Report No. 5073-CV

Cape Verde Issues and Options in the Energy Sector

August 1984

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

JOINT UNDP/WORLD BANK ENERGY SECTOR ASSESSMENT PROGRAM
REPORTS ALREADY ISSUED

Country	Date	Numbers
Indonesia	November 1981	3543-IND
Mauritius	December 1981	3510-MAS
Kenya	May 1982	3800-KE
Sri Lanka	May 1982	3792-CE
Zimbabwe	June 1982	3765-ZIM
Haiti	June 1982	3672-HA
Papua New Guinea	June 1982	3882-PNG
Burundi	June 1982	3778-BU
Rwanda	June 1982	3779-RW
Malawi	August 1982	3903-MAL
Bangladesh	October 1982	3873-BD
Zambia	January 1983	4110-ZA
Turkey	February 1983	3877-TU
Bolivia	April 1983	4213-BO
Fiji	June 1983	4462-FIJ
Solomon Islands	June 1983	4404-SOL
Senegal	July 1983	4182-SE
Sudan	July 1983	4511-SU
Uganda	July 1983	4453-UG
Nigeria	August 1983	4440-UNI
Nepal	August 1983	4474-NEP
Gambia	November 1983	4743-GM
Peru	January 1984	4677-PE
Costa Rica	January 1984	4655-CR
Lesotho	January 1984	4676-LSO
Seychelles	January 1984	4693-SEY
Niger	March 1984	4642-NIR
Ethiopia	July 1984	4741-ET

FOR OFFICIAL USE ONLY

Report No. 5073-CV

CAPE VERDE

ISSUES AND OPTIONS IN THE ENERGY SECTOR

AUGUST 1984

This is one of a series of reports of the UNDP/World Bank Energy Sector Assessment Program. Funding for this work has been provided, in part, under the supplementary "Small-Country Assessment Program" financed by the Swedish Government through the UNDP, and the work has been carried out by the World Bank.

ABSTRACT

The energy situation of Cape Verde is characterized by a total reliance on imported petroleum fuels for meeting the needs of transport, industry, and a third of the households, and the gradual destruction of the naturally sparse plant cover which provides fuel for two-thirds of the households. An unrelenting drought, which has lasted since 1967, has contributed to an extremely high level of external dependence and has accelerated the process of desertification. Faced with these difficult conditions, the Government's overall development objectives are to reduce external dependence and combat desertification, and the energy sector's objectives are to minimize the economic cost of energy and increase the reliability of its supply. On the demand side, this can be done by increasing the efficiency of energy use, through improvements in the power plants and distribution networks, reducing the losses of desalinated water and popularizing the use of fuel efficient woodstoves. On the supply side, efforts need to concentrate on the development of the country's own energy resources, the most important of which is firewood. Finally, the achievement of these objectives requires that energy prices reflect their full economic costs, and the consumption of energy intensive goods, such as desalinated water, not be subsidized.

ACRONYMS

CILSS	International Commission to Combat the Desertification of the Sahel
DGE	Directorate General of Energy (Planned)
ENACOL	National Enterprise for Fuels and Lubricants
INIT	National Institute of Technological Research
MDR	Ministry of Rural Development
SEINE	State Secretariat of Industry and Energy, Ministry of Economy and Finance
USAID	United States Agency for International Development

ABBREVIATIONS

cap	capita
c.i.f.	cost, insurance, frieght
f.o.b.	free on board
GWh	Gigawatt hour
ha	hectare
hp	horsepower
kgoe	kilogram of oil equivalent
km^2	square kilometer
kWh	kilowatt hour
l	liter
LV	low voltage
m	meter
mn	million
m^3	cubic meter
MW	Megawatt
MV	medium voltage
n.a.	not available
ton	metric ton
toe	metric ton of oil equivalent
tpy	tons per year

PREFIXES

kilo	-	1,000
mega	-	1,000,000
giga	-	1,000,000,000

CURRENCY EQUIVALENTS

Currency Unit: Escudo de Cabo Verde (ECV)
Exchange Rate: 77.00 ECV/US$ 1/

Fuel Conversion Factors

(Net calorific content expressed in tons of oil equivalent of 10.2 million kilocalories)

Product	Conversion Factor	Density
Electric Power	86.00 toe/GWh a/	-
Butane	1.05 toe/ton	0.58
Gasoline	1.03 toe/ton	0.74
Kerosene	1.01 toe/ton	0.83
Jet Fuel	1.02 toe/ton	0.83
Gas Oil	1.00 toe/ton	0.84
Fuel Oil	0.94 toe/ton	0.96
Firewood	0.33 toe/ton	0.70
Other Biomass b/	0.25 toe/ton	-

a/ This reflects the energy content of electricity. The amount of fuel that is required to generate electricity in Cape Verde is about 250 toe/GWh, which implies a conversion efficiency of 34%.

b/ Includes bean stalks, corn stalks, shrubs, agave leaves, palm leaves, coconut husks, dung, and grasses.

This report is based on the findings of an energy assessment mission which visited Cape Verde in November, 1983. Its members were Andres Liebenthal (mission leader), Franciscus Bertrums (power engineer, consultant), Geoffrey Gray (forester, consultant) and Jean-Rene Leidner (wind energy expert, consultant). A draft of the report was discussed with the Government in July 1984.

1/ This was the exchange rate in November, 1983.

TABLE OF CONTENTS

ANNEXES

TABLES

MAPS

SUMMARY

Energy Situation and Priorities

1. The energy situation of Cape Verde is characterized by a total reliance on imported petroleum fuels for meeting the needs of transport, industry and a third of the households, and the gradual destruction of the naturally sparse plant cover to provide fuel for the remaining two thirds of the households. In 1982, commercial energy consumption was 116 kgoe per capita, and firewood and other biomass use was tentatively estimated at 163 kgoe per capita. Imports of petroleum fuels have gradually increased from about 29.5 thousand tons in 1979 to 35.1 thousand tons in 1982, equivalent to about 9% of total imports and one-third of export earnings in 1982. In addition, Cape Verde services an important international bunker market (at the port of Mindelo and Sal Airport), which consumed 149 thousand tons of petroleum fuels in 1982 (down from 174 thousand tons in 1979) and contributed about half of total export earnings. The consumption of firewood and other biomass fuels has been estimated at 49 thousand toe per year, but this consumption rate is associated with a very severe shortage of firewood. People burn wood and twigs when they can, but dried stalks, leaves and dung appear to be equally important sources of fuel. Excessive trimming of trees and uprooting of shrubs and grasses for fuel and forage have been a major cause of erosion, but have been virtually impossible to control in the absence of affordable substitutes.

2. Faced with these difficult conditions, the Government's overall development objectives are to reduce the country's dependence on foreign aid and to combat desertification, and the objectives for the energy sector are to minimize the economic cost of energy and increase the reliability of its supply. Based on these objectives and a review of the energy situation, the mission concluded that the first priority for the sector is to increase the efficiency of energy supply and utilization, and to continue developing the country's single major energy resource, firewood.

Principal Issues and Recommendations

Energy Pricing

3. The Government understands the importance of encouraging the rational use of energy and the development of domestic energy resources by setting the prices of the various energy forms used in Cape Verde at levels that reflect their full economic cost. However, the pricing methódology currently used is based on unrealistic amortization schedules and returns on capital that are not sufficient to allow the companies to replace their fixed assets when they wear out and finance their future

expansion. In view of the need to strengthen the financial foundation of the enterprises, it is recommended that the Government request separate cost accounting for power and water, realistic amortization scheduling based on revalued assets and explicitly recognize the capital costs associated with energy supply (paras. 4.1-3). With regard to firewood prices, the mission recommends that the Government develop a strategy to ensure that the entire producible output is sold, even though a portion of it may have to be priced at a level below replacement cost, as a way to reduce the pressure on the country's sparse vegetative cover (para. 4.7). In addition, in view of the fact that water desalination uses more energy than any other industry, the current subsidy of the price of desalinated water is equivalent to a subsidy on energy consumption. Here again, the mission recommends that its price be raised to reflect its full economic cost and encourage its more rational utilization (para. 4.4).

Power Investments

4. The most economical way to increase the supply, and at the same time reduce the cost of electricity, is by improving the efficiency of power generation (paras. 2.12 and 5.10) and reducing the losses between generation and sales from the current level of 38% to about 12-15% (para. 2.13). Electra is already preparing the replacement and rehabilitation of its major distribution systems for which the budget estimate of 81 million ECV (US$1.1 million) appears to be inadequate. Further preparation is needed to determine the scope and financial requirements of the projects that will be required to bring down losses to an acceptable level. These projects, plus a few minor ones that involve the overhaul of equipment and improvement of working conditions, deserve the highest priority (para 5.2).

Afforestation Investments

5. Firewood from forest plantations is the lowest cost fuel available to the country and the lowest cost fuel that can be supplied to the rural population to reduce the pressure on the remaining vegetative cover (para. 3.5). The current budgeted funding level of about 125 million ECV (1.6 million US$) per year appears to be sufficient for the afforestation of 3,000-3,500 ha. per year. This rate of afforestation needs to be sustained to plant all the lands suitable for tree planting by the end of the century (para. 5.5). In addition, to balance fuelwood supply with demand and reduce the use of shrubs, grasses and other organic materials that are needed to protect the soil, it is absolutely crucial that the afforestation effort be complemented by a program to introduce efficient woodstoves (paras. 2.7-8).

Wind Energy Development

6. Given the favorable wind regime in Cape Verde, the utilization of wind energy for power generation, water desalination and water pumping appears to have a significant potential for economic development. Based

on the technical and economic characteristics of the system, which remain to be verified in pilot tests, hybrid wind/diesel power generation systems have the potential for substituting about 390 toe of gasoil per year (para 3.8) and wind water pumps could obviate the need for 200-400 toe of gasoil per year (para. 3.12). Therefore, the projects to demonstrate and develop these applications, budgeted at 70 million ECV (0.9 million US$) for 1984/85, deserve high priority.

Technical Assistance Requirements

7. On the basis of the discussions in the report, the following recommendations would benefit from appropriate technical assistance projects:

(a) the consolidation of the recently created Directorate General of Energy to formulate energy development strategies, coordinate sectorwide planning and prepare the energy sector investment program (paras. 1.4 and 5.7);

(b) the creation of an Energy Information Center to collect, process and publish energy sector data, operate a technical library, and run a public information program (paras. 2.2 and 5.7);

(c) the organization of an Improved Woodstoves Commercialization Program, as a critical component of a strategy to balance firewood supply with demand (paras. 2.8 and 5.8);

(d) the implementation of a Management Information System (MIS) to enable Electra's management to separate power-related from water-related costs and thus provide a solid basis for setting tariffs. The MIS would also allow management to set technical and financial performance targets and monitor their achievement (para. 4 and 5.9);

(e) the design of a Power System Loss Reduction Program to evaluate the introduction of modern power plant control systems and load management techniques, the redesign of system standards, and the improvement of maintenance and operational practices and procedures (para. 5.10);

(f) a review of the desalinated water supply system, to develop a long term expansion program to meet anticipated requirements, and to analyze the possibilities for reducing the losses and improving the reliability of water distribution (para 2.15 and 5.11);

(g) the establishment of a forestry data recording and collection system that would gather information on planted areas, survival rates, growth rates, standing volumes, planting costs, production, rainfall, etc. (para. 3.5a);

(h) the formulation and implementation of a forest management program that would seek to maximize the economic value of existing plantations (para. 3.5c);

(i) an expanded training program for Forest Service staff to ensure that sufficient staff will be available to execute the national afforestation program as it is planned (para. 3.5e).

I. THE ECONOMIC AND INSTITUTIONAL CONTEXT

Energy in the Economy

1.1 Cape Verde is a small country of approximately 300,000 inhabitants, with a GDP of about US$260 per capita, scattered over nine semi-arid, volcanic islands with a total area of 4,033 km^2. The country's natural resource base is poor and has been rapidly deteriorating as a result of the severe drought which has afflicted it since 1967. The overwhelming characteristic of Cape Verde which conditions its political, economic and social development is its extreme dependence on foreign aid. In recent years, close to 40% of basic food needs have had to be met by international donations, and more than 80% of investment needs have been met through foreign grants and credits. This high degree of external dependence is expected to be a feature of the country's economy in the foreseeable future. Faced with these difficult conditions, the Government's development strategy, as described in the First National Development Plan (1982-85), is aimed at reducing the country's external financial and economic dependence and combatting desertification.

1.2 The energy situation of Cape Verde is characterized by a total reliance on imported petroleum fuels for meeting the needs of transport, industry, and a third of the households, and the gradual destruction of the naturally sparse plant cover which is the only source of fuel for two thirds of the households. As of 1982, commercial energy consumption amounted to 116 Kgoe per capita, and firewood and other biomass use was tentatively estimated at about 163 kgoe per capita. Imports of petroleum fuels have gradually increased from about 29.5 thousand tons in 1979 to 35.1 thousand tons in 1982, which was equivalent to about 9% of total imports and about one-third the value of export earnings. In addition, Cape Verde services an important international bunker market (at the Port of Mindelo and Sal Airport), which consumed 148 thousand tons of petroleum fuels in 1982 (down from 174 thousand tons in 1979) and contributed about half of total export earnings. Thus, the country's traditional role as a fueling station for international traffic continues to provide a quarter of its GDP. Table 1.1 illustrates the recent trend of these variables in relation to major economic indicators. The consumption of firewood and other biomass fuels has been estimated at 49 thousand toe per year, but this consumption rate is associated with a very severe shortage of firewood. People burn wood and twigs when they can, but dried stalks, leaves and dung appear to be equally important sources of fuel. Excessive trimming of trees and uprooting of shrubs and grasses for fuel and forage have been a major cause of erosion, but have been virtually impossible to control in the absence of affordable substitutes. Given the importance of energy to the country's future development, the Government has planned to invest about 420 million ECV (5.5 million US$) per year during the 1984-85 period, equivalent to 6% of the total public investment budget, and 5% of GDP, in the energy sector including afforestation investments.

Table 1.1: MAJOR ECONOMIC INDICATORS

	1979	1980	1981	1982
Population (thousands)	293	296	298	300
GDP/cap (constant US$ of 1982)	249	244	207	260
(millions of constant US$ of 1982)				
Gross Domestic Product	73	72	62	78
Gross Domestic Investment	56	41	58	63
of which: Energy a/	1	4	4	7
Exports of G and NFS	16	21	24	31
of which: Services to Transportation b/	8	9	15	21
Imports of G and NFS	98	98	105	101
of which: Petroleum Products c/	5	5	8	9

a/ Including desalination and not including afforestation.
b/ Includes services, fees and sales of fuels and other goods to international transportation, net of import costs.
c/ Does not include reexports.

Source: Cape Verde: Country Economic Memorandum (in preparation).

Institutional Framework

1.3 The management of the energy sector is centered around the following Government agencies:

(a) the State Secretariat of Industry and Energy (SEINE) of the Ministry of Economy and Finance is charged with the planning and regulation of supply and distribution systems for petroleum products, electric power, water desalination, new and renewable energy sources, energy conservation and energy pricing;

(b) the Forestry Service of the Ministry of Rural Development (MDR) is in charge of afforestation, forest protection, forest management, and the exploitation and sale of forest products;

(c) the Division of Renewable Energies (DER) of the MDR is in charge of promoting the use of renewable energies in rural areas. It is primarily active in the testing, installation and manufacture of windmills for water pumping, desalination and small scale electricity generation;

(d) the National Institute for Technology Research (INIT) is in charge of the transfer and adaptation of available technologies to meet the country's requirements. It is studying the potential for wind power generation, geothermal energy, biogas and solar ponds.

In addition, the actual supply of commercial energy is handled by the following companies, which are regulated by the SEINE:

(e) the National Enterprise for Fuels and Lubricants (ENACOL), a government owned company created in 1979, which supplies about 38% of the domestic market and 7% of the reexport market for petroleum fuels;

(f) Shell Cabo Verde, a private company established in 1977, which supplies the rest of the petroleum fuels market;

(g) Electra, a government-owned utility created in 1982 with the merger of the Praia, Mindelo and Sal power utilities, is in charge of the major generation and water desalination systems. It operates a 2822 kW power plant in Praia, a 6560 kW power plant plus a 2400 m^3/day multi-stage flash desalination plant in Mindelo, and a 1000 kW power plant plus a 660 m^3/day reverse osmosis desalination plant in Sal;

(h) ten rural power plants, owned and operated by the local councils and supervised by the Ministry of Interior, with a total capacity of 1692 kW;

(i) two rural power plants owned and operated by the MDR, with a total capacity of 360 kW;

(j) two captive power plants are operated on Sal by the airport and a hotel. Their total capacity is 1740 kW.

1.4 These institutions have now reached the size and stage of development that makes it necessary to establish a sectorwide project planning and coordination capability that would optimize the sector's investments in the light of the country's development priorities and overall financial constraints. Coordination is needed to organize the gradual takeover of the rural utilities by Electra, and the integration of INIT's wind energy devices into the Praia power network. Planning is needed to steer the public enterprises of the sector away from dependence on grants and subsidies towards financial independence and least cost expansion. Analysis is needed to understand the structure of energy demand, estimate the requirements for the future, and the associated investment needs. Thus, the mission supports the Government's initiative to create the Directorate General of Energy (DGE) out of the Directorate General of Industry and Energy within the SEINE as a center of expertise to formulate energy policy, coordinate and screen energy investments and regulate energy prices. In the mission's view, the following could constitute the main tasks of the recently created DGE:

(a) the formulation of alternative energy development strategies and policy measures;

(b) the analysis of energy resources, supply and consumption and the preparation of forecasts of energy supply and demand;

(c) the formulation and implementation of an energy pricing policy consistent with the need to encourage the development of domestic energy resources and maintaining the financial health of the sector enterprises;

(d) the preparation of an energy sector investment program consistent with national development objectives and the country's financial capabilities and the review of the budgets of the public enterprises in the sector;

(e) the coordination of international technical assistance projects in the energy area. DGE should participate in the definition of the projects and the selection of qualified Cape Verdean institutions to implement them.

(f) the establishment of an energy information center with three components: an energy statistics collection, processing and publication system, a technical library, and a program to promote and inform the public about energy policies and technologies. The need for a statistical system will be discussed in greater detail in para. 2.2. The promotional function of the center could play a major role in the energy conservation strategy (see para. 2.8);

For these tasks to receive sufficient attention, the DGE staff will have to be supported initially by technical assistance to develop the capabilities, procedures and technical instruments necessary to perform their functions. In view of the immediate need to prepare the energy part of the Second (1986-89) National Development Plan, it is recommended that this opportunity be used as a catalyst to consolidate the DGE and prepare it to fulfill its role (see para. 5.7).

II. ENERGY CONSUMPTION: CURRENT STATUS AND CONSERVATION OPPORTUNITIES

Introduction

2.1 Two facts stand out regarding the overall level of energy consumption in Cape Verde: the value of petroleum product imports in 1982 amounted to about a third of the value of export earnings, and only about half of the firewood requirements of the population is met by firewood. The rest are met by other biomass fuels such as stalks, shrubs, leaves and dung, whose continued use contributes to the erosion and degradation of the soil. While the trends in firewood and other biomass consumption are not known, the domestic consumption of petroleum products increased at 6.0%/year over 1979-1982. This was almost three times the growth rate of real GDP, which averaged 2.2%/year during the period. The average commercial energy consumption of 116 kgoe per capita appears to be high in relation to the estimated GDP of $260 per capita in 1982, probably a result of the heavy reliance of the economy on such energy-intensive activities as water desalination, interisland transport, fisheries and irrigation pumping. The overall structure of energy consumption and several important conservation opportunities are discussed below.

The Data Base

2.2 The energy sector and statistical services of the country are still being organized and have not yet developed a comprehensive energy information collection and processing system. In their current stage of development, the oil companies report their imports and sales, but not yet the changes in stocks or the type of consumer (e.g., industrial, commercial, household, etc.). Electra reports its production and sales of electricity and water but almost nothing is known about the rural utilities, as they are operated by the local councils who report only financial data to the Ministry of the Interior. Only limited information is available about the production and consumption of firewood; as the official sales by the Ministry of Rural Development (MRD) constitute only a fraction of the total supply, the remaining sales are largely illegal, and the amounts collected by the users themselves have not been surveyed in detail. To obtain a better overview of the pattern of energy use in the country for the planning and evaluation of energy projects, it is recommended that the Government establish an energy statistics collection, processing and publication system, as proposed in para. 1.4. Under such a system, the oil companies and their wholesale agents, Electra and the rural utilities, the MDR and other firewood producers would report their imports, production, consumption and sales of energy products on a regular basis, with due consideration of the need to avoid duplication with existing reporting networks. These reports need to be complemented by periodic surveys of energy users, particularly those about whom no information is available from the energy suppliers, including users of commercial fuels and firewood.

2.3 As a provisional step, the mission has produced a tentative energy balance for 1982 based on the available information. This energy balance is shown in Annex 2 and summarized below.

Table 2.1: SUMMARY ENERGY BALANCE (1982)
(toe)

	Firewood	Other Biomass	Electricity	Petroleum Products	Total
Production	28,000	21,000			49,000
Imports				184,014	184,014
Reexports				(149,068)	(149,068)
Gross Consumption	28,000	21,000		34,946	83,946
Power Generation			1,521	(4,922)	(3,401) a/
Trans. & Dist. Losses			(585)		(585)
Net Consumption, of which:	28,000	21,000	936	30,024	79,960
Industry			218	n.a.	n.a.
Transport				n.a.	n.a.
Household/Commerce	28,000	21,000	718	6,260	55,978

a/ Conversion losses (waste heat).
Source: Annex II

The Consumption of Firewood and Other Biomass Fuels

2.4 As shown in Table 2.1, about 60% of the energy consumed in the country is met by firewood and other biomass, but this constitutes one of the aspects of the energy situation about which not enough is known. Recent estimates of firewood consumption (variously defined) range from 29,000 tons (9,700 toe) 1/ to 108,000 tons (36,000 toe). 2/ The mission's estimate is drawn from De Gier 3/ who in 1981 surveyed the energy use of 133 families (0.9% of the population) in the rural areas of Santiago. De Gier's main findings were:

1/ Freeman e.a. (1978).

2/ Soares e.a. (1982).

3/ De Gier (1982).

(a) the average energy requirement for cooking is about 2.0 kg of firewood (0.66 kgoe) per person per day; and

(b) when firewood is not sufficiently available, the difference is made up with other biomass fuels and kerosene. Thus, the energy needs of the rural areas of Santiago were met as follows:

18% by firewood sticks greater than 2 cm in diameter
32% by firewood sticks between 0.5-2 cm in diameter
13% by congo bean stalks
12% by scrubs
9% by agave leaves
8% by corn stalks, palm leaves and coconut husks
4% by dung and
4% by kerosene;

(c) a separate survey in Praia (Santiago) indicated the cooking fuel needs of the urban population were met as follows:

22% by firewood
60% by kerosene
18% by butane.

These survey results extrapolated to the entire population lead to a tentative estimate of 84,600 tons per year (28,000 toe) of firewood and 83,000 tons per year (21,000 toe) of other biomass fuels being consumed by about 70% of the households.

2.5 In addition to the firewood and other biomass fuels consumed by households for cooking purposes, some firewood is also consumed by bakeries, lime kilns, ceramic kilns, rum (<u>aguardente</u>) distilleries and other rural industries about which no statistics are available. The bakeries are of particular interest, as they prefer to use firewood even though gasoil would be cheaper, because of the better flavor it imparts to the bread. There are even reports of occasional firewood imports (from Guinea Bissau and Portugal) to meet the needs of the bakeries, which is another indication of the stringency of the firewood shortage and of the price that some users are willing to pay to obtain this fuel. A recent report 4/ has estimated the firewood consumption by the bakeries in Praia and Mindelo at 800 tons per year (266 toe).

2.6 Given the shortage of firewood which has led some households that depend on it to burn leaves and shrubs and bakeries to resort to occasional imports, it is evident that better information on site-specific firewood consumption and production patterns would be useful for planning future afforestation and forest management programs. To provide

---

4/ Soares, e.a. (1982).

a better basis for judgement, it is recommended that the Government undertake a nationwide survey of energy use patterns in the households. To improve the reliability of the survey, it is recommended that the actual consumption of a small stratified sample of survey respondents be measured daily (over one-two weeks) to compare actual with stated consumption of all types of fuel. This survey could be one of the first technical assistance projects organized or coordinated by the energy information center proposed in para. 1.4.

2.7 In addition to measures related to the supply of firewood, which will be discussed in para 3.2-3.4, the imbalance between supply and demand could be greatly reduced through the use of improved stoves. The relatively high use rate of 2 kg per person per day (0.24 toe per person-year) is twice the consumption level estimated for other Sahelian countries and considerably above the minimum requirement of 0.02 toe per person-year of useful energy to meet basic cooking needs. On the one hand this is due to the popularity of cachupa, a maize-and-bean dish that requires three to four hours cooking time. Any reduction in the popularity of this dish would reduce the pressure on firewood supplies. On the other hand the high firewood use rate is due to the prevalence of the traditional three-stone fires, whose end-use efficiency is only about 10-15%. If the three-stone fires were replaced by fuel-efficient portable metal stoves with efficiencies of 20-30% (and supplemented by hayboxes), firewood requirements could be reduced by one-half. All that is required is the sale of a stove to each of the approximately 50,000 households in the country.

2.8 The possibility of introducing improved woodstoves has already been discussed at a seminar organized in Cape Verde by CILSS-Club de Sahel, with participants from the MDR, the Organization of Women (OMCV), INIT, the Fogo-Brava Integrated Development Project (FBIDP) and other organizations. Woodstove components are also included in the work program of the FBIDP and the FAO/Belgian Forestry Project. Nevertheless, while there is a considerable amount of interest in this subject, the woodstove program that is evolving out of the CILSS seminar aims at reaching only half the households by the year 2000. Given the critical contribution that efficient woodstoves can make to balancing the supply and demand for firewood and thus reducing the pressure on the islands' scant vegetative cover see para. 3.6), it is recommended that the woodstove program be aimed to cover all firewood users (about 70% of households) within ten years. The recommended program would contain the following steps:

(a) select a technically sound stove (and hay box) design adapted to local requirements and purchasing power;

(b) establish a large scale production capability based on local metalworking shops;

(c) launch a commercialization effort using modern marketing techniques with the objective of selling 5-10,000 stoves in the first year. Only by designing this effort on a large scale can one hope to achieve an improvement in the country's battered ecological balance.

As a supplement to energy saving woodstoves, this program should also consider the possibility of popularizing more efficient cooking utensils such as pressure cookers, and less energy consuming ingredients such as precooked grains.

The Consumption of Petroleum Products

2.9 Outside of the traditional fuels, Cape Verde's energy requirements are met entirely by imported petroleum products. As shown in Table 2.2, the country's petroleum products market is characterized by an unusually large share of reexports, which in recent years have amounted to between four and six times the level of domestic consumption. Thus, in 1982, reexports of 148,600 tons of fuels were equivalent to 4.2 times the total domestic consumption of 35,100 tons of petroleum products. This high level of sales to foreign airlines and ships is one of the major dividends of the country's location, but the future level of these sales and the net revenue that can be derived from them largely depend on factors that are beyond Cape Verde's influence: the volume of international traffic, the refuelling range of planes and ships, the pricing policies of competing ports (mainly Dakar and Las Palmas), and international political developments. Thus, while fuel reexports and ancillary services currently constitute an attractive market, which has contributed over half of the country's export earnings, the future of this market is associated with competitive and political risks whose evaluation is beyond the scope of this report.

2.10 As shown in Table 2.2, the domestic consumption of petroleum products has grown at an average rate of 6% over the 1979-1982 period, and this growth has been led by the consumption of gasoil and jet fuel. The structure of final consumption is not known in detail. However, the major fuel users (in 1982) are water desalination plants (about 4,900 toe of fuel oil), power plants (about 4,922 toe of gasoil), national shipping - interisland and overseas (5,135 toe of gasoil), national aviation (2,415 toe of jet fuel and 148 toe of gasoline), national fisheries (681 toe of gasoil and 201 toe of gasoline), household and commerce (4,641 toe of kerosene and 1,619 toe of butane), road transport (about 6,000 toe of gasoil and 2,033 toe of gasoline) and irrigation pumping (about 200-400 toe of gasoil). Thus, on a very tentative basis, the domestic consumption of petroleum products can be attributed to the following activities:

44% to transportation,
10% to industry (including agriculture and fisheries),
18% to the residential/commercial sector,
14% to water desalination, and
14% to power generation.

This pattern of consumption and the burden it imposes on the country's balance of payments make it worthwhile to evaluate closely the opportunities for reducing petroleum product imports through increases in efficiency and substitution of other fuels. While transport and industry constitute the major petroleum using sectors, their consumption is highly dispersed and less amenable to concentrated policy attention. On the other hand, the potential for energy conservation in the public utilities (water desalination and power distribution) appears to be very high and will be discussed in the following sections. In addition, this report will briefly discuss the potential for wind energy use in power generation (see para. 3.8), water desalination (see para. 3.11) and irrigation pumping (see para. 3.12). The inter-island pattern of petroleum products consumption is shown in Map 18132.

Table 2.2: PETROLEUM PRODUCTS CONSUMPTION, 1979-1982
(metric tons)

	1979	1980	1981	1982	Avg. Growth Rate (1979-82) (%)	(toe) 1982
Domestic Consumption						
Fuel Oil	5,983	5,695	5,833	6,880	4.8	6,467
Gas Oil	12,641	16,020	18,628	17,420	11.3	17,420
Jet Fuel	1,800	1,879	1,988	2,368	9.6	2,415
Kerosene	5,479	5,314	4,512	4,595	-5.7	4,641
Gasoline	2,019	2,139	2,244	2,313	4.6	2,382
Butane	1,600	1,137	1,420	1,542	-1.2	1,619
Total Domestic Consumption	29,522	32,184	34,625	35,118	6.0	34,944
Reexports						
Fuel Oil	76,746	48,732	51,069	29,429	-27.3	27,663
Gas Oil	10,456	7,246	6,411	7,847	-9.1	7,847
Jet Fuel	86,683	99,540	110,063	111,331	8.7	113,558
Avgas	-	7	11	1	-	1
Total Reexports	173,885	155,525	167,554	148,608	-5.0	149,069

The Consumption of Electricity

2.11 The consumption of electricity is growing rapidly and represents a large share of petroleum use in the country. At the major consumption centers (Mindelo, Praia and Sal), electricity sales amounted to 8.8 GWh (754 toe) in 1982, up 28% from 1981. Power sales of the rural utilities are not known, but based on total sales of gasoil for power generation and assumed distribution losses of 30%, they may be estimated at 2.1 GWh. The capacity distribution of the power supply system is shown in Map 18133. About 76% of total electricity use in the country may be attributed to the residential-commercial sector and the rest to industry. The potential conservation savings that could be achieved at the generation plant and distribution system level are of particular interest because of the simplicity of implementation.

2.12 The size of the fuel savings that can be obtained at the power plant cannot be estimated without a detailed evaluation of their operations. Electra's gasoil consumption in 1982 was 3545 toe, and the remainder of the gasoil sales for power generation (i.e., 1,377 toe) was attributed to the rural utilities and used as a basis to estimate their power generation. In order to identify the scope for fuel savings, it is recommended that Electra and the rural utilities maintain a record of the fuel consumed and electricity produced by every unit. Such a record of the actual fuel consumption by individual generating units would be invaluable in the scheduling of units, making more efficient use of units, planning maintenance work, and planning an equipment replacement schedule. This record would also provide a valuable first step towards a power loss reduction program (see para. 5.11). In addition to reducing the consumption of fuel, the introduction of modern power plant control systems, the improvement of operational and maintenance procedures and other innovations that could introduced by a loss reduction program would also improve the reliability of the system and discourage the duplication of capacity. 5/

2.13 A second area where major conservation savings can be achieved is through the reduction of distribution losses. These are reported to be about 36% in Praia and 39% in Mindelo, much higher than the 12-15% level that may be expected in a system of that size and fuel cost. 6/ A review of the system layout suggests that the technical portion of these losses may be due to the design of the system: factors such as inadequate cross-section in the medium- and low-voltage conductors, excessive transformer capacity and excessive length of low-voltage lines. The replacement of the medium- and low-voltage distribution system is already contemplated under the 1982-85 National Development Plan, and its cost has been tentatively estimated by Electra at 81 million ECV (1.1 million US$). This estimate appears to be inadequate and further preparation is needed to determine the scope and financial requirements of the projects that will be needed to reduce distribution losses to 12-15% of generation. At this reduced loss level an additional 3.2-3.7 GWh of electricity (i.e. a 40% increase over 1982 sales) could be sold at no increase in fuel expenses (or generating capacity). Considering the fuel cost saving of 24-28 million ECV/year (1,192-1,378 toe of gasoil), the preparation and implementation of these projects deserve the highest priority.

5/ Such as the 3 x 55 kW recently installed at the new grain silos in Praia.

6/ These losses include technical losses, unbilled and unpaid electricity, and theft. The relative shares of these categories is not known, but Electra believes that they are mostly due to technical reasons.

The Consumption of Desalinated Water

2.14 Because of the shortage of sweet water resources on Sao Vicente and Sal, these two islands depend on desalination of seawater for almost all of their requirements. In 1982, Sao Vicente produced 510,000 m^3 and Sal 10,000 m^3 of desalinated water. An estimated 4,900 toe of fuel oil were used to produced this water, equivalent to 14% of the country's petroleum consumption. Thus, water desalination uses more energy than any other industry in the country, and the consumption of desalinated water is of major interest from an energy planning perspective.

2.15 Of particular concern is that only 58% or 18 liters/cap/day of the total amount of water produced was sold to the end-users, while the remaining 42% (equivalent to 2,058 toe of fuel oil) was lost in the distribution system, because of frequent ruptures and excessive leaks. This level of leakage appears excessive in the light of the high cost of desalinated water (estimated at 310-460 ECV/m^3) and suggests that a comprehensive review of the desalinated water supply system is urgently needed. This review should consider not only the replacement or rehabilitation of the existing water distribution network but also the possibility of installing a two-tier delivery system with separate systems for drinking water - of which only 2 to 4 liters/cap daily are needed - and secondary uses, for which lower water quality standards may be acceptable. To minimize investments, the drinking water distribution system could rely more on tankers and bottles, and the secondary water distribution system could use the existing pipes, which would reduce the cost of the distribution losses. Because of the important cost and fuel savings that could be achieved through an improvement in the existing desalinated water distribution systems, it is recommended that this review be undertaken as soon as possible (see para. 5.12).

III. ENERGY RESOURCES: DEVELOPMENT POTENTIAL AND CONSTRAINTS

Introduction

3.1 To meet its growing energy requirements, Cape Verde is faced with the need to develop its domestic energy resources to the full extent that is justified by the high cost of imported energy and the current state of technology. While the available natural resources are not abundant, they can make a substantial contribution to the country's energy balance and their development needs to be planned in coordination with power and petroleum related investments that depend on imported fuel. The most important of the domestic energy resources is firewood, which already meets about a third of the country's energy consumption. Its further development to the extent technically and economically feasible is an urgent priority not only because it is an economic substitute for petroleum products but also because it can help to reduce the consumption of grasses, leaves and shrubs which is aggravating desertification. The second most important available resource is wind, which is already being harnessed for water pumping and can also be used as a direct substitute for imported petroleum in power generation. The third resource that needs to be considered for the future is geothermal energy; it is available on Fogo but its economic development potential remains to be proven. 7/ The development of these resources is discussed below.

The Development of Firewood Resources

3.2 For the 70% of the population that cannot afford kerosene or butane, there is a severe firewood shortage, which has led to the extensive use of other organic fuels, putting pressure on the islands' sparse vegetative cover. The excessive trimming of trees and uprooting of shrubs and grasses for fuel and forage has been a major contribution to erosion but has been impossible to control in the absence of affordable substitutes. The effects of erosion, continued over centuries, have been staggering. While in the 16th century, the higher islands were reported to be well forested and the lower islands were covered with grasses, it is now estimated that about 69% of the total area of the country (i.e., 279,300 ha) is wasteland caused by periodic droughts, uncontrolled grazing by goats, removal of plant cover for fuel and forage and the erosive action of wind and water. Of the original natural forest only individual trees are left. The situation is aggravated by the length of the current

---

7/ Of the remaining resources being considered, biogas has a very limited scope because of the lack of large quantities of waste materials, and solar ponds have not reached a state of development that would permit a judgement of their economic potential.

drought, which has lasted since 1967 and which suggests that present conditions may be part of a longer term shift of the climate. Given the risk that, with the continuation of present trends, Cape Verde might become a desert, afforestation has a vital role to play in the restoration of the vegetative cover to reduce erosion, improve water infiltration and retention, and to produce fuelwood and forage.

3.3 The conditions for afforestation are particularly difficult for the following reasons:

(a) the number of species that can tolerate the arid and semi-arid conditions is very limited. The results of four years of trials under the FAO/Belgium project have identified a few species able to produce fuelwood and forage (see Annex III). It is particularly important in the current period of prolonged drought that the most drought-resistant species be emphasized;

(b) the short duration of the August-October "rainy season", which in 1983 allowed 4-7 days of planting in the low areas and 20-30 days in the high areas, requires mobilization of the work force for planting at a day's notice. The Government has responded to this constraint with careful planning of preparations and a massive mobilization program of volunteer workers drawn from government departments, the political party (PAICV), rural organizations and the general public;

(c) the lack of rain in some years makes planting impossible unless water can be obtained and transported to the planting sites. In addition, water is also needed in the mid to late stage of the dry season following planting which is the most critical period for plant survival. Irrigation at this stage produces a much higher survival rate but unfortunately, water is rarely available for this purpose. The lack of water, in the form of rainfall or irrigation, is the most important limitation faced by the afforestation program; and

(d) trees planted in arid zones must be mulched to retain moisture. In Cape Verde, plant material for mulching is rarely available since such material is used for fuel or fodder.

In spite of these difficult conditions, the Government's afforestation program has achieved impressive progress. The total reforested area has increased from about 3,000 ha at independence in 1975 to about 11,500 ha in 1981 and perhaps 16,500 ha today. The location of existing forest plantations is indicated in Map 18134. Table 3.1 summarizes the status of afforestation in each of the islands. These projects are highly labor intensive 8/ and are being financed by the National Fund from the proceeds of the domestic sale of international food aid. The cost of soil preparation and planting has been estimated at about 18,000 ECV/ha (about US$230) in the low areas and 40,000 ECV/ha (about US$520) in the high areas. Thus, considering that about 9,400 ha remain to be planted in the high areas and 45,600 ha in the low areas, the additional investment required to afforest all the land suitable for trees may be estimated at 1,200 million ECV (about US$16 million), or about 67 million ECV (US$1 million) per year. To this should be added the cost of management, protection, harvesting, and replanting of harvested areas to arrive at the full cost of the forestry program.

Table 3.1: AFFORESTATION AREAS

	Areas Planted to 1981 (ha)			Areas to be Planted by 2000 (ha)		
	High Areas	Low Areas	Total	High Areas	Low Areas	Total
Boa Vista	-	1,409	1,409	-	2,520	2,520
Brava	27	81	108	250	480	730
Fogo	1,037	640	1,677	2,450	7,340	9,790
Maio	-	963	963	-	1,850	1,850
Sal	-	28	28	-	170	170
Santiago	2,025	2,913	4,938	3,815	24,760	28,575
Santo Antao	1,208	202	1,410	3,225	8,830	12,055
Sao Nicolau	252	412	664	480	2,880	3,360
Sao Vicente	-	325	325	-	950	950
Total	4,549	6,973	11,522	10,220	49,780	60,000

Source: Soares, et al (1982).

3.4 While the benefits of afforestation will lie primarily in the slowdown or reversal of the desertification process, the reforestation program can also make an important and valuable contribution towards meeting the country's energy requirements. Table 3.2 shows estimates of the potential for firewood production from the islands, based on a detailed evaluation of the available soil types and land use potential. The postulated annual yields are based on recent experience obtained in Cape Verde with the named species, i.e. they were observed after the start of the recent drought. If the rainfall were to improve, the yields could be substantially higher. On the other hand, if current (post-1967) rainfall patterns were to continue indefinitely, the estimate suggests that the long term sustainable firewood production would amount to about 80,000 tons per year, equivalent to 9,720 tons of kerosene, with a retail

8/ About 2,500 laborers are employed year-round, plus many more volunteers at planting time.

value of 275 million ECV (US$5 million). 9/ If the use of improved woodstoves becomes widespread, as recommended in para. 2.8, the quantity of avoided kerosene consumption could double. To this could be added the value of 15,000 tons per year (21,500 m3) of timber and 24,000 tons per year of forage that would also be provided from the same trees.

Table 3.2: FIREWOOD PRODUCTION POTENTIAL

	Plantation Type					Production Potential	
	Timber a/	Sylvo-pastoral b/	Sylvo-agricultural c/	Total	Actual d/ vs. Potential	Timber	Firewood
					(%)	(tons/year)	
Boa Vista	-	2,565	-	2,565	55	-	6,840
Brava	-	325	630	955	8	-	1,585
Fogo	1,195	2,095	5,020	8,310	8	3,346	11,695
Maio	-	1,750	-	1,750	55	-	4,565
Sal	-	385	-	385	7	-	1,040
Santiago	1,580	17,250	7,800	26,630	11	6,104	34,920
Santo Antao	1,225	4,800	2,570	8,595	2	5,145	12,695
Sao Nicolau	115	2,440	660	3,215	13	420	4,100
Sao Vicente	-	920	-	920	35	-	2,365
Total	4,115	32,530	16,680	53,295	22	15,015	79,805

a/ Assumed that the entire available highland (above 800 m) area that is humid enough for afforestation will be planted with pine and eucaliptus, with annual yields of 3-4 tons/ha of timber and 1.5-2.5 tons/ha of firewood.

b/ Assumed to be planted with prosopis and parkinsonia, with annual yields of 1 ton/ha of firewood.

c/ Assumed to be planted with acacia with annual yields of 1.2 tons/ha of firewood, interspersed with congo beans, with annual yields of 0.8 ton/ha of stalks usable for fuel.

d/ Areas planted in 1981.

Source: SCETAGRI (1979) and Soares, et. al (1982).

3.5 While the overall economic viability of the afforestation program cannot be demonstrated because of the difficulty of quantifying the value of its environmental benefits, the economic value of its measurable outputs (firewood, timber, forage) appears to be (after the

---

9/ Based on DeGier's (1982) observation that, as used by the rural households of Santiago, 0.3 liter of kerosene is equivalent to 2 kg of firewood. This is consistent with the postulate of an end-use efficiency of 15% of firewood and 40% for kerosene.

first rotation, about seven years for firewood species and 30 years for timber) sufficient to cover the costs of the program, particularly so if the efficiency of the operation can be improved. 10/ With this in mind, it is recommended that the following avenues for increasing the economic returns of the program be explored:

(a) the systematic recording and collection of basic information, on a country wide basis, on planted areas, survival rates, growth rates, standing volumes, planting costs, firewood production, forage production, rainfall, etc. Among other benefits, this would help to verify the applicability of the firewood yield data (used in this report), which is based on limited sample measurements, and identify the type of plantations that yield the best returns;

(b) the revision and updating of the existing Forest Legislation in order to delimit clearly the forest domain, define a forest management and exploitation policy, strengthen forest protection measures and strengthen the financial base of the Forest Service;

(c) the formulation and implementation of a forest management program that would seek to maximize the economic value of existing plantations. Thus, a modest timber production program using portable sawmills could possibly be established in some of the older plantations. The commercialization of fuelwood also needs to be put on a more systematic basis - current production by the Forest Service is only a few hundred tons, but could be 3,000-4,000 tpy, based on areas planted by 1975;

(d) the extension services need to be strengthened to increase the cooperation and participation of the rural population in the afforestation programs. Particular aspects that need to be popularized are the basic concepts of land protection, agroforestry and silvipasture and the techniques of tree planting, protection (from goats) and harvesting to encourage afforestation on private lands, and the protection of existing trees. This would ensure that the existing stock of trees (which produced about 84,000 tons of firewood in 1982) will not continue to be damaged through excessive trimming and browsing;

10/ E.g., even in the sylvopastoral areas, which cost 18,000 ECV/ha to afforest, and are expected to yield 1 ton/ha/year, with a seven year rotation, the 7 tons of firewood that will be produced from each cycle could be sold at 21,000 ECV (at the MDR's current roadside price of 3 ECV/kg) and will be equivalent to 0.86 tons of kerosene, with a retail value of 25,800 ECV.

(e) the Forestry Service needs to increase its professional and technical staff, not only to implement the recommendations discussed above, but also to improve the quality and efficiency of the ongoing planting, research and extension programs, and to obtain the maximum benefit from the ongoing technical assistance projects. 11/ The most effective way to reduce the shortage of trained staff is to expand the training components of the existing technical assistance projects. Such an expanded training program is necessary to ensure that sufficient staff will be available to implement the national afforestation program as it is planned.

With the implementation of these measures, the supply of firewood from the afforested areas should gradually increase to 17,000-20,000 tpy in 1990 (based on the areas planted to date) and about 75,000 tpy in 2000 (based on the area to be planted by 1993).

3.6 In addition to the timely implementation of the national afforestation program, a resolution of Cape Verde's firewood shortage will require the careful management and protection of the existing trees, which already produce about 84,000 tons per year of firewood. This level of production is too high to be sustainable under current drought conditions, but it is possible that about half that level, about 42,000 tons per year, should be compatible with proper protection and harvesting techniques (such as would be popularized by an expanded extension service - (see para. 3.5(d)). If the supply of firewood from the existing trees and shrubs (mostly located on private farms) is added to the expected production from the afforested areas, about 110-120,000 tons per year of firewood would be produced by the year 2000.

3.7 The country's maximum firewood production potential (by the year 2000) of 110,000-120,000 tpy will not be sufficient to meet current or future demands if the average firewood demand remains at its current level of 2 kg/person/day. Thus, unless a way is found to curb the demand for firewood, the imbalance between supply and demand will continue to be met by other organic materials, with the resulting damage to the vegetative cover. In the mission's view, as discussed in para. 2.7, there is great potential for reducing the imbalance through the use of improved stoves which have an average efficiency about twice that of the traditional three-stone fires. As suggested in Table 3.3, the universal adoption of improved stoves would reduce firewood demand to about 108,800 tpy in the 2000, which would just suffice to balance supply with demand. As pointed out in para. 2.8, in addition to the introduction of energy-saving woodstoves, there is a series of supplementary measures, like the

---

11/ The forest services current staff consists of 3 professionals (including the director), 1 technician, 6 foremen and 24 guards. The estimated requirements are about 23 professionals, 16 technicians, 30 foremen and 82 guards.

popularization of pressure cookers, hay boxes and pre-cooked grains for bringing firewood demand in line with the projected supply.

Table 3.3: FIREWOOD PRODUCTION AND CONSUMPTION POTENTIAL

	Production Potential from Plantations	Current Demand	Demand by 2000 a/ Without Efficient Woodstoves	With Efficient Woodstoves
Boa Vista	6,840	1,800	2,600	1,300
Brava	1,585	3,900	5,800	2,900
Fogo	11,695	19,600	29,000	14,500
Maio	4,565	2,100	3,200	1,600
Sal	1,040	3,600	5,400	2,700
Santiago	34,920	73,700	109,000	54,500
Santo Antao	12,695	25,700	38,000	19,000
Sao Nicolav	4,100	7,800	11,600	5,800
Sao Vincente	2,365	8,800	13,000	6,500
Total	79,805	147,000	217,600	108,800

a/ Assumes population to increase at 2.2%/year, as suggested in the National Development Plan, and the percentage of firewood users to remain unchanged at 70%. Without efficient woodstoves, their average firewood consumption is assumed to remain at 2 kg/person-day. With the universal adoption of efficient woodstoves (such as portable metal woodstoves with an efficiency of 30%), average fuel-wood use is postulated to decrease to 1 kg/person-day.

The Development of Wind Energy

3.8 As Cape Verde is subject to almost constant northeasterly tradewinds, the possibility of harnessing wind energy is of special interest for uses such as power generation, water pumping, water desalination and others where it would substitute for expensive imported fuels. The wind regime appears to fulfill most of the conditions necessary for the economic development of this resource in at least some applications. The wind is strong, with a yearly mean wind speed of 6.6 m/sec, 12/ steady, 13/ and largely from a single direction - the northeast.

12/ Measured at Praia Airport, with a height of mast of 8 m above ground.

13/ With a mean k value (of the Weibull distribution function) of 3.04.

Finally, the economic value of wind energy is high because competing imported petroleum products are expensive and the country has no hydroelectric resources. Nevertheless, the economic viability of substituting wind energy devices for imported fuels by cannot be taken for granted.

3.9 The greatest potential for the economic substitution of imported gasoil lies in the interconnection of wind energy conversion (WEC) devices with existing power grids (of at least 1 MW) in a fuel saving mode. The limit for this application lies at about 50% of the grid's minimum load in order to avoid increased operating costs on the diesel component. Up to this range, the wind component can be treated as a negative load bringing into the grid unexpected random load variations similar to those of a big customer but in the opposite direction. Large diesel engines perform efficiently in the 50-100% range without being unduly affected by the resulting mechanical and thermal stresses, and the system's voltage and frequency control should be able to follow sudden changes in this range without too much voltage fluctuation. Considering the installed capacity of the existing power systems, the only locations where hybrid wind/diesel generation is possible are Praia, Sao Vicente and Sal. Based on the minimum demands of the systems, the current potential for hybrid systems is limited to 480 kW, which could generate about 1.7 GWh/year (at an average wind speed of 8 m/s) 14/ and substitute about 390 toe of gas oil per year. The economic viability of this substitution will depend on a strict control of investment costs, careful site selection and a verification of the operational characteristics of WEC systems under local conditions. 15/

3.10 To test the operational characteristics of an interconnected WEC system under local conditions, the $1.7 million INIT/UNDP/DANIDA project is currently installing two 55 kW wind generators in a suburb of Praia, as well as providing training and instrumentation to operate and monitor the system. This project is scheduled to become operational in late 1984. To make this pilot project most effective in providing realistic parameters with which to evaluate the economic potential of this

---

14/ Which the mission believes can be found at selected sites, although the available data is not sufficient to predict this with confidence.

15/ A preliminary economic analysis suggests that this sort of investment should have an internal rate of return of 6%, assuming that 55 kW wind generators can be bought and installed for US$120,000, an operational cost of $1,000 per year, a 20 year lifetime, an average wind speed of 8 m/s, a k value of 3, (i.e., 193 MWh/year of output) and an avoided fuel cost of 0.06$/kWh, based on the tax-exempt price of gasoil paid by the power plants. At the retail price of gasoil paid by other customers, the avoided fuel cost would be 0.075$/kWh and the internal rate of return would rise to 9%.

new technology, the following aspects need to be considered in the course of its implementation:

(a) Project Management: As far as could be determined, there is no clear definition of responsibility for the success or failure of the project. To strengthen control of daily operations, such as delivery of equipment, installation, erection, interconnection and operation, project accountability needs to be vested in a single organization. In view of the objectives of the project, it is recommended that INIT be made fully responsible for the project, and that plans be made to gradually transfer the project to Electra.

(b) Performance recording and evaluation: To be able to evaluate the results of the project, performance evaluation procedures need to be carefully planned in which, for instance, INIT could assume the leading role with regard to wind data evaluation and Electra with regard to electricity production, interconnection and grid stability. These procedures should also assist economic evaluation through recording of all project-related costs.

(c) Maintenance Procedure: Plans should be made for the preparation of a standard maintenance and operations manual after two years of closely monitored operating experience.

(d) Involvement of Electra: As the primary recipient of the generated electricity, Electra is expected to become the eventual owner and operator of the WEC system. Plans need to be made regarding Electra's participation in this project to clarify the necessary financial arrangements, and to transfer the operational know-how.

3.11 A second major potential application for WEC devices is in autonomous wind/diesel generating systems for rural electrification. In systems like these, which generally are limited to a few hundred kW capacity, the diesel-powered generator must also be sized to cover the peak demand, but wind generation can be sized up to about half the capacity of the diesel generator. Thus, wind energy can cover full demand in periods of reduced load while the diesel turns idly, but when wind supplies more energy than the instantaneous load requirements, an additional load has to be connected either to dissipate this extra power (e.g., into heat) or use it on a time-independent application (e.g., pumping water into a storage tank). While autonomous wind/diesel systems represent a potential for fuel saving, the technology is new and insufficient experience is available to make a confident estimate of costs and performance characteristics. Thus, a modest program of pilot installations - such as the one being planned by the INIT/UNDP/DANIDA project and the MDR/Dutch/USAID project - is all that is needed for the present to obtain more experience with this technology. To ensure the development of a standardized system design for rural electrification, it is recommended that Electra participate in project design, evaluation and equipment selection.

3.12 One particular application for autonomous wind/diesel systems which could be of great interest to Cape Verde is in small reverse osmosis desalination plants. Present day reverse osmosis processes desalinate seawater by forcing it at high pressure through membranes that allow water to pass but retard the flow of dissolved salts. The mechanical energy required for pumping water from the well and through the membranes can be supplied by a wind-electric plant, using batteries or a diesel motor as backup for periods of insufficient wind. Such a desalination system can be combined with a power generation system to achieve economies of investment and operating costs. Here again, while the potential looks attractive, the technology is new and insufficient experience is available to make a confident estimate of costs and performance. Yet because there are several villages on Santiago, Boa Vista and Maio that are desperately short of drinking water, it is recommended that the existing modest program of pilot installations be supported as necessary so that it can be carried out on schedule. The existing programs are those of INIT which, with Italian assistance, is working on a wind-electric desalination project (using batteries) in Moia Moia (Santiago) and the MDR which, with Dutch assistance, is planning a wind/diesel power/desalination plant for Sal Rei (Boa Vista).

3.13 A fourth important opportunity for the economic substitution of gasoil by wind energy is in water pumping. Two private workshops have already manufactured and installed over a hundred windmills to pump water from shallow (less than 10 m) wells on Sao Vicente, but their production has ceased because of declining ground water availability. As a complement to this private initiative, the MDR has, with Dutch and USAID assistance, installed about 20 wind pumps for deeper (20-50 m) wells and with greater capacity on several islands. The MDR's objective is to support the Government's program to develop the island's ground water resources (by the year 2000) by installing about 400 windmills which represent the estimated potential market for this technology in Cape Verde. 16/ With this objective in mind, the MDR/Dutch/USAID project has constructed a local manufacturing facility with a production capacity of two windmills per month. Once it is in operation, this production capacity would be sufficient to meet the needs of the country because of the installation capacity of the project and also because it will represent the replacement rate for 400 windmills with a 20-year life span. Assuming that all these windmills will be installed as replacements for motor pumps, it has been estimated that about 200-400 toe per year of gasoil will be saved.

16/ The economic attractiveness of the use of windmills is highly sensitive to site specific factors that have to be estimated from case to case. Thus, while the estimate of 400 windmills is tentative, there appears to be a sufficient number of economic sites to warrant the continued support of this program at the current level of operation. This economic evaluation also will have to consider that the water table may decline or the salinity of the water increase as a result of increased pumping.

The Development of Geothermal Resources

3.14 A second alternative source of energy for power generation and other uses being considered in Cape Verde is the exploitation of geothermal resources. Recent (1951) volcanic activity and some fumaroles on Fogo are the principal indications of the existence of this resource. A preliminary geological reconnaissance by a group from Lund University, Sweden, suggests that there might be a reservoir with temperatures of 270-300°C, which would be usable for power generation, in a crescent-shaped zone inside the Fogo caldera. To follow up on this work, the Swedish group, in cooperation with INIT, is planning to undertake a drilling program of about 10 stratigraphic (200-400 m deep) wells to investigate geothermal and groundwater properties.

3.15 A review of the economic development potential of this resource will have to await the results of the statigraphic wells. In addition to the geological uncertainty, an important question relates to the potential size of the market for the power (and/or heat) that could eventually be produced, in relation to the costs of geothermal development. Fogo's current generation capacity is 600 kW, for a population of 31,000. The major potential use for electricity is for irrigation pumping. Thus, Fogo's groundwater resources (located at sea level) are believed to be sufficient to irrigate 650 ha (located at 200-500 m above sea level) with 40 m^3 of water per day, but the sustainability of this extraction rate would need to be confirmed, particularly in the light of the current shortage of rainfall. This extraction rate would require a supply of 2 MW of power if sufficiently high-valued crops can be found to justify the cost of the water. In view of the high costs of geothermal development, it is recommended that, after the conclusion of the ongoing stratigraphic drilling program, any future work on geothermal resources be placed within the context of the existing Fogo Integrated Development Plan and that the economic value of future work be evaluated in the light of its market potential.

IV. ENERGY PRICING

Petroleum Product Prices

4.1 The economic costs of petroleum products are unusually high in Cape Verde because of the high costs associated with transporting, handling and packaging the small volumes that are consumed (gasoline is imported and distributed in drums and butane in bottles). Thus, it is important to encourage the rational use of energy and the development of domestic energy resources by setting the retail prices of petroleum products at a level that fully reflects their high economic costs. The SEINE understands the importance of economic pricing and has been regulating petroleum product prices on the basis of actual costs reported by the companies, with no explicit subsidies. As shown in Table 4.1, the retail price of every product (except "captive" gasoil - which is used for power generation) exceeds the economic cost and also reflects a 8% import duty, a 25% sales tax (on gasoline only), and a series of minor Government fees. 17/ However, while on the aggregate the companies cover their operating costs, the high debt/equity ratio (8:1 as of end of 1982) and low net earnings (0.9% on assets in 1982) reported by ENACOL suggest that its revenues are not sufficient to build up a capital reserve such as would be needed to finance the expansion and replacement of the companies' facilities and equipment. In addition, the foreign exchange risks and some financing costs are borne by the Banco de Cabo Verde. In view of the desirability of having prices reflect full economic costs including the capital costs associated with importing and distributing petroleum products, it is recommended that the Government request realistic amortization scheduling - including periodic revaluation of assets) and explicitly allow the companies to earn a reasonable return on assets.

17/ The sale price of petroleum fuels to international transportation is determined on the basis of competitiveness with neighboring ports, but is not known to the mission. The main direct source of revenue for the Government from these sales is a petroleum tax of 35% of the companies' profits. In 1982, this tax yielded 179.6 million ECV (US$3 million), of which 2.9 million ECV was paid by ENACOL.

Table 4.1: PETROLEUM PRODUCT PRICES a/
(US$/ton)

Product	Rotterdam FOB	Mindelo CIF	Economic Cost d/	Retail Price	Percent of Economic Cost
Butane b/	280	448	470	1,164	248
Kerosene	286	298	322	391	121
Gasoline (Super) c/	294	414	435	684	157
Gasoil	249	260	273	325	119
Gasoil (for power generation)	249	260	273	263	96
Fuel Oil	170	182	191	205	107

a/ As of September 1983.
b/ The high cost of butane is due to the fact that it is imported and distributed in 12.5 kg and 50 kg bottles.
c/ The high cost of gasoline is due to the fact that it is imported and distributed in drums.
d/ Tentatively estimated on the basis of import cost plus an 8% allowance for distribution costs.

Source: ENACOL

Power Tariffs

4.2 Electra's tariffs are regulated by the SEINE on the same principles as petroleum product prices, i.e. on the basis of covering operating costs, with no explicit subsidies (except for desalinated water). 18/ As shown in Table 4.2, the resulting tariff level is high in relation to that of other countries 19/ as a direct result of the fuel cost, the small size of the system (requiring small units with high unit costs), the high reserve requirements (installed capacity of 1.5-2 times demand), and the low load factor (about 4,000 hours/year). Nevertheless, the tariffs may still not be sufficient to cover Electra's operating costs and make no allowance for the need to accumulate capital for future investments. 20/

18/ The rural utilities are supervised by the Ministry of Interior and their tariffs and regulatory framework are not known to the mission.

19/ Except for the capacity charges, which are relatively low.

20/ As of end-1982, Electra had a debt-equity ratio of 1.5:1 and ran an operating loss equivalent to 4% of assets in 1982.

Table 4.2: ELECTRIC POWER TARIFFS a/

Consumer Category	Capacity Charge (US$/kW)	Energy Charge (US$/kWh)
Industries and Government		
High Voltage	1.56 US$/kW	0.099 US$/kWh
Low Voltage	1.10 US$/kW	0.123 US$/kWh
Residential and Commercial		
Upto 40 kWh/month	-	0.136 US$/kWh
Above 40 kWh/month	-	0.164 US$/kWh

a/ As of November, 1983.

4.3 Electra's power generation costs are not known because the company did not, in its 1982 financial statement, separate power-related costs and desalination costs in its 1983 budget. A first step towards cost center identification was made by allocating consumables to either power or desalination, but without allocating salaries, services and other administrative costs (amounting to 33% of the budget). Thus, while projected 1983 power revenues exceed the budget for consumables (fuels and lubricants) by 30%, it is not certain that this margin will be sufficient to cover salaries, maintenance, materials, depreciation and a return on capital, particularly since the projected increase in power revenues of 100% (from 1982 to 1983) appears to be optimistic in relation to a 9% tariff increase. To resolve this uncertainty, the mission supports Electra's current efforts to upgrade its accounting system with the objectives of obtaining an accurate identification of costs by product, cost center and category of consumer and establishing a realistic amortization schedule based on the actual life expectancies of the assets and an updated estimate of their replacement cost. In combination with upgrading the accounting system, it is recommended that Electra establish a management information system (see para. 5.9) and prepare a corporate development plan and financial strategy.

The Price of Desalinated Water

4.4 While water is not itself a form of energy, the amount of energy required to desalinate water is so high that, in the Cape Verdean context, any subsidy on the price of water is equivalent to a subsidy on energy consumption. As Electra's water production costs cannot be accurately identified, the cost of desalinated water can only be tentatively estimated on the basis of the budgeted (1983) input cost (86.25 million ECV (US$1.1 million)) and a share of Electra's administrative budget (allocated in proportion to the cost of inputs), at about 140 million ECV

(US$1.8 million), or about 310-460 ECV per m^3 (US$3.9-5.8/$m^3$). 21/ This is over four times the expected 1983 revenue from water sales of 32 million ECV (about 70-110 ECV per m^3), and the gap is only partially covered by the bugeted subsidy of 90 million ECV (about US$1.2 million). Here again, a closer reflection of economic costs in the price of the product may contribute to a greater appreciation of the value of water and a rationalization of its use. This could be reflected in significant overall savings for the economy both on the supply side - where the value of rehabilitating and/or replacing the leaky distribution network would become more evident - and on the consumer side where the use of water flow control heads on faucets, showerheads, water closets, etc. needs to be promoted.

4.5 A second important consideration in relation to the desalination subsidy is that the delays and uncertainties associated with its approval are inevitably reflected in the financial health of Electra and hence on its ability to reliably supply electricity and water. In view of the need for Electra to establish its financial autonomy so as to be able to seek financing for its growing investment program, it is recommended that the Government consider transferring the water distribution function to the public works departments of the local councils. Electra could then become a self sustaining, solvent public utility that could essentially cover its costs and earn a reasonable return on capital on the basis of adequate tariffs on power and bulk sales of desalinated water to the public works departments. Such a transfer also makes sense from a technical point of view, as it would concentrate the electrotechnical, mechanical and chemical expertise applied to seawater desalination, power generation and electricity distribution in Electra, and civil engineering and hydraulic expertise in the public works departments which are already charged with water line construction, sewers and streets.

Firewood Prices

4.6 The pricing of firewood is of particular interest because it is the fuel of choice, or of last resort, for 70% of the population and because the Government has budgeted over 140 million ECV/year in afforestation and will eventually become the dominant supplier. Currently the MDR sells only a few hundred tons a year at the plantation roadside at a

---

21/ The higher figure assumes that 1983 water sales were the same as in 1982; the lower figure assumes a 50% increase.

price of 3 ECV/kg. 22/ In Sao Vicente, the Asociacao dos Amigos da Natureza (AAN), which operates the afforestation program there, is delivering firewood to the bakeries at 5 ECV/kg. In Praia the bakeries are purchasing firewood at 8-10 ECV/kg, and firewood is sold in the city markets at 10 ECV/kg. Thus the fuel cost of cooking a meal with commercially purchased firewood may be estimated at 20 ECV per person, while the equivalent amounts of kerosene and butane will cost 7.5 ECV and 8.3 ECV respectively. 23/ This estimate is consistent with the impression that most of the firewood passing through commercial channels goes to the bakeries (which consume about 800 tpy) and that most of the firewood that is being consumed by the households, including those in the urban areas, is self-collected or obtained through some non-monetary exchange. Even at the plantation roadside price of 3 ECV/kg (at which the cost of daily cooking would be only 6 ECV per person), most of the firewood appears to be purchased by bakeries and kilns.

4.7 The extent to which the supply of firewood from forest plantations compares with the requirements of bakeries and kilns is not known with accuracy, but based on the areas planted before 1975 and the reported yields of representative plantations, it should be possible with systematic management to produce an excess available for sale to the households (see para. 3.5). 24/ However, with an average laborer wage of 80-90 ECV/day, and an average rural family size of 6-7 persons, even a cash outlay of 3 ECV/kg of firewood may appear prohibitive to a large proportion of the population. In view of the substantial but non-assessable benefits of regulating the production of firewood, the Government needs to balance its desire to cover a portion of its afforestation costs through firewood sales with the need to supply firewood to those who cannot afford to buy it, and who would otherwise meet their firewood needs in an ecologically damaging way. Thus, it is recommended that the Government not only increase the production of firewood through a more intensive management and exploitation of existing plantations (as discussed in para. 3.5) but also develop a policy to ensure that the entire output of firewood is sold, even though a portion of it may have to be priced at a level that is below the replacement cost of firewood. This

---

22/ The 3 ECV/kg price can be regarded as the replacement cost of firewood. For example, if planting costs are 18,000 ECV/ha, the annual growth rate is 1 ton/ha, and the rotation period seven years, the eventual revenue of 21,000 ECV/ha will roughly cover the cost of havesting and replanting. The cost of second and third generation growth is likely to be much lower.

23/ Assuming cooking efficiencies of 15% for firewood, 40% for kerosene and 50% for butane.

24/ Bakeries in Praia and Mindelo report a shortage of firewood, and the MDR reports that there is a surplus of unsold firewood at its plantation in Maio.

policy could be reflected in a lower price for firewood directed at household use (e.g. through the introduction of a graduated pricing system with lower prices for lower diameter and quality wood) and/or in the distribution of an eventual unsaleable balance as a wage supplement to laborers on rural development projects (including afforestation) financed by the National Fund. The latter would take advantage of an existing program to assist the neediest strata of the population.

V. INVESTMENT AND TECHNICAL ASSISTANCE PRIORITIES

Sectoral Development Priority

5.1 The sector's priorities are determined by the Government's overall objectives to reduce external dependence and combat desertification, and by the sectoral objectives of minimizing the economic cost of energy and increasing the reliability of its supply. Based on these objectives and the discussion in the preceding chapters, the mission concluded that the highest priorities of the sector are to increase the efficiency of energy supply and utilization and to continue developing the country's single major energy resource, firewood.

Power Subsector Investments

5.2 The demand for electricity still exceeds the available supply by a wide margin, as reflected in the long waiting lists for connections and the relatively low numbers of connections. 25/ The most economical way to increase the available supply, and at the same time reduce the cost of electricity, is through an improvement in the efficiency and reliability of power generation (para 2.11) and a reduction of the losses between generation and sales from the current level of about 38% to a level of 12-15% (see para. 2.12). As shown in Table 5.1, Electra is already preparing the replacement and rehabilitation of its distribution systems in Praia and Mindelo. The current budget for these projects of 81 million ECV (US$1.1 million) appears inadequate and further preparation is needed to determine the scope and financial requirements of the program that will be needed to bring down losses to an acceptable level. These projects, plus a few minor ones that involve the overhaul of equipment and improvement of working conditions at the plant, deserve the highest priority and should be implemented as soon as possible. The projects to expand the generation capacity at Praia and Sal also deserve a high priority, but if the funds should not be available to carry them out as scheduled, a delay in their implementation may have to be considered. In view of the fact that the productive sectors of the economy can be supported more effectively and at lower cost in Praia and Mindelo, the mission recommends that rural electrification be delayed if necessary until more resources become available. In the meantime, efforts in the rural areas could concentrate on improving the service in existing centers by increasing the reliability of power supply, increasing the efficiency of power generation, and reducing distribution losses.

25/ The number of connections is about 1 per 10 inhabitants in Praia and Mindelo, and 1 per 31 inhabitants on a country-wide basis.

Table 5.1: PLANNED ENERGY INVESTMENTS, 1984/85

	Period	Cost (10^6ECV)
Electric Power		
Praia Capacity Expansion, 1.5 MW	1984	30.1
Praia M.V. System expansion	1984	23.4
Praia L.V. system rehabilitation	1984	10.5
Mindelo M.V. system replacement	1984	36.6
Mindelo L.V. system rehabilitation	1984	10.5
Sal Capacity & Transmission Expansion, 0.5 MW	1984	58.2
Other a/	1984/85	34.5
Total Electra	1984/85	173.7
Rural Electrification	1984/85	120.9
Total Electric Power		294.6
Petroleum Supply (ENACOL)		
Butane bottling plant (total cost 165 x 10^6 ECV)	1984	17.0
Interisland Tanker	1984	52.7
Other b/	1984	27.0
Total Petroleum Supply		96.7
New and Renewable Energy Sources		
Rural Wind Energy (MDR)	1984	27.4
Wind Energy Pilots (INIT)	1984/85	42.3
Fogo Geothermal (INIT)	1984/85	40.6
Wind Energy Center (INIT)	1984/85	7.9
Energy Conservation Center	1984/85	73.2
Biogas and Solar Pond Pilot Project (INIT)	1984/85	10.5
Total New and Renewable Sources		201.9
National Afforestation Program c/		
Santiago	1984/85	119.6
Fogo/Brava	1984/85	74.6
Santo Antao	1984/85	57.0
Total Afforestation		251.2
Total Energy	1984/85	844.4

a/ Equipment overhaul, planning studies, vehicles, etc.
b/ Building improvements, transport equipment, local pipelines, other equipment.
c/ Includes only major projects.

Source: Plano Nacional de Desenvolvimento 1982/85 - revised version, 1983.

Petroleum Subsector Investments

5.3 The most recent major investment in the petroleum subsector was the construction of a 2,000 tpy butane bottling plant in Praia (with a planned expansion to 4,000 tpy) which is intended to reduce the high cost of importing butane in bottles and which will be shared by ENACOL and Shell. 26/ The largest investment that is being considered is the purchase of a 300-600 ton tanker for interisland and possibly also import use, for which 52.7 million ECV (US$0.7 million) have been budgeted. The mission has no basis on which to judge the relative priority of this proposal. Another investment that could be of interest is the construction of a storage tank for gasoline to enable the country to import gasoline in bulk rather than in drums. On a very tentative basis, it would appear that the US$200,000 cost to build a 1,000 ton tank, of about 200 thousand US$, could be recovered in less than a year. 27/

New and Renewable Energy Investments

5.4 A substantial portion of the energy investments included in the First National Development Plan are dedicated to new and renewable energy sources. However, as indicated in Chapter III, the development potential of these energy sources is limited by technical and economic constraints, and their relative priority has to be carefully evaluated in light of the country's limited financial resources. As discussed in Chapter III, the utilization of wind energy for power generation, water desalination, and water pumping appears to have a significant potential for economic development, and therefore the projects to develop these applications, 28/ budgeted at 69.7 million ECV (US$0.9 million) for 1984-89, deserve a high priority. The relative priority of the remaining projects cannot be reviewed using economic criteria as their output is too uncertain to be quantified. They therefore should be regarded as research projects and, given the country's financial constraints, it is recommended that their expenditures be kept to an essential minimum until more resources become available.

26/ The commissioning of this plant in 1984 should lower the economic cost of butane and allow its price to be adjusted to reflect the full costs. Any expansion of this plant should follow the growth of the market when butane is priced on a full-cost recovery basis.

27/ On the basis of freight cost savings of US$75.80/ton, drum amortization costs of US$30-40/ton per trip, and gasoline imports of 2,300-2,500 tons per year.

28/ i.e. the INIT's Wind Energy Pilot Project and the MDR's Rural Wind Energy Project.

Afforestation Investments

5.5 Considering the Government's objectives of reducing dependence on imported fuels and combating desertification, the entire National Afforestation Program deserves the highest priority. Firewood from plantations is the lowest cost fuel available to the country, and whatever amounts can be produced should be supplied to the rural population to reduce the pressure on the remaining vegetative cover. The Government already has dedicated about 1.4% of its total investment budget to afforestation, or about 125 million ECV (1.6 million US$) per year. These resources appear to be sufficient for the afforestation of 3,000-3,500 ha per year. While this rate will suffice to plant all of the lands suitable for afforestation by the end of the century, several measures could be taken to increase the economic returns from the plantations by increasing the efficiency of the program (para 3.5).

Technical Assistance Requirements

5.6 Technical assistance priorities revolve around the need to strengthen the institutions of the sector and increase the efficiency of energy supply and utilization. On this basis, the following recommendations of the report could benefit greatly by the support of foreign technical assistance.

Energy Planning

5.7 Consolidation of the Directorate General of Energy (DGE). The energy sector has now reached the size and stage of development that made it necessary to establish a sector-wide project planning and coordination capability. Assistance will be required to develop the capabilities, procedures and technical instruments necessary for the DGE to perform its functions. One of the more important of its functions will be the preparation of the energy sector investment program. Since preparations for the Second National Development Plan (1986-89) are due to begin in 1984 and the investment program will be needed as an input, this provides a good opportunity for defining an institution building project that would get DGE going and produce an identifiable output in the process.

5.8 Creation of an Energy Information Center (EIC). Assistance will be needed to create the proposed center, which could possibly be placed in the DGE. The center would have three principal functions:

(a) to collect, process and publish energy statistics: this data would have to be gathered from existing reporting networks, additional regular reports by the institutions of the sector, and periodic surveys, especially of energy consumers. One survey that deserves high priority should cover the energy use pattern of the households. The result of this survey would be quite useful for planning the afforestation and forest management programs and the proposed promotion of improved woodstoves;

(b) to operate a technical library;

(c) to run a public information program: the main purpose of this program would be to promote energy (and water) conservation practices to all types of energy users (industry, commerce, public employees, drivers, housewives, school children, etc.) through the organization of educational compaigns, training courses, publicity and other means. One priority object of such a public information program would be to provide promotional support to the improved woodstoves program.

5.9 Improved Woodstoves Marketing Program. As discussed in paras. 2.8 and 3.6, improving the efficiency of firewood use for cooking is a critical component of a strategy to balance firewood supply with demand and restore the country's vegetation cover. The most immediate step available to reduce firewood demand is to organize a concerted effort to market improved woodstoves and hay boxes. For the longer term, this program should also consider the possibility of popularizing more efficient cooking utensils, such as metal pots and pans (to the extent that ceramic pots are still being used), pressure cookers and less energy consuming ingredients, such as precooked grains.

Power Subsector

5.10 Implementation of a Management Information System (MIS). While Electra is already upgrading its accounting systems, expert assistance will be needed to establish a MIS that will produce regular performance indicators on a systematic basis for both technical and financial aspects of its operations. Such a system would allow management to separately identify power-related and water-related costs and thus provide a solid basis for setting tariffs at economic levels. The MIS would also allow management to set appropriate performance goals (e.g. on plant performance, reliability and maintenance, fuel consumption, accounts receivable, etc.), monitor their achievement on a weekly and monthly basis, and identify problems much sooner and with a greater degree of accuracy than under the current system.

5.11 Power System Loss Reduction Program. In addition to the replacement and rehabilitation of the Praia and Mindelo distribution networks, a concerted effort needs to be made to reduce total system losses from their current level of 38% to 12% or lower. Technical assistance will be needed to evaluate the introduction of modern power plant control systems, the applicability of load management techniques, the redesign of system standards, and the improvement of maintenance and operational practices and procedures.

5.12 Review of the Desalinated Water Supply System. This review would look at the long term demand for desalinated water for the country as a whole and develop a least cost program to meet the demand. The review would evaluate the commercially available desalination technologies and their relative merits for Cape Verde - this is particularly important because of the gradual depletion of natural drinking water wells at Praia and several villages on Santiago, Maio and Boa Vista. The review would also consider the possibility of reducing the losses and improving the reliability of wider distribution in Mindelo through implementation of a two-tier distribution system (see para. 2.15), the addition of storage and reserve capacity, and the utilization of waste heat from the power plant.

Afforestation

5.13 As discussed in para. 3.5, various avenues for increasing the efficiency of the current afforestation effort need to be explored. Foremost among these are the establishment of a forestry data collection and recording system, the formulation and implementation of a forest management program, and an expanded training program for Forest Service staff. All of these will require some expert input but appear to already be covered under existing technical assistance projects.

SELECTED BIBLIOGRAPHY

Aydemir, H., 1983, Essais d'Elimination d'Especes, Rome, FAO, Rapport du Projet GCP/CVI/002/BEL.

Beurskens, H.J.M., 1981, Wind Energy for Water Pumping in Cape Verde, Amersfoort, Netherlands, Steering Committee for Wind Energy in Developing Countries (SWD).

Bjelm, Leif and C. Swennson, 1982, Geophysical Investigation on Ilha do Fogo, including a Proposed Geothermal Drilling Program, Lund, Sweden, Lund Institute of Technology, School of Civil Engineering.

Bucarey, J.R.E., 1982, Formacao e Vulgarizacao Forestal, Rome, FAO, Rapport du Projet GCP/CVI/002/BEL.

de Bonte, J.A.N. and M. Dielman, 1984, Autonomous Wind Diesel Systems in Rural Areas in the Republic of Cape Verde, Amersfoort, Netherlands, Steering Committee for Wind Energy in Developing Countries (SWD).

DeGier, A., 1982, Formation et Vulgarisation Forestiers, Rome, FAO, Rapport du Projet GCP/CVI/002/BEL.

Food Strategy Study: The Republic of Cape Verde, Preliminary Report, 1982, Amsterdam, Netherlands Directorate of Foreign Affairs.

Freeman, Peter H., et al, 1978, Cape Verde: Assessment of the Agricultural Sector, McLean, Virginia, General Research Corporation, Report CR-A-219A submitted to USAID.

Hydbom, Bjorn, et al, 1980, Energia Geotermica nas Ilhas de Cabo Verde, Lund, Sweden, Lund Institute of Technology, School of Civil Engineering.

Machado, F., 1965, Carta Geologica de Cabo Verde, Nota Explicativa da Folha da Ilha do Fogo - Estudos Petrograficos, Lisboa, Garcia de Orta, Vol. 13, No. 4., pp. 597-604.

Machado, F., 1965, Mechanism of Fogo Volcano, Cape Verde Islands, Lisboa, Garcia de Orta, Vol. 13, No. 1, pp. 51-56.

Machado, F., 1965, Vulcanismo das Ilhas de Cabo Verde e das Outras Ilhas Atlantidas, Lisboa, Junta de Investigacoes do Ultramar.

Primeiro Plano Nacional de Desenvolvimento 1982/85, 1983, Praia, Secretaria de Estado da Cooperacao e Planeamiento.

Round Table of Development Partners, 1982, Praia, Secretaria de Estado da Cooperacao e Planeamiento.

Sarles, Margaret, 1982, Watershed Management in Cape Verde - Interim Evaluation, Washington, D.C., USAID.

Saussay, Charles du, 1982, Rapport provisoire sur la legislation forestiere au Cap Vert, Rome, FAO.

SCETAGRI, 1981, Esquisse du Schema directeur de developpement rural des iles du Cap Vert, Paris and Praia, Ministere de la cooperation et du developpement francais/Decretaria de Estado da cooperacao e Planeamiento.

Soares, Horacio, et al, 1982, Analyse du Secteur Forestier et Propositions: le Cap Vert, Paris, OECD/CILSS/CLUB DU SAHEL, Rapport SAHEL D/82) 179.

Strasfogel, Sylvain, 1983, Programme Regional Foyers Ameliores, Republique des Iles du Cap-Vert: Rapport de Mission d/Appui Technique, Paris, CILSS.

World Bank, 1980, The Republic of Cape Verde: Economic Development in a Small Archipelago, Washington, D.C.

CAPE VERDE: ENERGY BALANCE FOR 1982
(toe)

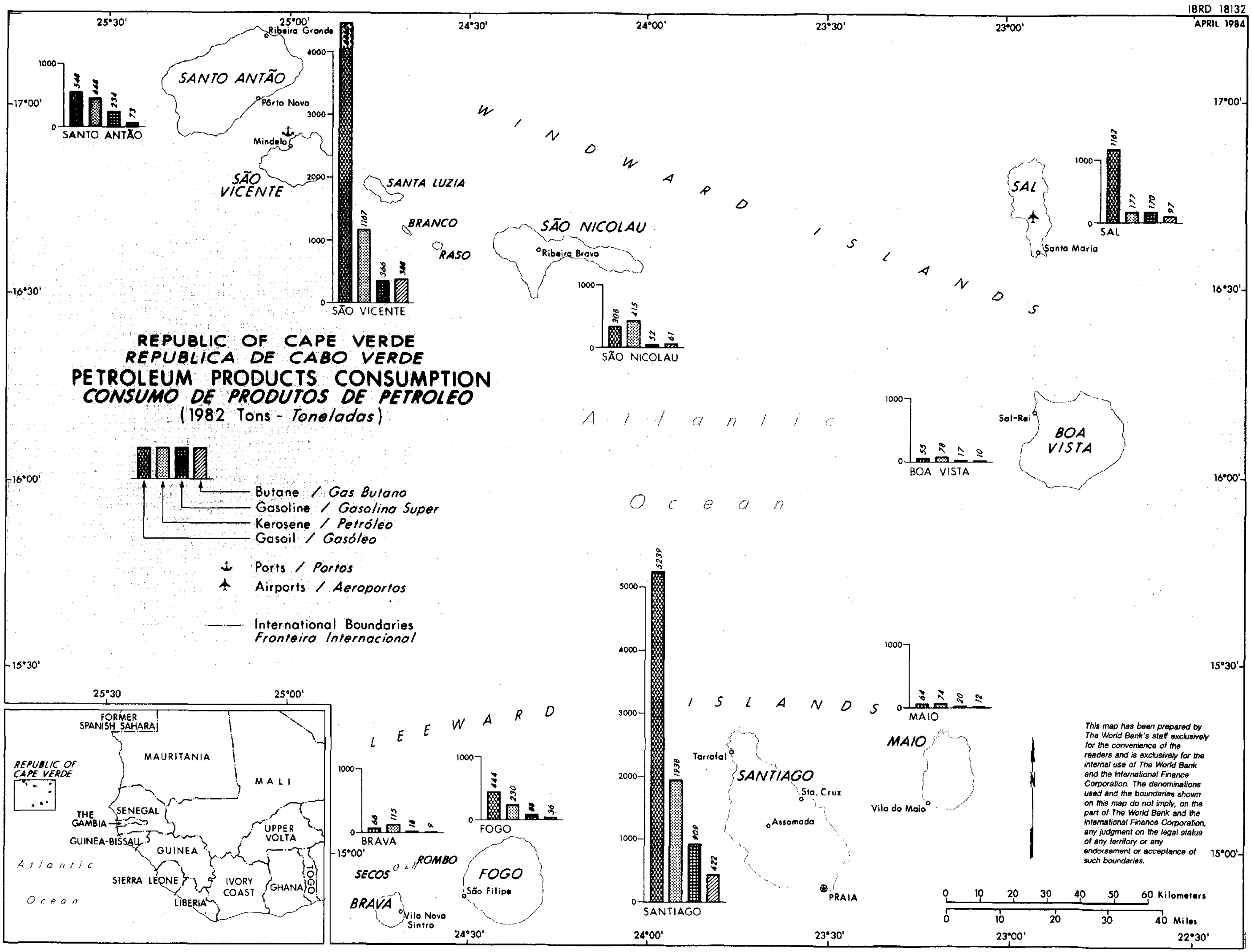
	Firewood	Other Biomass a/	Electri-city	Butane	Gasoline b/	Kerosene	Jet Fuel	Gas Oil c/	Fuel Oil	Pet. Prods. Total	Line Total
Gross Supply											
Production	28,000	21,000	-	-	-	-	-	-	-	-	49,000
Imports	-	-	-	1,619	2,384	4,641	115,973	25,267	34,130	184,014	184,014
Change of Stock	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-
Total Available	28,000	21,000	-	1,619	2,384	4,641	115,973	25,267	34,130	184,014	233,014
Conversion											
Power Generation	-	-	1,521	-	-	-	-	(4,922)		(4,922)	(3,401) g/
Trans. & Dist. Losses	-	-	(585)	-	-	-	-	-	-	-	(585)
Net Supply Available	28,000	21,000	936	1,619	2,384	4,641	115,973	20,345	34,130	179,092	229,028
Reexports	-	-	-	-	1	-	113,557	7,847	27,663	149,068	149,068
Net Domestic Consumption	28,000	21,000	936	1,619	2,383	4,641	2,416	12,498	6,467	30,024	79,960
Consumption by Sector											
Industry d/	n.a.	-	218	-	195	-	-	n.a.	413.00	417.00	n.a.
Transport e/	-	-	-	-	2,188	-	2,416	n.a.	4,604.00	4,609.00	n.a.
Household/Commerce f/	28,000	21,000	718	1,619	-	4,641	-	-	6,978.00	55,984.00	55,978

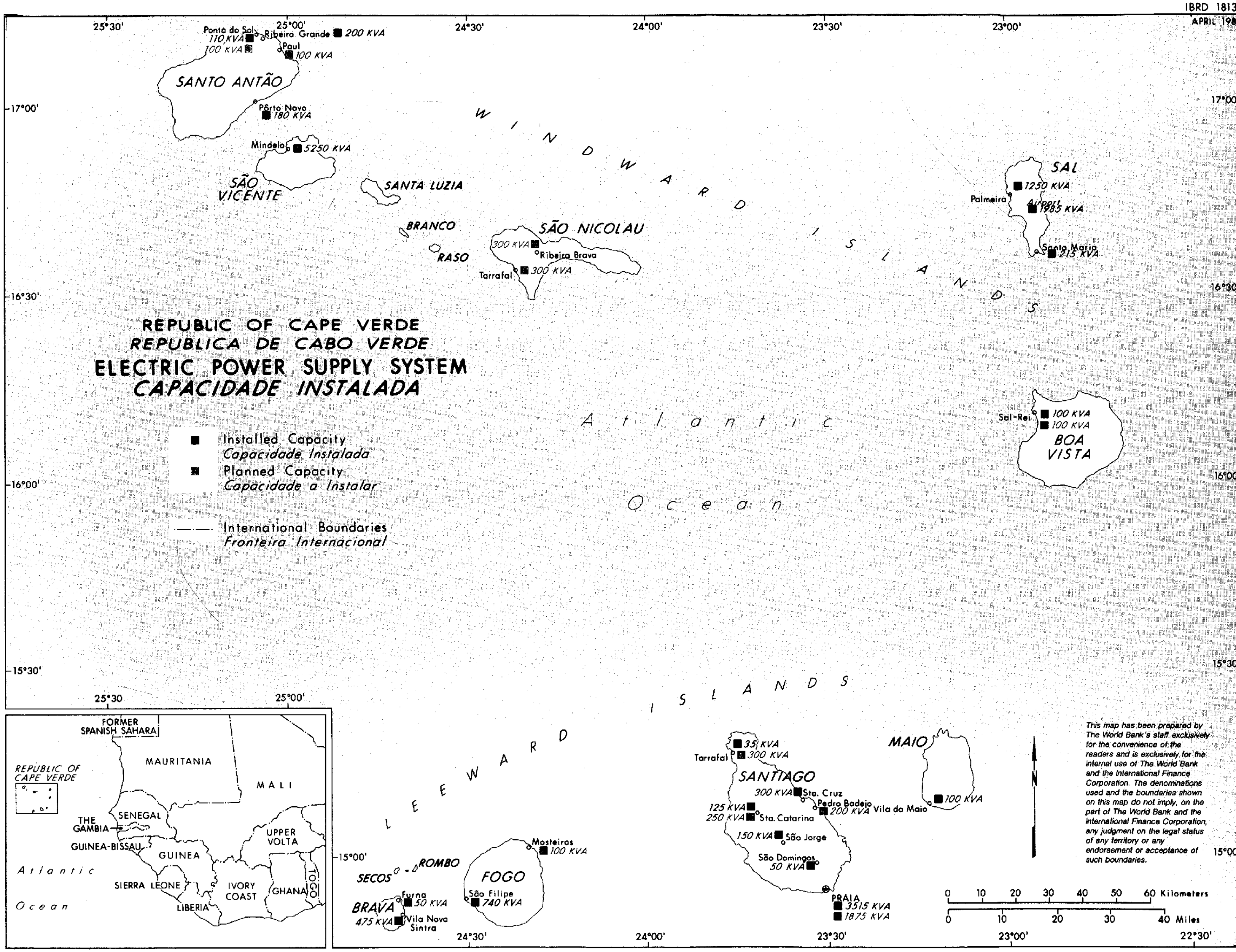
a/ Includes beanstalks, cornstalks, shrubs, agave leaves, palm leaves, grasses, coconut husks and dung.
b/ Includes avgas and methanol mixture.
c/ Includes diesel oil.
d/ Includes agriculture and fisheries.
e/ Includes national merchant navy.
f/ Includes government.
g/ Conversion losses.

Source: Mission estimates.

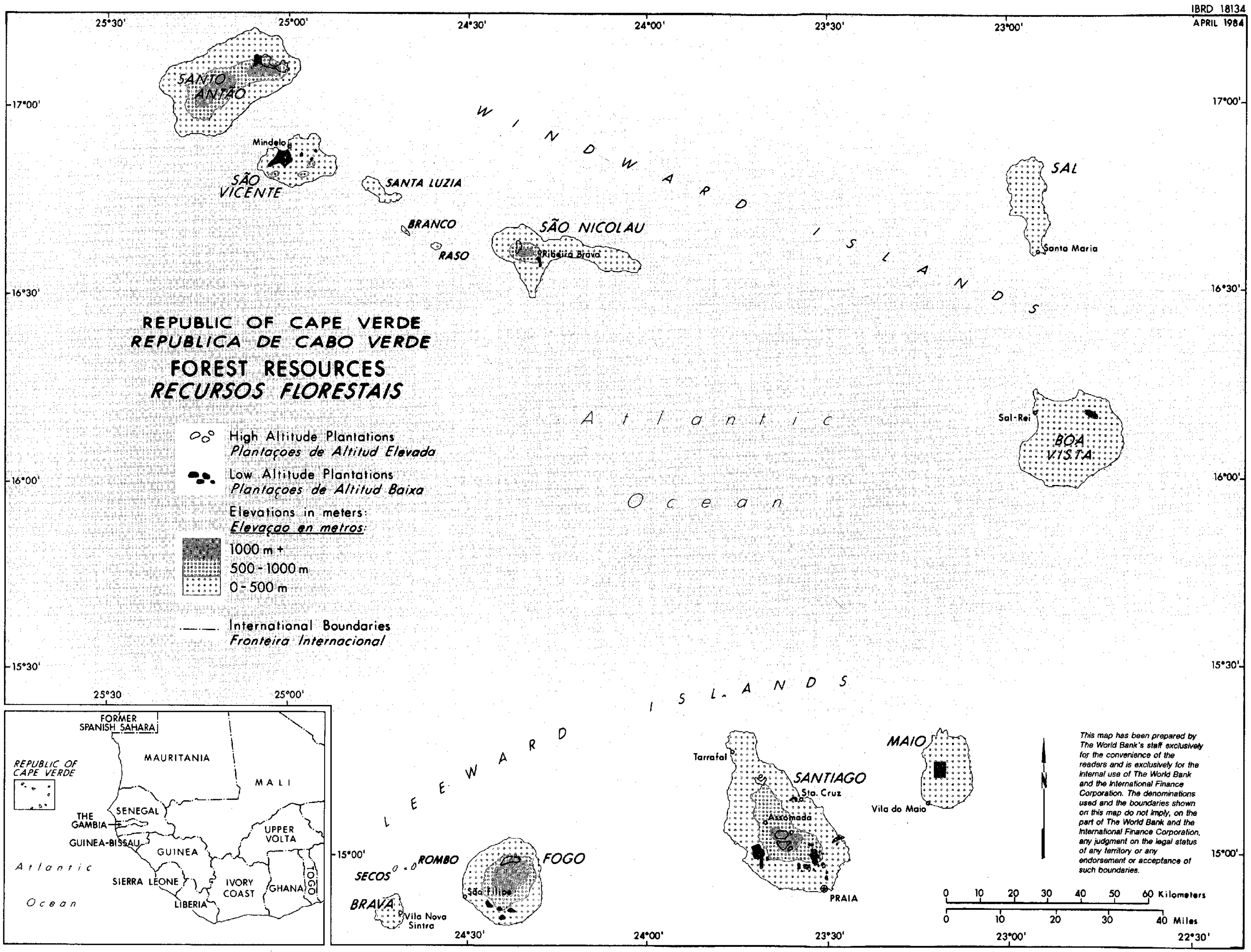
TREE SPECIES FOR AFFORESTATION

Fuelwood Production	<u>Lower Elevation, Arid Zones</u>
	Prosopis juliflora
	Prosopis chilensis
	Prosopis glandulosa
	<u>Higher Elevation, Humid and Sub-humid Zones</u>
	Eucalyptus camaldulensis
	Eucalyptus tereticornis
	Eucaluptus gomphocephala
	Acacia cyanophylla
Forage Production	<u>Lower Elevation, Arid Zones</u>
	Parkinsonia aculeata
	Acacia victoriae
	Atriplex nummularia


IBRD 18132
APRIL 1984
REPUBLIC OF CAPE VERDE
REPUBLICA DE CABO VERDE
PETROLEUM PRODUCTS CONSUMPTION
CONSUMO DE PRODUTOS DE PETROLEO
(1982 Tons - Toneladas)
Butane / Gas Butano
Gasoline / Gasolina Super
Kerosene / Petróleo
Gasoil / Gasóleo
Ports / Portos
Airports / Aeroportos
International Boundaries
Fronteira Internacional
WINDWARD ISLANDS
LEEWARD ISLANDS
Atlantic Ocean
SANTO ANTÃO
546
448
234
73
Ribeira Grande
Pôrto Novo
Mindelo
SÃO VICENTE
1167
366
SANTA LUZIA
BRANCO
RASO
SÃO NICOLAU
Ribeira Brava
308
415
52
61
SAL
Santa Maria
1162
177
170
97
BOA VISTA
Sal-Rei
55
78
17
10
MAIO
Vila do Maio
64
74
20
12
SANTIAGO
Tarrafal
Sta. Cruz
Assomada
PRAIA
5239
1938
909
422
FOGO
São Filipe
444
230
36
BRAVA
Vila Nova Sintra
66
115
18
9
SECOS
ROMBO
0 10 20 30 40 50 60 Kilometers
0 10 20 30 40 Miles
This map has been prepared by The World Bank's staff exclusively for the convenience of the readers and is exclusively for the internal use of The World Bank and the International Finance Corporation. The denominations used and the boundaries shown on this map do not imply, on the part of The World Bank and the International Finance Corporation, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.
FORMER SPANISH SAHARA
MAURITANIA
MALI
REPUBLIC OF CAPE VERDE
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
UPPER VOLTA
SIERRA LEONE
LIBERIA
IVORY COAST
GHANA
TOGO



IBRD 18133
APRIL 1984
REPUBLIC OF CAPE VERDE
REPUBLICA DE CABO VERDE
ELECTRIC POWER SUPPLY SYSTEM
CAPACIDADE INSTALADA
Installed Capacity
Capacidade Instalada
Planned Capacity
Capacidade a Instalar
International Boundaries
Fronteira Internacional
WINDWARD ISLANDS
LEEWARD ISLANDS
Atlantic Ocean
SANTO ANTÃO
Ponta do Sol
110 KVA
100 KVA
Ribeira Grande 200 KVA
Paul
100 KVA
Pôrto Novo
180 KVA
Mindelo
5250 KVA
SÃO VICENTE
SANTA LUZIA
BRANCO
RASO
SÃO NICOLAU
300 KVA
Ribeira Brava
Tarrafal
300 KVA
SAL
1250 KVA
Palmeira
Airport
1985 KVA
Santa Maria
215 KVA
Sal-Rei
100 KVA
100 KVA
BOA VISTA
MAIO
100 KVA
Vila do Maio
SANTIAGO
35 KVA
Tarrafal
300 KVA
300 KVA
Sta. Cruz
Pedro Badejo
200 KVA
125 KVA
250 KVA
Sta. Catarina
150 KVA
São Jorge
São Domingos
50 KVA
PRAIA
3515 KVA
1875 KVA
FOGO
Mosteiros
100 KVA
São Filipe
740 KVA
SECOS
ROMBO
BRAVA
Furna
50 KVA
475 KVA
Vila Nova Sintra
FORMER SPANISH SAHARA
MAURITANIA
MALI
REPUBLIC OF CAPE VERDE
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
UPPER VOLTA
SIERRA LEONE
LIBERIA
IVORY COAST
GHANA
TOGO
Atlantic Ocean
0 10 20 30 40 50 60 Kilometers
0 10 20 30 40 Miles
This map has been prepared by The World Bank's staff exclusively for the convenience of the readers and is exclusively for the internal use of The World Bank and the International Finance Corporation. The denominations used and the boundaries shown on this map do not imply, on the part of The World Bank and the International Finance Corporation, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.



IBRD 18134
APRIL 1984
REPUBLIC OF CAPE VERDE
REPUBLICA DE CABO VERDE
FOREST RESOURCES
RECURSOS FLORESTAIS
High Altitude Plantations
Plantaçoes de Altitud Elevada
Low Altitude Plantations
Plantaçoes de Altitud Baixa
Elevations in meters:
Elevaçao en metros:
1000 m +
500 - 1000 m
0 - 500 m
International Boundaries
Fronteira Internacional
25°30'
25°00'
24°30'
24°00'
23°30'
23°00'
22°30'
17°00'
16°30'
16°00'
15°30'
15°00'
SANTO ANTÃO
Mindelo
SÃO VICENTE
SANTA LUZIA
BRANCO
RASO
SÃO NICOLAU
Ribeira Brava
SAL
Santa Maria
W I N D W A R D I S L A N D S
A t l a n t i c
O c e a n
Sal-Rei
BOA VISTA
L E E W A R D I S L A N D S
MAIO
Vila do Maio
Tarrafal
SANTIAGO
Sta. Cruz
Assomada
PRAIA
ROMBO
SECOS
FOGO
São Filipe
BRAVA
Vila Nova Sintra
N
This map has been prepared by The World Bank's staff exclusively for the convenience of the readers and is exclusively for the internal use of The World Bank and the International Finance Corporation. The denominations used and the boundaries shown on this map do not imply, on the part of The World Bank and the International Finance Corporation, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.
0 10 20 30 40 50 60 Kilometers
0 10 20 30 40 Miles
FORMER SPANISH SAHARA
MAURITANIA
MALI
REPUBLIC OF CAPE VERDE
THE GAMBIA
SENEGAL
GUINEA-BISSAU
GUINEA
UPPER VOLTA
SIERRA LEONE
LIBERIA
IVORY COAST
GHANA
TOGO
A t l a n t i c
O c e a n