crest financed by FED.

IV. Hydroelectric Power

A. Introduction

Hydroelectric power is the primary source of energy for Rwanda's industries, administrative sector and a small part of the urban population. Although hydropower has been exploited since the 1950's, it is only recently that the network has been extended to include most of the major towns. Production is increasing at an average 10 to 13% per annum - a trend which is likely to continue for at least the next decade in view of the fact that imported substitutes (e.g. diesel) are extremely expensive, and local substitutes such as methane gas or solar energy are still at a very early stage of development.

B. Production

The majority of Rwanda's hydroelectric power is presently supplied by two main stations, with a third to open in late 1981. By far the largest supplier in 1980 was Ruzizi I, jointly owned by Rwanda, Burundi and Zaire, (28.2 MW) which satisfied 66.5% of Rwanda's total consumption. This plant is located 5 km from Lake Kivu on the frontier with Zaire, and supplies the Katana region of Zaire as well as Rwanda.

The second major supplier is the Ntaruka station (11.25 MW) between Lake Ruhondo and Lake Bulera in Ruhengeri. In 1980, 30% of Rwanda's total consumption came from here. This station reached maximum capacity in 1969 and due to a decline in the level of Lake Bulera annual production has since decreased. A twin station to Ntaruka, Mukungawa, which will have an estimated annual out put of 48 GWH, over twice that of Ntaruka, is almost completed on Lake Ruhondo and will open in late 1981.

Several smaller stations complete the inventory. The Gisenyi hydroelectric station which began production in 1958 was out of operation during 1979 and a part of 1980 but reopened in December 1980 and will produce about 6 GWH in 1981.

This station supplies the town of Gisenyi, the Nyundo mission and Bralirwa, as well as part of the town of Goma in Zaire. Two other plants, one near Ruhengeri and one near Gisenyi, are privately owned and have very low production levels.

C. Distribution

The present distribution system relies on two high-tension lines; one (123 km) from Ntaruka to Kigali and into the mines of Rutongo, Musha, Rwinkwavu and Bugarama, and the other, (185 km) linking Ruzizi with Kigali. Several medium-tension lines extend this network to major urban centers. On the Ruzizi-Kigali line there is a link from Kigoma to Butare and Gikongoro, and another from Kigoma to Gitarama & Gatumba. There are several shorter MT lines linking Ruhengeri, Kibuye, Ngoma, Byumba & Mulindi with the HT network. Thus eight of the 10 major towns (prefectural centers) are supplied by this system. Gisenyi has its own station, and a MT line linking it to Ruhengeri is planned. Kibungo is presently supplied by diesel-generated power, but Belgian funding has been obtained for a MT line linking it with the major HT network.

D. Present Supply and Demand

The potential and actual supply (in GWH) of hydropower available to Rwanda in 1980 is shown in Table II:

TABLE II
Supply of Hydroelectric Power

Source	Potential Supply	Actual Supply
Ruzizi I	53[1]	44.8
Ntaruka	22	20.5
Gisenyi	5.4	.7[2]
	80.4	66.0[3]

Notes: 1 Total production is 160; Rwanda, Burundi and Zaire are each entitled to share equally.
2 Out of operation during part of 1980.
3 An additional 1.4 Kwh supplied by diesel brings 1980 total production to 67.4.

Source: Ministry of Natural Resources, Water and Energy Section, 3rd 5-year Plan, June 1981.

Effective demand for electricity is heavily concentrated geographically and sectorally. Major consumers include the mines and tea factories, the service sector (administration buildings and hospitals) infrastructure (radio relay station, roads & airport) and private consumers in Kigali. (Kigali consumption is approximately 65% of total consumption in the country.)

E. Future Supply and Demand

The production and annual rate of increase over the past 5 years is shown in Table III.

TABLE III
PRODUCTION AND ANNUAL RATE OF INCREASE
IN HYDROPOWER 1976-1980

	1976	1977	1978	1979	1980
Prod. (GWH)	40.4	45.7	48.4	53.3	59.6
Rate of Inc. (%)		13%	5.8%	10.2%	11.7%

Assuming an annual increase in demand for energy of 11.7%, the needs over the next year will be as follows:

	1980	1981	1982	1983	1984	1985	1986
Demand (GWH)	59.6	66.6	74.4	83.1	92.2	103	115

The present supply of 80 GWH will be increased at the end of 1981 by the new station at Mukungwa (12 MW) which will have a potential annual output of 45 GWH, thus increasing the total supply to 125.4 GWH. Allowing for 10% loss in transmission and distribution this will be insufficient by 1986.

Total supply will be further increased by Ruzizi II, which should be operational in 1985. Annual output is estimated at 140-200 GWH. This power station will supply Zaire as well as Rwanda and will be managed along with Ruzizi I by a yet-to-be formed power board consisting of representatives of the countries concerned.

Also planned to start production in 1985 is the Gihira station (Gisenyi II) with an estimated output of 15 GWH per year. The other major new source of energy is Rusomo on the Tanzanian border, planned to come into production in the 1990's with a capacity of 100 MW.

F. Small Hydropower Schemes

The potential exists for the development of small hydropower schemes. Four sites have been considered economically feasible by the 1980 Klock report. All the sites are located in western, or southwestern Rwanda in the Zaire-Nile crest where rainfall is high and where suitable waterfalls exist.

The smallest, Nkora site (1.0 MW) has a hydropower station which is at present in a state of disrepair, but which can be made functional by a relatively minor investment ($10,000-$15,000). The construction costs of the other three stations Akanyaru II (2.7 MW) Karundure (2.5 MW) and Kamiranzovu (1.1 MW) are estimated at $3.7 million, $2.4 million, and $1.6 to 2.2 million respectively, including the cost of transmission lines. A study presently being undertaken by Swiss aid is examining the question of small hydropower schemes should be available in April 1982.

G. Donors

FED has been the principal donor ($16 million) partially financing the Mukungwa station and a number of HT & MT lines and studies. The BADEA ($9 million) has also financed equipment for Mukungwa, Swiss, German and Belgian aid have financed studies & extensions of the distribution network.

Other interested donors include the BAD, and French aid. A meeting is scheduled for early 1982 at which it is hoped firm commitment will be made by donors to finance the extension of the present distribution network.

H. GOR Policy

The development of hydropower resources including planning, financing, and policy considerations is the responsibility of the Ministry of Natural Resources. The actual management and maintenence of installed stations is performed by the parastatal "electrogaz".

The exploitation of hydroelectric power is strongly supported by the Government. In the past, priority was given to the construction of large power plants, but more recently the Government has expressed a desire to develop smaller hydropower plants serving local needs. As far as distribution is concerned, proposals have been drawn up by the Government for approximately 30 new MT extension lines for which financing is being sought.

GOR policy regarding power to be used for industries related to the methane gas in Lake Kivu, could have a profound effect on the energy situation. Official policy is that the heavy industries envisioned, e.g. production of urea fertilizer or methanol, which have high energy demands, must use hydroelectric power for the transformation processes. If these industries are developed in the next 5 to 10 years there could be problems ensuring adequate energy supplies.

V. Methane Gas

A. Introduction

Since the discovery of methane gas in Lake Kivu in 1936, a large number of scientific and technical studies have been carried out with financing from Belgium, Germany, the U.N. (UNIDO) and the U.S. (Woods Hole Oceanographic Institute). These studies indicate the existence of 50 to 60,000 million cubic meters of methane gas, at depths of approximately 300 to 500 meters, in water which, though warmer than surface water, is more dense due to a high level of salinity. There is no conclusive evidence of the origin of the gas, though it is generally believed to result from biological rather than chemical activity, and to be renewable.

B. Exploitation of the Resource

The only existing project is a small extraction plant, built by Belgium in 1962, at Cap Rubona, 8 km southeast of Gisenyi. This was originally intended to be a 5-year pilot project, but actually functioned for 10 years relatively efficiently and for another 2 to 4 years intermittently. Since 1977 it has been under repair (with U.N. financing) and it is due to reopen in December 1981.

The degassed, but otherwise untreated saline waters are returned to the surface of the lake. The gas, which is then composed of 24.9% methane (CH_4) and 73.5% carbon dioxide (CO_2) as well as some inert gases, is purified, mainly by removal of the CO_2 to a 70 to 80% methane content. Water used in this process and containing the excess CO_2 flows onto the surface of the lake. The ecological effects of this are unknown.

C. Uses of the Resource

At present the methane gas is only used to provide power for the Bralirwa brewery in Gisenyi. The gas is compressed at Cap Rubona and pumped through a 3-km pipeline to the brewery. Two other potential users of methane gas are located in Zaire. The first is the Katana Cement factory which has not been functioning since 1962, but if renovated and reopened could absorb up to 16 million m^3 of gas per year with 80% methane content. The second potential user is the Pharmakina (quinine treatment) enterprise at Bukavu which would take 375 to 600,000 m^3 per year.

D. Donor Agency Contributions

Several countries are presently interested in implementing projects to extract and transform methane gas.

Belgium has completed a pre-feasibility study on a methanol plant and is planning to provide 25% financing for a $50,000,000 plant to extract and transform methane gas into methanol. The proposed capacity of this plant (30 million m^3 per year) will be 15 times greater than the existing Cap Rubona plant. It is estimated that the price of methanol will be competitive with that of peat.

The U.N., in addition to financing and supervising the renovation of the Cap Rubona gas extraction plant, is presently studying a project to dry the residue of malt and yeast from the Bralirwa brewery in order to produce animal feed. This project would be financed by UNCDF and supervised by FAO technical assistance. The animal feed produced would satisfy 80% of the total food needs of the FAO livestock breeding project at Kabuye. The major cost of this project is derived from the high energy requirements to dry the brewery

wastes which have an initial 80% water content. AIDR is studying the possibility of using methanol for this process.

The FED has also financed studies and plans a small project to compress gas (for possible use on motor cars in the Gisenyi area) in 1982 and a urea factory in Gisenyi in 1986.

E. GOR Policy

The Government of Rwanda and Zaire have formed a "Societe Mixte" for the exploitation of methane gas. An agreement was reached in 1978 that 47.2% of production would belong to Rwanda, and 52.8% to Zaire.

VI. Peat

A. Introduction

It is estimated that peat reserves of from 5 to 50 million tons exist in Rwanda, of which 10% are believed to be of high quality. Peat was first used in Rwanda in the 1960's, when the Gishoma marsh (located in the extreme south west of the country) was exploited to provide peat for the Katana cement factory in Zaire. When the cement factory closed, peat extraction was terminated. Since 1974, peat from the Cyabaralika marsh in Ruhengeri has been used by OPYRWA for drying pyrethrum. Peat from Kiguhu marsh in Ruhengeri is presently used in the Belgian Project - pouzzolanes-chaux-tourbe (PPCT), which will produce cement using volcanic material. The most recent peat bog to be exploited is that of Busoro in southern Rwanda, where a pilot extraction project is being undertaken.

B. Formation

In Rwanda, the marshes in which the peat is found are located in the bottom of river valleys at various altitudes and with areas of from a few hectares to several dozen square kilometers. Since these marshes are stream fed they contain impurities and the peat is generally of low quality.

C. Exploitation

Peat is extracted manually, with drainage of the marshes in Cyabaralika and Kiguhu, and without drainage in Busoro. Where drainage is necessary main and lateral drains are first excavated and peat is cut from the sides of the lateral drains and deposited beside them for partial drying. It is then transported to the drying area, dried, turned, and stacked in piles. The excavation normally takes place at the time of year when the water level is lowest. The rate of production depends on the size of the drying area and the rate of drying, which in turn depends on climatic conditions. A similar

process is followed where drainage is not required or not possible. The main difference is the absence of drainage structures. In Busoro geological conditions do not permit drainage of the marsh, making exploitation extremely difficult.

The quality of peat extracted manually is inferior to that which would be obtained by a mechanized or semi-mechanized process. However, this must be weighed against the problems inherent in importing, setting up and maintaining equipment. Only where the peat is beneath several meters of water is mechanization essential.

Peat of high quality (i.e. with low ash and moisture content) may be transformed into coke, which has a higher calorific value. This product would be important primarily for industrial uses, since dried peat as such is adequate for domestic purposes.

D. Donor Involvment

Three donors have been involved in the development of this resource: Ireland, Belgium and the UN (UNIDO).

Following two 1978 reports by a UNIDO consultant, an agreement was reached in early 1980 between the Rwandan Ministry of Natural Resources and the Irish Foreign Ministry to implement the first phase of a peat exploitation project. This consisted of investigating posible peat production areas, evaluating the quality of the peat by laboratory analysis, and implementing a pilot exploitation to test techniques and produce a preliminary 1,000 tons of dry peat.

As a result of this agreement, a survey was undertaken, starting in the environs of Kigali, particularly the Nyabarongo and Akanyaru valleys. The nearest site to Kigali suitable for exploitation was found to be Butaro marsh, on which some trials had been made by the Ministry of Natural Resources in 1979. During 1980, only 150 tons of sod peat were obtained, due to technical difficultues in exploiting the peat. The production cost of this peat was estimated as 1,050 Frw per dry ton, on the basis of labor costs of 100 Frw per 8 hour day. In 1981 it was planned to produce 500 tons of peat from Busoro between mid July and the end of October by using a semi-automatic machine for macerating the peat. The production target for 1982 is 1,000 tons.

Belgian aid produced a report on the exploitation of peat in 1980 and is interested in contributing to the development of the resource at the preparatory stages, - identification of reserves and sampling and analysis of peat. They also intend to use the peat from Cyabaralika for the PPCT cement-making enterprises.

E. GOR Policy

The Ministry of Natural Resources is responsible for the development of peat resources in Rwanda. They are presently engaged in a comprehensive survey of the country's reserves. Exploitation of the Busoro marsh is being accompanied by an education campaign on the uses of peat as a preliminary measure to its marketing as a replacement for charcoal in Kigali and other urban areas. The main objective of Government policy is the replacement of charcoal as far as economically feasible in order to alleviate the fuelwood problem.

VII. Non-Traditional Energies - Solar, Biogas, Geothermal and Wind

A. Introduction

In order to exploit the potential of the non-traditional energy sources in Rwanda, the Government instituted in 1974, the "Centre d'Etudes et d'Applications de l'Energie au Rwanda" (CEAER) which is part of the National University of Rwanda. This institution is responsible for studying potential new small-scale energy sources and for designing and testing appropriate technologies for its exploitation. The Center is presently organized in four departments which specialize in biomass, solar energy, meteorology and mini hydropower plants.

B. Solar Energy

The CEAER has been carrying out research on solar energy since 1874, and has collected meteorological data since 1977. Statistics are collected from 30 stations covering all the climatic zones of Rwanda. This information will provide the basis for planning the future development of this resource.

In addition to research, the Center has developed solar equipment including waterheaters, distillers, cookers and dryers. So far 27 water heaters have been installed, two in hotels (Guest House Gabiro and Hotel Akagera), one in Kigembe Hospital, one family unit in Kigali, 11 in the SOS Village, Kigali and 12 in the UNR houses. Two water distillers have been installed, one in Kigembe Hospital and one in Gisagara health center. Cookers and dryers are being tested at the Center and initial results are positive. Refrigeration units have also been tested and 10 are to be in place by 1982.

Because of its potential widespread use, most research is now concentrated on the solar cooker. The major problems to be solved relate to the fact that it does not operate at night and that these is no temperature control. The former point is particularly important since most Rwandan families have their main (often only) meal in the early evening.

Apart from the work being undertaken by the CEAER, two other projects are of interest. The first is a radio relay station on Mount Kinanira near Cyangugu for short wave transmission beyond the Zaire-Nile crest. This installation is powered by a solar generator and includes 52 m^2 of photovoltaic pannels. It was constructed in early 1981 by a German company (AEG - Telefunken).

Plans for the future development of solar energy are mainly concentrated on increasing the number of solar generators in rural health centers. The Government in the 1981 development budget provided 50% finfncing for generators in two health centers, and the FED will contribute the other 50%. The energy produced will be used mainly for lighting and refrigeration. The Government plans eventually to provide a further 100 health centers with solar energy. There is also a proposal to equip 100,000 households with solar power for lighting: a project which would be spread over 8 years.

The first biogas digester was tested in late 1977 using cow manure and papyrus wastes from the Zaza paper-making project. Experiments using papyrus alone produced only half as much gas as when combined with a small amount of manure. Animal wastes alone produced the greatest amount of gas.

Three digesters are currently being used to produce gas as a substitute for wood or charcoal. The CEAER, in collaboration with the authorities of the Ecole Technique Agricole de Butare (ETAB) designed and installed a 12 m^3 digester which produces most of the energy for cooking meals at this school. A second digester is used in Butare prison, also to provide energy for cooking, and a third, small (2m^3), installation provides gas for a house used by French volunteers.

Financing from several donors has been obtained for the further development of this resource. Since 1979, USAID has been providing funds for CEAER activities; a German society, BORDA, is supporting a project for the installation of 210 household digesters; and the FED signed an agreement in 1980 to aid experimental production of biogas.

D. Geothermal

Geothermal energy is generally found in regions which experience, or have in the past experienced, volcanic activity. Several thermal springs are known to exist in Rwanda in the area of Lake Kivu, in proximity to the volcanoes, with temperatures in some cases in excess of 60°C. No studies are known on this source of energy in Rwanda.

E. Wind

There does not seem to be much potential for the development of this source of energy in Rwanda since the wind is irregular

and generally not strong. Howver, in Kibungo Prefecture, Makarange Parish, a small installation is in place and produces about 100 W. Wind speed here averages around 4m/sec, slightly above the minimum required of 3m/sec.

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SENEGAL

I. National Energy Policy

One of the goals of Senegal's sixth four-year plan (1981-1985) is to further develop and strengthen a national renewable energy program as a response to rising oil prices and accelerating deforestation. In the short-term, emphasis will be on exploiting new and renewable energies which address the basic needs of rural population. Five priority needs have been identified:

- water pumping,
- more efficient use of firewood/charcoal,
- food preservation,
- identification and exploitation of fuel substitutes,
- production of electricty in secondary centers.

II. Institutional Framework

Organizational responsibilities for planning, coordination, R & D, and commercialization are summarized below:

Function	Organization 1/
Coordination of R & D	SERST
Formulation of National R & D Program	Centre National de l'Energie (includes representatives from the following Ministries: MDIA,SERST, E & F, Hydraulique, Equipment, Finances, Cooperation).
Research and Field Testing	• CERER • IUT • EPT • ISRA • Faculte des Sciences, Universite de Dakar.
Installation and Commercialization	SINAES
Exploitation of Conventional Energy	MDIA

1. Note key to acronyms in Appendix.

III. Energy Consumption

About 60% of total energy consumed in Senegal is derived from wood. Petroleum accounts for the remaining 40% and is the major energy source in urban and semi-urban areas. Currently Senegal imports all its petroleum, although deposits have been discovered at Dome

Flore in the Casamance. Senegal's petroleum bill has increased tenfold in less than a decade; in 1980, Senegal paid 47 billion CFA for imported oil, which represented 42% of the country's receipts.

La Societe Africaine de Raffinage (SAR) has a monopoly on all imports and refining of petroleum and petroleum products. Refining capacity, currently 900,000 tons/year, will be increased to 1,200,000 tons/year by 1983. In addition to supplying its own needs, Senegal exports refined products to Mauritania and Mali.

Petroleum use by sector in 1980 is summarized below:

Electricity	24%
Transport	30%
Industry	20%
Other	26%

A. Electricity

In 1980, Senegal consumed 534 GWH of electrical energy. Consumption is heavily concentrated in the west central portion of the country with the main focus on Dakar. Secondary centers consumed 6.2 GWH, or slightly more than 1% of the national total.

Power plants on the Cap Vert peninsula supply Dakar, Thies, St. Louis, Diourbel and Kaolack. Towns in the rest of the country rely on individual power plants, of which there are 21. In most cases these stations use diesel generators. A recent study concluded that there is no justification for attaching the secondary centers to the Cap Vert grid, with one possible exception, and recommended that Senegal continue to decentralize its generating capacity. Electrical energy production is subsidized by supplying fuel oil below cost. The cost of production is 3¢/kwh at Cap des Biches, 6¢/kwh at Bel Air, 19¢/kwh at Matam and 52¢/kwh at Dahra. These would presumably be higher if fuel were not subsidized.

IV. Energy Resources

A. Conventional Energy

Natural Gas. Reserves are estimated at 70 million cubic meters, sufficient to produce 90 million kwh. Produced at Diam Niadio, it is piped 15 kilometers to the Cap des Biches electric power plant. No other economically exploitable gas deposit is known.

Peat. Concentrated in the Niayes, peat reserves are estimated to be 50 million m^3, or enough to fuel two 30 Mw thermal power plants for 30 years. A company is being formed to exploit the peat. Partners will include the GOS, Senelec, Caisse Centrale, Canada, France and Germany. Feasibility studies and further research will be undertaken before mining begins.

Lignite. Evidences of lignite resources in Senegal were detected during a 25-year period of oil exploration by several organizations, who identified organic materials, identified as lignite, in the cores of drill holes. A significant deposit is thought to exist in the vicinity of M'Backe; the seam is 4 meters thick with an overburden of 50 meters and could be exploited by conventional mining technology. The validity of the available evidence needs to be confirmed by new drilling.

Petroleum. Petroleum deposits have been discovered at Dome Flore off the coast of Senegal. Between 100 to 200 million tons are thought to exist. Of this, about one million tons is light crude.

B. Renewable Energy Resources

Hydropower. The potential of Senegal's hydropower resources in the Senegal and Gambia river basins is considerable:

Senegal River and tributaries	550 Mw
Gambia River	140 Mw

This resource will be exploited in cooperation with Senegal's neighbors within the context of regional development organizations which are the OMVS (Organization pour la Mise en Valeur du Fleuve Senegal) and the OMVG (Organisation pour la Mise en Valeur du Fleuve Gambie). Given the remote location of the proposed dams, long transmission lines will be required.

Small hydropower sites are thought to be few.

Biomass from Agricultural Wastes. No exhaustive studies have been undertaken of Senegal's biomass resources (rice hulls and straw, peanut shells, bagasse). However, Molle 1/ makes the following estimates of collectable agricultural wastes in Senegal:

1979	12,300 TEP 2/
1984	22,000 TEP
1989	58,800 TEP

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1 MOLLE, J.F. "Sur les potentialites de la Biomasse au Senegal". Compte rendu de Mission au Senegal, du 7.8.79 au 25.8.79, GRET and CNEEMA.

2 Tonnes Equivalent of Petroleum (TEP) is calculated by equating 2.5 kilograms of dry vegetable matter to 1 kilogram of petroleum.

By 1989 agricultural wastes could replace about 7% of petroleum imports assuming this remains at the 1980 level of 900,000 tons.

Solar Energy. The solar energy resource in Senegal is reasonably large. However, with the exception of Dakar, accurate measurements of sunshine duration, intensity and insolation, are non-existent. Dakar has an average of 3,066 sunshine hours per year, and an average insolation of 605 cal/cm^2/day. In north-central Senegal, insolation probably approaches 700 cal/cm^2/day, while southern Senegal could be expected to receive approximately 13% less than Dakar.

Wind. Senegal's wind energy resource is limited to a narrow coastal strip between Dakar and St. Louis. Strong winds occur in this area during the spring when water pumping requirements are at their highest. Measurements of wind speeds and wind distributions are available for major cities.

V. Renewable Energy Projects

Research,development and field testing of a range of renewable energy technologies are well underway, and are summarized in Table I.

TABLE I: SUMMARY OF RENEWABLE ENERGY ACTIVITIES AND PROJECTS IN SENEGAL

TECHNOLOGY	NUMBER OF PROJECTS	LOCATION	AGENCY FINANCING	AGENCY IMPLEMENTING
Passive Solar Heaters	14	10 Dakar 1 Somone 1 St. Louis 1 each, Thies, Nianing	Individuals Fonds National de l'Energie	SINAES
Photovolataics	11	Dakar/Baback/Bambey/Affiniam Samane/Ndioudiouf/Gourou/Aere/ Lao/Kanel/Montrolland	FAC FED CARITAS	SINAES IUT
Thermovoltaic Pumps	7	Dakar-IPM/ONUDI/IUT/Medina Dakhar/Niakene/Meouane/Bondie Samb/Bakel	FAC FIRST USAID	SINAES IUT
Bioconversion (Biogas Digestors)	5 (Prototypes)	Nianing/Ndiouk Fissel/Bambey/ Badiatte	CATWELL FIRST	CARITAS ISRA
Windmills (Multipale, Savonius, Aerowatt)	30 (that have been account-ed for)	(17) Cap Vert Region/Diagle/ Saou Mbodienne/Keur Bacar/Louly Bentegne/Mboro/Peycouck/Dakar/ Mbaye/Fandene	FAC FED CARITAS CEE FIRST	IUT SINAES LVIA
Woodburning Stoves (Ban-Ak-Suuf)	2,000	Fleuve/Sine Saloum/Casamance	USAID/FNE CEAO/Pro-motion Humaine/ SODEVA	CERER/Peace Corps/Promotion Humain PVOs (Private Vol-untary Organi-zations), SODEVA
Solar Dryers	2	Dakar/St. Louis/Mbour/Joal	USAID/ FIRST/ CIDA	ITA CERER
Meules Casamancaises (Improved Charcoal Making)		Foret de Tobor/Casamance	USAID MRD	Ministry of Rural Develop-ment

Source: Benjamin, Danielle: Survey of Renewable Energy Activities and Programs in Senegal. November 1981.

Table 1: SUMMARY OF RENEWABLE ENERGY ACTIVITIES AND PROJECTS IN SENEGAL

TECHNOLOGY	NUMBER OF PROJECTS	LOCATION	AGENCY FINANCING	AGENCY IMPLEMENTING
PASSIVE SOLAR HEATERS	14	(10) Dakar (1) Somone (1) St. Louis (1 each) Thiès, Nianing	Individuals Fonds National de l'Energie	SINAES
PHOTOVOLTAICS	11	Dakar/Baback/Bambey/Affiniam/Samane/Ndioudiouf/Gourou/Aérê/Lao/Kanel/Moutrolland	FAC FED CARITAS	SINAES IUT
THERMODYNAMIC PUMPS	7	Dakar-IPM/ONUDI/IUT/Medina Dakhar/Niakène/Méouane/Bondie Samb/Bakel	FAC FIRST USAID	SINAES IUT
BIOCONVERSION (BIOGAS DIGESTORS)	5 (Prototypes)	Nianing/Ndiouk Fissel/Bambey/Badiatte	CATWELL FIRST	CARITAS ISRA
WINDMILLS (Multipale, Savonius, Aérowatt)	30 (that have been accounted for)	(17) Cap Vert Region/Diaglé/Saou Mbodienne/Keur Bacar/Louly Bentégné/Mboro/Paycouck/Dakar/Mbaye/Fandène	FAC FED CARITAS CEE FIRST	IUT CARITAS SINAES LVIA
WOODBURNING STOVES (Ban-Ak-Suuf)	2,000	Fleuve/Sine Saloum/Casamance	USAID/FNE/CRAO/PROMOTION HUMAINE/SODEVA	CERER/PEACE CORPS PROMOTION HUMAINE PVOs (Private Voluntary Organizations) SODEVA
SOLAR DRYERS	2	Dakar/St.Louis/Mbour/Joal	USAID/FIRST/CIDA	ITA/CERER
MEULES CASAMANCAISES (Improved Charcoal Making)		Forêt de Tobor/Casamance	USAID/MRD	MINISTRY OF RURAL DEVELOPMENT

Source: Benjamin, Danielle: Survey of Renewable Energy Activities and Programs in Senegal. November 1981.

Table 2

MAJOR FORESTRY/CONSERVATION PROJECTS IN SENEGAL - 1981

Project Title	Donor	Classification	($ 000) Estimated Total Cost	General Description
. Senegal Fuelwood Production	USA (USAID)	Reforestation	3,912	Industrial-scale reforestation around urban centers in Western Senegal (685-0219)
2. Management & Reforestation of the Eastern Central Forests	FRANCE (FAC) World Bank (1.1.82)	Reforestation and Integrated Development	13,000	Intensified management of existing forests with industrial reforestation included. Similar to Senagal Fuelwood production.
3. Village Woodlot Development	USA (USAID & AFRICARE, Peace Corps)	Reforestation	337	Community woodlot development in Diourbel and Thies regions with and without Peace Corps forest technicians (685-0243)
4. Teak and Gmelina Production	FAO/UNDP	Commercial	18,669	Commercial Development of Southern regions timber and pulp industry including milling & export facilities
5. Cashew Production	GERMANY (GTZ)	Commercial	N.A.	Commercial development of cashew nut and oil industry with industrial and village level plantations
6. Title III Dune Fixation	USA (USAID)	Conservation	6,900	Stabilization of coastal dunes and protection of truck farm regions from roving dunes in west-central Senegal
7. Gandiolais Dune Fixation	UNDP	Conservation	4,435	Same objectives as above in north-western Senegal
8. Amelioration of the Sylvo-Pastoral zone	GERMANY (GTZ) USA (USAID)	Reforestation/ Integrated Development	5,510	Reforestation & range improvement of north-central region. Forestry efforts emphasize an Albida production, managed primarily by Germany
9. W fire Control	CANADA (ACDI) IBRD AFDB	Conservation/ Integrated Development	7,840	Wildfire control in Southern Senegal's timber and farming regions. Forest problems handled by ACDI exclusively. Equipment procurement and training

Source: Compiled by David Gibson

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APPENDIX

KEY TO ACRONYMS

SERST	Secretariat d'Etat a la Recherche Scientifique et Technique
MDIA	Ministere du Developpement Industriel et de l'Artisanat
E & F	Secretariat d'Etat aux Eaux et Forets
CERER	Centre d'Etudes et de Recherches sur les Energies Renouvelables
IUT	Institut Universitaire de Technologie
EPT	Ecole Polytechnique de Thies
ISRA	Institut Senegalais de Recherches Agricoles

SIERRA LEONE

I. Introduction

Sierra Leone is a small country with a humid tropical climate. Annual rainfall, almost all of it received in the period May-October, can exceed 150 inches. The total area is 72,500 sq. km; the population is roughly 3.3 million and growing at 2.3 percent per year. GNP per capita, currently about $250, has not experienced any real growth in recent years. Annual per capita commercial energy consumption has been recently estimated at 89 kg. of coal equivalent, and growing at 4.5 percent annually.

An upwardly spiraling oil import bill, a stagnant domestic economy and reduced prices for its exports have recently brought the energy crisis home to Sierra Leone and stimulated the Government's first hard look at the country's energy situation and prospects. Results include an attempt to institute a national energy plan and to encourage increased energy-related research, both economic and physical.

While most of the attention is focused on oil (imports, utilization and production prospects) and hydroelectricity, biomass, particularly fuelwood, is a major component of the total energy picture. Over 80 percent of the population relies exclusively on fuelwood for food preparation. Deforestation and consequent land resource degradation, while not a major problem at present, could easily become one over the next decade. Improved, small scale fuelwood production and harvesting technologies, integrated with improvements in the crop production system, are definitely needed. It is in this area that AID may be able to make significant contribution.

II. Energy Sources

The country's primary energy sources are petroleum (all imported at present) and fuelwood. Hydropower, though largely unexploited at present, appears to have considerable potential. Imports of crude oil for local refining were roughly 240,000 and 250,000 metric tons (MT) in 1979 and 1980 respectively; 20 to 30 percent of this was subsequently reexported, mostly as bunker and jet fuels. Between 1978 and 1980 the country's oil import bill more than doubled; in 1980 $71 million (35 percent of total foreign exchange earnings) was spent on oil. Offshore oil exploration is now underway; promising geologic formations have been located and the first test well is now scheduled for early CY 1982. However, even if exploitable reserves are located, commercial production is still two to three years in the future.

In terms of fuelwood and timber resources, roughly 5 percent of the land surface is "closed high forest", most of which is under government protection/management in constituted forest reserves. The total volume of timber in these forests has been estimated at 3.7 million cubic meters, nearly all of which is natural growth;

forest plantations are negligible. The variety of tree species found in these primary forests (roughly 200) is greater than in any other West African country. The offtake goes almost entirely into sawn lumber and pole wood.

Another 50 percent of the land area at any one time is in various stages of regrowth forest stemming from the prevailing bush fallow cultivation system. It is from this regrowth that the bulk of the country's fuelwood is supplied. The fact that fuelwood production is basically a byproduct of the farming system means that this important activity is almost exclusively in the hands of individual small farmers. Most (perhaps 80 percent) of the total fuelwood offtake is for subsistance use. However, where access to markets exists this activity is commercialized (the value of fuelwood can come close to the value of agricultural produce on some upland farms), and it is, of course, in these areas that the tendency toward over exploitation of the regrowth forest resource is encountered. Also, an increasing population with no corresponding improvement in agricultural productivity is beginning to necessitate shorter fallow periods and extension of cultivation to marginal areas, e.g. steep hillsides, with serious long-term implications for both agriculture and fuelwood production.

The most promising renewable energy resource for Sierra Leone is undoubtedly hydropower. The theoretical hydroelectric potential is estimated to be greater than 2000 MW, of which 1100 MW may be technically/economically realizeable. At present only 2.4 MW of hydroelectric generating potential exists, with another 4 MW facility under construction. Design work has been completed for the proposed Bumbuna Hydroelectric Project (total installed capacity of 305 MW), and funding is now being solicited. Phase I, with an installed capacity of 70 MW, is targeted for completion in 1987.* Design work for other projects, both large and small scale, is underway.

Other energy sources are generally considered insignificant. Lignite deposits do exist, but their extent and quality have not been assessed. Biomass (other than timber) is negligible, as is biogas, the latter largely because of the scarcity and low concentration of livestock. Wind and solar energy may have some potential. Direct solar energy is now used for drying most agricultural produce. Limited research into improved solar applications, particularly in drying, is underway. However, solar energy is limited by the heavy cloud cover during much of the year.

III. Energy Consumption

As noted above, 80 percent of oil imports are for the domestic

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* The estimated cost, including distribution system, will be roughly $3.5 million per MW of installed generating capacity, an extremely high figure. GOSL officials, however, are of the opinion that there is no alternative but to proceed.

market. Of this, 60 percent is for the industrial sector, primarily electricity generation, 22 percent for transport, and 18 percent kerosene and cooking gas for household use. Demand for petroleum-derived energy is increasing at an annual rate of 4.5 percent, led by households and transport at 7 percent. Under even conservative assumptions Sierra Leone's import bill for petroleum could reach $150 to $170 million by 1986 which, if mining output remains in its current depressed state, could claim 45 to 50 percent of projected export earnings, clearly a critical situation.

Sierra Leone is served by a total installed electricity generating capacity of 95 MW, 93 of which is oil or diesel-powered. Of this, 38 MW (40 percent) are in "captive" plants directly serving the mining operation. The balance is owned and operated by the Sierra Leone Electricity Corporation (SLEC), 80 percent of which is concentrated in the Western (Freetown) Area. For the year 1979/80 SLEC reported sales of 94.7 million KWH, roughly 25 percent of which was for household use. A conservative projection for the rate of annual growth in demand for electricity, not including requirements of proposed mining operations or any increase in rural electrification, is 5 percent. At this rate, the domestic demand would more than double by 1994, and installed generating capacity would be reached by 1984.

Energy for agricultural production in Sierra Leone is supplied almost entirely by human labor. The number of working tractors probably does not exceed 300 and draft animals are essentially nonexistent. Use of chemical fertilizers is also very low; annual imports over the past 10 years have averaged only 3,200 MT.

Fuelwood consumption is estimated at 2.5 million m^3 per year, 95 percent of the total harvest. Approximately 80 percent of the population relies exclusively on fuelwood for its household energy needs (confined almost entirely to food preparation). Fuelwood demand is expected to increase somewhat slower than the population growth rate. perhaps in the range of 1.8 to 2.0 percent per year. Charcoal is insignificant; total production in 1978 did not exceed 10,000 m^3. Consumption is mostly confined to Freetown.

IV. Energy Pricing

The retail pricing of petroleum products basically reflects their real cost; there is no overt subsidy except for kerosene, which is probably socially justifiable as it is used almost exclusively by lower income families. Electricity pricing, however, is subsidized at approximately 4 cents per KWH, a saving that accrues almost exclusively to businesses and upper income families.

While accurate, detailed marketing and price data for fuelwood do not exist, it appears that the fuelwood market is dominated by small entrepreneurs, with prices determined solely on the basis of supply and demand. A 1978 study found that prices received by fuelwood producers varied between 6 and 12 dollars per cubic meter

depending on quality and location, while end user prices in Freetown ranged from 16 to as high as 40 dollars. 1/ The substantial price spread (almost 200 percent) reflects the high local costs of transport and an apparently inelastic demand; it also seems to indicate the presence of gross market inefficiencies. A major study into the fuelwood market now underway should clarify the situation.

V. GOSL Energy Policy

A national energy committee, comprised of representatives of the Ministeries of Energy and Power, Agriculture and Forestry, Development and Economic Planning, Trade and Industry, the Sierra Leone Electricity Corporation, and the University of Sierra Leone, has recently been instituted. This committee is charged with formulating a national energy policy and coordinating energy-related activities; policy guidelines will be formulated in such areas as conservation, control of energy resources, priorities in energy use, investment, and regional cooperation. The committee is now undertaking an assessment of the energy situation and is also following-up on recommendations of the recent ECOWAS Energy Symposium regarding development of short and medium term project proposals.

Over the period of the next Five Year Plan (1982-1986), the largest share of energy-related investment is programmed for hydroelectric development, primarily the above-mentioned Bumbuna Project. Development of fuelwood plantations and increased charcoal production are also planned.

VI. Other Donor Activity

In hydroelectric power, financing for the Bumbuna Project is the primary concern at this time. The GOSL is attempting to line up a consortium of multilateral and bilateral donors; likely participants include the World Bank, the Italian and West German Governments, and the Kuwait Development Fund.

In forestry, the West German Government is involved in assistance to the timber industry; however, this does not yet extend to fuelwood production or marketing. A major sectoral study was recently funded by the EEC, which included pre-feasibility analysis for fuelwood plantation. The EEC and West German Government are reportedly considering further assistance along this line.

The Soil and Water Division of the Ministry of Agriculture and Forestry (initiated and assisted by UNDP/FAO) is undertaking research in integrated watershed management, attempting to analyze

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1/ These figures appear overstated. Current fuelwood costs in Freetown are in the 15-25 dollar range.

and improve agricultural production (including fuelwood) while preserving the soil resource.

VII. Commercial Activity

Commercial activity in the energy field is presently limited to offshore oil exploration by Mobil Oil Company. Mobil reportedly is prepared to invest up to $14 million in this endeavor. Planning for increased electricity generation for Freetown is underway, including consideration of possible use of domestic lignite or imported coal rather than oil.

VIII. AID Program

The AID program in Sierra Leone is quite small ($2-3 million annually over the past few years), with one major project in Adaptive Crop Research and Extension (ACRE) as its centerpiece. ACRE attempts to take an integrated "farming system" approach rather than considering specific crops or inputs in isolation, with particular emphasis on the upland farms that account for the bulk (perhaps 80 percent) of Sierra Leonean agricultural output. Because fuelwood production is an integral and often valuable component of this upland farming system, and is carried out by the small producers AID is directed to assist, it is logical to address the issue within the context of ACRE. Specifically, ACRE can investigate the potential for fast-growing, legumenous tree crops (e.g. *Leucaena sp.*) to stabilize and enrich upland soils, both under mixed cropping and modified bush fallow (clear-burn-farm-fallow) regimens.

AID has also received requests for assistance in other energy-related areas, especially rural micro-hydroelectric generation. This is an area where we may be able to make real contributions with relatively small inputs under regional or centrally-funded projects, e.g. in inventory of possible sites and support of pilot or demonstration activities, and which accords well with our rural development focus.

SOMALIA

I. Sources of Energy

A. Conventional Energy

The primary source of conventional energy in Somalia is imported petroleum. Fuel imports into Somalia in 1980 consisted of 210,400 metric tons of petroleum and petroleum products. Diesel fuel (both locally refined and imported) comprised 56 percent of the total imports and was the largest single component. During the first half of 1981 (January - June) a total of 116,000 metric tons of refined petroleum products was imported. The country's refinery was not in operation during that period due to the unavailability of Iraqi crude oil.

B. Traditional and Renewable Energy

The main sources of traditional and renewable energy in Somalia are charcoal and firewood. The estimated consumption of 5.6 million cubic meters of wood per annum represents in the order of 86 percent of the total national energy consumption. Annual consumption of charcoal is estimated at about 80,000 tons. Fuelwood and charcoal represent 96 percent of the country's total wood consumption. Charcoal producers are organized into cooperatives by the government; there are over 100 such businesses in the country. Licensed producers account for about 80 percent of the country's production according to the National Range Agency. Traditional charcoal production methods in Somalia are estimated to be about 10 percent efficient. Other sources of renewable energy include a hydroelectric facility in the Juba River which produces 5 MW of power generation. A number of windmills were introduced into Somalia in the 1960's, but many of these are no longer functional due to lack of maintenance, upkeep and spare parts. Potential for wind power development is highest along the coastal areas.

Some experimentation has been undertaken with photovoltaic pumps for shallow wells. By the end of 1982 approximately 36 such pumps will be in place. The pumps are used primarily for supplying water from rivers to the refugee camps. The initial cost of the pumps is high and it is not known yet whether they will prove to be economically feasible.

II. Energy Consumption Patterns

Approximately 80 percent of the electrical power generated is consumed in Mogadishu. Sixty percent of the public power generation goes to state organizations, the other 40 percent is provided to private customers. Energy consumption by industry probably amounts to about 6 percent of the total produced. The

total national consumption of energy is 15.6 x 10^{12} kilocalories per annum.

Electrical energy sales increased at a rate of 10.2 percent from 1965 to 1978. The current overall growth rate is about 12 percent. Fuel imports consume 56 percent of export foreign exchange earnings and as such it is one of the main contributors to the persistent balance of payment deficit.

III. Energy Resources

Although several oil companies have searched for both gas and oil reserves in Somalia, no economically viable supply has been located to date. The geology is encouraging, however, and several companies are continuing to explore.

The Federal Republic of Germany, after conducting a three-man fact finding mission late 1979, is funding a one million dollar Phase I prospecting program to determine the extent of coal and bituminous shale in a region between Berbera and Alulu. This program is to start in mid-1982 when field personnel are expected to arrive. Initial estimates of reserves show resources of sufficient quantity (2.5 million tons) and quality (net calorific value greater than 3500 kilocalories/gram) to supply a 20 Mw power station for at least 15 years. The resources in the area include Jurassic bituminous shale, Cretaceous hard brown coal (subbituminous) and Tertiary lignite.

Alternative energy technology development has not been explored to any great extent in Somalia. This condition is changing as PVO's and other international organizations introduce solar power, wind power and hydroelectric schemes. However, these activities are on a very small scale in relation to the size of the problem.

The present annual consumption of wood in Somalia is 5.6 million m^3 and total growing stock is estimated at 81 million m^3. With a population growth rate of 2.8 to 3.1 percent and a continually-growing refugee population, the demand on wood reserves will triple by the year 2010. Land clearing and agricultural techniques contribute to the reforestation problem, and this coupled with overgrazing precludes regeneration of the forest. It has been estimated that the carrying capacity of the range is exceeded by three times.

Fuelwood conservation is a perceived need in Somalia at the policy making level. However, the lack of trained technicians and funding has severely limited the Government's capability for initiating conservation programs.

Proposals for improved cookstove projects have been submitted but not funded. A pilot charcoal conversion project, funded by UNIDO will explore kiln production methods.

The environmental implications of the deforestation problem are ominous. No formal Environmental Protection Agency exists in Somalia, however the functions of such an agency are partially performed by the Ministries of Agriculture (land allocation) the Ministries of Livestock (National Range Agency land use planning) and the Ministry of Planning (Energy Coordination.)

IV. Government Energy Policy

The Ministry of National Planning has recently been given authority for coordinating all ministries with energy-related functions and will undertake an EEC funded 2-3 person month study of manpower requirements for an energy planning unit to be established within the ministry. The Somalia Petroleum Agency (a public agency) is responsible for the purchasing, storage and distribution of petroleum and petroleum products. Electrical power delivery is managed by the National Agency for Electrical Energy (ENEE) which is a parastatal agency under the Ministry of Public Works. Energy resource exploration and development is overseen by the Ministry of Mineral and Water Resources.

Diesel fuel is subsidized by the Government in an effort to encourage farmers to increase agricultural productions; gasoline is not subsidized.

The Ministry of National Planning has compiled a Five Year Development Plan (1982-1986) which proposes to combat desertification through a program of research, training, coordination of surveys and implementation of forestry projects.

Specific projects proposed for funding are strengthening the Forestry Department, improvement of charcoal production methods, village forestry lots, improvement of frankincense and myrrh production and strengthening and intensification of sand dune fixation. These projects will be added to an already established National Range Agency program of nursery establishment, sand dune stabilization and shelter belt construction. The National Range Agency is a parastatal agency under the Ministry of Livestock, Forestry and Range and overseas forest management and government replanting schemes.

V. Private Sector Involvement

Multinational company involvement in the conventional energy field is limited to oil exploration and a recent crude oil supply contract. Cooperatives are involved in the production and distribution of charcoal as described previously.

A larger role for the private sector would most likely contribute to the efficiency of energy distribution and maintenance systems, however, both the scarcity of foreign exchange for capital investment and the dominance of parastatals in the economy preclude such involvement at present. This may change in the near future as

the Government has stated that the private sector will henceforth assume a larger role in the country's economy.

VI. The Government's Strategy

The Government of Somalia is in a difficult position in the energy section. Demand for electrical power and petroleum increases yearly, (average growth rates in sales of electricity for private lighting show a 12 percent increase) and the total supply is met with foreign exchange. Foreign exchange accumulation is based primarily on livestock sales which fluctuate with the drought cycle. The continual degradation of the range may limit exports in the future. The Government's activities in the Five Year Plan (1982-1986) are aimed at stabilizing the supply of petroleum through refinery reconstruction and retrofit of power generation equipment. In addition the country will attempt to increase hydroelectrical power generation on the Juba River, re-examine energy tariffs in an effort to promote regional development and initiate renewable energy utilization project. Donors are assisting in both the forestry and energy sectors, however, the thrust of their assistance is in the research and analysis areas in an attempt to improve an extremely weak data base and allow for long range planning.

Of primary interest in energy data collection is the World Bank's National Energy Assessment and Planning Study ($261,000; commencing November 1981).

The EEC has agreed to provide short term assistance to establish the new Energy Planning Unit in the Ministry of Planning. By mid-1983 enough data should be accumulated to enable the Government to set long-range energy development goals.

Exploration will continue in groundwater development, geothermal resources, oil field drilling, and lignite deposits.

The Somalia response is weakened by lack of technical specialists in both the energy and forestry fields. It is doubtful that current government staff will have the capability of implementing the projects in the Five Year Plan without additional technical assistance.

VII. USAID assistance in 1982 will include:

A. ETMA- sponsored 3 day awareness workshop on energy and environment.

B. IRT- windpower development ($100,000).

C. CDA Forestry Sector Grant (several million) to include a food-for-work program, institution building and training in range and forestry.

Even with a weak data base for analysis, it is evident that Somalia is on the brink of an energy crisis. Current efforts to date in this sector have been meager outside of the research area. The recently launched CDA program is intended to accelerate donor strategy development and permit a more extensive transfer of donor funds.

SUDAN

I. Introduction

Energy, in its various forms, is the backbone of the economy of any country in the world. It reflects the state of health of the economy. The consumption of energy is taken, in many cases, as a measure of the development of human communities. In a recent survey, the Western world and Japan produced about half the total electrical energy of the world, while they comprised less than one third of the world's population.

The Sudan is one of the 25 least developed nations of the world. This is easily verified by the fact that the per capita average consumption of electrical energy in the Sudan is 50 kWh, which is far below the 2,500 kWh of the developed world. In 1979/80, 95 percent of the Sudan's foreign exchange was absorbed by its oil imports.

II. Sources of Energy

Regarding fossil fuels, the Sudan annually imports 1.2 million metric tons of petroleum products, which constitute about 98 percent of the commercial energy used, or about 21.63 percent of the total energy. The skyrocketing prices of petroleum products prevent the adequate import of these products, with consequent adverse effects on industry and agriculture and eventually on the whole economy.

Hydropower, as a source of renewable energy, has been developed in the Sudan to a considerable extent. It produces about 78 percent of the total electrical power. The installed capacity of hydropower is about 250 MW, while its estimated potential is over 3,370 MW.

Fuelwood is the major source of renewable energy used in the Sudan, wither as direct firewood or as charcoal. In 1979/80, about 13 million metric tons of wood fuel was consumed, mainly as household fuel in rural areas. This huge consumption, together with the low rate of afforestation (7,000 hectares annually) would seriously affect the balance of supply and demand of fuelwood, and if no steps are taken to obviate this imbalance, then fuelwood will be deficient by 1985.

Less than 4 percent of the 3 million metric tons of crop residues now available is utilized. Ambitious plans to produce ethanol from molasses for the purpose of blending with gasoline are under serious consideration by the Government.

Solar energy has been used in the Sudan, in a primitive way, for many decades in such applications as the drying of agricultural products. In 1955, scientific research was begun at the University of Khartoum on power generation and measurements of solar energy. The National Council for Research, through its organ, the Institute of Energy Research, has been involved in research and the

development of solar energy technology since 1970. The geographical situation of the Sudan means that it is in a most favorable condition for collecting and exploiting this boundless source of energy. Duration of sunshine is about 11 hours and the solar flux amounts to 80 calories per hour per square centimeter.

Wind energy was introduced in the Sudan in 1950, when 250 windmills were installed in Gezira Province to pump water from artesian wells. Unfortunately, the operation of these windmills was abandoned for a number of reasons. Improper repairing and bad maintenance were some of the reasons.

The average wind speed in most areas of the Sudan is about 10 mph. There is thus great hope that wind energy will meet part of the increasing demand for energy in the Sudan.

III. Government Plans

Sudan has ambitious plans and projects to make the maximum use of these new and renewable energy sources and direct them into commercial utilization, but there are a number of obstacles. The production of alcohol from sugar residues, for example, needs financing. The improvement of charcoal production needs advanced technology. Also, the field of research and training is still in its infancy in the Sudan, which also presents an obstacle.

In order to overcome these difficulties and develop new and renewable energy sources effectively, the Government is undertaking a number of steps, namely:

- Organization of the energy sector to enhance and accelerate the effective implementation of new energy technologies, and to avoid duplication of the efforts of various organizations working in the energy sector;

- Energy strategies and planning: the Sudan is embarking on a project for the assessment of the energy situation in the country; on the basis of the results of this assessment, the country will formulate plans and strategies that will focus on the development of the energy sector;

- International cooperation and bilateral agreements: the Sudan needs the cooperation and help of developed countries that have taken the lead in new and renewable energy research. The field of cooperation may include the financing of projects, the training of personnel, and the donation of demonstrating equipment.

Bilateral cooperation between the Sudan and neighboring countries in research fields of common interest is also very important. The following joint projects are good examples of such cooperation:

- Sudan/Uganda: improvement of charcoal kiln production;

- Sudan/Kenya: development of biogas and geothermal energy;

- Sudan/Ethiopia/Somalia: forest plantations.

It is a challenge not only for the Sudan but for the whole of Africa to devote every effort to acquiring the necessary technology of new and renewable energy sources in the remaining part of the twentieth century in order that these sources may contribute to the continent's energy needs in the twenty-first century.

SWAZILAND

I. Introduction

While Swaziland is more fortunate than many other countries in that it has a number of alternative energy sources, it is not currently energy independent and there is little likelihood that it will ever be a net energy exporter. However, it may be able to avoid increasing external dependence.

A. Physical Setting

Swaziland is a small, landlocked country located in south-southeastern Africa. It is bordered by the RSA except for a small area on the east which joins Mozambique. The country has a maximum north-south length of 193 km and a maximum east-west width of 145 Km. Swaziland covers approximately 17,400 sq. km and is divided into four geographic regions going from west to east: Highveld, Middleveld, Lowveld and Lebombo. The Highveld covers nearly one third of the land area with elevations over 1000 meters, and many steep slopes. The Middleveld covers nearly 30% of the country and contains hilly country and well-watered valleys with undulating grasslands on the eastern side. The Lowveld is one third of the land area, between 182 and 364 meters above sea level, with very gentle slopes. The Lebombo region covers less than 10% of the land area and is a plateau over 600 meters above sea level.

The climate varies from the subtropical, near humid Lebombo region, to the dry, hot Lowveld to the humid, near temperate Highveld. Rain varies with altitude and is seriously deficient in one year out of ten.

Swaziland forms part of the eastern watershed region of southern Africa and has an extensive network of rivers. The Lomati/Komati system drains the extreme northwest. They originate in South Africa, flow through Swaziland and then discharge back in South Africa. The Mbuluzi river originates in Swaziland and discharges in Mozambique. The four major tributaries of the Great Usutu river originate in the RSA, combine to form the Great Usutu in central Swaziland and discharge into the RSA eventually flowing into Mozambique. The Ngwavume river rises in souther Swaziland. It discharges into the RSA.

B. Economy

The economy is agriculturally based and export oriented. It is well diversified but highly dualistic with a modern capital intensive sector and a traditional sector engaged primarily in subsistence agriculture. Approximately 70% of the population is dependent upon traditional agriculture. Maize is their principal crop, but increasingly this sector is growing some cash crops. Modern agriculture involves primarily sugar,

citrus, pineapples and cotton production. The manufacturing sector includes the processing of agricultural commodities plus a lumber and mining industry. Tourism is also a significant sector in the economy. The lumber plantations are primarily in the Highveld, with plantation type agriculture in the Middle and Lowveld.

II. Current Energy Resources

A. Coal

Coal is the only fossil fuel source available in Swaziland. The one producing coal mine is in the Lowveld at Mpaka. In 1980 it produced 180,000 tons, and has reserves to last 50 years at the current extraction rate. However, the entire eastern fourth of the country is a coal seam covering about 2000 sq. km.

Current estimates of mineable coal resources in this area total just over 100 million tons, with potential reserves of 550 million tons. In 1980 coal provided 28.3% of the energy available for use in Swaziland, however 87% of coal production was exported, primarily to Kenya. Thus, Swazi coal contribution to Swaziland's energy use was only 3.7% of total energy used.

B. Hydroelectric Power

The topographical structure of the country is characterized by a progressive decrease in elevation from West to East and most rivers follow the same west to east trend. Despite an average level difference of about 1000 meters between the Western mountainous valleys and the eastern plains, there are only a few sites combining significant discharge with concentrated head. One generally optimistic report indicated 21 possible sites for hydroelectric power plants. However, the increasing number of dams in South Africa has already reduced the amount of water available since many of the best sites use rivers that originate in South Africa.

If the proposed dams in South Africa are constructed, this would result in severe shortages of annual discharges of these rivers at the Swazi border.

Currently there are two hydro plants, both operated by the Swaziland Electricity Board (SEB). They presently generate 130 GWh; 1/ or 2.1% of the energy used in Swaziland in 1980. There are many locations that could produce electricity with micro-hydro stations but generally the cost per kilowatt is high.

Of the 21 proposed sites for hydro stations, 12 have been eliminated because of high investment cost or unduly large water abstractions upstream. Of the nine remaining, two are

considered most promising and one is currently under construction.

The Lupohlo/Ezulwini scheme, on the Little Usutu River, is under construction and should be able to produce 93 GWh annually; the "Lower Scheme" is on the Great Usutu and it is hoped to have it commissioned in 1986. It is downstream from one of the existing dams and should be capable of producing 53 GWh per year. These two dams will increase hydroelectricity production in country by over 100%; but they will still only provide a small percentage of total energy needs within the country.

C. Wood

One of the largest man-made forests (over 60,000 ha) in Africa is to be found along the Usutu River in the Highveld. Another large forest area is in the northern Highveld at Pigg's Peak (approximately 32,000 ha). In addition to these there are approximately 8000 ha of man-made forests on Swazi Nation Land.

The plantations along the Usutu River process wood mainly into pulp for export. Those in the Pigg's Peak area process their wood into lumber which is used for construction and the making of small crates, both mainly for export.

Wood as an energy source, in the form of firewood, is only of minor commercial importance. It accounts for 0.5% of total commercial energy production. There are only a few small dealers selling firewood for domestic consumption. Employees at the wood factories are supplied with waste wood.

Most of the firewood for domestic purposes is put to use in the rural areas and collected and/or cut there by the rural population. This unregulated collecting of wood has increased steadily with the growth in rural population and price increases for alternative fuels. This has resulted in some wood shortages so that people must travel greater distances to gather wood. Wastewood resulting from felling and processing can supply some of domestic fuelwood needs, but problems with collection and distribution appear to make this economically nonviable.

D. Bagasse and Sugar Cane By-Products

In 1980 approximately 2.8 million tons of sugar cane was processed into sugar and molasses producing 840,000 tons of bagasse. This was used by the sugar industry for generating the steam necessary for processing the cane, and also to meet their own electricity needs. While the efficiency can be improved, there are technical difficulties in moving the surplus amay from the sugar mills.

Cane and molasses can be used indirectly as an energy source via the manufacture of ethanol. Aside from economic considerations, there are political questions about using potential sugar cane areas with the necessary irrigation or produce an "energy crop".

E. Agricultural Wastes, Biogas

The use of organic wastes for the generation of gas and fertilizers has a long tradition in some developing countries. In Swaziland the production of biogas could be of interest not only for small-holding farmers but also for major livestock enterprises, slaughterhouses and food processing concerns. At present there are only minor scattered examples of biogas generation and detailed cost estimates to determine economic viability have not been undertaken.

F. Solar

Swaziland is located between the 25th and 28th parallel of latitude in the Southern hemisphere, where insolation is exceptionally high. Data accumulated by the Water Resources Department for the average hours of sunshine per day reveal a practically constant insolation when expressed in terms of hours of sunshine per day. There is little seasonal variation as monthly averages vary by no more than 13% from the yearly average.

Solar panels have been installed in only a few places so far. The largest, at Tambankulu Estates, is used to provide hot water for showers. The performance is satisfactory and the quantities of hot water produced are acceptable even in the winter months without supplementary power.

G. Non-Sugar Company Sources

The Havelock Asbestos Mines at Bulembu in extreme northwestern Swaziland generates 80% of its electrical energy itself, purchasing the remaining from SEB. The electricity is used to operate the caleway that transports the asbestos ore to Barberton, South Africa, to dry the asbestos ore and for underground and domestic use. The generators use South African coal.

The Usutu Pulp Company's power plant produced 65% of the mill's electrical requirements. It is the largest single electrical self producer in the country. Ninety-six percent of its power source is from waste by-products, and 4% comes from heavy fuel oil. Peak Timbers, in the Pigg's Peak area has four turbine generators with a 2500 kW capacity, using waste wood. The company supplies free firewood for domestic use to its employees. SEB supplies residual electrical needs.

III. Energy Imports

A. Petroleum

As Swaziland does not possess oil or natural gas resources and does not have its own oil refinery, the necessary liquid and gaseous fuels are imported, almost without exception, from South Africa. The oil refineries in Capetown and Durban ship refines products to Maputo where they are transported by rail to the main depot at Matsapa.

The importation and distribution is under the direct control of the oil companies of South Africa. In 1980, imported oil represented 22.3% of total energy used in Swaziland.

B. Coal

While Swaziland exports almost all of its coal, it still imports 12.8% of its energy needs in the form of South African coal. The imported coal is better suited for industrial application such as firing in boilers.

C. Electricity

The domestic sources of supply for the Swaziland Electricity Board have remained unchanged in the past few years. Thus the proportion of total electricity use which is locally generated has dropped to 39% in FY 79/80. The balance is purchased from South Africa and comes through two 87-km overland transmission lines.

IV. Energy Consumption

A. Domestic and Commercial

This comprises all rural and urban energy consumption for households, commercial users and government. It is estimated that commercial users consumed 597 TJ of energy in 1980, 46% of which was electricity and 44% coal, and 4% LPG. The remaining amount of energy consumed for commercial purposes was diesel, paraffin and heavy fuel oil.

In rural areas the main domestic source of energy is firewood but coal is also important. Paraffin and LPG play a secondary role. Access to electricity is limited.

In urban areas electricity and coal constitute the main sources of energy, while the contribution made by wood, LPG and paraffin are small. Coal is used to a considerable extent only in company towns. The estimated energy breakdown in rural and urban areas is shown below:

Source	Rural Consumption in TJ	% of Total	Urban Consumption in TJ	% of Total
Firewood	944.00	60.5	24.67	5.5
Electricity	5.04	0.3	184.86	41.6
Coal	498.40	31.9	216.89	48.8
Paraffin	90.50	5.8	15.55	3.5
LPG	23.49	1.5	2.76	.6
TOTAL	1561.43	100.00	444.73	100.00

Subtracting out self-generation of electricity the total energy consumption of the domestic sector (rural and urban) is 1,992 TJ.

B. Transportation

This is the most important oil consumer in Swaziland's energy system. Almost 63% of all the petroleum products were used for transport in 1980.

The energy consumed in the transport sector is split into gasoline (40.4%), diesel (38.6%), coal (17.7%), aviation gasoline (0.3%) and jet fuel (3.0%) with total energy consumption in 1980 of 3,283 TJ. By making assumptions based on the registration of private vehicles and commercial vehicles, estimates can be made of the use of transport energy.

Thus, 57% of the gasoline is consumed by individual vehicles and 26% is consumed by panel vans. Fifty-nine percent of the diesel is consumed by small trucks.

C. Industry

The Swazi Chemical Industries consumed SEB electricity and coal imported from RSA. The petrol and diesel consumed is counted under the transport sector. Total energy consumption in 1980 was 246 TJ.

Altogether the mining sector consumed 1,046 TJ of energy almost all of which used by the Havelock Asbestos Mines.

In 1980, the Swazi mills consumed approximately 5,828 Tj of energy with over 90% being bagasse. The balance is coal (mainly imported) and SEB electricity.

The food and beverage industry consumed approximately 185 TJ of energy, exclusive of transportation requirements. Over 84% was in the form of coal, and over two thirds of this was imported coal. Fourteen percent of energy needs came from SEB electricity.

The pulp industry was second only to the sugar industry in energy consumption. Its total energy consumption was 4,801 TJ with 77% being in the form of waste products. Just over 2% of needs was provided by SEB. It was the only large consumer of heavy fuel oil in the Kingdom.

The timber industry consumed approximately 776 TJ of energy in 1980, being 97% of which was wood waste and black liquor solids. The balance was diesel and SEB electricity.

D. Agriculture

In agriculture two forms of energy predominate:

- electrical energy is used mainly for driving irrigation pumps;
- diesel fuel is used primarily for tractors and harvesters primarily.

Sugar cane is the main irrigated crop but some irrigation is used in cotton, vegetable and citrus farms. Around 650 TJ of energy is used in this sector split about equally between electricity and diesel.

E. Power

The electric utility sector is represented solely by SEB. It used 26 TJ of energy in the form of diesel to operate the Edwaleni generating station.

V. The Energy Balance for 1980

A. Domestic Production

Energy Input	TJ	% of Total
Mpaka coal	5,501	32.7
SEB hydro electricity	412	2.4
Bagasse	5,545	33.0
Black liquor solids	3,120	18.5
Waste wood, firewood	2,244	13.3
TOTAL	16,822	

B. Energy Imports

Energy Import	Source	TJ	% of Total
ESCOM electricity	RSA	677	9.0
Petroleum Products	RSA	4,329	57.7
Coal	RSA	2,494	33.3
TOTAL		7,500	

C. Energy Exports and Losses

The only energy export was Mpaka coal and it amounted to 4,788 TJ.

One hundred and five tera joules of energy were lost in electrical transmission and distribution.

Thus the total energy available for use in Swaziland is equal to domestic production plus imports, minus exports and net losses. This totals 19,429 of which 38.6% was imported for RSA.

D. Energy Consumption

As discussed earlier the energy is consumed in the following sectors.

Sector	TJ	% of Total
Domestic	1,992	10.2
Commercial	597	3.1
Transportation	3,283	16.9
Chemical	246	1.3
Mining	1,046	5.4
Sugar	5,828	30.0
Food & Beverage	185	1.0
Pulp	4,801	24.7
Timber	776	4.0
Agriculture	650	3.3
SEB	26	0.1
TOTAL	19,430	

VI. Energy Comparisons

A. Energy and GDP

Detailed GDP estimates have not been done on the Swazi economy since 1975/76. However, the Swazi Central Statistical Office is currently attempting to estimate GDP for the intervening years. A preliminary estimate is that GDP at factor costs was E249.7 million or U.S. $345.1 million in 1980. Pricing the

energy used, without excise tax, gives an estimate of the value of energy used of E55.3 million or U.S. $66.9 million. The non-commercial energy sources such as firewood, bagasse and black liquor were not taken into account since they are waste products from industrial processes. Since the value of the waste products is already incorporated in GDP at market prices we do not need to increase GDP when we value the waste products. However, if we place a value on the firewood collected we must also increase the value of GDP by the same amount. The result is that the value of energy used, including firewood and waste products is E69.1 million or U.S. $83.6 million, and GDP is raised to E252.8 million or U.S. $305.8 million. Twenty seven percent of GDP at factor costs went to energy costs.

In 1980 82% of all energy expenditures were for petroleum products; including the value of waste products and firewood reduces this to 65%.

B. Energy Consumed Per Capita

The World Bank's World Development Report for 1981 reports energy consumption per capita in kg of coal equivalent per capita. Converting tera joules to of coal equivalent per capita in 1980 yields 1,228 kg per capita.

In 1970 other southern African countries consumed:

Country	Kg. of Coal Equivalent Consumed Per Capita
Malawi	70
Mozambique	139
Angola	208
Zimbabwe	791 (was 1,346 kg per capita in 1960)
Zambia	858
South Africa	3,479

The World Bank lists Swaziland's income per capita as U.S. $650. The comparable kg of coal equivalent consumed by countries with roughly comparable income per capita is:

Country	Income Per Capita	Kg of Coal Equivalent Per Capita
Bolivia	550	470
Cameroon	560	148
Thailand	590	376
Philippines	600	356
Congo	630	213
Swaziland	650	1228
Nicaragua	660	455
Papua New Guinea	660	299
El Salvador	670	351
Nigeria	670	83
Peru	730	737
Morocco	740	315

Swaziland consumes considerably more energy than other southern African countries, with the exception of South Africa, and also consumes considerably more energy than countries with comparable income levels.

C. Ability to Pay for Energy Inputs

The other comparable figures that the World Bank reports are for energy imports as a percent of merchandise exports (both figures for 1978). In 1978 Swaziland imported E25.8 million (U.S. $29.6 million) worth of minerals, fuels and lubricants, and its merchandise exports were E170.6 million (U.S. $196.2 million). Thus the ration of energy import to merchandise exports is 15.1%.

Only Malawi and Zambia report comparable figures among the southern African countries and they are 22% and 11% respectively. Thus while Swaziland uses much more energy per capita than these countries it is less dependent on imported energy than Malawi, although more dependent than Zambia.

Among the countries with comparable income levels the results are:

Country	Energy Imports as % of Merchandise Exports
Bolivia	1%
Cameroon	9%
Thailand	28%
Philippines	32%
Congo	1%
Swaziland	15%
Nicaragua	14%
El Salvador	13%
Nigeria	2%
Peru	20%
Morocco	28%

The spread among the numbers is great, but once again, Swaziland's ability to pay for imported energy out of merchandise exports is roughly average.

VII. Government Energy Plans and Objectives

The objectives of the third five year plan (ending 1982/83) are economic growth, self-reliance and social justice with stability. Energy is specifically mentioned under the first two objectives. That is, "Steps will be taken to ensure as far as possible that no irrigation, hydroelectric, or industrial projects are held up or restricted in scope because of inadequate water supply; in addition to the dams and storage schemes planned for these five years, the feasibility of longer range water development schemes is to be investigated." And for self-reliance, "Under study is the possibility of establishing a thermal power station fueled by Swaziland's coal reserves; this would end dependence on a foreign source of electricity."

The objectives of the power sector for the third plan are:

- To continue to expand and reinforce electricity supply to meet the growing demand throughout the country.
- To make the base use of Swaziland's coal and water resources for power generation.
- To achieve independence of electricity supply as quickly as is economically feasible.

In 1978 when the Third Plan began the total amount of gigawatt hours generated or purchased came to 224.0 GWh; of which 102.1 GWh was purchased from RSA, or 45.5%. For 1980, 305.2 GWh was generated or purchased with 187.87 GWh coming from RSA, or 61.5%. While the new hydroelectric plant at Lupohlo/Ezulwini will probably only be able to take care of the planned increases in energy uses

and it is not expected that the dependence on foreign electricity will be reduced. However, it is hoped that this new plant will preclude any increase in the dependency on RSA.

While domestic production of energy by SEB has not been increasing over the plan period, it has been able to meet the increased demand through expansions in the capacity of the ESCOM link and through purchases from them. Thus the amount of electricity sold has grown by 10-15% each year during the plan period.

Other hydroelectric stations are being discussed, as are possible expansions of coal production. The government has recently commissioned an energy sector review that will lay the groundwork for a master plan in the energy field. This is to be tied in with work being done by the U.S. Army Corps of Engineers, to advise the Swazi government on the impact on planned and proposed new dams by South Africa on rivers that flow through Swaziland. It is hoped that within a year there will be an energy master plan for increasing domestic production which will not result in unnecessary increases in the cost of energy.

TANZANIA

I. Introduction

The Republic of Tanzania has a land area of about 365,000 square miles (945,000 square kilometers) and a population of nearly 18 million people, with a growth rate of approximately 3.4% per annum. The country currently imports all of its petroleum products. Tanzania's current economic crisis is, in part, due to the country's extreme dependence upon imported crude oil as an energy source. It is estimated that over 50% of the country's export earnings in 1981 will be devoted to purchases of crude oil and its refined products.

II. Sources of Energy

A. Petroleum

In 1979, Tanzania spent U.S. $149,700,500 (T.Shs. 1,250 million) for importation of 570,652 MT of crude oil. In 1980, the country spent U.S. $180,500,000 (T.Shs. 1.48 billion) for importaion of 756,930 MT of crude oil and another U.S. $90,371,257 (T.Shs. 754.6 million) to import 225,204 MT of refined petroleum fuel products. In addition to crude oil imports in 1980, the country also imported 36,184 MT of other petroleum products (i.e. bitumen, lubricants, greases, etc.,) at a cost of U.S. $1,904,191 (T.Shs. 15.9 million). Tanzania did however re-export to Rwanda, Burundi and Eastern Zaire a total of 12,043 MT of various petroleum products valued at U.S. $6,395,209 (T.Shs. 53.4 million). The country also exported 92,740 MT of residue fuel oil valued at U.S. $12,718,562 (T.Shs. 106.2 million). Residue fuel oil exports in 1981 are projected to be minimal due to substantial increases in the consumption of fuel oil in the country as a result of the commissioning of two new cement factories. Tanzania also sold 45,333 MT of fuel oil to foreign ships in 1980 earning the country U.S. $6,227,544 (T.Shs. 52.0 million) in foreign exchange. However, the country's projected petroleum import needs in 1981 are estimated at U.S. $359,281,437 (T.Shs. 3,000 million) - over 50% of the country's export earnings.

B. Natural Gas

Tanzania has embarked upon an ambitious energy program to reduce its dependence upon imported fossil fuels. Field explorations and drilling activities are underway at various locations in the country, as well as, offshore to ascertain the country's potential hydrocarbon reserves (gas and oil). One test well drilled offshore has shown some promising signs of potential large natural gas deposits. The government is in the process of negotiating with several oil companies for further exploration activities in the prospective areas.

C. Coal

Tanzania has some fairly rich known coal reserves in the southwestern and southern areas of the country. The major coal fields are Ketewaka-Mchuchuma, Songwe-Kiwira, and Ngaka. Exploitation investigations have begun at the Songwe-Kiwira and Ketewaka-Mchuchuma fields. It is estimated that these fields have an estimated total geological reserve of 1.24 million tons of coal with a BTU value equivalent to most good African coals. At present, only one (Ilima Colliery) of Tanzania's known nine coal fields is in production. The Ilima colliery produces about 7,000 metric tons of coal per year. The national demand for coal is expected to rise to 150,000 tons per year by 1982 due to energy requirements of new industries, such as the Mufindi Pulp and Paper factory, Mbeya cement plant, and the proposed iron and steel factory expected to be developed near the Ketewaka-Mchuchuma fields.

D. Fuelwood

Approximately 90% of Tanzania's population live in rural areas. In rural Tanzania, fuelwood is the dominant source of energy utilized in the domestic households for cooking and heating. Wood is also utilized in the rural industrial sector for brick kilning, baking, tobacco and tea drying. The demand for fuelwood is estimated to range from 1 m^3 to 3 m^3 per capita per year. In areas where trees are scarce, wood is supplemented by cattle or sheep dung, grass, sorghum, and corn stalks. The extensive use of firewood and charcoal for energy in the rural areas of Tanzania has started to show serious environmental degradation. Tanzania has approximately 8,000 villages each requiring an average of 3,000 m^3 of fuelwood per year. The growth increment of 40 m^3 per hectare would require 75 hectares of consolidated forest per village per year. Although Tanzania has some 11.2 million hectares of woodlands, the country has an estimated afforestation deficit of 18 million m^3 per year. It is predicted that large parts of Tanzania will be desert in 60 years if urgent afforestation and forest control measures are not taken soon. The indigenous forests are shrinking quickly and most villagers get their firewood outside the boundary of the village. It has been reported that in areas of East Africa and Tanzania fuelwood gathering round trips of up to 100 kilometers are not uncommon. The traditional practices of utilizing wood fuel to cure tobacco and drying tea take a tremendous toll on the country's woodlands. It takes one hectare of savanna wodland to cure one hectare of tobacco. Tobacco growing in Tanzania is expanding at the rate of 20% annually, and the savanna is disappearing at that rate. Urgent conservation measures are needed to control this degradation process.

E. New and Renewable Energy Sources

Tanzania has made some significant progress in its

investigations on the use of other indigenous energy resources which are renewable and abundant in the country, such as biomass, sunshine, wind and small streams. Solar dryers, stills, water heaters and photovoltaic prototype devices are being developed and field-tested at various locations throughout the country. To date only solar water heaters are under commercial production on a very limited basis.

Biogas units for cooking, and some lighting, are being introduced in several regions in Tanzania. The Arusha Appropriate Technology Project (AATP), supported by the Small Industries Development Organization (SIDO) has started production of a 2 m^3 methane generator system using oil drums which currently cost U.S. $90 (T.Shs. 700). A larger biogas plant is planned for a residential area of the Dodoma city as a solution to refuse collection and as a measure to help meet domestic energy requirements.

F. Hydroelectric Power

Tanzania's hydroelectric potential is estimated to be between 3,000 MW and a potential firm yield of about 20,000 Gwh. Presently, only 246 MW of Tanzania's potential hydroelectric power has been developed and provides power to the country's existing electricity grid system. Tanzania's hydroelectric potential is found mainly in the Kagern River Basin in northwest Tanzania and in the major rivers draining into the Indian Ocean. Tanzania's largest individual potential hydroelectric site exists in the Rufiji River basin area at Stiegler's Gorge. It is estimated that this station would be capable of producing between 300 MW to 3,000 MW of electricity.

The government has estimated that approximately 10% of the country's oil import requirements can be replaced by hydroelectric energy. This reduced oil requirement will occur mostly in area where diesel driven electric generators would be replaced by hydroelectric networks.

G. Geothermal

Studies are underway to investigate Tanzania's known geothermal resources. Over seventy thermal springs have been located in the Ngorongoro, Mbeya, Dodoma and Rufiji River basin areas in the country. Most of the thermal springs are found in the vicinity of the Rift Valley and along the known fault zones in the country. Further exploration is needed to estimate and prove the country's geothermal resources.

III. Government Energy Policy

Realizing that there are no immediate solutions to the country's current economic and energy problems, Government of Tanzania has introduced energy curtailment policies of fuel rationing, pricing,

and other conservation measures. Although the program appeared to be technically sound, lack of policy coordination between the government's energy producing and consuming agencies have offset the expected achievements of the energy conservation program. For example, while one agency of the government was trying to promote fuelwood conservation measures to check the environmental degradation of the country's woodlands, another agency of the government was encouraging rural as well as urban communities to use burnt bricks rather than cement blocks in building - since cement factories utilize fuel oil for operation purposes. The government has, however, launched many campaigns to educate the people about the necessity of protecting the natural forests and replacing the dwindling forest resource. The government is mounting a special country-wide campaign on village afforestation. The Government has also commissioned the International Institute for Environment and Development from London, England with assistance from the Middletown Associates, Toronto, Canada, to review the existing energy situation in Tanzania and assist the government in the formulation of national energy policies.

IV. Private Sector Involvement

The Government of Tanzania is currently negotiating with two oil companies, AGIP and Amoco to further investigate the country's oil and gas potential. Tanzania has also signed a participation agreement with an American firm, Agrico, for the construction of an ammonia/urea plant to produce 345,000 MT per year of ammonia and 520,000 MT per year of urea, mainly for export. The American company will acquire 26% shares in the venture and the remaining 74% will be owned by the Government of Tanzania through the Tanzania Petroleum Development Corporation (TPDC).

UPPER VOLTA

I. Introduction

Upper Volta is an arid, landlocked country of some 274,000 square kilometers. Rainfall varies from more than 1,000 mm per annum in the southwest to less than 600 mm per annum in the Northest. Vegetation ranges from Sudano-Guinean open forests and bushland in the southwest to Sahelian grasslands in the northeast. The resident population is estimated to be 6.2 million. The vast majority of the population live in rural areas and there is considerable population pressure on the central (Mossi) plateau.

II. Sources of Energy

The only source of conventional energy in Upper Volta is imported petroleum. Imports of petroleum products into Upper Volta doubled over the last five years for which statistics are available. The total imports were 145,673 MT in 1979. (Table I gives quantities and value, 1975-79). There is no coal, nuclear or hydroelectric energy either produced in or imported into Upper Volta.

Traditional energy sources are fuelwood, charcoal, crop residues and animal wastes. Fuelwood is by far the largest source of energy in Upper Volta. Production is almost entirely by regeneration of natural forests. Harvesting is done by final users in rural areas and by small-scale entrepreneurs near urban areas.

III. Consumption of Energy

In spite of a doubling of retail petroelum prices in the last three years (Table II), consumption of petroleum products has continued to rise sharply (more than 10% per annum) in recent years (Table III). Principal uses of petroleum products are for transportation, electricity (all of which is generated by oil), and light industry. Agricultural uses are minimal.

In 1979 petroleum imports of more than 7 billion FCFA accounted for about 11% of all imports and represented 45% of the value of Upper Volta's exports. The cost of petroleum imports represented half of Upper Volta's current account deficit in 1979.

Approximately 94% of all energy consumed in Upper Volta comes from a traditional source - fuelwood the bulk of which is used for cooking. Annual per capita consumption of fuelwood is estimated to be 1.0 m^3/year in rural areas and 1.3 m^3/year in urban areas. This translates into about 6.8 million m^3/year nationwide. As the estimated annual natural regeneration of the nation's forests is about 5.4 million m^3, there is an annual shortfall of 1.4 million m^3.

The impact of this shortfall on the nation's biomass is devasting, particularly on the Mossi plateau. Although the rate of deforestation is not readily measurable, the magnitude and

seriousness of the problem is evident even to the most casual observer.

Beyond the physical impact of deforestation, the process has substantial social and economic consequences. Other important uses of forest products such as foodstuffs, medicinal ingredients, shade, construction materials, forage and fencing are necessarily diminished as forest resources dwindle. Families, and particularly women, must spend an ever increasing proportion of their time gathering firewood. What is more, to the extent that deforestation contributes to declining soil fertility, food production suffers.

In the urban setting the need to buy firewood for cooking is becoming a crushing burden on poorer families who spend 20 to 30% of their incomes on firewood. One donkey cart, which may last 2 months, costs from 4,500-6,000 FCFA. The impact this cost has on resources available to the family for food, health, education or small investments is clearly major and negative.

IV. Energy Resources

Upper Volta has no known oil, gas, or coal potential. There is a modest potential for development of hydroelectric power, although this has yet to be realized.

A number of alternative energy schemes have been investigated including improved woodstoves, biogas, windmills, solar cookers, and a variety of other solar energy activities. None of these alternative technologies has been disseminated on a wide scale.

The country has an estimated 246 million m^3 of forest resources on 13 million hectares of forest area, exclusive of wildlife reserves and farmers' fields. As noted above, replanting and natural regeneration fall substantially short of utilization.

There are three principal sources of pressure on the country's forest resources: land clearing for agricultural production; fuelwood cutting; and animal browsing. All contribute to the deforestation problem. While there is widespread recognition in heavily populated areas that the disappearance of the forests is a major problem, there is no consensus among rural users of forest resources of the steps which need to be taken to resolve the problem. Forest resources are generally perceived as a public good in Upper Volta -- available for exploitation by the first comer -- so that there is little or no incentive for potential private users to exercise constraint or conserve forest resources. At the public level, there is a perceived need to address the problem of fuelwood conservation, but, as with other development problems facing Upper Volta, there is no well-defined plan for dealing with problems, nor are adequate resources available to finance such a plan.

The environmental implications of Upper Volta's deforestation problem are immense. These are principally declining soil fertility through erosion, degradation of the nations's range and

forests, and ultimately a lowering of the water table. As a primarily agricultural country, the probable consequences of these trends are no less than catastrophic. While efforts are underway to monitor the extent of the deforestation through remote sensing and other survey technologies, there is as yet no reliable and consistent source of information on the problem.

V. Government Energy Policy

Energy matters are handled by three different ministries. Conventional energy concerns fall under the jurisdiction of the Ministry of Commerce, Industrial Development and Mineral Resources. Forest resources fall into the domain of the Ministry of Environment and Tourism (MET), although any efforts to promote agroforestry techniques and other village-level interventions must rely on the Ministry of Rural Development for extension.

Multinational oil companies (Shell, BP, Total, Mobil, Texaco) are the major importers and retailers of petroleum products into Upper Volta. These companies purchase from the Societe-Ivorienne de Raffinage (SIR) (of which the Government of Upper Volta (GOUV) is part owner) for importation and sale of a price fixed by the government (SEE Table II for SIR and retail prices). Until recently there was a subsidy on the price of gasoline although this has now been phased out due to the high cost of subsidizing an ever-increasing demand for petroleum products. Electricity is not subsidized.

The MET policy on fuelwood and reforestation is diffuse, and therefore difficult to define as a precise strategy. Some of the principal elements are as follows:

- Promotion of the planting and use of local species
- Promotion of village-level reforestation efforts
- Better control of bush fires
- Support to decentralized production of seedlings at the level of each sub-prefecture
- Improvement and intensification of the management of the forest reserve system
- Promotion of soil conservation and erosion control through agro-forestry techniques
- Promotion of energy-efficient woodstoves
- Increased support to Forest Service personnel (housing, vehicles, operating expenses)
- Improved data collection and analysis of wood production and consumption
- Increased wood production on industrial plantations for urban areas.

VI. Private Sector Involvement

As noted above, the role of oil companies is circumscribed since they buy from a refiner partially owned by the GOUV and sell at prices fixed by the GOUV. Electricity production is controlled by

a parastatal monopoly. Therefore, apart from experimentation by energy companies with alternative energy sources (some of which is already taking place), there does not appear to be a major role for multinational oil companies in addressing Upper Volta's energy problems.

A more promising avenue for a private sector contribution to resolving Upper Volta's energy problems is the potential for artisan production of fuel-efficient woodstoves. Masonry is a well established trade in rural Upper Volta and training institutions exist which can teach traditional masons the new woodstove techniques. A number of woodstove-promotion schemes are already trying to build on this traditional base.

VII. Response to the Problem

In terms of conventional energy utilization, the GOUV has taken a rational approach to limiting consumption by setting prices at predominating market levels. In this way not only will consumption be curbed, but scarce financial resources will be conserved.

Concerning traditional fuels, the Ministry primarily responsible for the most important fuel -- forest products -- receives about 1% of the national budget resources, or $2 million/year, the bulk of which goes for salaries. Consequently, any investment will inevitably be financed by outside donors. Current efforts, which will certainly fall short of needs, are summarized below:

Agency/Project	Hectares
Ministry of Environment	2,000
Village Reforestation:	
USAID/Peace Corps	200
Swiss funding	480
Dutch funding	220
German funding	1,000
Africare	150
World Bank	400
Large-scale Reforestation	
German	3,950
French	3,500
FAO/UNDP	1,800
Other	1,200
TOTAL	16,250

In addition, USAID is involved in a major training effort at the Dinderesso forestry agent training center under the Forestry Education and Development project (686-0235). The project is both training agents at the school and developing a model forest management plan for the nearby Dinderesso Forest Reserve.

Due to its complete lack of conventional energy resources and resulting reliance on firewood as a source of energy, Upper Volta's energy strategy must (and does) concentrate on its forest resources. Areas to which priority should be given over the next five years are as follows:

- Research: Basic research is needed to select and develop sound local species. Applied research is needed to learn more about how rural dwellers perceive their forest resources and about how private incnetives can be developed to promote public forest conservation objectives.

- Management of National Forests: Vast forest resources are available in the National Forests which, if properly managed and harvested, could significantly reduce the fuelwood production/consumption gap. USAID is gaining experience in such management techniques at Dinderesso. This effort should be followed by larger scale implementation of these techniques.

- Institutional Development: The capacity of the MET to analyze and address the nation's forest crisis is extremely limited. This capacity should be augmented through continued management and technical training, as well as through financial support for operations.

TABLE I
Import of Petroleum Products into Upper Volta 1/
1975-1979

	1975	1976	1977	1978	1979
Volume (in metric tons)	75,090	65,406	85,971	119,911	145,673
Value (CIF in millions of CFA Francs)	2,864	2,700	4,357	4,347	7,236

1/ Source: BCEAO, Statistiques Economiques et Monetaires, No. 294, May, 1981, p. 27.

TABLE II
Prices of Petroleum Products (1978-1981) 1/
(In CFA Francs/liters)

Import Prices (f.o.b. Abidjan)	March 1978	April 1979	February 1980	August 1981
Premium gasoline	33.18	44.66	63.68	108.00
Regular gasoline	31.80	43.28	63.15	105.00
Kerosene	34.08	36.06	34.08	60.00
Diesel	29.70	39.03	61.95	102.50
Retail Prices (Ouagadougou)	**February 1978**	**February 1979**	**February 1980**	**August 1981**
Premium gasoline	110	125	165	238
Regular gasoline	102	117	156	225
Kerosene	77	89	95	124
Diesel	79	93	133	198

1/ Sources: Ministere du Commerce, du Developpement Industriel et des Mines, BUVOGMI; and Direction Generale du Commerce et des Prix, Secretariat Permanent a l'Homologation des Prix.

TABLE III
Consumption of Petroleum Products In Upper Volta 1/
1976-1980

	1976	1977	1978	1979	1980
		(in cubic meters)			
Premium gasoline	4,159	5,657	7,282	8,483	9,395
Regular gasoline	41,410	47,100	52,171	58,480	61,778
Kerosene	12,121	11,870	12,464	13,162	13,629
Diesel	17,149	21,296	24,455	25,050	27,913
		(in metric tons)			
Light Distillate	19,764	22,881	25,998	23,256	25,611
Fuel Oil	5,838	4,581	5,765	14,612	17,362

1/ Source: BCEAO, Statistiques Economiques et Monetaires, No. 294, May, 1981, p. 27.

ZAIRE

I. Summary

Zaire relies primarily on wood, charcoal and imported petroleum for energy. Deforestation has begun to occur near population centers; no firm government policy exists for reforestation. National policy calls for hydropower to substitute increasingly for traditional and imported fuels. Exported crude oil helps to offset the import costs of refined petroleum. Electricity and petroleum distribution are managed by parastatal corporations; the remainder of most energy production and distribution is in the private sector.

II. Energy Sources

A. Petroleum

Petroleum is imported in refined form to supplement that which is pumped offshore from Zaire's short coastline. Zaire spent $240,000,000 in 1980 to import petroleum products. The offshore reserve is proven at 60 million barrels; a joint Zairian-Italian refinery processes the crude. Processed fuels are distributed by SEP Zaire, a parastatal which allots supplies and assists in setting retail prices. In 1979, nearly 75 percent of all petroleum fuels was consumed in the metropolitan Kinshasa area.

B. Coal

Coal is mined in three locations of Shaba region. Most of the output goes to smelting and cement production.

C. Electricity

Hydroelectric generation provides 92 percent of Zaire's electrical production. The remainder is produced mainly by diesel generators. While large urban centers are electrified, rural distribution lines exist only in portions of Bas-Zaire and Shaba regions. The majority of small towns, villages, and rural installations depend on power generated by diesel or small hydro facilities. Mining absorbs 60 percent of all electricity in Zaire; metropolitan Kinshasa accounts for another 18 percent.

The Inga Dam, located on the Zaire River where it cascades down the African escarpment, has 1,620 mw of Zaire's 2,382 mw installed capacity. Expansion of distribution to rural parts of Bas-Zaire and southern Shaba is planned. Power is available from the Inga-Shaba transmission line but expansion is constrained by the costs of equipment and technology and inadequate numbers of trained personnel.

Electrical generation and distribution is controlled by the Societe Nationale de l'Electricite (SNEL), a parastatal

corporation. Trained professionally in the U.S. and Sweden, SNEL personnel operate and maintain the major hydroelectric plants, including Inga, and the distribution network. With a limited capital budget, existing plants and lines have been maintained but not renovated or expanded.

D. Wood and Charcoal

Firewood is the major source of cooking and heating fuel. Zaire has approximately 100 million hectares of rain forest and 21 million hectares of lightly forested savannah. The majority of the population is located in the savannah areas, placing a significant demend for fuelwood on limited resources. Deforestation is becoming evident around the cities and the more densely populated rural areas.

Charcoal is preferred for cooking and artisanal use, especially in cities. Traditional methods of wood conversion yield about 20 percent by weight in charcoal. Despite a higher price, charcoal is chosen for its convenience.

Consumption of wood and charcoal is estimated at one cubic meter of wood and 36 kg of charcoal per capita per year. National consumption in 1980 was estimated at 25 million cubic meters of wood and 450,000 metric tons of charcoal. The demand is projected to rise to 48 million cubic meters and 836,000 metric tons, respectively, by the year 2000. Demand will be concentrated in the lightly forested savannah and the mountain areas of the Great Lakes.

E. Solar Energy

Solar Energy has been used traditionally for drying crops. Small solar collectors are installed in selected areas to supplement diesel-powered generators. No large installations of collectors are foreseen at present.

F. Alternative Fuels

Alternative fuels available in Zaire include some ten million tons of economically recoverable shale oil near Kisangani. In Bas-Zaire, a deposit of 300 million tons of 20 percent tar sands was exploited until 1958. Two hot springs are found on the eastern border. Methane has been discovered in economically usable quantities under Lake Kivu. Lastly, a large sugar company drives a 4 mw generator in Bas-Zaire region with mill wastes.

III. Environmental Implications

A. Fuelwood

Demand for fuelwood in the populated areas of the southern

savannah and eastern mountains has already begun to exceed natural regrowth. Young trees are cut along with mature trees, and no organized replanting is being done. Major cities already are ringed by belts of cleared land up to 50 km wide.

The practice of cutting nearly all trees except palms is exacerbated by the traditional practice of burning the savannah grass each dry season. Young trees are killed; older trees are damaged; wildlife disappears. The loss of ground cover encourages rapid erosion of the sandy clay soils, with large, steep gullies resulting. Soil losses of up to 160 tons per acre annually have been recorded in Kivu province. There, the rich volcanic soils on steep slopes are especially vulnerable. Terracing has been tried and found successful as an erosion deterrent, but is not widespread.

B. Shifting Agriculture

In the rain forest of the Cuvette Centrale, farmers slash and burn new fields every two to three years. Without the constant replenishment of organic nutrients from the forest cover, the soil quickly loses its source of natural nutrients. The abandoned fields grow up into bush, but do not return to the tall forest. The Cuvette is very lightly populated and does not need to support intense agriculture at present.

On the savannah, soils have little organic matter and are prone to erosion and loss of nutrients. Natural release of phosphorus and potash can support light cropping, but intense agriculture cannot be practiced without substantial external infusions of nutrients. Farmers traditionally clear all plants from an area before cultivating. The resulting bare soil is easily leached and eroded, necessitating a shift to another place after several years.

IV. Zaire Energy Policy and Implications for A.I.D.

A. Energy Policy

Zaire's developing energy policy rests on the development of electrical generation and distribution, efficient use of wood resources, and reduction of gasoline usage. Pricing policy for retail gasoline sales, and customs duty on large cars, act as a disincentive for gasoline use. Diesel fuel receives more favorable treatment. With other donor assistance, some efforts have begun to improve the efficiency of charcoal conversion. Some private sector interest has been shown in reforestation. Plans exist for extending electrification to selected areas of Zaire, but implementation is inhibited by the large foreign exchange requirements.

Zaire's energy policy is an unofficial and evolving one. Various state agencies are engaged in analyzing the energy

sector and developing recommendations for a national policy. This activity gained some momentum in 1980 with the convening of all concerned agencies to begin a concerted dialogue on the numerous issues and options. This dialogue is continuing, but a coherent and comprehensive official national policy has not yet been defined. Wherever such a policy might point, Zaire's general economy at present is in no condition to permit the undertaking of any aggressive energy development program. Few additional GOZ inputs to the energy sector are anticipated over the next several years.

B. Implications for A.I.D.

USAID continues to include energy in its dialogue with the Government of Zaire. Selected energy sector officials are preparing for short-term participant training in the U.S. USAID is assisting the development of a small rural hydropower facility and is designing a larger project to help the GOZ establish an institutional capability for rural hydroelectric development. Some assistance also is being provided for the installation of solar panels in rural areas. USAID's and other donors' capacities to assist Zaire's energy sector development will be constrained for the immediate future by the GOZ's very limited capacities in this sector (as in others). USAID's strategy is based on limited assestance to the GOZ, within the latter's very limited absorptive capacities, and corollary assistance to the private sector where the motivation and capacity for energy development exist. The major energy sector role presently envisioned for USAID will be in small rural hydroelectric facilities development. This will take advantage of a widespread natural resource and will permit the major load of development to be carried by the private sector where appropriate assistance can be absorbed. At the same time, this activity will help lay an institutional base, within the GOZ, upon which longer term rural power development can grow.

ZAIRE ENERGY STATISTICS

Energy Sources

Wood and Charcoal	86%
Petroleum Fuels	9%
Electricity	4%
Coal	1%

Coal Production (metric tons)

1977	127,955
1978	106,646
1979	109,190

Petroleum Consumption (000 cubic meters)

	Gasoline	Diesel	Kerosene	Fuel Oil
1977	181	326	73	73
1978	192	379	59	69
1979	178	377	80	62

Petroleum Imports (metric tons)

	Gasoline	Diesel	Kerosene	Fuel Oil
1977	87	196	14	1
1978	96	290	14	-
1979	83	175	-	-

Hydroelectric Production (Gwh)

	Shaba	Kivu and Haut-Zaire	Bas-Zaire	Imports	TOTAL
1977	2,755	152	962	40	3,919
1978	2,548	165	1,051	7	3,782
1979	2,584	178	1,036	13	3,815

Note: 1979 diesel generated production estimated at 673 Gwh.

Hydroelectric Consumption (Gwh)

	Industry	Urban	Exports	TOTAL
1977	2,567	928	91	3,919
1978	2,322	972	140	3,782
1979	2,408	1,046	106	3,815

ZAMBIA

I. Introduction

Zambia is a sparsely populated, landlocked country with eight border states. It is situated on a high plateau with an elevation of 3,000 to 5,000 feet above sea level. According to the 1980 census, there are 5.7 million Zambians living in a country slightly larger than the state of Texas. Although sparsely populated, currently there are 40 percent more Zambians today than 10 years ago, and the present growth rate of 3.1 percent per annum implies a doubling of the population in 23 years. Approximately 40 percent of the population lives in urban areas.

The economy is dominated by copper mining. During the first 16 years since independence (1964) the copper industry accounted for over 90 percent of Zambia's export earnings, between one third and one half of the GNP and over 50 percent of the total government revenue receipts. However, a steep decline in world copper prices beginning in 1975, the war in Zimbabwe, foreign exchange shortages, rising costs of production (including oil prices), a shortage of expertise and transport problems have seriously affected Zambia's mining sector during the past several years. As a result Zambia has a policy to restructure and diversify the economy to lessen its dependence on the mining industry.

Since independence, Zambia has moved from complete dependence on external sources of energy to a high degree of self-sufficiency. By the late 1970's Zambia had achieved self-sufficiency in both electrical power and coal production, and, although still dependent on a significant amount of oil imports, it had established a new oil supply line and refining capacity.

II. Sources of Energy

Zambia's three major energy sources are hydroelectricity, coal and oil. Hydroelectricity, which supplies 58 percent of Zambia's energy needs, and coal, which supplies about 12 percent, are produced domestically. Imported oil constitutes approximately 26 percent of Zambia's annual energy needs, coking coal from Zimbabwe supplies 1.5 percent, and wood and charcoal supply approximately 2 percent.

TABLE I
Sources of Energy (%)

	1977	1978	1979	1980
Hydroelectricity	57.7	58.2	58.2	58.1
Oil	14.5	12.6	12.4	13.0
Coal	25.4	25.8	26.8	26.4
Coke	2.0	1.4	1.1	1.0
Other (Wood, Charcoal,etc.) 1/	0.3	2.0	1.5	1.5

1/ Source: Bank of Zambia.

A. Hydroelectricity

Hydroelectric power is by far the most important source of Zambia's energy supply. Approximately 93 percent of Zambia's total electrical generation is by hydropower (5 percent gas turbine, 1 percent waste heat and less than one half percent diesel). Total generation for 1980 was approximately 9,635 million KWH. Domestic production of hydroelectricity exceeded consumption by (5,726 million KWH) 3,909 million KWH or 30 percent of production. This surplus energy, minus a loss during transmission, is exported to Zimbabwe and Zaire.

B. Coal

Zambia's second most important energy source is coal, of which there are abundant supplies in Southern and Western Provinces. Presently it is estimated that Zambia has 21 million metric tons of recoverable coal using the present "open cast" method of mining (24 million metric tons if the underground method is used as well). Coal production was as high as 930,000 MT in 1972, but with the increased availability of hydroenergy demand has fallen steadily since 1975. Approximately 520,000 MT was produced in 1980. The main users of this form of energy are the mining industry, Chilanga Cement factory and the Nitrogen Chemicals of Zambia, Ltd. plant.

Although plentiful at present, Zambia's coal is of low quality with a high ash content, and quality coke is therefore imported from Zimbabwe's Wankie deposit (just across Zambia's borde near Livingstone) which is said to have up to a 100 years supply recoverable coal at present extraction rates.

C. Oil

The state-owned Zambia National Energy Corporation currently imports roughly 15,000 barrels per calendar day of spiked, Saudi Arabian crude oil through the 10.7 inch TAZMA pipeline which runs 1,705 kilometers from the harbor tank farm in Dar es Salaam to the Ndola Storage Facility in Zambia's cooperbelt. The crude oil is refined at the Ndola Refinery which operates at only 50 to 60% capacity. Roughly seven percent of the oil which Zambia imports is exported to Shaba Province in Zaire with small amounts sporadically to Malawi and Burundi. Erratic supply at Dar es Salaam, pipeline maintenance problems and chronic shortage of foreign exchange have reduced Zambia's oil stocks down to a relatively low level. Although the volume of oil imports dropped somewhat between 1975 and 1980 due to higher prices and compression in the Zambian economy, the volume of oil imports for the 1970-1980 decade doubled and foreign exchange expenditures on these oil imports increased four-fold in constant dollars.

D. Wood/Charcoal

With Zambia's sparse population and vast tracts of wooded lands, there are at present adequate supplies of firewood and charcoal, which are important sources of fuel for rural villages. Wind and solar power although as yet undeveloped, are viewed as important future sources of supply which can supplement power in the rural areas.

III. Energy Consumption

Below are estimates of Zambia's energy demand by sector and year in order of importance.

TABLE II
Energy Consumption (%)

	1977	1978	1979	1980
Mining	62	59	47	54
Commerce & Services	18	24	26	24
Manufacturing & Construction	16	12	19	16
Transport	3	3	5	4
Agriculture	1	2	3	2

The mining industry is by far the largest energy consumer, using at least 50 percent of the total energy supply in Zambia. Since 1975, when copper prices and production dropped there has been a slight reduction in the amount of energy used by the mining industry, but mining is expected to remain the dominant energy user in the foreseeable future.

Although imported oil provides only about 12 percent of Zambia's energy needs, at present the demand for oil is relatively inelastic. The mines consume about 40 percent of all oil imports and the transport sector consumes 27 percent. Since the mines earn virtually all Zambia's foreign exchange, and since transport is critical to this large landlocked nation, the relatively small amount of oil imports is an indispensable minimum. Transport and mines would cease to function if there was a major oil supply disruption.

IV. Development of Domestic Energy Resources

A. Hydroelectric Power

Zambia's greatest potential lies in further development of its hydroelectric resources. It is well endowed with sites for

hydroelectric development mainly on the Zambezi River (its border with Zimbabwe) the Kafue river (wholly within Zambia) and the Luapula river (its border with Zaire). Over the past decade growth has been rapid, and the Third National Development Plan (TNDP) anticipates a 4.3 percent growth rate through 1983.

The dramatic increase in the cost of imported oil during the 1970-1980 period focused attention on the need for Zambia to reduce oil consumption. High oil costs have eroded the profitability of the mining sector, weakened the financial viability of the already inefficient state-controlled manufacturing sector and strained the government's budget. As noted above, prolonged disruption in the TAZAMA oil supply would paralyze the mining sector and cripple the transport sector. Given this economic and strategic vulnerability, the major thrust of Zambia's energy development plans call for increasing hydropower and substituting it for oil. Key to this effort will be the extent to which the mines and the Zambian railway systems can be switched from an oil power base to an electrical one.

Electrification of the mines is not only important as a means to hold down oil imports, but electrification would reduce costs significantly and help Zambia's ailing mines remain internationally competitive. Unfortunately it would also reduce production at the oil refinery which is presently operating at 50 percent.

The World Bank's Third Railways Rehabilitation Project is in process, and it is making limited efforts toward electrification of Zambia Railways (ZR). Some funds to study electrification of ZR are also being provided by the EEC under Lome II. Progress on electrification of ZR will proceed slowly in the next few years, however, primarily because both domestic and international finance is lacking and because ZR's human infrastructure is weak.

B. Coal

Present coal production comes from one open pit mine with reserves that should last at least another 30 years. New coal deposits have been discovered recently in Western Province, however no estimates of these reserves have been made yet. The Government plans to increase coal production by an annual rate of 2.4 percent over the five year period ending 1983. Shortage of capital and expertise are constraining factors. As previously noted Zambian coal is low in quality and is not suitable as coke. The possibility of a coal liquefaction or gasification plant is being considered for study, but the feasibility of such a project is unknown.

C. Oil

There are no known exploitable deposits of oil or natural gas in Zambia. The government is considering allowing some aerial surveying, mostly in Western Province.

D. Nuclear

Zambia's uranium potential is not well measured. An airborne radiometric survey of the entire country was conducted in 1977. The radiometric anomalies are currently being investigated by thre private companies holding prospecting licenses. The most active is AGIP/SpA (Italian) which has spent $25 million since 1970 and presently is spending approximately $5 million annually on exploration. One estimate puts known deposits of uranium at 10,000 tons and estimated reserves at between 30,000 and 100,000 tons. There are four prospecting sites and numerous unprospected regions with uranium potential. Even the most optimistic plans, however, do not anticipate any mine development before 1985. Nuclear energy will probably not play a role in Zambia in the 1980's, but the potential exists further in the future.

E. Solar

Although the potential for solar energy in Zambia is good, the TNDP mentions the development and testing of solar energy (for water heating) only briefly. Over the course of five years $132,000 is earmarked for solar development. Much movement in the direction of solar energy use over the next decade is unlikely unless donors come forward and aggressively encourage a solar program.

F. Windpower

Wind-generated water pumps are commonly deployed on farms and in rural communities. There are very little data on the extent of windpower use. It is probably small, but significant for rural areas. The TNDP allocates only $125,000 for study of wind resources.

G. Ethanol

In mid 1981 Jager Associates of Zimbabwe began a feasibility study for a plant to produce ethanol from molasses which is currently available. (Jager has done similar work for ethanol plants in Malawi and Zimbabwe). Zimbabwe presently uses some ethanol in its petrol. At present Zambia has an annual output of about 40,000 tons of molasses at the state-owned Nakambala Sugar Estate. The proposed plant is designed to produce 16 million gallons of alcohol fuel annually. The IFC and World Bank have expressed interest in financing of the project. A second phase of the Jager study will look at the viability of using other agricultural raw materials to produce ethanol. If

present GOZ plans are realized ethanol could save up to 5 percent of Zambia's present oil bill.

H. Wood/Charcoal

Firewood and charcoal are major fuels for domestic household use. Although there appears to be some localized deforestation near the major urban areas, abundant supplies of wood are available in Zambia. The Department of Forestry has plans to reforest near urban areas, but lack of funds has hindered progress. Improved efficiency of fuelwood utilization has received some research attention (e.g. improved conversion ration of wood to charcoal), but little is known about significant actions taken to date. Although Zambia has a good deal of surplus electrical energy to replace firewood and charcoal for domestic consumption, the high installation costs are a major constraint to expansion of this service to individual domestic households.