Report No. 5222-BEN

Benin: Issues and Options in the Energy Sector

June 1985

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

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BENIN

ISSUES AND OPTIONS IN THE ENERGY SECTOR

JUNE 1985

ABSTRACT

Benin has a diversified resource base which, in principle, can meet the country's projected energy needs. The ample forest resources, which account for most of the potential annual production, currently satisfy 86% of gross energy requirements. Although the supply-demand balance is positive on the national level, fuelwood shortages have developed in the densely populated areas of the south and in the climatically less favored zones of the north. Therefore, the report proposes opening for exploitation the forest areas in central Benin and assisting the rural sector in integrated agro-silvicultural project development. Offshore hydrocarbon resources have been discovered, and oil production started in 1982; efforts to quantify natural gas resources and determine their commercial production potential are envisaged. Crude oil is being exported, and there are no economic incentives to process it locally because of the small size of the internal market, the oil production profile, and the international refining situation. Petroleum products meet 13% of internal energy needs and are being imported at competitive prices. Benin's hydropower resources are large in comparison with present demand (2% of gross energy input), and can economically be developed in the context of an interconnected West African power system. In addition, the country has a substantial agricultural potential, offering the possibility of residue to energy conversion. General energy policy recommendations include the need to structure efficient institutions to manage the sector, to set up incentives for private sector involvement in decentralized energy production and to assist consumers in achieving efficient energy use. Finally, the report recommends actively pursuing cooperation with neighboring countries in the development of energy resources, the introduction of new technologies, and the procurement of their imported requirements.

ACRONYMS

ADB	African Development Bank
BBD	Banque Beninoise de Développement
DBCD	Banque Commerciale du Benin
BOAD	Banque Ouest Africaine de Développement
CARDER	Centre d'Action Régionale pour le Développement Rural
CEB	Compagnie Electrique du Benin
CIB	Ceramique Industrielle du Benin
CTL	Centrale Thermique de Lomé
CIMAO	Société des Ciments de l'Afrique de l'Ouest
DEFC	Direction des Eaux, Forêts et de la Chasse
EDF	Electricité de France
EECI	Energie Electrique de la Côte d'Ivoire
FAO	Organisation des Nations Unies pour l'Alimentation et l'Agriculture
FED	Fonds Européen de Développement
GMB	Grands Moulins du Benin
IBETEX	Industrie Beninoise des Textiles
INSAE	Institut Nationale de la Statistique et de l'Analyse Economique
MDRAC	Ministère du Développement Rural et de l'Action Cooperative
MERS	Ministère de l'Education Supérieure et de la Recherche Scientifique
MFEEP	Ministère des Fermes de l'Etat, de l'Elevage et de la Pêche
MIME	Ministère de l'Industrie, des Mines, et de l'Energie
NEPA	Nigerian Electric Power Authority
OCBN	Organisation Commune Benin-Niger des Chemins de Fer et des Transports
ONAB	Office National du Bois
OTP	Office Togolais des Phosphates
SBEE	Société Beninoise d'Eau et d'Electricité
SCB	Société Ciment du Benin
SOBETEX	Société Beninoise des Textiles
SONARA	Société Nigérienne de Commercialisation de l'Arachide
SONACI	Société Nationale des Ciments
SONACOP	Société Nationale de Commercialisation des Produits Pétroliers
SONICOG	Société Nationale pour l'Industrie des Corps Gras
SONIDEP	Société Nigérienne des Produits Pétroliers
SONAFEL	Société Nationale de Fruits et Legumes
SNS	Société Nationale de Sidérurgie
SSS	Société Sucrière de Savé
VRA	Volta River Authority
UNDP	United Nations Development Programme
UNSSO	United Nations Sahel Sudan Organization
USAID	United States Agency for International Development

ABBREVIATIONS

b/d	barrels per day
GDP	Gross Domestic Product
LPG	Liquid Petroleum Gas (Butane)
K	thousand
M	million
m^3	cubic meter
cal	calorie
kcal	kilocalories (10^3)
Mcal	megacalories 10^6
MCF	thousand cubic feet
koe	kilogram of oil equivalent
toe	ton of oil equivalent
kWh	kilowatt-hour
MWh	megakilowatt-hour (10^3 kWh)
GWh	Gigwatt-hour (10^6 kWh)

This report reflects the conclusions of the Energy Assessment mission which visited Benin in July 1983. The mission was composed of Ms. U. Weimper (leader) and Messrs. A. Larreture (consultant, renewable energy specialist), A. Streicher (consultant, energy conservation expert) and J. Hatfield (consultant, electric energy economist). The mission also received the technical cooperation of the following Bank staff: Messrs. J. Fishwick (forestry expert), J. Toktar (petroleum engineer), and M. Wilton (electricity specialist). The text for the final report was processed by Ms. Norma Kraushaar.

CONVERSION FACTORS

Monetary:

50 FCFA = 1 French Franc
370 FCFA = 1 US$ (June 1983)

Energy:

	Original Units	Specific Gravity 1/	Calorific Value	Oil Equivalent	Oil Equivalent
			(kcal/kg)	(toe/ton)	(toe/m^3)
LPG	kg	0.54	10,700	1.049	0.566
Fuelwood: (25% HC-solid) 1/	m^3	0.7	3,500	0.343	-
Charcoal	ton		7,000	0.686	-
Oil Equivalent	ton	-	10,200	1	-
Gasoline - Super	m^3	0.735	10,500	1.029	0.731
- Regular	m^3	0.71	10,500	1.029	0.731
- Aviation	m^3	0.71	10,500	1.029	0.731
Kerosene	m^3	0.78	10,300	1.010	0.788
Kerosene - Aviation	m^3	0.80	10,400	1.020	0.816
Gasoil/Diesel	m^3	0.82	10,200	1	0.820
Fuel Oil - Light	ton	0.92	9,900	0.971	0.893
- Heavy		0.96	9,800	0.961	
Electricity:					
28.5% efficiency	kWh	-	3,018/kWh	295.88/GWh	-
100.0% efficiency	kWh	-	860/kWh	84.314/GWh	-
Natural Gas	m^3		9,000/m^3	-	0.880/Mm^3
Biogas	m^3		5,500/m^3	-	0.539/Mm^3
Corn Cobs	tons		3,500	0.343	-
Corn, Rice, Sorghum, Millet straw	tons		2,500	0.245	-
Oil Palm stems	tons		1,300	0.127	-
Oil Palm fibers	tons		2,500	0.245	-
Oil Palm hulls	tons		4,000	0.392	-
Oil Palm leaves	tons		2,000	0.196	-
Cotton stalks	tons		4,100	0.402	-
Groundnut hulls	tons		4,000	0.392	-
Rice husks	tons		3,000	0.294	-
Coconut hulls	tons		4,300	0.422	-

1/ One stere of wood = 1 m^3 of stacked wood = 0.6 m^3 of solid wood.

TABLE OF CONTENTS

ANNEXES

MAPS

I. SUMMARY AND RECOMMENDATIONS

Economic Overview

1.1 The People's Republic of Benin is a corridor-shaped country of 112,000 km^2, with a population of 3.8 million and a per capita GDP of about US$270 (in 1981). Its main economic activities are agriculture and trade with neighboring countries. During the 1970s the State became the predominant economic agent, investing in resource development and industrial projects and exercising control over operations in all sectors. Real economic growth increased from an average annual rate of 0.9% during 1971-1976 to about 3.6% during 1976-81. However, in the early 1980s the country's balance of payments and the fiscal budget ran into critically large deficits. It became apparent that many of the public enterprises were not commercially viable and that the Government's intervention in the rest of the economy had produced severe distortions which discouraged private production. To redress the economy, the Government has sought international assistance and defined a new strategy aimed at promoting agricultural development and rehabilitating the industrial sector. The Bank estimates that this policy will allow a sustained minimum economic growth rate of 2% p.a. during the rest of the decade. A higher growth rate could be achieved if crude oil production from the Sémé field exceeded present estimates and if the two large industrial units (clinker plant at Onigbolo and sugar mill at Savé) became competitive and their output could be exported. The longer term prospects for economic growth depend on the country's efforts to overcome internal, technical, and managerial constraints and on the economic cooperation among the countries of the West African region.

Main Energy Issues

1.2 The energy balance indicates that energy in physical terms should not be a limiting factor in Benin's economic development. Gross energy consumption is projected to increase from 840 Ktoe in 1982 to 1,600 Ktoe in 1998, which compares with a potential productive capacity of 2,300 Ktoe p.a. This potential is estimated on the basis of present economic and technical conditions and includes both renewable energy sources and hydrocarbons. The full development of these resources and their conversion into the energy forms required by a gradually modernizing economy is constrained by the market size and the availability of financial and technical production factors. Regional cooperation in the context of the West African countries has been recognized as a means to achieve optimum economic exploitation, sharing investments, markets, and technical and managerial know-how.

1.3 Fuelwood and, to a lesser extent, agricultural residues are the most important resources in Benin, as they satisfy the bulk of internal energy requirements. Completely replacing biomass consumption with imported petroleum products would cost the economy some US$50 million per year. It is evident that the highest priority of the energy strategy is to ensure an adequate long term supply of fuelwood at competitive prices. To achieve this it is necessary to formulate a management plan for the rational exploitation of existing forest resources and to evaluate the energy potential of agricultural residues and the cost of converting them into usable energy forms. The active involvement of the private sector in these activities should be further promoted.

1.4 Oil production from the Sémé hydrocarbon field started in 1982 and by 1983 Benin had become a net petroleum exporter in physical terms. It is still too early to assess the long-term productive capacity of this field and of the rest of Benin's sedimentary area. At present it appears that oil production will peak in the late 1980s and reach economic limits in the early 1990s. The Government actively seeks to interest private companies in exploring the offshore areas outside Sémé, and a program to delineate the extension of the Sémé field is under way. Better knowledge of the oil and gas potential will permit the definition of balanced development and production programs which take into account technical and financial constraints as well as long-term economic objectives.

1.5 Benin's hydropower potential is estimated at 70-80 Ktoe p.a., which compares with a projected electric demand of 40 Ktoe by 1998. However, the development of this resource is only economical in the context of a larger market. It is therefore advisable to strengthen cooperation with Togo in the existing binational system and to take active interest in the implementation of the wider West African electric interconnection.

1.6 All electricity and petroleum product supplies are imported. The cost of these imports absorbed more than 20% of Benin's foreign exchange earnings in 1982. The oil import bill was expected to increase by US$8 million in 1984 as a result of the curtailment of electricity supplies from Ghana and the closing of the Nigerian border. Internal thermal generation to make up the deficit requires additional imports of petroleum products equivalent to 12,000 toe. In 1982, some 16,000 toe of low cost petroleum products were illegally imported from Nigeria (equivalent to 7% of the officially imported tonnage). It is evident that an energy conservation program covering all consumer groups is urgently required to minimize the disruptive effect of these events on the economy.

1.7 Benin's energy management capacity must be strengthened if the energy programs are to be implemented efficiently and in good time. In answer to this requirement, the mission proposes technical assistance programs with an intensive training component. These programs have the objective of building up the administrative capacity of the operating entities in the sector, as well as developing a capacity for designing energy policies at the macro-economic level and for translating them into effective guidelines.

Investments

1.8 The public investment requirements in the energy sector are conservatively estimated at about US$200 million for the period 1984-1988. These funds are to be allocated to the following objectives:

(a) evaluation and development of the hydrocarbon potential (34%); (b) development of hydropower resources jointly with Togo and expansion of the electric network (50%); (c) reforestation projects (12%); (d) basic project identification and demonstration in the areas of energy conservation and conversion; and (e) training. This is a very large investment plan (5% of GDP), especially when considering the needs in other priority sectors such as agriculture and social infrastructure. However, a significant portion (60%) of these requirements already has been ensured through external funding. The concerted action of international financial and technical organizations is necessary to help Benin in implementing the rest of the energy sector program.

Medium Term Priorities

Resource Evaluation

1.9 Significant advances have been made in evaluating Benin's hydrocarbon potential. The Sémé offshore field, discovered in 1968, until recently was only considered marginal in terms of recoverable reserves. However, after a first development phase executed under a service contract at the risk of the Government, it appears that the reservoir extends over a larger area and has a better water drive than initially was expected. A second stage development project is currently envisaged with IDA support. By optimizing production and draining the extension areas, the project would help to lower unit production costs and allow a higher rate of return on the investment.

1.10 Non-associated natural gas resources have been identified in a deeper structure (2,600 meters) of the Sémé field. The mission believes priority should be given to an evaluation of this potential. Bulk energy consumers could absorb a large enough flow of gas to initially justify the construction of a pipeline. The Bank's project for the second phase development of the oil field includes engineering services for testing the gas structure and for carrying out a detailed gas market study. If the tests are successful, the mission suggests that additional wells be extended into the gas structure to evaluate the resource base and provide the information necessary to formulate a field development program and carry out a detailed market analysis.

1.11 Also, a recent evaluation of the rest of the sedimentary basin of Benin has indicated that additional prospects for oil accumulation exist in the offshore area west of Sémé. The Government is currently preparing a promotional package and revising the legal framework for private participation in the exploration of this acreage.

1.12 Initial steps have been taken to assess Benin's hydropower resources, currently estimated at 240 MW (840 GWh/year). The recent inventory of hydro sites (larger than 10 GWh) revealed the need for additional topographical and hydrometric data before feasibility studies can be made. The potential sites are located on rivers with large fluctuations in seasonal and annual water flow, gentle slopes and wide river valleys so development would be relatively expensive and must be envisaged in a system context. CEB, the binational utility (Benin and Togo), envisages developing these hydropower resources for seasonal interchanges of energy with Ghana, using Akosombo to regulate hydropower production. It is also suggested that mini hydropower resources in Benin that could supply electricity to towns of the interior be further assessed, to save liquid hydrocarbons.

1.13 Given Benin's strong agricultural sector, the opportunities for converting residues into energy should be examined. A tentative quantification of the energy potential of residues associated with the 1982/83 crop yield indicates a value of 450-600 Ktoe, which compares to a present fuelwood consumption of about 700 Ktoe. The mission therefore recommends that a balance of available residues be drawn up for each major agricultural zone, taking into account alternative uses of biomass waste and soil recycling needs, to use in planning economic energy applications.

<u>Supply Options</u>

1.14 <u>Forestry</u>. In view of the country's low population density and climatic conditions, wood production could be substantially enhanced in Benin. The main constraint to effective management of forest resources is the present weakness of the institutions guiding the sector. There are several reforestation and forest management projects currently being implemented which the mission believes are well conceived and suited to the absorptive capacity of the country. Most of the intensive forest plantations in the south focus on timber production, with fuelwood as a subproduct; one high cost project caters specifically to the energy needs of the densely populated coastal area; another project is attempting to temporarily alleviate the erosion and wood scarcity problem of the dry zones of north Benin.

1.15 To increase the future supply of fuelwood and charcoal for households in the coastal and urban areas, the mission recommends a two-pronged approach: (a) expand efforts to open up new forest areas in the center of the country, and introduce efficient charcoal conversion equipment; to enhance the economics of forest management projects, consideration should be given to multipurpose exploitation objectives, including the production of service wood, fuelwood for industrial and power applications, as well as firewood for household consumption; (b) promote rural reforestation, through the expansion of technical assistance services. The mission also recommends that coordination between agriculture and forestry be strengthened in defining a land use policy in South Benin and promoting agro-silvicultural projects.

1.16 <u>Other Biomass</u>. Several industries already use agricultural residues for boiler fuel, thus replacing imported petroleum products. An additional opportunity for substitution was found in Bohicon, where there is an estimated surplus of 3,000 tons of sawmill waste and cottonseed hulls. Instead of separately utilizing these waste materials, the mission suggests that their use in a multi-fuel boiler at the planned brewery of Abomey be studied. The mission's preliminary evaluation indicates that steam generation or cogeneration of steam and electricity are attractive alternative uses for this surplus. On the other hand, the mission suggests that, to promote the conversion of residues into electric power in isolated areas, consideration be given to signing sales agreements with enterprises interested in producing electric power from biomass, at a tariff equal to the long run marginal cost for the specific local environment ("producer tariffs"). In view of CEB's mandate to licence self-generation, such contracts for areas to be served by this binational utility should be negotiated by SBEE with CEB's agreement.

1.17 Electric Power. Although the level of electrification is low in Benin (only 20% of the urban population has access to it) and the share of electricity in final energy consumption is less than 2%, the mission recommends for the medium-term a policy which emphasizes: (a) completing the distribution networks in centers already served, improving the service reliability and reducing the systems' physical and financial losses; (b) extending the services to new areas on the basis of evidence that electricity is the least cost option for meeting specific energy requirements. In view of the low average income level of the majority of Benin's population and considering that basic social services have not yet been brought to the reach of the population, the mission considers that rural electrification projects should be carefully reviewed, taking into account that energy needs in most applications can be provided more economically by direct use of liquid fuels.

1.18 A distinctive feature of Benin's electric power sector is the fact that its coastal system was interconnected in the early 1970s with Togo and Ghana and through this cooperative scheme benefitted from relatively low cost hydropower supplies. Currently Benin has to adjust to an unexpected event which has a significant impact on its economy. Due to severe drought, Ghana curtailed its electric supplies by 50% in December 1983. These power imports supplied almost 90% of Benin's internal electric power requirements the year before. To compensate for the increased share of higher cost thermal generation, Benin had to increase tariffs by 80%. Such a sudden and substantial increase will dampen growth in energy demand.

1.19 For planning purposes, the Bank projects electricity sales in Benin to grow at an average rate of 9% p.a. in the coastal system and at a much higher rate in the inland centers (14% in long established centers, 20% in the newly established ones). Demand in the binational interconnected system of Benin and Togo is projected to average 8% p.a. Togo and Benin have unilaterally pursued the policy of maintaining full back-up capacity for imported power supplies, contravening the 1968 binational treaty in which they agreed to assign full responsibility for enacting future expansion requirements to CEB. At present thermal capacity in Benin and Togo is large enough to meet the demand in the interconnected system until 1987-88, even if imports remain curtailed at the present level. It is expected that by 1988 the Nangbeto hydro power plant on the the Mono River will be commissioned. This station's energy output of about 150 GWh per year can be absorbed fully by the system, replacing thermal generation. Further, the Nangbeto reservoir will help to regulate the seasonal water flow and allow economic development of another downstream hydroelectric site on the Mono River.

1.20 The long-term expansion of the interconnected power system of Benin and Togo is subject to three major uncertainties: the duration of Ghana's export curtailment, the results of continued hydro studies, and progress on the project to interconnect the power systems of the West African region (WAPSI).

1.21 The aim of WAPSI is to link Nigeria's mixed hydro-thermal (gas-based) system with the predominately hydro system of Ivory Coast and Ghana, and to allow for the least cost expansion of the region as a whole. CEB, the joint Benin-Togo power utility, acts as coordinator for the study of this project. However, it must be realistically expected that the full implementation of the project will take some time. It is therefore prudent to formulate a binational expansion program to meet incremental demand assuming that during its first operational phase, the regional transmission line will primarily facilitate exchanges of contingency power and energy.

1.22 Further hydro studies are needed to determine the economic feasibility of developing both countries' hydropower potential. The developable energy potential on the Mono and Ouémé Rivers is estimated to be 1,100-1,300 GWh, which compares with a projected demand of 1,700 GWh by 1998 for the binational system. Because the attainable degree of stream-flow regulation is limited, a large part of the potential is secondary energy. Seasonal energy exchanges with Ghana on the existing transmission line or the support from WAPSI will provide the most economic option for firming up hydropower generation.

1.23 The confirmation of commercially exploitable natural gas resources in the Sémé field would offer another possible option for power generation in the binational electric system.

1.24 In view of the high cost of power generation in isolated centers, careful consideration should be given to each center's expansion options. For the region of Abomey-Bohicon, interconnection with the coastal system has been found to be the most economic alternative. The mission also suggests that a study be made to determine the optimum use of agro-industrial residues available in this area. For the Load center of Parakou, the mission suggests that a feasibility study be made to assess wood-based power generation, united to an efficient management of the wood resources available at the Toui and Ouémé Superieur forests. For the northwestern region of the Atacora, electric interconnection with the Togolese Kara system offers an economic medium-term alternative if a fuel oil based thermal plant is installed in Lama Kara. In the north-eastern region, the development of the Dyodyonga project on the Mekrou River could provide power at an attractive cost, if developed as a joint Benin-Niger project. The energy could be readily usable in Niger's Niger Valley System and allow Benin the opportunity to start electrification in a remote area.

1.25 Petroleum Products. SONACOP has been successful in importing petroleum products at a competitive price and with an adequate level of security of supply. This is achieved by deploying a careful and aggressive procurement policy and by constructing ample storage capacity. The company had some difficulties in meeting LPG requirements due to the temporary shutdown of the Nigerian refineries closest to Benin and later due to the closing of the Nigerian border. The mission expects that more than adequate LPG supplies will be available in Nigeria and suggests that a long-term purchase agreement be sought which would enable SONACOP to plan LPG market penetration in the transport and industrial sectors, substituting more expensive oil products.

1.26 In view of the readjustment of the international refining industry, the critical financial situation of West African refineries, the small size of Benin's internal market, and the relatively short expected life of crude production at Sémé, the mission strongly advises the Government not to construct a refinery in Benin. On the other hand, the mission does suggest that the Government participate actively in the search for regional oil procurement agreements to lower the cost of petroleum supplies to West African countries. Given SONACOP's experience in international petroleum trade, the Government should solicit its advice in the regional discussions.

Demand Management Measures

1.27 Pricing. The current market price for fuelwood and charcoal does not reflect its economic cost, which includes the cost of reforestation. The mission recommends that the Government explore alternative mechanisms for collecting stumpage fees for fuelwood cut in national forests as a means to enhance private planting of trees and encourage conservation at the users' end.

1.28 Retail prices for petroleum products are set by the Government above economic costs. The price structure should be modified in the future to bring prices into line with international standards. However, the effect of such a measure on fiscal revenue depends on the permeability of the border with Nigeria.

1.29 The average electricity tariff is adequate to meet the long run marginal cost, although it implies a cross subsidization of energy consumers in isolated centers. A recent tariff study, however, suggests that changes be made in the tariff structure. The present low-voltage tariff is complex, difficult to administer and not conducive to economizing peak demand. The medium voltage tariff provides no incentive to save energy at peak time. An improved tariff structure will be implemented once the necessary computing equipment (financed under the Nangbeto credit) is installed.

1.30 Conservation Opportunities. Most industrial enterprises face severe financial problems and their operations are constrained by the availability of feedstocks, markets and managerial capability. The largest industrial plants are new, well designed, and show good levels of energy efficiency. The mission suggests that large scale efficiency programs not be envisaged at present, but rather that energy audits be made in selected enterprises which are undergoing rehabilitation and that a series of seminars be held on energy conservation opportunities in individual sectors.

1.31 For the short term, the mission recommends: (a) conducting energy audits in the large industrial plants as part of the rehabilitation program and surveying energy consumption in small and medium scale industries as a first step to identifying conservation opportunities; (b) providing basic information on opportunities to improve energy efficiency in small and medium scale enterprises and assisting them in formulating conservation projects; (c) conducting a seminar at SBEE about the efficient use of electricity in the industrial sector; (d) insuring institutional coordination between SONACOP and SBEE; (e) conducting a feasibility study for using agro-industrial residues available at Bohicon for steam or co-generation.

1.3' For the medium term, the mission recommends: (a) connecting all major plants currently using diesel generating units to SBEE's distribution network; to that end the voltage fluctuations in the network must be corrected; (b) establishing a producer tariff as an incentive for power generation from agricultural residues; (c) investigating the economics of using natural gas and/or imported coal in the Onigbolo cement plant and in other major industries; (d) conducting a feasibility study for a fast-growing wood plantation at Savé, to replace diesel oil used during the dry season for irrigation; (e) investigating the installation of solar water pre-heating systems in the breweries, oil palm processing units, hotels and hospitals; and (f) evaluating energy use in residential, commercial and institutional buildings.

1.33 Information available on the transport sector is insufficient to draw up a concrete and exhaustive proposal for an energy conservation program. A detailed transport study should be made as a basis for planning the long-term expansion of the transport infrastructure. For the specific purpose of fuel conservation in the sector the mission recommends: (a) setting up a statistical data system at the Direction Générale de Transport Terrestre to monitor the vehicle fleet; (b) providing training to the technical vehicle inspection center in Cotonou to measure energy efficiency and to disseminate information on good driving habits and vehicle maintenance practices; (c) enforcing regulations in the main arteries of Cotonou to ensure smooth flow of traffic; (d) promoting the introduction of mini-buses for Cotonou; and (e) analyzing the composition and use of the publicly held vehicle fleet and assessing ways to enhance fuel efficiency.

1.34 In the household sector, the energy efficiency of fuelwood and charcoal stoves can be improved substantially. Modest efforts to disseminate stoves under the Direction d'Action Coopérative (Groupement des Femmes) indicate that the population is already sensitized to the issue. The mission therefore recommends that technical assistance be provided to a research center -- still to be identified -- for the evaluation of improved stoves, and that the Cooperative Women's Association (which answers to the Ministry of Rural Development) be financially strengthened to disseminate new stoves and more efficient cooking techniques. This project should be coordinated with the Direction de la Recherche Scientifique et Technique and carried out as a joint effort with the Solar Energy Laboratory in Togo.

1.35 The artisanal activity in Benin is very important, but not well known. The mission suggests that a survey be carried out to study current practices and operations in the following areas: processing of oil palm products; drying and smoking of fish; and manufacuture of gari, akassa, and salt.

Institutional Aspects

1.36 At present, there is no energy planning capability in Benin, nor is there an institutional framework to provide coordination and guidance to the various subsectors. The mission recommends that, as a first step, basic training be provided to individual services in the use of appropriate, simple techniques of data collection, processing and analysis and that technical staff be encouraged to participate in regional energy planning seminars. For specific issues that need interministerial attention, it is suggested that working committees be convened, integrated by representatives of the subsector planning units. In the medium term, the creation of an Energy Council at the Cabinet level should be envisaged to speed up decision making. To insure proper coordination, it would be necessary to establish a technical secretariat in charge of analyzing project documents submitted by the individual services in terms of sectorial priorities and their insertion in the national economic plan.

1.37 The Ministry of Rural Development and Cooperative Action (MDRAC) is responsible for all aspects of the forestry sector. After some reorganization, the Direction des Eaux, Forêts et Chasses (DEFC) is responsible for legislation, planning, reforestation and management. The current Bank project has an important technical assistance component to strengthen this unit. The recently created public enterprise, ONAB, has been assigned the responsibility for commercial forest exploitation, and receives technical assistance from the Federal Republic of Germany. The regional CARDER, which plays an important role in cooperative agricultural development, has recently been assigned responsibility for rural reforestation. This institutional arrangement is favorable for integrated agro-silvicultural development and for the introduction of biomass energy conversion systems. The mission therefore recommends that technical assistance be provided to strengthen these entities.

1.38 The Ministry of Finance and Economy (MFE) has, in principle, responsibility for monitoring oil exploration through its Service des Hydrocarbures. In practice, the operations of Saga Petroleum, holder of the service contract for the Sémé oilfield, are supervised by Beninese officials appointed to Saga. For the implementation of the second phase development of this field, the Goverment has decided to establish a separate project unit to monitor the project.

1.39 SONACOP has a monopoly on importing and distributing petroleum products in Benin. It appears to be well directed and successful in meeting internal needs at a competitive price. The society is profitable but faces severe constraints on working capital.

1.40 There are two public utilities active in the electric sector: (a) the national SBEE, formed in 1974, with the purpose of electric power generation, transmission and distribution, as well as water supply and waste water disposal; and (b) the binational CEB, established under the 1968 treaty between Benin and Togo, with a dual mandate as a public utility for the two countries and as a directorate with the authority to regulate many aspects of the electric utility industry. Under the broad mandate conferred on CEB, a pragmatic division of responsibilities among CEB and the national utilities should be established.

1.41 To implement the proposed conservation measures, the mission proposes that part of the staff of the Service des Hydrocarbures be retrained and reorganized as a national Energy Conservation Center. This service has a group of professionals, mostly chemical engineers, who are currently underutilized. This team should be given technical assistance to monitor energy use in the industrial and transport sectors, survey energy consumption patterns in the artisanal sector, serve as liaison between consumers and energy suppliers (SBEE-SONACOP), and develop projects for increasing energy efficiency.

II. DEMAND MANAGEMENT PROGRAM

Energy Balance

2.1 Benin's energy balance for 1982 reflects the country's predominantly rural economy. In 1982, gross per capita energy consumption was on the order of 220 kgoe, of which commercial energy consumption was only 29 kgoe (13%) per person. The mission estimates that 86% of energy requirements are supplied from fuelwood and other biomass which are mainly used as cooking fuels in households and artisanal activities. Official imports of petroleum products represent about 11% of energy supply. In addition, the mission estimates that in 1982 some 16,000 toe of petroleum products, equivalent to about 7% of total official imports, were smuggled into Benin from neighboring countries. Transport uses about 69% of these hydrocarbons, industry 11%, households 16%, and power generation 4%. Electricity supplies only 1.3% of the final energy needs; 41% goes to households mainly in the coastal area, 37% to industry and 22% to commerce and administration.

2.2 Energy losses average a low 5% of primary inputs, due to the limited amount of conversion activities in the power sector and in the fuelwood chain. The average efficiency with which energy is used by the final consumer is estimated at a low 15%, due to the large share of fuelwood in household consumption and the fact that improved stove technology has not yet been introduced in Benin at a significant scale. The importance of increasing the efficiency factor cannot be overstressed as the most economical means to meet incremental demand. For example, a 2 point increase in the energy efficiency factor has the same effect in volumetric terms as the discovery of the Sémé oil field.

Table 2.1: BENIN ENERGY BALANCE, 1982

Energy Sources	Annual Productive Capacity	Gross Demand		Sector of Consumption	Final Demand		Effective End-Use	
	(Ktoe)	(Ktoe)	(%)		(Ktoe)	(%)	(Ktoe)	(%)
Biomass	2,000	732	86	Households	707	82	96	74
Petroleum	190 a/	108 b/	13	Industry	30	4	15	12
Electricity	70	13	2	Transport	74	9	16	12
				Commerce & Adm.	3	-	3	2
				Losses Energy System	39	5	-	-
Total	2,260	853	100		853	100	130	100

a/ Petroleum production refers to 1983.
b/ Includes illegal imports of oil products.
Source: Mission estimates - Annexes 2.1-2.2.

2.3 Benin imports most of its commercial energy requirements. In 1983 the cost of petroleum imports (net of re-exports to Niger) amounted to FCFA 13.8 billion (US$47.9 million), which is equivalent to 20% of the value of merchandise exports and 8.4% of total merchandise imports. Electricity imports from Ghana, which account for 90% of total power consumption, have an estimated cost of FCFA 1.473 billion (US$4.4 million), 1/ representing 2% of export revenue. In December 1983, Ghana imposed rationing on electricity supplies because of the critically low water level in the Volta Lake. A preliminary estimate indicates that oil imports to thermally generate the required supplies will amount to some 27,000 toe, or US$7 million 2/ in 1984.

2.4 The statistical basis underlying these estimates is extremely weak. Therefore the mission recommends: (a) to centralize energy data collection to check the consistency of primary statistical data; (b) to carry out a survey to assess actual fuelwood, charcoal and commercial energy consumption in the household sector; (c) to survey the energy consumption in small scale and cottage industries; (d) to develop a transport sector study. Given the significance of non-recorded oil imports from Nigeria, a best estimate of this demand component should be made.

Projected Energy Balances

2.5 As a framework for examining policy options and to assess the likely demand for hydrocarbons, the mission projected the energy balance to 1988 (five year horizon) and 1998 (fifteen year horizon). On the demand side, the projections reflect the economic growth scenarios projected by the Bank on the basis of the perceived constraints of the economy such as a slowdown of demand in neighboring countries and difficulties in achieving rapid gains in agriculture or implementing new industrial activities. (See Table 2.2.)

2.6 On the supply side, the mission assumed an unconstrained supply of biomass and the supply schedules for hydropower and imported electricity as prepared in the master plan. The main conclusions that can be drawn from this exercise under the low growth scenario are:

(a) Total gross energy requirements are projected in the energy balances to grow an average of 4.4% p.a. between 1982-88 and at 3.6% p.a. between 1988 and 1998. Assuming an average GDP growth of 3%, this would indicate an energy/GDP elasticity of

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1/ The total amount of electricity imported was 151 GWh at FCFA 9.75/kWh. The exchange rate averaged FCFA 336/US$ in 1982.

2/ Based on the assumption that the 252 GWh available to CEB are distributed: Togo, 177 GWh and Benin, 75 GWh and that the power requirements of the Interconnected system in Benin are 187 GWh.

1.5 during the five-year period and 1.2 for the second period.

Table 2.2: ECONOMIC STRUCTURE AND ECONOMIC GROWTH

	GDP Structure		Annual Growth Rate			
					1982-90	
	1972	1981	1972-76	1976-81	Best	Alternative
	(% Current Prices)		(1978 Prices)		Estimate	Scenario
Primary Sector	46.8	43.7	0.8	0.7	2.7	1.0
Secondary Sector	12.0	12.8	-1.1	6.8	6.2	4.5
Services	41.2	43.5	0.9	4.7	3.3	2.2
GDP	100.0	100.0	0.9	3.6	3.4	2.1

Source: Benin: Economic Performance and Prospects. IBRD - 1983.

(b) The relative share of biomass in total gross energy supplies will gradually decline (from 87% in 1982, to 80% in 1988, and to 70% in 1998) and the demand for petroleum products will increase to about 4,700 b/d in 1988 and 10,000 b/d in 1998. Under the present envisaged development scheme for the Sémé oil field, crude oil production will peak in 1988/89 and probably cease by 1992-94. One important objective of the energy policy should be to carefully monitor petroleum demand, to foster energy conservation measures, and promote the substitution of cheaper fuels.

(c) The share of electricity in final non-biomass consumption decreases from about 11% in 1982 to 9% in 1988 due to the sharp rise in electricity tariffs necessary to compensate for the reduction in cheaper imported supplies. A higher growth of electricity demand and the substitution of electricity is warranted in the long term if reliable and cheaper supplies become available through the West African interconnections.

(d) In the projections, the gross demand for biomass grows at a slower rate than the average growth rate for total energy requirements and the assumed population growth, mainly because of the underlying assumptions that efficiency in biomass use will increase and that the modern sector of the economy will depend on commercial fuels. Given Benin's important biomass resources, policies encouraging the conversion of agricultural residues into industrial fuels and into electricity must be evaluated.

Substitution and Conservation

2.7 The following section has the objectives of: (a) studying the current energy use in each sector of consumption; (b) explaining the assumptions for projecting energy demand to 1988 and 1998; and (c) evaluating energy conservation and substitution opportunities.

Industrial Sector

2.8 Energy is not the most important issue in the industrial sector in Benin. Large energy using facilities (e.g., cement, sugar) were built only recently and technically are well conceived. Unfortunately, these plants are either shut down or operating at 10-20% capacity because of constraints on the availability of feedstocks and raw materials, markets for products, and working capital. For example, the Onigbolo cement plant, which is by far the largest potential user of heavy fuel oil (45,000 tonnes at full capacity) is idle because expected sales to Nigeria have not taken place; the brand new sugar plant at Savé (SSS) is not likely to meet its 1983 and 1984 production goals because housing facilites for temporary manpower during the cane harvest season were not built and because the sugar sales agreement with Nigeria has not been concluded.

2.9 The cash flow situation of most enterprises is alarming and if solutions are not found in the short term, plants will have to be shut down, eliminating any need for programs to improve energy efficiency.

Industrial Energy Use Patterns

2.10 The amount of fuel and electricity consumed in the industrial sector is not known precisely. The mission's estimates indicate that petroleum consumption in 1982 was around 11,000 toe and electricity consumption around 50 GWh, for a maximum peak demand of 22 MW (Table 2.3). 3/ The 1983 energy consumption was probably lower as most plants were operating at levels well below those of 1982.

2.11 Nine plants engaged in the production of clinker (ONIGBOLO), cement (SONACI and SCB), tiles and refractories (CIB), food and beverages (La Beninoise, SONICOG) and textiles (SOBETEX) consumed two-thirds of the oil and electricity used by the sector in 1982.

2.12 The energy efficiency levels of the two most energy intensive plants in Benin (i.e., ONIGBOLO and SSS) are not known because neither of these plants has operated yet under normal conditions, and during the mission's visit both plants were idle. Detailed reviews of their design showed, however, that these plants were well conceived and should lead to satisfactory levels of energy efficiency.

3/ Indicating a very low plant load factor (26% on the average).

2.13 The energy efficiency levels were also good at both cement grinding plants (35 kWh/tonne of cement). SONICOG's oil mill in Bohicon operates on waste fuels (cotton seed hulls) and uses just a small amount of fuel oil for start-up, and diesel oil to generate electricity. The MIFOR sawmill (Bohicon) also generates its electricity from diesel generators and does not require fuel for thermal uses. There are plans underway to assess the feasibility of using biomass gasifiers running on wood wastes to generate power and subsequently eliminate all purchased fuel requirements (Chapter V). The mission considers that at present electricity tariffs, industries do not have an incentive to generate power from waste materials.

Table 2.3: INDUSTRIAL ENERGY DEMAND
(1982)

Plant/Activity	Production (10^3 tons/year)	Fuel: Heavy Oil (toe/yr)	Fuel: Diesel Oil (toe/yr)	Electricity: Peak (MW)	Electricity: Energy (GWh/yr)
ONIGBOLO (clinker) * a/	45.0	4,140	neg.	8.	14.0
SONACI (cement)	122.3	--	--	2.0	4.3
S.C.B. (cement)	125.0	--	--	2.0	4.5
C.I.B. (const. mat.) *	.2	--	96	.7	1.0
La Beninoise (beer) Cotonou * b/	36.0	--	1,514	2.2	2.0
Parakou *	15.0	651	980	0.8	2.2
IBETEX (textile)	n/a				
SOBETEX (textile)	n/a	--	1,000 c/	2.0	4.0
MIFOR Bohicon (wood) *	4.0	--	77	--	--
SONICOG - Cotonou (oil) *	13.0	314	843	2.9	--
Porto Novo (soap) * d/	6.0	623	58	0.16	neg.
Bohicon (oil) * d/	2.6	50	(300)	1	neg.
SONAFEL (raw materials) *		20	--	0.2	neg.
GMB (flour) *	44.0	--	0.2	1.3	2.5
Subtotal		6,208	4,868	19.2	37.4
Others				2.8	12.5
Total				22.0	49.9

* Plants visited during in-country mission.
a/ Started operation in 1982.
b/ Assuming .005 toe/hl and 12 kWh/hl.
c/ Rough estimate.
d/ SONICOG's capacity exceeds 30,000 tons. Production in 1982 was only 2,600 tons.

Opportunities for Energy Conservation

2.14 Efforts to improve energy efficiency and to identify substitution opportunities should be part of the industrial rehabilitation program. The mission believes that in the short-term, the potential for achieving savings in oil and electricity consumption is limited. Regarding electricity, the only possibility for improvement identified by the mission pertains to reactive power. Potential electricity savings are, therefore, estimated at 2-3% of total electricity needs or 1-1.5 GWh/year under 1982 conditions, which correspond roughly to a limited FCFA 20-30 million. Improving the efficiency of diesel oil used in self-generation would be difficult to achieve. The only remaining option lies in the diesel and fuel oil used for steam raising and direct heat generation. Based on on-site observation (which revealed a lack of instrumentation and inadequate insulation and air/fuel ratio control) and experiences from other countries where detailed audits have been conducted (e.g., Peru, Tunisia, Thailand, Argentina), it is estimated that ten percent could be saved with minor maintenance and operation modifications and minor equipment retrofitting. This figure corresponds to approximately 1,000 toe/year or FCFA 130 million. Improving the energy efficiency in the combustion of agricultural residues in the food processing plants (which do not have sufficient instrumentation and controls) could result in potential savings and increase the availability of these residues to other industries. However, careful analysis of transport and storage costs is warranted to assess their alternative use. In the longer term, substitution of oil by natural gas, coal and agricultural residues should be envisaged.

Industrial Energy Demand Forecast

2.15 The mission estimated future energy demand (Table 2.4) using (a) information obtained from interviews with individual plant managers and government officials responsible for industrial programs; (b) information contained in long-term planning documents; and (c) rough estimates of the future evolution of the industrial sector (for the aggregate consumption of small plants). It is expected that:

(a) Total oil consumption will increase from its 1982 level of 11,000 toe to 51,000-61,000 toe in 1988 and 110,000 toe in 1998, mainly due to increased production at ONIGBOLO and to SSS's outside energy requirements for irrigation. These figures translate into an average growth rate of 15% p.a.

(b) Total electricity consumption will increase from an estimated 47 GWh in 1982 to 85-96 GWh in 1988 and to 167-183 GWh in 1998. This is an average annual rate of increase of 7.3-7.8%. ONIGBOLO will consume roughly 40% of the oil and electricity used by the whole sector through the forecast period.

Recommendations

2.16 The mission's recommendations for energy demand management are divided into short term (within the next three years) and longer term (after 1986).

2.17 Short Term

(a) Conduct an energy survey to estimate fuel and electricity consumption in the small and medium-sized industry (currently unknown). Responsibility for the survey could be given to the Ministry of Planning or the Ministry of Finance and Economy.

(b) Provide basic information on opportunities for improving energy efficiency to small and medium-sized enterprises consuming more than 100 toe/year (probably less than 50 enterprises).

(c) Conduct seminars at SBEE on the efficient use of electricity in the industrial sector.

(d) Include plant energy audits in major rehabilitation programs.

(e) Ensure that the institutional framework allows coordination between SONACOP and SBEE in industrial energy supply.

(f) Study the possibility of establishing a producer tariff for enterprises using agricultural residues for power generation.

(g) Conduct a feasibility study for cogeneration in Bohicon to supply power to SBEE, and power and steam to a few industrial plants using available agricultural by-products and wood wastes as fuel.

2.18 Long Term

(a) Investigate the economics of substituting natural gas, if available. This implies evaluating retrofitting requirements and preliminary economic evaluation (Chapter III).

(b) Connect all major plants currently using diesel generating units to the SBEE grid.

(c) Conduct a feasibility study for converting the ONIGBOLO cement plant to use an alternative, cheaper fuel, such as natural gas or coal.

(d) Conduct a feasibility study for establishing a fast-growing wood plantation in Savé. The amount of bagasse available at SSS will not be sufficient to provide both the mill's requirements and irrigation pumping needs during the dry season.

(e) Conduct feasibility studies for the use of solar water heaters to preheat industrial water (Chapter V).

Table 2.4: INDUSTRIAL ENERGY DEMAND FORECAST TO 1988 (5 YEARS) AND 1998 (15 YEARS) IN BENIN

Plant facility	1982 Production (10^3 tons/yr)	1982 Fuel: Heavy Fuel Oil (toe/yr)	1982 Fuel: Diesel Oil (toe/yr)	1982 Electricity: Peak (MW)	1982 Electricity: Energy (GWh/yr)	1988 Production (10^3 tons/yr)	1988 Fuel: Heavy Fuel Oil (toe/yr)	1988 Fuel: Diesel Oil (toe/yr)	1988 Electricity: Peak (MW)	1988 Electricity: Energy (GWh/yr)	1998 Production (10^3 tons/yr)	1998 Fuel: Heavy Fuel Oil (toe/yr)	1998 Fuel: Diesel Oil (toe/yr)	1998 Electricity: Peak (MW)	1998 Electricity: Energy (GWh/yr)
ONIGBOLO (clinker) * a/	45	4,140	neg	8	14.0	350-450	31,800-41,000	n/a	8	29.7-38.2	500	45,000	n/a	12 b/	60-75
SONACI (cement) *	122.3	--	--	2.0	4.3	150	--	--	2.0	5.3	200	--	--	2	7
S.C.B. (cement)	125	--	--	2.0	4.5	150	--	--	2.0	5.3	150	--	--	2	5.3
C.I.B. (const.mat.) *	.2	--	96	.7	1.0	2-4 d/	--	400-850	1.5	2-4	2-4	--	850	1.5	2-4
La Beninoise (beer) e/	26.5	--	1,600	1.2	3.2	35	--	2,200	1.2	4	35	--	2,200	1.2	4
IBETEX (textile)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SOBETEX (textile) f/	n/a	--	(1,000	(2.0)	(4.0)	n/a	--	(1,500)	(2.5)	(5)	n/a	--	(2,000	(2.5)	(7)
MIFOR (wood) *	4	--	77	--	--	28 g/	--80	--	--	28 l/	--	80	--	--	
SONICOG Bohicon (oil) *	(12)	50 h/	(300)	1	neg	(30)	(50)	(800)	1	neg	(30)	(50)	(800)	1	neg
Bohicon (corn mill) * i/	--	--	--	--	--	n/a	--	(100)	(.5)	1.0	n/a	--	(100)	.5	1.0
S.S.S. (sugar) * j/	--	--	--	--	--	35	--	10,000	n/a	n/a	40	--	10,000	n/a	n/a
LAKOSSA (textile)	--	--	--	--	--	--	--	--	--	--	n/a	(2,000)	--	2 k/	5-7 k/
Subtotal		4,190	3,073	16.9	31.0		31,800-41,000	15,080-15,530	18.7	48.3-62.8		47,050	16,030	24.7	92-109
Others (GWB, SONAFEL)			18,000 l/	(5.0)	16.0		(5,000)	(26,300)	(9.0)	(28.32		(10,000)	(38,400)	(23.3	(73.6)
Total (------)		4,200	21,100	21.9	47		37,000-46,000	31,400-41,800	27.7	76.6-91.1		57,050	54,450	48.0	166-183

* Plants visited during in-country mission.
n/a Not applicable or not available.
() To be revised.
a/ Plants started test operation in September 1981. 1985 forecast: 350,000 tons (local grinding capacity) - 450,000 assumes high level of sales to Nigeria); 1998 forecase: full capcity at startup of grinding plants in early 1990s. Specific energy consumption - Fuel: .092 Toe/t in 1983 - .090 Toe/t in 1998. Electricity = 85 kWh/tonne over the period.
b/ 9 MW for clinker; 3 MW for cement grinding.
c/ 35 kWh/tonne of cement.
d/ After rehabilitation. Assumption highly speculative (See ONUDI report). Company currently in liquidation prior to restructuring.
e/ Assuming .005 Toe/hl and 12 kWh/hl. Full capacity between 1988 and 1998.
f/ Closed.
g/ For power generation. Wood waste gasifier likely to be installed prior to 1988. Diesel oil used for backup only.
h/ Only for startup - use cotton waste otherwise. Generate their own power from diesel generators.
i/ May start operation in late 1983.
j/ Installed generation capacity = 16.4 MW. Fuel oil consumption is net, after excess bagasse combustion.
k/ From e/di p.48.
l/ Looks too high.

Source: Mission estimate.

Transport Sector

2.19 Data on energy consumption in the transport sector is poor. SONACOP's retail sales of gasoline and gasoil showed drastic declines after the price increases of 1979 and 1981. Since the vehicle fleet continued to grow during those three years and energy in the transport sector is generally price inelastic, the sales fluctuations must be due to the consumers' direct fuel purchases in Nigeria. The mission attempted to estimate actual fuel consumption in the transport sector based on the scant data available on the vehicle fleet, traffic flow and transport demand structure. With a considerable margin of error due to these uncertainties, the mission estimates the 1982 petroleum consumption at about 90,000 m^3 (Table 2.5) in the transport sector.

Table 2.5: 1982 - ESTIMATE OF PETROLEUM CONSUMPTION

Type of Transport	Number of Vehicles a/	Average Distance per year	Specific Consumption	Total Consumption
		(km)	(lts/100 km)	(m^3)
Road Transport				
Cars	7,814	10,000	9.0	7,033
Taxis	1,034	80,000	9.0	7,445
Pick-ups	3,750	50,000	13.5	25,313
Light Trucks (to 7 tons)	1,878	50,000	15.0	14,085
Medium Trucks (7-13 tons)	927	50,000	20.0	9,270
Heavy Trucks and Road Tractors	997	50,000	50.0	24,925
Buses	95	60,000	35.0	1,995
Subtotal	16,495			90,066
Railroads	.	438,000	50	3,300
Total				93,366

a/ Estimated on the basis of annual registration, assuming a 10% p.a. scrappage rate, and a 20% adjustment to include second-hand and resale registrations.

2.20 A comparison of the mission's estimate of fuel consumption in the industrial and power sectors with SONACOP's total gasoline and diesel sales (Table 2.6) indicates that a significant portion of the transport requirements are being supplied through unrecorded imports from Nigeria.

Table 2.6: 1982 - TRANSPORT FUEL CONSUMPTION a/
(in m^3)

	Gasoline	Diesel
Total Sales SONACOP	36,855	48,805
Industrial use		5,830
Power generation		5,550
Available for Transport	36,855	37,425
Road transport requirements	53,876 b/	36,190 c/
Railroads		3,300
Marine diesel		2,886
Total deficit	17,021	4,951
Deficit relative to total sales	46%	10%

a/ Aviation gasoline and jet fuel are excluded because they refer mainly to international bunkers.
b/ Including estimates for cars, taxis, pick-ups and light trucks.
c/ Includes estimates for medium and heavy trucks and buses.

Source: Mission estimates.

2.21 The road infrastructure has been developed considerably since 1975. As a result, the vehicle fleet has grown at almost 25% p.a., and a dramatic shift of traffic away from railroads has taken place. At present, three-fourths of freight and nine-tenths of passengers in international traffic are carried by road. Further displacements would be likely if the "Benin Route" were completely paved. 4/ The demand for transport is highly unbalanced, leading to low load factors. The most important traffic flow originates at the Port of Cotonou, which handled about 1.1 million tons in 1982. Imports represent 95% of the port traffic, exports only 5%. Internal merchandise demand for transport represented 68% of the total in 1982, followed by transit traffic to and from Niger (29%). The transit flow to and from Niger consisted of 317,000 tons upwards, and only 7,000 tons on the downward haul. 5/

4/ The Benin Route extends over 1,100 km between the Port of Cotonou and Niamey (Niger). This route competes keenly with the Togo and the Nigeria routes for the Sahel traffic. A railroad line links Cotonou to Parakou, a distance of 440 km, where merchandise is loaded on trucks. The Government is considering paving the 230 km road between Dassa and Parakou and the corresponding economic study is under preparation. If this project turns out to be justified, it would complete the paving all the way from Cotonou to Niger.

5/ More than 90% of the flow from Niger to Cotonou consists of uranium oxide.

Public enterprises and government also own a considerable transport capacity. It should be investigated whether part of the transport demand met by this fleet could be economically transferred to the railroads or private truckers, to improve their load factors.

2.22 The demand for passenger transport in urban areas is low outside of Cotonou, and even there about 50% of trips still are made on foot. According to a recent socioeconomic survey, the most important transport means used in Cotonou are: two-wheeled vehicles (37%), taxis (49%), private cars (8%), and bus (5%). 6/

Forecast of Fuel Demand in the Transport Sector

2.23 Between 1975 and 1979, the Beninese economy grew an average 2% a year, while gasoline and diesel oil sales increased at about 13% a year. 7/ During the latter part of the decade, the country developed its transport infrastructure and became motorized. Annual vehicle registration jumped from an average of 850 units during 1970-75 to an average of 3,200 units during the second half of the 1970s. 8/ Despite this growth, the level of motorization remains very low (7 vehicles per 1,000 inhabitants). In view of this factor and the continued expansion of the road network, the mission expects road fuel demand to increase at 6.1% p.a. to 1988 which, in light of the assumed economic growth rate of 3.4% p.a. in the optimistic case, would indicate an elasticity of 1.8. In projecting SONACOP's sales, the mission estimates that Nigeria progressively will raise domestic prices to their opportunity cost, and that illegal imports will tend to phase out. Thus, SONACOP's sales will increase at about 13% p.a. between 1982 and 1988.

6/ According to a 1981 study, "Transports en Commun à Cotonou" - Wabi Issa, Ecole Normale Supérieure de Porto Novo, 1,034 taxis are in service in Cotonou. They consist mostly of Japanese and French cars, with engines of 2-7HP. On the average, they travel some 250 km per day and transport 130 persons. About 95% of the taxis are driven by hired drivers. Bus service is provided by the Société du Transports de la Province de l'Atlantique. In 1981, this company owned 40 buses serving nine lines. This equipment (Mercedes made in Brazil) has deteriorated badly; consequently, today less than ten buses serve Cotonou. On the average, bus lines have an extension of 207 km. The low population density of Cotonou and the low bus frequency lead to a relatively small share of bus service in Cotonou.

7/ This period was chosen because petroleum prices remained relatively stable.

8/ An important factor in the explosion of the vehicle fleet was duty-free imports from Nigeria. In 1983, severe measures were taken to reduce these imports.

Table 2.7: FORECAST OF PETROLEUM SALES TO TRANSPORT SECTOR

		1982	1988	1998
Gasoline	- Road a/	36,855	76,750	165,700
Diesel	- Road a/	23,873	49,700	107,300
	- Railroad b/	3,300	3,940	4,000
	- Marine c/	2,886	2,880	2,880
Aviation Gasoline d/		105	118	150
Jet Fuel e/		19,514	29,285	57,610
	Total	86,533	162,673	337,640

a/ Projected at 13% p.a. growth to 1988 and 8% p.a. to 1998.
b/ Projected at 3% p.a.
c/ Most of marine diesel consists of sales to international shipping. The sales volume tends to decline, given the competition for bunkers.
d/ The small internal aviation services primarily consist of military requirements. Projected at 2% growth p.a.
e/ Estimated at 7% p.a. growth rate to international aviation companies.

2.24 Between 1988 and 1998, the projected annual rate of increase in petroleum sales to transport is estimated at 8%, based on the assumption that economic growth and diversification of the economy will raise the demand for transport services.

Road User Charge

2.25 A tax increase on gasoline and diesel has been proposed to compensate for the maintenance cost of the road infrastructure. At present, the road traffic bears only a small portion of the investment cost in the road network. In 1983, the taxes on gasoline and diesel earmarked for road maintenance were, respectively, FCFA 8/liter and FCFA 6/liter. The total revenue is estimated at FCFA 800-900 million, which compares to annual road maintenance requirements on the order of FCFA 1.8-2.0 billion. In view of the fact that international traffic uses Benin's road network at no charge, the mission suggests studying the establishment of a toll system at the main border crossings. However, the study should carefully analyze the impact of such measures on the competitiveness of the Benin route.

Recommendations

2.26 (a) In the newly reorganized Direction Generale des Transports Terrestres, set up a statistical data system to record the evolution of the vehicle fleet and its composition by age, ownership, utilization, engine rating, brand, etc.

(b) In the new technical inspection center in Cotonou, introduce the technical capability to assess the energy efficiency of the vehicles presented for inspection. Initiate the program with the publicly-owned fleet.

(c) Enforce stopping and parking regulations on the main arteries of Cotonou, and complete their paving.

(d) Enforce import duty charges on vehicle imports and make them selective in terms of the energy efficiency of vehicles imported.

(e) Assess the true costs of road transport, allocating at least the cost of road maintenance to road users. The mission also suggests studying the possibility of setting up a toll road system, charging trucks in transit an equitable road user fee.

(f) Study the transport capacity of public institutions in terms of costs and load factors.

Energy Consumption in the Hotel Sector

Sheraton/Cotonou

2.27 This new hotel started operation in mid-1982, two years later than anticipated. It has 201 rooms, of which 60 are single suites and 8 are double suites, representing a total of 235 single room-equivalents. Numerous problems were encountered during construction and some of them still had not been resolved at the time of the mission's visit. During his first six months on the job, the new deputy technical director had to tackle many technical problems, ranging from electrical breakdowns to the installation of insulation on laundry steam lines.

2.28 Because the hotel started operation just in 1982, no annual energy consumption record was available. On the basis of current readings and invoices, the hotel's annual fuel consumption (for laundry, hot water, and cooking) is estimated at 165 m^3 and electricity consumption at 5.8 GWh. These figures correspond to 0.702 m^3 of oil per room and 24,681 kWh per room. Using an average annual occupancy rate of 65%, these numbers translate into 1.08 m^3 of oil per occupied room and 37,970 kWh per occupied room. 9/

2.29 A visit to the utility installations and discussions with hotel technical personnel showed that much energy can be saved, and that both fuel and electricity consumption could be lowered to international

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9/ These numbers are comparable to those for the Sarakawa Hotel in Togo.

standards (i.e., less than 1 m^3 of oil per year and per occupied room, and less than 19,200 kWh per year and per occupied room).

2.30 Work in progress or planned includes the installation of a condensate return system, additional insulation in the laundry and on cold water circuits, and fuel meters. To achieve the international standards mentioned above, it is recommended that plant technical management investigate the installation of a reliable and simple energy management system, with the following functions: (a) shaving of electric peak loads; (b) switching off of air conditioning according to programmed rules based on occupancy, higher acceptable temperature and humidity; and (c) managing lighting.

2.31 The cumulative benefits of those actions are likely to reduce fuel oil consumption to 130-150 m^3/year (CFA 2-5 million annually); electricity peak demand by 100-200 KVA; and electricity consumption by 10-20% or 0.6-0.12 MWh/year. Total potential electricity savings, including reduced demand charges, are estimated at CFA 15-28 million.

2.32 As most improvements are currently under way or planned for the near future, the only additional investment to achieve such savings is likely to be in the CFA 13-22 million range (for an electricity management system). Paybacks shorter than one year can be expected.

2.33 If all the above measures are implemented, the annual consumption of diesel oil should fall to roughly 140 m^3 and hotel electricity consumption should be around 4.5-5 GWh for the year ahead.

Households and Cottage Industry

2.34 The energy consumption of these sectors cannot be separated because artisanal activity still is carried out largely as part of current household chores. Present and projected consumption is estimated in Table 2.8.

2.35 The per capita consumption of household fuelwood has been estimated at 1.21 kg/day (440 kg/year) for fuelwood in urban areas and 20% higher in rural zones; charcoal consumption was estimated at 110 kg/year. These figures are based on: (a) minimum energy requirements for cooking 2.5 meals a day; (b) a fuelwood-charcoal supply survey of the city of Cotonou; and (c) comparison with other African countries (Annex 5). The consumption of fuelwood in cottage industries, such as fish smoking, bakeries, palm oil extraction, and others is estimated at about 10% of total household consumption.

Table 2.8: ENERGY CONSUMPTION BY HOUSEHOLDS AND ARTISANS
(in toe)

	1982	1988	1998	Growth Rate (% p.a.)
Fuelwood	619,740	753,030	938,090	2.6
Crop Residues	54,900	54,900	76,900	2.1
Charcoal	10,980	15,300	26,210	5.6
LPG	548	1,047	2,973	11.0
Kerosene	16,617	24,938	49,057	7.0
Electricity	4,469	7,863	12,854	6.8
Total	707,266	857,078	1,106,084	2.8

Source: Mission estimate.

2.36 Projections to 1988 and 1998 are made on the basis of: (a) population growth; and (b) an increase in the share of charcoal due to the fact that with increased personal incomes, the city dweller will tend to replace fuelwood with charcoal and, possibly, with hydrocarbon products. Kerosene is currently used mostly for lighting. LPG is consumed in commercial activities (such as hotels and restaurants) and by high income households in Cotonou. Ninety percent of sales are in the Atlantique province. Important fluctuations in kerosene sales appear in provinces bordering Nigeria. In Ouémé, kerosene sales decreased from 4,100 m^3 in FY75/76 to 100 m^3 in FY80/81.

Potential for Energy Savings

2.37 The efficiency of the fuelwood chain can be improved through the dissemination of improved stoves, through more efficient charcoal kilns, and through better wood harvesting methods.

Improved Stoves

2.38 The efficiency of fuelwood stoves in use in Benin has been measured on average at 14%. 10/ Modern improved stoves achieve efficiencies of 20% and higher. The introduction of this technology in Cotonou and other major urban areas could reduce fuelwood consumption by as much as 120,000 tons or 42,000 toe. At the individual household level, it would reduce consumption by about 0.25 toe per year,

10/ Verbal communication to the mission by I. Gattegno of the Upper Volta Energy Institute, August 1983.

representing savings on the order of FCFA 7,500 p.a. 11/ The cost of manufacturing the "Ouaga" metal stove in Burkina is about FCFA 1100 for an artisan producing about 60 stoves per week. It would therefore become an attractive line of artisanal activity to produce such stoves in Cotonou.

2.39 Metallic charcoal stoves appear to be considerably more efficient (about 25%) and already are made in Benin as a cottage industry. The use of charcoal will expand, especially if fuelwood resources in the southern provinces become scarcer, given the qualitative advantages of this fuel in terms of transport costs, storage space requirements and convenience of use. Thus, if the charcoal manufacturing process could be improved from the present 25-35% efficiency (in energy terms) to 45%, then the overall efficiency of both modalities of wood consumption would be the same. The mission suggests that technical assistance be provided to Benin for the transfer of wood and charcoal stove technology.

Improvements in Artisanal Activity

2.40 This is an important economic sector in Benin, especially in food processing activities. It uses significant quantities of energy, mainly fuelwood, provides employment to a large segment of the population, and supplies the food requirements of urban areas. These activities offer the most propitious environment for the development of an autonomous industrial sector. The mission therefore recommends that the sector be studied to determine current practices, means to improve the operations that are performed, the cost of transformation, and marketing procedures. Among the most important activities that should be covered and for which technical assistance should be provided are: (a) transformation of the oil palm products (oil, soap, etc.); (b) drying - smoking of fish; (c) manufacture of akassa (corn paste); (d) manufacture of gari (cassava semolina); and (e) salt production. The mission also recommends that the feasibility of introducing less conventional energy technologies in this sector be studied. For example, solar drying of agricultural crops and fish generally should be cost effective and substantially reduce losses.

11/ Cost of wood in Cotonou: FCFA 10,700/ton x wood consumption of 0.44 tons/person/year x 5.3 persons/household x 0.3 increase in efficiency.

III. HYDROCARBON SUBSECTOR

Resources

3.1 The offshore and onshore sedimentary basin of Benin constitutes an area of approximately 15,000 km^2, of which only some 2,000 km^2 on the continental shelf seem to have a fair hydrocarbon potential. Within the eastern half of the offshore basin, mature rocks, fair to good quality reservoirs, and multiple trapping mechanisms are mapped or inferred. In this area, one oil field has been discovered (Sémé). Exploration and development drilling in this field indicate commercially recoverable reserves of a sweet, 22° API crude oil. Production started in October 1982. In the deeper structure of the Sémé field, gas resources have been identified, and these should be confirmed by additional drilling.

3.2 Petroleum exploration in Benin began in 1964 when Union Oil acquired acreage both onshore and offshore. Later Shell and Pivipoy held leases, but all were relinquished by 1977 because they considered the oil potential as marginal. Both Union and Shell shot several seismic surveys of a detailed and regional character. Union drilled a total of nine wells. Four of these, on two separate accumulations, were classified as discoveries and resulted in the later development of the Sémé oil field.

3.3 In 1979, the Government of Benin decided to develop the Sémé oil field, awarding a service contract to Saga Petroleum Benin a.s., but retaining 100% ownership for the field. The government of Benin put 10% equity and obtained financing for the first development phase from Norwegian commercial banks and export credit agencies guaranteed by the government of Norway. Later on, they completed financing by obtaining a small loan from a British commercial bank. The Phase I program, which cost about US$140 million, included the drilling of four production wells in North Sémé and two in the South Sémé field. One exploratory well drilled on the western portion of Northern Sémé indicated that the field extends in an east-west direction. Several detailed studies (three dimensional seismic) were included to assist in determining the full extension of the field and the degree of faulting. The actual size of the fields' recoverable reserves however, will only be determined once additional delineation wells have been drilled.

3.4 Since the rest of Benin's sedimentary basin was little known, the Government decided to get more data to see if it could promote exploration by foreign companies. With IDA funding under a technical assistance project, 12/ 1500 kms of seismic lines were shot and an evaluation of the sedimentary basin was made. The overall conclusion of the basin evaluation study is that the most prospective trends are located in the eastern half of the offshore basin.

12/ Credit 1207-Ben, approved in 1982.

3.5 Parallel to this study, the petroleum investment framework has been reviewed and amended in order to attract the interest of foreign oil companies. Also, the Government has concluded negotiations to delineate the offshore border with Nigeria and has initiated discussions with Togo on the same subject.

3.6 Natural gas has been discovered in the Sémé field, but the size of the deposit and the chemical composition of the gas have not yet been determined. Two of the wells (SC-1 and S4) drilled in the western and eastern portion of the North Sémé field penetrated a deeper zone of the reservoir and found non-associated natural gas. This well confirmed the existence of gas resources previously identified in the eastern part of the Sémé field and indicates that the reservoir sand is stratigraphically continuous. Under the second development phase (para. 3.7), the gas bearing structure will be tested. Because even relatively small reserves could be of commercial interest in Benin (para. 3.23), the mission suggests that, if the gas tests are positive, the gas resources be evaluated as soon as possible and gas utilization be considered in applications such as: (a) in the field, substituting gas lift for diesel powered subsurface pumps; and (b) building a gas pipeline to bring the gas ashore for use in a power plant and/or to substitute for fuel oil in the Onigbolo cement plant. The Phase II development project includes technical assistance for a detailed gas market study.

3.7 A second phase development project for Sémé is being implemented. 13/ Its basic objective is to fully develop the proven reserves of the Sémé field, including the western extension of the field, and outline optimum development of the field. The project consists principally of drilling five additional wells in the North Sémé field to optimize field production. The project also includes the drilling of two confirmation wells in possible north and northwest extensions of the field. If these wells prove additional reserves, the Phase II project would be followed by a Phase III project to develop them. The reservoir simulation studies predict the existence of natural water influx in the reservoir. If the water influx proves to be insufficient to maintain the pressure of the reservoir, a secondary recovery project by water injection also might be implemented at a later stage if technically and economically feasible. The cost of the Phase II development is estimated at US$45 million.

3.8 Under the present assumptions of oil in place and production schedules, the Sémé oil field would reach peak production in 1986-87 and attain the limit of economic production by 1992. This is a project which has limited financial returns for the Government of Benin but significant

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13/ In mid-1982, the GOB officially requested IDA's assistance for this project, which was approved in June 1984. The European Investment Bank is a co-financier for Phase II. The project is to be implemented over the period from mid-1984 to mid-1986.

secondary effects in terms of employment and training of Beninese, and transfer of technology and management capability.

3.9 It should be stressed that production costs at Sémé are high. It is an offshore field of relatively small size, for which all infrastructure has to be created. Because fixed costs represent a large share of total costs, accelerated production offers the best opportunity to rationalize costs. The economic profitability of Phase I is expected to be considerably less than originally anticipated due to delays in production, lower international oil prices, and some cost overruns. From the financial point of view, the setbacks encountered by the project have led to a rescheduling of Phase I loans. The Bank has calculated, on the basis of conservative reserve estimates, that Phase II, by accelerating production and tapping the recently discovered western extensions of the field, would increase the overall rate of return for the development of the field.

3.10 Under the service contract, Saga Petroleum Benin is the operator for the field and supervision is exercised by Beninese officials appointed to Saga. To improve the supervision during the implementation of Phase II, the Government will establish a project unit with three professionals assisted by specialized expatriate consultants.

Current Petroleum Supply

3.11 SONACOP has the monopoly on importing, domestic marketing and re-exporting of petroleum products. Excepted from this rule are the fuel oil requirements of the Onigbolo clinker plant, which are being supplied directly by Nigeria. In recent years, SONACOP has developed a certain degree of sophistication in its imports policy, carefully balancing term contract and spot purchases in order to minimize costs and insure an adequate level of security of supply. The company has diversified its sources of supply: while in FY79/80, 75% of imports originated in Algeria; by 1983 the purchases from Algeria had decreased to less than 10%. The new most important suppliers are Brazil, the Netherlands and Venezuela. LPG is most economically trucked in from Nigeria but due to the closure of the border in 1984, it had to be imported from Ghana. SONACOP also imports asphalt, lubricants, insecticides, and other specialty products.

3.12 The evolution of imports is shown in Table 3.1. In October 1979, a new agreement was signed between SONACOP and SONIDEP (Niger) whereby the Nigerien corporation directly imports its bulk requirements and pays SONACOP a storage and right-of-way fee.

3.13 SONACOP directly serves the largest industrial consumers, public entities and provincial institutions, and supplies the retail market through a network of distribution stations. About 45% of the total volume was sold to wholesale consumers in 1984, and the area around Cotonou absorbs 52% of all retail sales.

Table 3.1: PETROLEUM PRODUCT MOVEMENT IN BENIN
(thousand metric tons)

Fiscal Year	Nigerian Transit Imports	Benin Re-exports	Internal Market
1977/78	-	84.3	114.4
1978/79	-	90.7	134.1
1979/80	74.3	29.3	111.6
1980/81	78.1	11.0	107.3
1981/82	90.6	17.3	121.6
1983	78.6	24.7	101.0 a/
1984	na	24.2	135.6

a/ Does not include direct imports of Société de Ciments d'Onigbolo which amounted to 14,472 tons in 1983.

na: not available.

Source: SONACOP.

3.14 Storage Capacity. SONACOP has a total storage capacity of 40,000 m^3 in Cotonou, 5,300 m^3 in Bohicon, and 6,400 m^3 in Parakou. Doubling of the storage capacity in Cotonou is under way to provide for transshipments and to increase the security of supply. In the short term, however, the utilization of the additional capacity is limited by SONACOP's lack of working capital. The company has estimated working capital requirements on the order of FCFA 2 billion. With the expansion of its facility in Cotonou to 70,000 m^3, the company will be able to store up to 80 days of supply (about 320,000 m^3 in 1984, including its own consumption, as well as the transit requirements for Niger, Burkina and Mali). The mission suggests that no further investments in liquid oil products be made and that any additional capacity required be leased from STH-Lomé.

Demand Structure

3.15 The demand for petroleum products appears to be distributed as follows: motor gasoline 37%; kerosene (both domestic and jet fuel) 24%; gasoil 32%; fuel oil 7%. Although the demand for petroleum products is very much a function of the level of economic activity in the industrial and transport sector of Benin, actual sales of products by SONACOP have fluctuated strongly over the years because of the purchases consumers make across the border in Nigeria. The level of these illegal imports depends on the perceived price advantages and on the severity of controls at the border. For example, the mission estimates that the actual demand for petroleum products did not grow significantly (Table 3.2) between 1982 and 1984 but SONACOP's sales increased by 24% (Annex 6) because the border was closed during 1984. LPG is the only product for which demand has grown steadily since 1975 (at an average rate of 9% p.a.), although its share in the market is still small (less than 1% of retail sales) and supply is restricted. There is evidence that it is displacing woodfuel in households in urban areas, mainly in Cotonou (86% of all LPG retail sales). Among the wholesale purchasers of oil products, the power company (SBEE) and the railroad system (OCBN) demanded about 20% of wholesale gasoil sales (Annex 2).

3.16 The future demand for petroleum products has been projected as indicated in Table 3.2:

Table 3.2: FUTURE DEMAND FOR PETROLEUM PRODUCTS a/
(in tons of oil equivalent)

	1982	1984	1988	1998
LPG	640	560	1,213	3,444
Gasoline	40,914	45,860	56,972	122,924
Kerosene	17,019	15,520	24,968	49,117
Diesel	42,549	39,600	71,209	150,790
Fuel Oil	6,423	10,340	51,236	85,850
Total	107,545	111,880	205,598	412,125

a/ Does not include jet fuel or marine bunkers.

Source: Mission estimate.

Petroleum Import Costs

3.17 SONACOP's efforts to reduce the imported cost of petroleum products appear to have been successful when compared to: (a) landed costs in Togo (Annex 9); and (b) border prices calculated by the World Bank (Table 3.3). It must be noted that, in the French Franc Zone countries, the reduction in world oil prices has been more than offset by the decline in the value of the French Franc (FF) relative to the US dollar. Thus, between May 1981 and May 1983, the FF depreciated by 27%, while border prices (expressed in US$) decreased at about 18%.

Table 3.3: COMPARISON OF LANDED COSTS IN BENIN
(FCFA/liter)

	SONACOP's Landed Cost a/			World Bank Border Prices b/		
	Premium Gasoline	Kerosene	Gasoil	Premium Gasoline	Kerosene	Gasoil
1979	39.20	38.61	37.22	39.06	40.16	35.83
1980	60.62	66.32	63.68	56.94	62.05	55.71
1981	70.34	72.37	65.83	75.23	76.04	72.00
1982	84.30	85.10	85.50	87.53	88.07	84.35
1985 (1st Q)	95.65	112.74	111.20	105.16	107.85	106.67

a/ Average annual cost, as recorded by SONACOP, except for 1985, where it reflects landed prices for one March shipment.

b/ Average annual border prices, which are calculated each quarter for mid February, May, August, November, based on Platt's Oilgram Price Service and the AFRA INDEX for transport costs in clean medium-sized tankers. Border prices for 1985 actually refer to the fourth quarter of 1984.

Retail Petroleum Prices

3.18 Petroleum prices have traditionally been set above economic costs; only the retail prices of kerosene are subsidized. Prices for gasoline, kerosene and gas oil are regulated by the Government and set for a fixed period of time. Fuel oil and LPG prices are set by SONACOP and change every time the landed cost warrants it. Retail prices have not been changed since January 1982. In view of the continued deterioration of the rate of the French Franc relative to the US dollar (68% between January 1982 and March 1985), landed costs had risen above retail prices in late 1984. The government compensates SONACOP for the difference, from the financial resources accumulated in the compensation fund. The mission supports SONACOP's efforts to elicit a price adjustment.

Table 3.4: 1983 PETROLEUM PRODUCT PRICES
(in FCFA/lt)

	Gasoline				
	Premium	Regular	Kerosene	Gasoil	Fuel Oil
Retail Price	165.0	162.0	100.0	132.0	114.7
Landed Cost	84.3	80.6	85.1	85.5	73.6
Economic Cost	128.0	126.0	112.0	110.0	103.1
Economic Cost MFCFA/Toe	179.3	182.7	145.0	131.7	104.5

Source: Annex 9.

3.19 The relative structure of petroleum prices has not yet caused significant market distortions in Benin, although the differential between gasoline and diesel is significant. The retail price structure will have to be aligned to that of the international market in the longer term.

3.20 The phenomenon of illegal imports of petroleum products (gasoline, kerosene, diesel) can be explained by the differences in retail prices for the various neighboring countries and by variations in the exchange rate. The traffic has become an organized business. The total closure of the border in 1984 has been effective in reducing the gasoline traffic, but not so the kerosene traffic, which extends to all Benin. Retail prices for the neighboring countries are shown in Table 3.5. The mission suggests that a regional pricing policy be developed in the longer term to avoid distortions. Coordination would become easier if Nigeria were to raise its internal prices toward opportunity costs.

Table 3.5: PETROLEUM PRODUCTS: REGIONAL COMPARISON OF RETAIL PRICES, 1983

	FCFA/lt			
	Gasolines			
	Premium	Regular	Kerosene	Gas Oil
Benin	165.	162.	100.	132.
Togo	205.	200.	135.	180.
Burkina	285.	272.	190.	240.
Niger	240.	225.	135.	170.
Ghana a/	140.	116.	n.a.	88.
Nigeria	104.	88.	54.	68.

a/ Prices being increased in line with IMF agreement.

Strategies for Reducing the Cost of Oil Imports

3.21 Benin does not have a refinery and its Government is fully aware that its market is too small and its own petroleum production too short-lived to warrant one. Nevertheless, in recent years the Government has studied several proposals to build a refinery in Benin, some of which were oriented towards exporting bulk and speciality products (lube oils, asphalt, petrochemical feedstocks, and nitrogenous fertilizers).

3.22 On the other hand, SONACOP has followed with keen interest the discussions on regional refining and oil procurement issues that have been held since 1981 in several West African economic forums. The adjustment of the international refining industry to the changes in the world petroleum situation has severely hurt existing refineries in the region. In 1982, their crude processing capacity was on the order of 29 million tons, while aggregate demand for the region is about 14 million tons per year (see Annexes 11 and 12). The mission strongly suggests that the countries of the region continue to seek a political agreement to group their oil purchases and achieve lower costs. As a first step, ECOWAS has requested technical assistance from the Canadian Development Agency (CIDA) to study the present petroleum supply schemes in the region and to recommend optimum procurement options. The mission wants to point out that the Bank has completed energy assessment studies in many of the countries of the region, so sufficient information on an aggregate level is available to study ways to improve the terms of petroleum imports into the region.

Oil Substitution Opportunities

3.23 Domestic Natural Gas. Consideration should be given to the use of Sémé gas in the industrial, power and transport sectors. It would be premature to engage in a detailed market study, given the fact that the gas resource base is not known. However, the mission considers that developing the field and constructing an offshore pipeline could be economically justified even if recoverable resources are relatively small (1 billion cubic meters). The mission's preliminary analysis focused on two potential bulk markets: the Onigbolo clinker plant, located about 80 km from Sémé (onshore), which could absorb the equivalent of 100-130 thousand m^3/day of gas by 1988; and a gas turbine (or combined cycle unit) for power generation to supply incremental requirements of the interconnected electric system (Togo-Benin). Secondary loads on the gas pipeline, such as gas for other industrial consumers (about 14,000 toe into Cotonou-Porto Novo area by 1988) and compressed gas for transport (estimated at about 9,000 toe, equal to 10% of gasoline and diesel oil for transport sold in the coastal area) could substantially improve the economic returns on the gas development. Consideration also could be given to extend the pipeline towards Togo, where a significant industrial market already exists. The analysis indicates that the following net returns on the integrated gas projects could be obtained:

Bulk gas uses:	Net Return on Gas a/
	(USc/m^3)
Power Generation - (Case A - Table 3.6)	4.6
Onigbolo-Clinker	1.7

a/ Does not include a depletion allowance element.

3.24 The mission evaluated the use of gas in a power plant in the binational CEB system. The analysis is based on the assumption that total recoverable gas resources are in Case A about 3 billion m^3 and about 1 billion m^3 in Case B. The calculations (Table 3.6) indicate that, given the considerable investment in the gas field development, 14/ only a relatively larger power plant (Case A: 120 MW operating at about 3,000 hours/year) could compare favorably with the fuel oil cost in the new power plant of Cotonou (FCFA 18.3/kWh for gas based power compared to FCFA 23.1/kWh in a fuel oil unit). The evaluation shows that a 60 MW power plant (Case B) would barely be an economic usage for the natural gas.

3.25 The net return on gas from its use at the Onigbolo clinker plant is obtained by comparing the unit supply cost of gas (USc14.8/m^3) with a fuel oil cost of US$180/ton (USc 16.5 per cubic meter of gas equivalent).

14/ Estimated at US$20 million, including production wells (15 million), pipeline to onshore Sémé (5 million), and gas treating facility.

Table 3.6: HYPOTHETICAL ECONOMIC ANALYSIS OF SEME GAS USE IN POWER GENERATION AND ONIGBOLO CLINKER

	Power Generation Case A	Power Generation Case B	Onigbolo Case A
Assumptions			
Annual Gas Availability ($10^6 m^3$/year) a/	100	50	36.5
Duration of Supply (years)	25	20	25
Power Generation: (34% efficiency)			
Energy (GWh/year) b/	360	180	-
Installed Capacity (MW)	120	60	-
Investment Cost (US$/million-1982 prices)	99	60	30
Field Development and Pipeline	20	20	20
Power Plant (US$600/kW)	72	36	-
Others	7	4	-
Onshore Pipeline to Onigbolo			10
Annual Costs (in US$ thousands)	17,830	11,248	5,405
Capital Charges (10%)	10,900	7,048	3,305
Operating Costs (7% of investment)	6,930	4,200	2,100
Unit Cost: US$/kWh	0.050	0.062	
FCFA/kWh	18.33	23.12	
US¢/m^3 c/			14.8
Net Return on Gas US¢/m^3 c/	4.6	0.0	1.7

a/ Basic data extracted from the Gibbs/Tractionel Report C on the Power Master Plan.

b/ The Saga estimates on potential gas resources are preliminary. Calculated assuming a net calorific value of gas of 9,000 kcal/Nm^3. Power operations during 3000 hours a year.

c/

	Case A	Case B
Fuel cost in new Cotonou plant	FCFA 23.1/kWh	23.1/kWh
Total cost for gas chain	FCFA 18.3/kWh	23.1/kWh
Difference	FCFA 4.8/kWh	0.0/kWh

Calorific content gas/Calories used per kWh
9000 kcal/m^3/2529 kcal/kWh: 3.559 kWh/m^3
Net return on gas FCFA 17.0/m^3 = US¢4.6/m^3

Nigerian/Natural Gas and LPG

3.26 Nigeria has a surplus production of liquified petroleum gas (LPG) and the country is actively promoting substitution of petroleum products by LPG in light of the increased production expected from refineries and natural gas treatment plants. 15/ SONACOP has been able to purchase LPG at the Nigerian refineries at economic border prices (US$220-230/ton) and has promoted LPG sales to households and commercial establishments in the southern urban areas. The mission's analysis of Benin's forestry balance suggests that fuelwood consumption can be met at competitive prices. Therefore, replacing a locally produced fuel with an imported fuel eliminates an important source of revenue for the population and creates an unnecessary drain on foreign exchange. The household energy needs of Cotonou and Porto Novo which are met by fuelwood and charcoal (4,300 toe in terms of useful energy), if replaced by petroleum products, would require annual foreign exchange outlays of at least US$3.1 million if kerosene is the substitute fuel, or US$2.4 million if Nigerian LPG is imported. On the other hand, LPG substitution for gasoline and diesel merits a more detailed analysis. Assuming that LPG is priced in Nigeria at the economic opportunity cost, the product could be made available to the final consumer at a price range between US$320 (for bulk industrial consumers) and US$420/ton (at the retail level) 16/ or US$305 to US$400/toe. This compares with an estimated supply cost of US$485-495/toe for gasoline, US$356/toe for gas oil and US$390/toe for kerosene.

3.27 LPG is being used successfully as a motor fuel in several countries, including Italy, the Netherlands, Japan, the United States, Bolivia, etc. The LPG fuel storage and supply system is made up of four simple components: a high pressure storage tank, a fuel lock, a vaporizer converter/regulator and a carburator. Several vehicle manufacturers now offer an LPG option for about US$800-900 for passenger vehicles, and about US$1,300 for medium-size trucks and buses. Retrofitting gasoline-powered vehicles is also possible, if safety regulations can be enforced. Automobile conversion kits are available from European manufacturers at about US$400-500. At the distribution level, LPG refueling systems could be added easily to existing gasoline and diesel fueling stations. The equipment is simple and commercially available, requiring only a bulk storage tank and a dispensing and metering station. For a station capable of serving 400 vehicles (a capacity equivalent to 1,000 lts/day), the investment in equipment is about US$15,000. Assuming an economic supply cost for LPG at the service station of US$320/ton (FCFA 82.5/lt of

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15/ The LPG production capacity in the Warri, Port Harcourt and Kaduna refineries is at present 186,000 tons per annum, which will increase to about 340,000 tons once the Kaduna refinery becomes fully operational. In addition, about 300,000 tons of propane and 200,000 tons of butane could become available in the future at the planned extraction plant attached to the proposed Warri-Lagos gas pipeline project, based on the assumption of an average throughput of 500 million CF/D of natural gas.

16/ Based on the following cost assumptions: US$230/ton ex-refinery price, US$50/ton transport cost; US$80/ton bottling cost; US$20/ton cylinder; and US$40/ton distribution margin.

gasoline equivalent) and an economic cost for gasoline of FCFA 128/lt, the consumer could recover the investment of US$1,000 in the LPG option equipment after consuming 10,400 liters of gasoline equivalent, which is about three years average consumption.

3.28 If the exploitation of Benin's gas resources proved not to be economic, consideration could be given to importing natural gas. Nigeria is in the process of developing an internal transport infrastructure for natural gas, which opens up the possibility of building a pipeline from Lagos to Cotonou and Lome. The feasibility of such a pipeline project will depend on the price of gas and the size of the market that could be converted to natural gas. The export price for gas is likely to be somewhere between the economic supply cost at Lagos (estimated at about US$2.20/MCF) and the opportunity cost defined in terms of the value of a given grade of fuel oil (assumed at the equivalent of US$3.50-4.00 per 1000 cu.ft.). The mission estimated that imported gas is competitive with imported coal when gas is priced at the lower end of the scale and the throughput is at least equivalent to 100,000 toe. Only the large industrial consumers in Togo or the electric sector could provide the base load necessary to make the gas pipeline project feasible. Assuming that natural gas is priced in Lagos at US$2.20/MCF (US$8.63/Gcal) and that the pipeline would only serve OTP and CIMAO, the landed cost of Nigerian gas in Lome would be around US$13.35/Gcal (US$3.40/MCF), 17/ which compares with a landed cost for imported coal of about US$13.4/Gcal (US$90/ton). Evidently, the unit transport cost decreases with additional throughput. On the other hand, the thermal generation requirements of the interconnected electric system of Togo and Benin could increase from about 130 GWh in 1988 to 960 GWh in 1998. 18/ The addition of this load to the gas pipeline throughput would lower the unit

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17/ Landed cost of gas includes the following elements:

		US$/MCF
(a)	Production and transmission costs, including producers' margin and depletion allowance	2.20
(b)	Transmission cost Lagos-Cotonou-Lomé*	1.20-0.35
	Landed cost:	3.40-2.55

* The transmission cost to Benin and Togo was estimated assuming an investment cost of US$30 million for a 12" pipeline, over more than 200 kms, with two compression stations. Annual costs were calculated assuming 10% opportunity cost of capital, economic life of 25 years, and operating costs equal to 5% of investment.

18/ The electrical load of the interconnected system is estimated at 809 GWh in 1988 and 1,638 GWh in 1998. Thermal loads were calculated assuming deliveries from VRA equal to contract levels (528 GWh) and generation from the Nangbeto hydropower plant (150 GWh). Gas requirements for power were estimated assuming a factor of 3,559 KWh/m^3 of natural gas.

transport cost from US$42.45/1,000 m^3 (USS$1.20/MCF) in the case when only the two large industrial consumers are served, to US$32.04/1000 m^3 (US$0.91/MCF) if the 1988 thermal electricity load is included, and to US$12.56/1,000 m^3 (US$0.36/MCF) when the 1998 load is included. In the event that the WASPI electric interconnection is built, the pipeline's throughput would be lower than estimated in the highest case. But the cost differential would be offset by increased security of supply in the integrated energy systems of the countries of the region. The mission recommends that detailed market and cost studies be made to evaluate the possible load buildup in the alternate gas pipelines (from Sémé or from Lagos) and the costs of secondary transmission and distribution once the gas resources at Sémé have been fully evaluated and the longer term economic viability of the large industrial plants of Togo and Benin has been confirmed.

IV. ELECTRIC POWER

4.1 The Bank has recently prepared an Electric Power Subsector Memorandum and consultants have completed studies 19/ addressing long-term planning issues and short term technical assistance requirements of the public utilities of Togo and Benin. This chapter summarizes the conclusions of the studies and highlights areas of uncertainty which merit further analysis.

Role of Electricity

4.2 The development of electricity demand in Benin has been remarkably steady, with annual growth averaging 13.4% in the 1960s and 1970s. This rate accelerated in recent years as a result of a more social oriented policy, aimed at extending service to residential customers. Also in FY81/82, the large clinker plant in Onigbolo was commissioned, which at full output will require about 60 GWh per year. In FY81/82, about 60% of electric consumption was production related, while 38% went to the household sector (Table 4.1). By mid-1982 the national utility reported 31,000 residential and 4,400 commercial customers. At a ratio of 5.2 persons per household, this would indicate that 161,000 persons or about 21% of the urban population has access to electricity. The actual percentage is probably higher because most connections serve several households.

Table 4.1: ELECTRICITY USE BY SECTOR
(for FY81/82)

	Sales	
	(GWh)	(%)
Large Commerce and Industries (includes Onigbolo)	64	46
Small Commerce and Industry	19	14
Residential	52	38
Street Lighting	3	2
Total	138	100

Source: Mission estimates from SBEE reports.

4.3 The mission suggests a moderate, selective electrification policy in the medium term, providing access to new areas where increased

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19/ "Etude d'inventaire des ressources hydroélectriques potentielles du Togo et du Benin et plan directeur de développement de la production et du transport," Sir Alexander Gibb & Partners, Tractionel S.A., 1983-84.

productivity can be achieved and improving the reliability of the service in areas already served. The projects to simultaneously provide potable water, sewerage and electricity in numerous inland towns and villages should be carefully reviewed, taking into account that energy needs for water pumping generally can be provided more economically by direct use of liquid fuels. On the other hand, the rapid service expansion since 1976 has resulted in a sharp increase in losses (from 10% in the 1960s to 17-21% in the years 1976-1983) and reduced reliability of supply in the inland centers. Therefore, the mission suggests that the overall efficiency of the power sector be emphasized by streamlining the existing network and by assisting consumers in making good use of electricity. The Bank estimates future average growth of electric demand at about 8.5% per year on the basis of the economic guidelines which seek to consolidate the modern sector and to develop agriculture. It is expected that the demand will grow at a considerably higher rate in inland centers than in the coastal area.

Characteristics of Benin's Electric System

4.4 It is important to underline the physical and institutional characteristics of Benin's electric system. Taking into account these characteristics, the issues treated in this chapter consider separately the coastal system and the isolated centers, and within the former, make a distinction between generation and transmission functions and the distribution function.

(a) There are two public utilities active in the sector: (i) the national SBEE, formed in 1973 to provide electric power generation, transmission and distribution, as well as water supply and waste water disposal, throughout the territory of the republic; and (ii) the binational CEB, established under the 1968 treaty between Benin and Togo, with a dual mandate as a public utility for the two countries and as a directorate with the authority to regulate many aspects of the electric utility industry. CEB has a monopoly on the generation and transmission of energy originating from all installations built after the date of the agreement. Excluded from this monopoly are small plants (less than 100 kVA), captive plants, and distribution. The treaty is flexible to the extent that in certain cases CEB can forego the exercise of its monopoly, as well as accept responsibility for operating installations belonging to the national power entities, including distribution facilities. SBEE's statutes make no reference to the mandate conferred on CEB. In the past, CEB has only partially fulfilled its mandate, becoming the bulk supplier of energy to Togo and Benin, using imports from Ghana as its only source. The national utilities continued maintaining thermal back-up capacity in the coastal regions and looked after their own generating capacity on the inland local centers. This practical division of tasks is likely to change. Until Nangbeto is commissioned, CEB will need increasing quantities of thermal energy from SBEE and CEET (Togo) plants. Central load dispatch and associated arrangements for buying and selling power will bring about the integration of all production facilities of the three utilities in the interconnected system, and the cutback of imports from Ghana will accelerate this process. The consolidation of CEB's role as the entity responsible for electric energy supply in Benin and Togo is considered by the Bank as a key element for the development of the power systems of these two countries.

(b) The southern region absorbs more than 90% of the energy sold in Benin. This system services Cotonou, Porto Novo, the small towns of Lokossa, Ouidah and Abomey-Calavi, and Onigbolo. Since 1973, CEB has supplied most of this market's requirements from imported sources. A double circuit 161-kV, 465-km long transmission line linking Akosombo in Ghana, Lomé and Cotonou, gives access to low cost, hydro-based electricity supplies from VRA. CEB sells these supplies to SBEE for distribution. The full implementation of CEB's mandate implies that the coastal area of the Benin power market will be supplied from CEB-owned or managed generation sources. SBEE will be responsible for streamlining and expanding the distribution network in this region.

Table 4.2: BENIN: ELECTRIC LOAD PROJECTIONS

	FY81/82		1988		1998	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
Coastal System	151	92	258	92	595	88
Inland Centers	14	8	23	8	84	12
Total	165	100	281	100	679	100

Source: Annex 14.

(c) Inland, seven smaller urban centers in the densely populated southern provinces have been electrified. In the north, only four towns have access to public electricity: Natitingou and Djougou in the provinces of Atacora, and Parakou and Kandi in the province of Bourgou. Because of the large differential in generation costs between the interconnected system and the isolated centers (Table 4.3), there is considerable interest in developing national transport networks. However, the large distances and low load densities limit the possibilities for interconnection. The Master Plan suggests that the Bohicon-Abomey load center can be economically connected to the coastal system. The cost differential between coastal and inland centers is even larger when the cost of imported supplies is factored into the average cost of the coastal system.

Table 4.3: MARGINAL GENERATION COSTS
(US$/kWh, 1983 prices)

	Fixed Charges	Fuel Cost	Total Costs
High Speed Diesels			
Inland Centers (1000 kW) a/	0.075	0.120	0.195
Medium Speed Diesels			
Inland Centers (1000-2000 kW) b/	0.056	0.097	0.153
Low Speed Diesels			
Atlantic Region (5000 kW) c/	0.049	0.065	0.114

a/ Fixed charges estimated on the basis of an investment cost of US$700/kW, economic life of 10 years, discount rate 10%, and assuming a 50% reserve capacity; fixed operating costs 5.5% of investment; load factor 3,000 hours/year. Fuel costs estimated at a cost for gasoil of US$360/ton and a consumption rate of 330gr/kWh.

b/ Fixed charges estimated on the basis of an investment cost of US$875/kW, economic life 15 years, discount rate 10%, and assuming a 50% reserve capacity; fixed operating costs 4.5% of investment; load factor 4,000 hrs/year. Fuel costs estimated at a cost for gasoil of US$360/ton and a consumption rate of 270 gr/kWh.

c/ Fixed charges estimated on the basis of an investment cost of US$1000/kW, economic life of 20 years, discount rate 10%, and assuming a 30% reserve capacity. Fixed operating costs at 3% of investment. Load factor 4,000 hrs/year. Fuel costs estimated at a cost for heavy fuel oil of US$274/ton, and a consumption rate of 240 gr/kWh.

Source: Bank's estimate.

Interconnected Coastal System

Benin Coastal System

4.5 Demand in Benin. Benin's steady load growth during the past twenty years can be at least partly attributed to an erosion of real electricity prices. As this is unlikely to occur in the future, the price elasticity will tend to result in lower growth, and income levels are unlikely to have much effect in the opposite direction. The Bank's load projections are intended to be used as a scenario for discussing the development issues and are based on the assumptions presented in Table 4.4.

Table 4.4: ASSUMPTIONS FOR LOAD PROJECTION

	1982-85	1986-90	1991-2000
Growth of Sales (%)			
Low Voltage	8	9	8
Medium Voltage	7	10	9
Losses	17	16	14
Load Factors			
Distribution	0.65	0.65	0.65
Onigbolo Cement a/	0.66	0.66	0.66
Lokossa Textile a/	0.60	0.60	0.60

Source: Power Sector Memorandum, Table 3.1 - 1985.

Note: Assumptions about the production levels of these two industrial plants are presented in Chapter II.

4.6 The load projections derived from the foregoing assumptions are summarized in Table 4.5. The implied growth rate is about 9% per year to 1998.

Table 4.5: BENIN: ELECTRIC NET DEMAND PROJECTIONS IN COASTAL SYSTEM

	1981/82		1988		1998	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
Sales						
Low Voltage Consumers	67	53	115	52	254	49
Medium Voltage Consumers	45	36	76	34	192	37
Onigbolo Cement	14	11	30	14	70	13
Lokossa Textile	-	-	-		6	1
Total Sales	126	100	221	100	522	100
Losses a/	31		37		97	
Total Requirements (GWh)	157		258		619	
Peak Demand (MW)	28		51		122	

a/ Distribution and Transmission

Source: Annex 14.

4.7 Medium Term Supply/Demand Balance. Until the end of 1983, most of the electricity requirements of Benin's coastal system were supplied by CEB and purchased from Ghana under a contract that guarantees Benin maximum delivery of 25 MW. This delivery corresponds to 243 GWh at a 90% availability factor. Thermal generation was minimal because energy imports exceeded demand. On December 1, 1983, VRA reduced deliveries by 50% due to power shortages in Ghana; the thermal generation in Benin and Togo are making up for the shortfall. The higher generation cost has forced SBEE to substantially increase its tariff. SBEE's capacity connected to the coastal system is 15.1 MW, of which two 4.2 MW plants were added between 1977 and 1979 even though the treaty provision allows CEB a monopoly on building new generation facilities. An additional two 8-MW diesel units were scheduled to be commissioned in late 1984 in Cotonou to increase energy security.

4.8 Although CEB is responsible for planning the expansion of generation and transmission facilities in Benin, and future supplies of most of the Benin power market will result from binational cooperation, it is interesting to note what the energy situation would look like from a strictly Beninese point of view. Under the assumption that imported supplies from Ghana will be restored to contract levels, the existing thermal capacity (31 MW), added to the country's share in the Nangbeto hydro plant (22.5 MW), would barely be sufficient to meet domestic demand until the end of the decade. Benin's hydro resources on the Ouémé River are 700-850 GWh, to which could be added 80 GWh from Adjarala on the Mono River (50% of the output allocated to Benin) and 70 GWh from other watersheds. Hence, the total developable hydro potential is about 850-1000 GWh, compared to a projected national requirement of about 800 GWh by the end of the century. The apparent balance of load and resources is only valid if hydro output fits under the load curve. The hydrologic regime of the rivers and the limited storage possibilities suggest that hydraulic regulations alone cannot produce much dependable power. Electrical interconnection, first by use of the existing 161 kV lines to Akosombo, and later by interchanges over the West Africa Power Systems Interconnection (WAPSI), will be a less expensive means of firming up the available hydro energy.

4.9 Developing the small potential of a few sites in the northern provinces would be expensive, and even by the year 2000 the low load density would make it difficult to absorb the output quickly. The only exception is the Dyodyonga project on the Mekrou River, which could provide readily usable power to Niger's Valley System at an attractive cost. The sizeable reservoir would have to be developed as a joint enterprise of the two countries and allow Benin to start electrification in a remote area.

4.10 In addition to the hydro potential, Benin has discovered non-associated natural gas in Sémé. Further drilling is required to confirm if this gas can be economically recovered, and a market study will be necessary to assess whether power generation is the most economic use for this gas (See paras. 3.6 and 3.23).

Binational Coastal System (CEB)

4.11 Demand Projections. The projections of the loads in Togo and Benin at the level of the CEB substations are summarized in Annex 16. The load components are the two national distribution systems and five industrial enterprises (CIMAO, OTP, SNS, Onigbolo Cement, and Lokossa textile). Total energy demand on the interconnected system is converted to CEB generation requirements, assuming 4% high voltage transmission losses. Estimated system peak loads are based on a diversity factor that became significant in 1979-1981, when CIMAO, OTP and SNS were connected. Based on 1981/82 records, the estimated coincidence factor is 0.87, a figure that is retained through 1990. Thereafter, the distribution peaks in the projection become proportionately more important and the coincidence factor is assumed to increase gradually to 0.93. The projected loads for 1998 are about 300 MW and 1,650 GWh, corresponding to an average annual growth rate of 8% over 15 years. This projection appears optimistic in light of the revised 1985 economic outlook. The CIMAO clinker plant was closed in 1984, and it is not certain whether economic operations can be resumed in the future. Other industrial rationalization measures may also lead to slower growth of power demand.

4.12 Medium Term Supply/Demand Balances. Since 1973, CEB is the main supplier of electric power in the binational coastal system. It owns the transmission lines Akosombo-Lomé-Cotonou-Sakete (double circuit, 161 kV), Sakete-Onigbolo (single circuit, 161 kV), and four single circuit lines (63 kV) from Mome-Hagou to OTP, Anfoin, Tabligbo and Lokossa. CEB's customers are the national distribution companies CEET (Togo) and SBEE (Benin), and the regional cement plant CIMAO. At present, its only source of electric power is energy imported from Ghana. Under a contract renewed in 1982 and extended to 1997, the Volta River Authority (VRA) guarantees a maximum capacity of 67 MW (about 528 GWh at 90% availability) to Togo and Benin. VRA indicated in 1982 that it was unwilling to make new formal commitments that might jeopardize Ghana's future needs, and on the other hand, the existing transmission line imposes a physical constraint to increasing the flow of imported energy estimated at beyond 600 GWh per year.

4.13 The actual supply from VRA to CEB was about 89 MW in 1982 -- well above the contractual limit of 67 MW and sufficient at that time to meet the combined loads of the coastal regions of Togo and Benin without need for local generation, except in emergencies. Since then, power shortages in Ghana have resulted in a 50% reduction of VRA deliveries as of December 1, 1983, and thermal generation in both Togo and Benin are making up the shortfall. As illustrated in Table 4.6, there is enough thermal spare capacity in the system to meet peak demand until the early 1990s. The share of thermal generation may be significantly lower than indicated if electricity demand grows at a lower rate than projected.

4.14 CEB's investment program to 1988 covers the construction of the Nangbeto hydro power station, to be commissioned in 1988, the associated transmission and substation facilities, and a load dispatch center which will permit coordinated least cost operation of the dispersed generating plants in the interconnected system. These investment requirements, estimated at US$106 million (in 1982 dollars), will be financed by IDA and co-financing resources. Half of these investments have been allocated to Benin in the Investment Summary (Table 6.1).

Table 4.6: TOGO-BENIN: INTERCONNECTED SYSTEM SUPPLY/DEMAND BALANCE

	1984	1985	1986	1987	1988
			(MW)		
Generation Requirements					
Togo	91	96	102	108	114
Benin	36	39	43	47	51
Total Coincident Peak	110	118	126	135	144
			(MW)		
Generation Capacity					
VRA (Ghana)	33	33	33	33-67	33-67
CEET-CTL (Togo)	100	100	100	100	100
SBEE (Benin)	32	32	32	32	32
Nangbeto	-	-	-	-	45
Total	165	165	165	165-199	210-244
Energy Requirements			(GWh)		
Total	601	648	698	751	809
From VRA	260	260	260	260	260-528
From Nangbeto	-	-	-	-	150
Thermal Generation	341	388	438	491	399-131

Source: Annex 16.

4.15 Long-Term Planning. Power planning is subject to three major uncertainties: the duration of Ghana's import curtailment, the results of continued hydro studies, and the progress on WAPSI. The Master Plan prepared by consultants is based on the hydro pre-feasibility studies available at the time and an assumed import ceiling of 600 GWh per year. Integration of storage operations in Ghana with unregulated production in Togo/Benin was not considered. The report on the Master Plan presents two investment sequences, one for constant fuel prices (in real terms) and one for rising prices. Both sequences start with the addition in 1991 of a steam component (28 MW) to the two existing (CTL Lomé) gas turbines, thus completing the combined-cycle plant. Under the constant-price scenario, Adjarala, to be commissioned in 1995, is the only hydro plant in the sequence. The second sequence shows Adjarala advanced to 1994 and three more hydro plants (Tetetou, Ketou and Olougbe) between 1997 and 2002. Neither sequence is sufficient to determine what to build after Nangbeto.

4.16 The main power resource within Togo and Benin consists of the hydro potential of Mono and Ouémé Rivers (Annex 13). The resource inventory of both countries and later pre-feasibility studies 20/ have identified two sites on the Mono River downstream of Nangbeto and four sites on the Ouémé River. The total potential, including Nangbeto's output of about 150 GWh, varies from 1,100 to 1,300 GWh, depending on how the Ouémé sites are developed. This resource base, which is still subject to confirmation by further study, compares to a generation requirement of 1,700 GWh by 1998.

4.17 A major constraint to the development of the hydro potential is the attainable degree of streamflow regulation. Virtually all natural runoff of the rivers in Benin and Togo occurs during four months of the year; this type of hydrologic regime calls for large storage volumes to regulate the flow. Nangbeto, one of the better storage sites, can accumulate 55% of the average annual inflow to provide a minimum regulated flow (net of evaporation losses) of only 35% of the average flow. The situation will improve somewhat in the Ouémé River Basin once several sites are developed in cascade, but in the first stage the regulation problem will be the same as on the Mono River. Hence a large part of the hydro energy potential of Togo and Benin is secondary energy that would displace fuel at existing diesel plants. However, the 161 kV interconnection with Ghana could be used, even after termination of the present CEB-VRA contract, to firm up this secondary energy by storing excess rainy season output in the Akosombo reservoir and supporting the CEB system in the dry season with a return flow of this energy. Eventually, transmission capacity may limit this possibility, but by that time WAPSI would have removed the bottleneck. Therefore, even the development of indigenous hydropower would require simultaneous support from the interconnection project.

4.18 One possible other resource is natural gas. If the Sémé deposit proves to be commercial, a detailed market study will have to be made to ascertain the markets of highest economic return to which this gas can be allocated.

4.19 Other Expansion Options. The imbalance of long term loads and resources suggests that Togo and Benin may be forced to import considerable volumes of energy to complement indigenous supplies. The most promising way to alleviate this problem is to continue expansion of regional cooperation. For a number of years CEB has promoted the study of an interconnection linking the VRA system in Ghana, the CEB system, and the NEPA system in Nigeria. Since Ivory Coast and Ghana completed a 220-kV tie line in 1983, the interconnection would link five countries. A feasibility study sponsored by the African Development Bank and coordinated by CEB was completed in mid-1984; engineering studies are continuing. The interest in the project arises from the diversity of resources in the region: Ghana and Ivory Coast may have temporary hydro energy surpluses and seasonal excess hydro capacity. Nigeria is headed for large scale development of gas-fired thermal plant for energy supply,

20/ Financed under IDA Credits 1189-BEN and 1190-TO.

which will permit off-peak energy generation at low marginal cost that could be traded for capacity imports at other times. The CEB system is strategically well placed to absorb part of the transfers within an interconnected system.

4.20 It must be realistically expected that engineering studies, financing and international agreements on WAPSI will take time. Furthermore, implementation is not likely until reservoir storage in Akosombo (Ghana) and Kossou (Ivory Coast) is restored to normal operating levels, which will require careful multi-year planning of the power operations in Ghana and Ivory Coast. Finally, the possibility of building thermal plant in the Ivory Coast (using recently discovered offshore natural gas) could change some of the original concepts of the interconnection benefits.

4.21 The addition of the steam component to the combined cycle plant at CTL appears attractive because the capital cost is low ($17.4 million or $670/kW) and per kWh fuel costs of the combined cycle plant are about the same as for heavy diesels, for plant capacity factors over 50%. These advantages must be weighed against:

(a) the technological risk of having a combined cycle plant running on residual fuel, for which there are few precedents in developing countries;

(b) operational problems in the early 1990s (especially in the months of high runoff) when VRA imports plus Nangbeto output leave little room under the load curve for operating the combined cycle plant at the high capacity factors required for fuel economy; and

(c) the combined cycle plant does nothing to lessen dependence on imported petroleum fuels.

4.22 Another possible alternative is the construction of coal-based thermal capacity in Togo, especially in the event the clinker plant CIMAO converts to imported coal. A preliminary comparison of these alternatives is provided in Table 4.7.

Binational Strategy

4.23 The binational strategy should be to prepare sufficient projects at feasibility stage to have an alternative ready if the West African interconnection is delayed. If interconnection is realized earlier, any projects that would be more expensive than newly contracted imports could be postponed. Implementation of this strategy requires a continuation of hydro resource investigations comprising:

(a) improvement of topographic and hydrometric data base; 22/

(b) study of optimum development of the Mono and Ouémé Rivers in cascade; and

(c) a feasibility study of the optimum site on the lower Mono River.

Table 4.7: BENIN-TOGO: COST COMPARISON OF POWER GENERATION ALTERNATIVES FOR LONG-TERM EXPANSION PROGRAM

	Size	Energy	Fixed Cost a/		Fuel Cost	Total
	(MW)	(GWh/yr)	(US$/kW)	(US¢/kW)	(US¢/kWh)	(US¢/kWh)
Generation Alternatives b/						
Hydro - Mono River c/	20	80	2,000	5.0	-	5.0
CTL-Combined Cycle d/	28.7	78	610	4.1	-	4.1
Steam Unit - Imported Coal e/	10	100	1,200	4.5	3.6	8.1
Slow Speed Diesel f/	10	100	1,200	4.5	4.5	9.0

a/ Includes capital cost calculated at 10% opportunity cost for capital, and operational costs estimated at 7% of investment except in hydro.

b/ Gas-based thermal generation should also be considered among the long term generation options. Cost estimates for such alternatives require, however, more definition of gas availability and pricing.

c/ Based on estimated costs of the Adjarala site, economic life 50 years.

d/ Assuming operation during 3000 hr/yr - economic life of 15 years. Fuel costs in combined cycle are zero if gas turbine output is required to meet the load.

e/ Estimated at an economic life of 20 years. Operation at 5000 hr/yr. Cost of coal estimated at US$90/ton. Thermal efficiency of plant 32%. The feasibility study for the conversion of CIMAO to coal indicated that the mineral port of Lome can handle coal ships of up to 35,000 tons and has a discharging facility in place capable of handling 4600 tons/day.

f/ Estimated with an economic life of 20 years, a thermal efficiency of 40%, and a price of US$200/ton for heavy fuel oil.

Source: Mission estimates.

Inland Centers

4.24 SBEE has performed reasonably well in planning the development of the isolated stations in terms of matching demand requirements and generating equipment. It is recommended that in equipping the new

22/ The proposed IDA credits for Nangbeto construction include financing for these power studies.

centers scheduled for construction, homongeneous equipment from one manufacturer be selected to reduce the initial investment cost, minimize spare part inventory requirements, and ensure adequate training of local maintenance personnel. Present maintenance practices seem to be satisfactory and well organized: the little repair work needed on generating units is done by local personnel and the larger jobs are performed as scheduled by the equipment manufacturers on site or in Cotonou. The average availability of the units is estimated at 90% and the out-of-service time rarely exceeds six weeks.

4.25 In the distribution networks, voltage drops and losses seem to be a problem. Older systems were built at 15 kV, while newer ones were built at 20 kV. Uniform design criteria should be adopted and in existing systems the primary distribution lines should be extended and additional transformers installed.

4.26 Future power generation requirements are projected to grow at about 14% in the longer established load centers (Parakou, Abomey, Bohicon) and at about 20% p.a. in the newly electrified towns. Because continued reliance on diesel based generation would represent growing foreign exchange costs, several cost reducing options are being sought.

(a) Abomey-Bohicon

The Master Plan found that interconnection with the southern system is already economic. Therefore, SBEE is considering the possibility of building a 63kV line from Lokossa. The mission also suggests that consideration be given to the use of agro-industrial residues available in this area for steam and power generation (paras. 5.25-27).

(b) Parakou

This is the most important city of north-central Benin. A new station with a generating capacity of about 3 MW was built in 1982 and has the capability of housing 3 x 2,500 kVA additional groups. The present peak demand of the system is on the order of 1.5 MW. With the 1984 connection of the brewery, the peak has increased to 2.3 MW. Additional demand from another self-generators will have to be served in the future; another -- the Ibetex textile plant, which has a peak demand of 1.8 MW and currently is operating at low capacity utilization, is interested in being served from SBEE's network. If this industrial consumer were to be connected, SBEE would have to expand its generating capacity in the near future. The mission suggests that a prefeasibility study be made of the option of building a wood-fired steam power plant to meet the incremental demand of this load center (para. 5.17) since interconnection is not economically feasible in the medium term. The first phase of this study should evaluate the availability and long term supply cost of wood.

(c) Djougou and Other Towns of the Atacora

For the northwestern region of Benin, the Master Plan analyzed the various options for developing the hydro power potential of the Oti Basin and establishing an integrated network with northern Togo. The analysis indicated that at the present level of knowledge of the hydro resources, this alternative would be 15% to 18% more expensive than the cost of thermal production.

The least cost alternative appears to be expanding the regional thermal based system of Kara in Togo.

Tariffs

CEB's Purchase and Sales Tariffs

4.27 A distinction should be made between CEB's wholesale purchases and sales, and SBEE's sales to final consumers. CEB's purchase agreement with VRA reflects the cost structure of hydropower, characterized by high fixed charges and low incremental costs. The purchase tariff has a three-part structure, and a similar structure is retained for CEB's sales tariff to CEET and SBEE. The level of CEB's purchase and sales tariff as of April 1982 is indicated in Table 4.8. CEB's average purchase cost in FY82 was about USc2.5/kWh and its average revenue USc4/kWh. The power purchase costs are nominated and payable in US dollars, and subject to revisions every three years, whereas CEB's sales to CEET and SBEE are settled in FCFA and the sales to CIMAO in dollar equivalents of FCFA billings. Therefore, CEB incurs a significant exchange risk because of short-term fluctuations in the exchange rate.

Table 4.8: CEB PURCHASE AND SALES TARIFFS
(as of April 1, 1982)

	Fixed Charges	Monthly Demand Charge a/	Energy Charge
Purchase Tariff: (US$)	24,500/month	6.35/kW	0.0115/kWh
Sales Tariff			
To CEET and SBEE (US$)	16,667/month	8.52/kVA	0.0127/kWh b/
To CIMAO (FCFA)	12,820,000/month	1,051.2/kVA	1.5/kWh

a/ 15-minute peak.
b/ Subject to penalties for power factor falling below 0.9.

4.28 A tariff study by EDF-DAFECO was completed in May 1982. Although the long term assumptions need to be reviewed, the study provides a useful guide for restructuring CEB's sales tariff in the medium term.

The proposed tariff has the following features: (a) elimination of the fixed charges; (b) replacement of metered demand charge by a charge for contracted capacity; (c) introduction of a significant differential in capacity charges to CEET and SBEE; and, (d) a shift towards lower capacity charges for all customers and much higher energy charges. (See Annexes 19-20).

4.29 The tariff study provides some indication of the impact of changes on the magnitude of VRA's supplies. The recommended tariffs were based on an import level of 67 MW from Ghana. A sensitivity test showed that a VRA supply of 90 MW would permit a 31% tariff reduction. The current 50% curtailment will have a similar impact on tariffs in the opposite direction.

SBEE's Tariffs

4.30 Electricity rates were increased in August 1981 for the first time since 1966, and further increases took place in May 1982 and January 1984. This latest and largest adjustment (about 80%) was triggered by the reduction of Ghana's supplies to CEB in December 1983.

4.31 SBEE applies a uniform national tariff and subsidizes much higher energy costs in the inland local centers. While the average tariff in 1984 throughout Benin is FCFA 57/kWh, the cost of fuel alone in the inland centers is at least FCFA 45/kWh. Consideration should be given in the longer term to introducing regionally differentiated electricity rates which reflect incremental costs. Such a decision would create the necessary incentive to convert alternative primary energy (such as agricultural waste products) into electric power. Until such a decision is made, the mission suggests that SBEE, with prior consultation with CEB, consider signing sales agreements with enterprises interested in producing electric power from biomass at a tariff equal to SBEE's long-term marginal cost for the specific local environment ("producer tariff").

4.32 The present tariff structure distinguishes between low voltage consumers and medium voltage consumers. The low voltage tariff distinguishes six different categories of consumers. It is excessively complex, difficult to administer, and not conducive to economizing on peak demand. The six categories of consumer include:

(a) Commercial lighting, FCFA 75/kWh after the first 20 kWh per month;

(b) Residential, increasing block tariff for first three blocks (FCFA 50-73 kWh), fourth block FCFA 68/kWh;

(c) Small industry and commerce: flat rate FCFA 58/kWh;

(d) Residential and air conditioning, increasing tariff for first two blocks (FCFA 67-73/kWh), decreasing tariff for next two blocks (FCFA 68-62/kWh);

(e) Air conditioning, flat rate FCFA 62/kWh; and

(f) Public lighting, flat rate FCFA 60 kWh.

4.33 The medium voltage customers pay a two-part tariff comprised of a fixed charge per kVA (FCFA 2,000/kVA/month) and a flat energy charge of FCFA 35/kWh. The structure of the tariff provides no incentive to conserve energy. A special case is Société des Ciments d'Onigbolo, which concluded a contract with SBEE in 1982 providing for a three-part tariff. The fixed charge (FCFA 40 million per month) is intended to amortize the cost of the 161 kV line Sakété-Onigbolo and receiving sub-stations; the capacity charge (FCFA 1986/kVA-month) applicable to metered demand is about the same as for medium voltage service and the energy rate which is much lower (FCFA 5.5/kWh). The cement plant's rate has the special feature that the demand and energy charge are indexed to the price of power purchased from CEB, the exchange rate, and the price of gas oil.

4.34 A tariff study, completed in 1983, recommended the following changes in the tariff structure:

(a) A declining block rate for residential customers, with a special rate for customers consuming about 400 kWh per year;

(b) Rates for small commercial customers (low voltage), which are virtually the same as the general residential service;

(c) Customers supplied at medium voltage and having a low load factor (average 1750 hours) would pay a time-of-day energy rate. Those with a high load factor (over 3,500 hours) would contract capacity and benefit from a lower time of the day rate.

4.35 The recommended structure is a significant improvement over the complex existing structure. Implementation of a new price structure is likely to be delayed because of the adjustment that was made necessary by the cutback in supplies from Ghana. Once the consumers have adjusted to the new levels, the recommendations of the tariff study should be re-examined with a view to implementing them as soon as possible.

V. RENEWABLE ENERGY SOURCES AND THEIR DEVELOPMENT POTENTIAL

Forest Resources

5.1 About 70 percent of Benin's 11.2 million hectares are covered with forests or bush of varying densities. Most of the productive high forest has been destroyed and converted to savannah woodland by farmers using fire to clear land for agriculture use. The remaining area of closed semi-deciduous high forest now includes remnants of the forest reserve of Lama in the south, probably less than 3,000 ha in total. This reserve, which had been reduced by infiltrations through illegal farming, will now be reforested. In addition, there are remnant islands of valuable high forest and gallery forests in the central west region (Bassila) covering about 870,000 ha which are being exploited to produce sawn lumber, but which are also subject to farming encroachment and depletion by fire. Most areas of Benin are relatively wooded with extensive areas of savannah woodlands, particularly in the center where there is about 1 million ha of national parks and "wildlife zones" along the northern frontier. The savannah woodlands are estimated to carry between 5 m^3 and 25 m^3 per hectare of wood and produce mainly fuelwood and poles. They play an important role in protecting the environment. A rather conservative estimate of the existing natural forest resources is shown in Table 5.1.

Table 5.1: INVENTORY OF WOOD STAND ($000\ m^3$)

Regions	Dense Forests Intact	Dense Forests Exploited	Woodland Formations Productive	Total
Lama	300	160		
Central-North	1060	2990	21,000	
Rest of Country	480	1170		
Total	1840	4320	21,000	27,160

Source: FAO Report 14/82 - Ben 5.

5.2 The yearly gross increase in the accessible forest resource can be estimated conservatively at about 6.3 million m^3 based on the ecological map of the vegetal cover (Table 5.2). 23/ This compares with an estimated current consumption of 2.8 million m^3 and a projected increase

23/ Drawn under a pilot FAO/UNDP/Benin project, based on Landsat images taken in 1975. Updated at the end of 1980, on the basis of comparing deforestation that occurred between 1950 and 1975 in two areas studied in detail.

to 4.6 million m^3 by 1998 (Table 5.3). The projection is mainly based on population growth 23/ and, to a lesser extent, on an increase in the share of charcoal consumption in urban areas. It should be stressed that little information is available on wood use in the cottage industry. However, even if consumption in this sector is three times higher than estimated, the balance would still hold over the projection horizon.

Table 5.2: CALCULATION OF ANNUAL WOOD GROWTH

Type of Vegetal Cover	Area	Total Annual Growth Rate	Increment
	(000 ha)	(m^3/ha/year)	(000 m)
Dense deciduous and semi-deciduous forests	54		379.5
Still intact	14	8	
Under exploitation	33	8	
Forest fallow	7	0.5	
- Woodland formations, mixed broad leaves: forest and gramineous	7,570		11,425
Productive	1020	2.5	
Unproductive	2800	2.5	
Fallow	3750	0.5	
- Other Shrub formations	3,075	0.5	1537.5
Total Forest and Woodland	10,699		13,342.0
Deduction for unproductive forests	2,800		7,000
Total	7,899	0.81	6,342.6

Source: Mission estimate.

23/ Benin has three definable population regions: (a) the northern region, composed of Borgou and Atacora provinces, with 73% of the country's area but only 29% of the total population; (b) the central region, covered by the Zou province, with 17% of the land area and population; and (c) the southern region, including Ouémé, Atlantique and Mono provinces, with 10% of the land area and 54% of the population; 36% of the southern region's population is urban. Future population growth is projected at 3.3% (to 1988) and 3.5% p.a. (1988-1998). The migration trend towards urban areas will continue and as a result, the urban areas will increase to 55% by 1998. The population of the two major coastal cities (Cotonou and Porto Novo) is likely to increase from 600,000 to 1.5 million between 1983 and 1998. The population density in southern Benin is estimated to increase from 154 persons/km^2 in 197° to 370 persons/km^2 by the end of the century.

5.3 Although from a global point of view there is no immediate danger of wood scarcity, imbalances have developed in the south because of increasing population density and in the north because of the present system of agricultural exploitation and the seasonal practice of lighting bush-fires. In addition, the north is a much drier area having only 800 mm of rainfall per year, compared to 1,100 mm on the coast. The choice of strategy for supplying future household energy requirements in the southern region has to take into account: (a) the scarcity of land in the region and the opportunity cost of land; and (b) the transport cost for supplying needs from the central-northern regions. Especially in the Atlantique province, there is going to be a growing competition for land if demography evolves according to current projections. It will become necessary to allocate areas such as swamplands, mangroves, and sea shores considered marginal for agricultural purposes to fuelwood production. Incremental fuelwood production from agricultural land can also be achieved by introducing well balanced agro-silvicultural practices.

Table 5.3: ANNUAL FUELWOOD AND CHARCOAL DEMAND PROJECTION
(in thousand tonnes)

	1983		1988		1998	
	Fuel-wood	Char-coal	Fuel-wood	Char-coal	Fuel-wood	Char-coal
Households: a/						
Cotonou-Porto Novo	145	13.7	203	19.2	345	32.7
Abomey-Bohicon	78	2.3	105	3.1	187	5.5
Parakou-Djougou						
Other Semi-Urban Areas	178	--	238	--	405	--
Rural Areas	1363	--	1515	--	1865	--
Total	1764	16.0	2061	22.3	2802	38.2
Fuelwood equivalent (000 m^3)	2648		3120		4308	
Cottage Industry Consumption b/	265		310		430	
Less Other Supplies a/						
Adjusted Fuelwood Consumption (1,000 m^3)	2763		3280		4588	

a/ Based on the following estimated consumption.

	Fuelwood Consumption			Charcoal Consumption		
	Share	kg/cap/yr	Average kg/cap/yr	Share	kg/cap/yr	Average kg/cap/yr
Cotonou-Porto Novo	0.542	440	238.48	0.205	110	22.55
Other Urban Areas	0.85	440	374.0	0.10	110	11.00
Semi-Urban Areas	1.00	440	440.0	-	--	-
Rural Areas	1.00	528	528.0	-	--	-

b/ Artisan: Estimated as indicated in Annex 5.
c/ Non-Fuelwood supply: includes coconut fibers and millet stalks.

5.4 The Government of Benin, with the help of UNDP, FAO and other international organizations, has been successful in identifying the critical supply issues of the south and in developing forestry projects. However, the projects already under implementation and currently being formulated fall short of meeting the incremental demand of the region (Table 5.4). Of the major projects, only two cater specifically to supplying the fuelwood and charcoal demand of the southern region, while the others are mainly oriented towards meeting timber requirements.

Table 5.4: FUELWOOD PRODUCTION EXPECTED FROM CURRENT FORESTRY PROJECTS ON THE SOUTHERN REGION

(m^3 of solid wood)

Projects	Expected Fuelwood Production
	m^3/year
1. African Development Bank Project,	
State Plantations	
Sémé 500 ha	8,500 a/
Pahou 500 ha	8,500 a/
Lama 2400 ha	51,000 a/
Rural Plantations 2400 ha	24,000 a/
Total	92,000
2. Federal Republic of Germany:	
Lama Forest 6,000 ha (management) b/	10,500
3. World Bank	
Lama Forest 4,000 ha b/	
	7,000
Toui Forest 210 ha c/	24,000
Total New Supply	111,900
To Compare with:	
a) Total Incremental Demand (by 1988)	297,000
b) Total Incremental Demand by 1998	947,000

a/ 85% of production consists of fuelwood.
b/ 15% of production consists of fuelwood.
c/ 100% of production consists of fuelwood.

5.5 Another option for supplying the southern region's fuelwood requirement is to open up and manage existing forests further north. In particular, consideration has been given to two areas: (a) Forest reserves of Ketou, Dogo and L'Ouémé Boukou, with a surface of some 50,000 ha located some 150-200 kms north of Cotonou on the Ouémé River. UNDP has estimated that the natural forest cover contains some 50-60 m^3/ha of wood. After cutting for fuelwood, intensive replantation with eucalyptus has been proposed. The feasibility of this project depends on identifying an economic mode of transportation. The mission strongly suggests that, among other alternatives, the feasibility of transporting this wood on river floats towards the south be further studied; (b) The Toui forest reserve, some 250-300 kms north of Cotonou, covering some 35,000 ha and containing some 150 m^3 of stacked wood per ha. The Bank has estimated that it is economically feasible to exploit these resources and convert wood into charcoal if labor intensive methods and efficient conversion methods are used. Low cost transport to the south could be provided by the railway.

5.6 The other areas of concern are the arid zones of the Atacora and Borgou provinces where the combined effects of agriculture and fuelwood use has caused deforestation and where important signs of soil erosion are apparent. The United Nations Sudano-Sahel Office (UNSO) is supporting a rural plantation project in these areas, financed largely by the Dutch government and staffed by Dutch volunteers. The Government is also promoting communal tree planting campaigns close to major urban centers of this region (e.g., Malanville) which appear to be successful. Integrated agro-silvicultural efforts have to be strengthened to avoid irreversible ecological damage to this region.

Fuelwood and Charcoal Prices

5.7 It is estimated that only about 15% of fuelwood requirements are commercially traded and sold to consumers in the largest cities. The rest is freely gathered by the semi-urban and rural population. There is a growing scarcity of fuelwood in the southern provinces. This is documented by the fact that fuelwood prices have increased 10-15 times during the last decade and that supplies have to be transported over ever increasing distances. Currently, the supply of fuelwood for Cotonou and Porto Novo comes mainly from the Ouegbo region and the area of the Lama forest, about 80-100 kms north of Cotonou. The Ministry of Rural Development indicated that fuelwood prices have risen from FCFA 10 per bundle in 1970 to FCA 150 per bundle in 1983, while charcoal prices have increased from FCFA 350 per sac of 30 kgs in 1970 to 1,500 FCFA in 1983. At the retail level, the price of fuelwood in Cotonou can exceed FCFA 7,500 per cubic meter of solid wood. In 1982, SNAFOR sold fuelwood in the wholesale market of Cotonou at FCFA 4500 per stere (0.6 m^3 solid) of the highly valued filao wood.

5.8 These price levels, viewed in terms of the average monthly income, appear to be quite high. With a consumption level of 1.2 kg per day per capita and assuming one income earner per household, the monthly expenditure for fuel is equivalent to 10% of the income of the urban working family.

5.9 On the other hand, these fuelwood prices translated into useful energy are still about 50% below the economic replacement cost, which is the economic cost of kerosene (Table 5.5).

Fuelwood Production Cost

5.10 The current market price for fuelwood and charcoal in most cases involves no plantation costs but only exploitation, transportation and trading costs. The prices of firewood offered for sale along the Cotonou-Bohicon road show only marginal fluctuations, from CFAF 3,500-4,300 per m^3 (CFAF 2100-2600 per stere). Assuming that about eight man-days are required to cut, gather and haul to the roadside one cubic meter of wood, the average return is CFA 440 per man-day. This work is being done by private individuals employing a labor intensive technology and the return on labor is less than the going wage rate for hired farm workers. This activity is important as a supplementary income earning opportunity for the rural population, including women, during the dry season. It can be estimated that 2.4 million man-days are required annually to supply the fuelwood requirements of the cities of Cotonou and Porto Novo (320,000 m^3).

Table 5.5: ECONOMIC COST OF FUELWOOD AND CHARCOAL

	Kerosene	Fuelwood	Charcoal
Economic Cost a/ (FCFA)	115.4/lt.	4,500/m^3 stacked	1500/sac of 30 kg
Price per kg. (FCFA)	142.5	10.7	50
Calorific Value (kcal/kg)	10,300	3,500	7,200
Price per Mcal (FCFA)	13.83	3.06	6.94
Stove Efficiency	40%	13%	25%
Price per Useful Mcal (FCFA)	34.6	23.5	27.89
Index	147	100	118

a/ Landed Cost plus in-land supply costs.

5.11 Of the FCFA 7,500/m^3 market price, about 15% is accounted for by trading costs and profit margins and CFA 500 is handling costs. Thus, a balance of about FCFA 2,000/m^3 is left to cover the cost of transportation. At the marginal cost of FCFA 10/km/m^3 for transport, the maximum economic handling distance is about 200 kms. 25/

5.12 The cost of establishing wood plantations in the southern provinces is estimated to be considerably higher than the present supply cost. From the ADB project, which envisages 3,400 ha of intensive plantations and 2,400 ha of rural plantations, the average production cost is estimated at FCFA 3650/m^3 stacked (or FCFA 6100/m^3 solid). This figure is derived from discounting at 10% the annual projected investment and operating costs and expected physical fuelwood production flows. It is based on the project's very optimistic assumption that an average growth of 20 m^3/ha/year will be obtained. It does not include the opportunity cost of land, the overhead costs of the institution responsible for the project, nor the transport and marketing costs.

25/ The freight tariff is FCFA 24/km/ton. However, fuelwood is transported towards the south, thus offering a load to trucks which otherwise would descend empty towards Cotonou.

Policy Issues

5.13 The mission considers that, with proper management, Benin's forests could supply not only the essential energy needs of households and the cottage industry, but also could become an important primary energy source for the modern sector of the economy, substituting for petroleum products. In view of the technical and managerial constraints of the institutions responsible for the sector, the mission proposes a gradual, selective expansion of forest activities.

5.14 The present price level for fuelwood and charcoal is such that intensive fuelwood plantations using mechanized production methods are not economic. On the other hand, the supply of fuelwood and charcoal to urban areas must be increased to avoid socially unacceptable price increases. It therefore is recommended that incremental supply be developed from: (a) rural forestry projects and (b) exploitation of forestry resources in the center of the country.

5.15 The regional CARDERs, who are in charge of promoting agricultural development, recently have been assigned the new responsibility for rural reforestation. This opens up the opportunity for integrating agricultural and silvicultural projects in a harmonious way. To bring this about successfully, technical assistance to the individual CARDERs is urgently required to insure proper training of their staff in forestry technology and to set up a basic infrastructure (such as nurseries). In many countries, village reforestation has been recognized as the cheapest alternative for supplying the population's fuelwood requirements. However, successes have been few because of the lack of technical assistance at the peasants' level and the lack of short term incentives. For example, the ADB project envisages the distribution of food rations to peasants planting trees. It has been shown in other countries, such as Haiti, that such an incentive leads to a very high loss rate, because seedlings are planted for the food ration and then they are abandoned. To lessen the CARDER's involvement in forestry projects, it might be worthwhile to investigate if private enterprises specialized in silviculture could be attracted to Benin, to provide technical assistance to peasant cooperatives for planting and exploiting resources and sharing in the marketing benefits of surplus production. International financial backing would be required in the initial phase for such a long term project.

5.16 For the forest management projects that would make accessible the forest resources of the central northern regions of Benin (under the responsibility of DEFC), the mission recommends that labor intensive methods be retained, but that training in efficient exploitation, replanting and charcoal conversion methods be emphasized. In the Bank's project of the Toui forest, consideration should be given to modern brick kilns, with separate combustion chambers, in which the energy efficiency of thermal conversion can be increased to 50% when wood is properly dried.

5.17 The mission recommends that a pre-feasibility study be conducted on the availability of fuelwood to supply a wood-based power plant in Parakou. This city has a current electric demand of 6.5 GWh (1.5 MW), and a projected demand of 14 GWh by 1988 (4MW). A significant part of the future demand is to come from industry. Interconnection with the coastal system was found to be uneconomic in the Master Plan (see para. 4.26), thus incremental demand would have to continue to be met by diesel units. Assuming a productivity level of 2 m^3 of wood per year and per hectare, an area of 13,700 ha would suffice to meet the 1988 energy requirements of this load center. A preliminary analysis indicates that such an investment is justified at present diesel prices, if wood could be supplied at less than US$61 per ton of dry wood. 25/

5.18 There are two large forests in proximity to Parakou: the Toui forest reserve with an extension of about 35,000 ha and The Ouémé Superieur forest of about 150,000 hectares. These are ecologically mature forests and their exploitation has to be carefully assessed. A portion of the Toui forest will be affected by a Bank financed management project (para. 5.5) and agricultural encroachment in the Ouémé Superieur forest appears to be significant. The mission therefore recommends studying the ecological advisablity of allocating a fraction of the area covered by these national forests to intensive exploitation of wood or whether it is preferable to envisage a grass roots plantation in the savannah land surrounding Parakou. The study must also provide a realistic assessment of the alternative supply costs (including for forest protection, management and/or plantation, exploitation and transport). At the equilibrium price for wood (calculated in Footnote 26), it is likely that the project would generate a financial surplus, which could be employed to enhance protection of remaining forest area.

5.19 It should be noted that considerable advances have been made in reducing the cost of small-sized steam power plants. At current diesel oil prices, these packaged steam plants are competitive at power output requirements higher than 500 kW (Annex 24).

25/ Economic Comparison: For an annual operation of 4,640 hrs.

- Medium Speed Diesel (US$875/kW)			
	Capital charges (15 years, 10%)	US$/kW	115.0
	Operating costs (5% of investment)	"	43.8
	Average fixed costs:	US¢/kWh	3.4
	Fuel (Table 4.3)	US¢/kWh	9.7
(A)	Total diesel generation cost	US¢/kWh	13.1
- Steam Power (Investment US$1,200/kW)			
	Capital charges (20 years, 10%)	US$/kW	141.0
	M&O costs (7% of investment)	"	84.0
(B)	Average fixed cost	US¢/kW	4.8
	Difference (A+B)	"	8.3
	Wood consumption (1.37 kg/kWh) Maximum Price	US$/ton	60.2

Agricultural Residues

5.20 Based on the 1982-83 agricultural production, the mission estimated the energy potential of unutilized agricultural sub-products at about 450-640 Ktoe. This total excludes the material that should be recycled in the field to maintain the soil's fertility, as well as current energy uses. The significance of this potential is best illustrated by comparing it to the current fuelwood consumption of 660 Ktoe. The availability of this resource by type of crop and region is indicated in Table 5.6 and discussed in detail in Annexes 21 and 22.

5.21 Agricultural waste products generally have a relatively low density and must be processed into a usable energy form. They are a fairly expensive energy source because of gathering, transport and conversion costs. Under current economic and technical conditions, only a fraction of the available potential is competitive as a substitute for fuelwood and commercial fuels.

Table 5.6: ENERGY POTENTIAL OF CROP RESIDUES
(thousand tons of oil equivalent)

By Type of Crop	Energy Potential	By Province	Energy Potential
Corn	101-235	Mono	104-130
Sorghum & Millet	13-47	Atlantique	105-140
Oil Palm	242-260	Ouémé	137-190
Cotton	52	Zou	26- 40
Coconut	26	Atacora	18- 50
Groundnut	3-5	Borgou	60-90
Rice	3-5		
Animal Waste	10		450-640
Total	450-640		

Source: Annex 21-22.

5.22 The gathering and transportation costs severely restrict the use of this resource in Benin. Agricultural productive units are small in Benin, widely dispersed, and agricultural activity is still itinerant, burning new plots every season. 26/ On the other hand, the existing agro-industry suffers from a continuous shortage of agricultural inputs, due to climatic induced fluctuations in production and an agricultural pricing structure which does not provide the necessary incentive for farmers to sell their products to the existing plants. Thus, the introduction of energy technologies based on agricultural waste products necessarily has to be gradual and coordinated with Benin's agricultural and agro-industrial policies.

5.23 The mission investigated the economics of briquetting residues. It appears that at present prices for fuelwood, only manual briquetting would be competitive for supplying urban fuelwood needs. Annex 24 provides cost estimates should such an alternative be considered in the future by one of the southern CARDERs.

5.24 Before such a project is implemented, a thorough soil analysis must be made to determine the quantities of residues that have to be recycled into the soil. 27/

5.25 For industrial energy of agro-industrial residues, the mission identified excess residues of 800-1,300 toe at MIFOR (sawmill) and SONICOG (cotton oil factory) in Bohicon, raising to 1,900-3,300 toe with increased processing. These quantities exclude the waste material already being used as an energy source by SONICOG. Both enterprises are currently considering projects to utilize these residues: MIFOR envisages building a gasifier to feed its diesel engines, and SONICOG is considering building a briquetting plant. The mission suggests the long term availability of the material be evaluated, that the conversion of this waste material be considered as a joint project, and that consideration be given to the energy needs of the brewery to be built in nearby Abomey.

5.26 Three alternative conversion routes were explored. The preliminary results indicate that the highest returns would be achieved by feeding the waste materials into an industrial multi-fuel boiler at the brewery, supplying that plant's requirements of steam and electricity and selling the surplus electricity to SBEE's network, or by simply generating steam. A prefeasibility study should be made to evaluate in

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26/ According to the Ministère de Développement Rural et de l'Action Cooperative, Report "Structure des Exploitationes Agricoles Traditionnels" (1976/77), the average size of privately owned exploitation units is 1.7 ha, of which 35% have an extension of less than 1 ha, 40% between 1 and 2 ha, 23% between 2 and 4 ha, and only 2% of more than 4 ha. About 50% of agricultural land is privately owned; 20% belongs to cooperatives. But even in the latter case the parcels of cultivated land remain small.

27/ Currently, residues are burned.

detail the availability of residues and the actual investment and operating costs of the two alternatives.

Table 5.8: INDUSTRIAL RESIDUE USE - COST COMPARISON
(in thousand FCFA)

Options	Multifuel Cogeneration	Multifuel Steam Only a/	Multifuel Electricity Only
Capital charges	54,400	18,700	48,915
Maintenance	16,700	5,800	21,750
Labor	1,600	1,000	1,600
Steam	-	-	99,880
Electricity	-	45,360	-
Total	72,700	70,860	172,145

a Electricity is assumed to be purchased at FCFA 54/kWh.
b/ Steam is generated from fuel oil.

Assumptions: Annual operations 2,800 hr.
Steam required 4T/hr, 1 ATM.
Electricity required 840 MWh.

Source: Annex 24.

5.27 There are also important institutional constraints that would have to be overcome to make such a project feasible. Already, the relations between SBEE and the industrial plants are strained. SONICOG and La Beninoise are unlikely to be willing to depend on SBEE for their steam requirements. Thus, the project would have to be managed by the industrial sector, and SBEE would have to be willing to purchase surplus electricity. If these constraints cannot be overcome, the mission suggests that SONICOG proceeds with its briquetting project, MIFOR with its gasification project, and the brewery should analyze the advantages of using agricultural waste for steam generation.

5.28 The sugarcane industry in Benin has no potential for generating surplus energy. The new sugar mill in Savé (SSS) has an installed capacity of 35,000 tons. Because there was no market for the sugar and no labor to harvest the cane, the plant operated at about 20% of capacity in FY82/83. SSS is an integrated operation (plantation-mill), in which surplus bagasse is converted into electric power for water pumping. The energy balance (Annex 23) shows that, even if full capacity is achieved, the industry will have a net energy deficit of 10-30%. In the medium term, this deficit is to be met by supplies from SBEE's electric network; for the long term, the enterprise envisages the establishment of an energy wood plantation. This project will have to be assessed once the development program for the hydro potential on the Ouémé River has been clarified.

5.29 As a third line of action, the mission supports the efforts to explore the dissemination of bio-digestors, which offer the advantage of producing simultaneously energy and organic fertilizer. The mission suggests that, as a first phase, the energy requirements at the pig farm in Kpinnou and the slaughterhouses of Cotonou and Parakou be evaluated. In all three locations the construction of larger scale biodigesters appears to be economically feasible. The mission has estimated that some 70 toe could be produced, with a total investment cost of some FCFA 45 million, and a unit production cost below petroleum products.

Other Renewable Resources

5.30 Solar Energy. Solar radiation in Benin is conducive to energy development. It is estimated to vary between 3.3 kWh/m^2/day and 5 kWh/m^2/day, and may increase to 6 kWh/m^2/day towards the north. The potential applications of solar energy should be limited in the short term to retrofitting industrial and commercial water heating systems. (See Annex 24) because other applications such as photovoltaic electric generation is not competitive at present prices with liquid fuels, except in very remote areas. The mission recommends that pre-feasibility studies be made for solar heating retrofitting of the following industries:

Breweries of Cotonou and Parakou
Soap factory at Porto Novo
Oil factories at Cotonou and Bohicon
Oil palm factories
Larger hotels: Sheraton - PLM
Hospitals.

Solar Air Heating

5.31 This technology could be applied in Benin mainly to crop drying and to some textile industries (SOBETEX). The mission found that large losses of agricultural products occur in spite of the fact that the Government has promoted the introduction of cribs at the village level and has built large centralized storage facilities. There are institutional, economic, and technical problems in the storage-marketing system that have to be resolved before solar crop drying systems can be considered. The centralized storage facilities are government-owned and are underused because the farmers prefer to sell their products through informal marketing channels. They have ventilation systems, which are not properly operated. To avoid rotting, the CARDER Borgou is currently envisaging using a phyto-sanitary powder (Actellic). 28/

28/ The mission investigated the characteristics of this product. It comes in two versions: (1) Actellic Powdering, containing one percent of Pyrimiphos Methyl and (2) Actellic Powder, containing two percent of Pyrimiphos Methyl. Both products are recognized in France. A legal delay of seven days is imposed between application of powder and commercialisation of agricultural products.

Wind Energy

5.32 Only the southern coast has wind speeds that would permit the installation of small windmills. The mission suggests that the results of the wind regime study completed by the Meteorological Service be reviewed by an outside consultant and used to formulate a follow-up windmill program.

VI. INSTITUTIONS, INVESTMENTS - TECHNICAL ASSISTANCE

Institutions 29/

6.1 Benin has no centralized energy planning institution. A certain degree of coherence in energy decisions is achieved because investment decisions of institutions related to commercial energy are integrated into the National Development Plan, which is prepared by the Ministry of Planning and Statistics. Energy pricing policies are the responsibility of the Ministry of Commerce, Artisanat and Tourism. Decisions on prices are taken on the basis of the recommendations of the individual energy supplying institutions, and decided upon in an Interministerial Committee.

6.2 The Ministry of Finance and Economy (MFE) does not have a functional unit responsible for global energy issues, but should supervise hydrocarbon exploration, development and production through the Service des Hydrocarbures (SdH). This technical unit is also responsible for the analysis of oil refining and petrochemical projects. At this stage, SdH's scope of work is limited. Its director is a member of the "Comité de Suivi" established to supervise the development of the Sémé field and to define the strategy for further exploration in the offshore basin. The service is seriously overstaffed with young professionals (mostly petrochemical engineers trained in Algeria). A few of them have been retrained by a Bank technical assistance program (para. 3.4), with the objective of forming a supervisory staff for the petroleum exploration promotion campaign. The mission suggests that about six engineers of this service be retrained to form an energy management unit. Two engineers are already being trained as energy economists. This group could work in cooperation with SONACOP and SBEE in establishing a data base on petroleum and electricity consumption and carry out market surveys to determine the pattern, volume and efficiency of consumption of all energy forms in medium and small scale industry, artisanal activities, households and transport.

6.3 SONACOP (Société Nationale de Commercialisation des Produits Pétroliers) has the monopoly on importing and distributing petroleum products in Benin, and was created in 1973 when private oil companies were nationalized. It appears to be a relatively well managed company (with a staff of about 440), which presents annual financial statements. The net benefits before taxes were equal to 5.57% of the company's turnover in 1983. Backlog payments from its clients averaged 32 days -- public enterprises being the ones with the longest delays in payment. The Commercial Bank of Benin (BCB) finances SONACOP's working

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29/ In August 1984 the Government of Benin announced a major ministerial reoganization, which may affect the institutions described in this chapter.

capital requirements and the Development Bank of Benin (BBD) its investments. The company's most immediate problem is to raise financing for increasing its working capital. The company retains only 15% of annual net benefits, and returns the rest to the National Investment Budget (80%) and to the National Operational Budget.

Electricity

6.4 Two enterprises make up this sector: the bi-national CEB and the national SBEE.

6.5 In principle, CEB has the monopoly on generation (including power imports and exports) and transmission in Togo and Benin, as well as extensive regulatory power concerning sector activities outside its monopoly, such as distribution and licensing of self-generation. In practice, implementation of the Treaty's provisions has been only partial. The Nangbeto hydro project will be CEB's first entry in the field of power generation and the company is also supervising the study of the West African interconnection that would link the systems of Togo and Benin with those of Nigeria and Ghana.

6.6 CEB's organization had been geared to its functioning as a bulk transmission company. Changes are being made to prepare the company to implement projects such as the central load dispatch, Nangbeto, the West African interconnection, to promote identification of the resource base of Togo and Benin, and to strengthen coordination of its activities with CEET and SBEE. Training should be systematically developed as a function of anticipated corporate developments.

6.7 The financial position of CEB is relatively favorable. Imported power from Ghana is sold with effectively a 50% markup -- enough to cover the cost of operating a small asset base and to show a satisfactory financial return. Accounting practices need continuing attention and receivables (6-7 months of revenues) must be reduced.

6.8 CEB has training capabilities which will be strengthened under the technical assistance projects. The mission recommends that an assessment be made of the training needs of the national utilities of Togo and Benin in energy planning, operation, maintenance, financial and administrative management, and that a training program to meet these requirements be set up.

6.9 The Société Beninoise d'Electricité et d'Eau (SBEE), created in 1974, is the organization in charge of providing electricity and potable water services to Benin and operating thermal stations in Benin. It falls under the supervision an Administrative Council, chaired by the Minister of Finance and Economy which approves policy development plans and programs, and the company's budget. The administrative and financial management is the responsibility of SBEE's General Director, who is assisted by seven functional departments. At the planning and project definition level, the specific functions for electric power and potable water are under separate Directors. All other functions are shared for both services. A study on the organizational problems of SBEE has been completed 30/ which provides specific recommendations on organizational measures and training requirements. Weaknesses are most important at the planning and control levels, due to a shortage of qualified personnel.

6.10 The company's financial statements are being audited by external consultants. The first of these audits, for FY80/81, indicated an urgent need to improve the accounting systems and procedures, to establish a method for regularly revaluating fixed assets, to revise the analytical accounting system to permit the distinction between water and electricity operations, and between the interconnected coastal electric system and each of the regional isolated centers. The study also recommended revision of the procedures for formulating and controlling budgets, and training and staffing requirements. SBEE's 1983 statement indicates that efforts are being made to improve management procedures, but that severe problems remain to be solved. Among the most critical are: (a) rapid growth in personnel not entirely justifiable by expanded activities. There were 1,633 employees in 1983, of which 51 are professionals and 98 are technicians. (b) unreliable services and high losses in the electricity distribution network (21.2%); (c) treasury illiquidity due to arrears which averaged 10 months of sales in 1983. In October 1983, the National Executive Council authorized compensation of debts among public sector entities.

6.11 Although electricity tariffs are set at the national level, the rate structure is based on the coastal system. Because electricity demand in the towns of the interior is expected to increase at a higher rate than in the coastal system, it may become necessary in the longer term to study the establishment of a regionalized tariff system, to insure SBEE's financial equilibrium.

Forestry

6.12 The Ministry of Rural Development and Cooperative Action (MDRAC) is responsible for all aspects of the forestry sector, covering legislation, planning, reforestation and management, including exploitation of the state forestry reserves and plantations. It executes its responsibilities for legislation, planning and forestry management through its Direction des Eaux Forêts et Chassés (DEFC). Social and rural forestry projects, which are comparatively less significant at present, and forestry surveillance are conducted by the provincial CARDERs, which fall under the same ministry and which are expected to work in liaison with DEFC. Until 1982, a state society reporting to MFEEP, the Société Nationale pour le Développement Forestier (SNAFOR), undertook forest exploitation, saw milling, marketing and reforestation on behalf of the Government. However, SNAFOR became over-extended financially and was dissolved in 1982. With a recent change in policy the Government has since transferred responsibility for reforestation to

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30/ SBEE - Etude Organisationnelle, by EDF-Jan. 1984.

DEFC. The remaining SNAFOR responsibilities were assigned to a new commercially oriented state society, the Office National du Bois (ONAB), which can also carry out reforestation programs under contract. Forestry research is carried out under the auspices of the Ministry of Medium and Higher Education and at present, adequate liaison with DEFC is being maintained. Given a clearly specified program and the means with which to carry it out, the research staff would be able to expand its efforts.

6.13 DEFC currently employs or liaises with about 150 professional, senior technical and technical staff, whose mandate includes monitoring forestry exploitation and legislation, research, reforestation, liaison with CARDERs and administration and finance. Most of the ten professional and senior technical staff at DEFC headquarters are young and almost all lack practical experience since DEFC has had virtually no operating budget, equipment or vehicles with which to work. Thus, the field staff, who number about 140 and are under the administrative control of the CARDERs, do not receive adequate technical guidance or support from DEFC. This results in poor control of forestry resource use by farmers and loggers. The headquarters staff recently has reorganized into several fragmented units, each lacking the critical size necessary for efficient performance.

6.14 Although the Government recently has conferred the responsibility for forestry regeneration on DEFC, it was found necessary to organize independent project units within DEFC to execute recently negotiated reforestation projects. Each of these units reports directly to the DEFC Director. If these projects would undertake to plant about 12,000 ha over the next six years, the present managerial and administrative capacity of DEFC would be exhausted. Moreover, there is a serious risk to the remaining forestry resources of delays in developing a coherent forestry strategy, proper administration and monitoring of forestry exploitation and reforestation programs. Therefore, the Government recognizes that it is critical that DEFC be reorganized and strengthened as soon as possible to allow it to lead this development and exercise its mandate. The recently appraised Bank forestry project addresses the problem and proposes to strengthen and reorganize the DEFC.

6.15 The ONAB, which is in the process of assuming the commercially oriented functions of SNAFOR, including forest exploitation, processing and marketing of wood and wood products, has received substantial assistance under a project financed by the Federal Republic of Germany (FRG). Most of the former SNAFOR staff continues to be employed by ONAB. They are organized into units which include inventory, logging and extraction, and saw milling, and currently are confined to conducting trials but could be expanded to fulfill contracted reforestation works. An embryonic study and planning unit also has been established to provide DEFC with forestry inventory and tree measurement data. The ONAB is coming under stricter financial and technical management. Its workshops, garages, and office buildings have been substantially improved as a result of the FRG supported project, and ONAB has begun mechanized forest clearing to establish forest sawlog plantations from which revenues from salvage logging will be generated.

6.16 Professional staff are presently being educated at the Forestry Facility at the University of Ibadan, Nigeria. Senior technical staff are educated at the Institute of Agriculture, Bouake, Ivory Coast. All candidates for forestry education must have completed an agricultural course at the Faculty of Agriculture, National University of Benin. The staff required for the ADB assisted fuelwood project and the IDA/FRG sawlog plantations project will have to be supplied through a reorganization of the present staff duties, but even with formal training, considerable in-service training would be required for all staff. There is a forestry course at the Agricultural Polytechnic, Sekou, which trains controllers, most of whom are employed in rural forestry carried out by CARDERs.

Other Institutional Issues

6.17 Other institutional problems encountered during the mission pertain to the relationship between SBEE and industrial self-producers, which appeared to be more based on competitiveness than on complementarity. In the Bohicon-Abomey area, for example, power supply from SBEE has not been adequate to meet new industrial loads (e.g. MIFOR, Corn Mill). Consequently, industries have installed diesel generating capacity to meet their own needs. Now SBEE is installing additional capacity (increase from 1.7 MW to around 3 MW) that would satisfy their industrial loads and result in very substantial cost savings to industries if the voltage characteristics improve. Better communications are required. In addition, SBEE sees its mandate as selling as much electricity as possible, which makes sense considering the very low level of per capita electricity consumption in a country like Benin. However, this view does not favor demand conservation as electricity prices are still relatively low. As a corollary, SBEE is not looking forward to dealing with potential cogenerators (mainly in the agro-industry where wastes could be used as a source of cheap fuel to produce steam and power).

6.18 On the industrial fuel side, SONACOP is not involved, to our knowledge, in any kind of conservation activities. In conclusion, the overall institutions in Benin are not adequate to stimulate energy conservation efforts and to achieve an optimal investment policy.

Investments

6.19 A summary of the projects being proposed in the energy sector indicates a total investment of about US$200 million between 1983 and 1988, equivalent to approximately 5% of the projected GDP. This is likely to be burdensome, considering the financial needs in agriculture, industrial rehabilitation and other priority sectors.

Table 6.1: INVESTMENT REQUIREMENTS - ENERGY SECTOR
(US$ Millions)

	1983	- 1988
Hydrocarbons a/		51.0
Sémé - Development Phase II	45	
Exploration - Rest Offshore Basin	private	
SONACOP	6	
Electricity		104.0
CEB b/	53	
SBEE-Inter-connected system	15	
Isolated centers	36	
Forestry		24.8
ADB	13	
FRG	5	
UNSO-FAO	1.4	
IDA	5.4	
Other Renewables		2.0
Energy Conservation		2.0
Training & Technical Assistance c/		3.3
Total		187.1

a/ In the case that the tests to be carried out under the second development phase of Sémé prove commercially exploitable gas reserves, additional investments in the hydrocarbon sector will be required for drilling production wells, building a well and a pipeline to bring gas ashore and a gas treatment plant (US$20 million in total).

b/ Allocated 50% of joint developments and 100% of lines and substations in Benin.

c/ Includes technical assistance to the power sector in the amount of US$2.5 million, which has already been asssured under the Nangbeto Credit.

Source: Mission estimates.

Technical Assistance Projects

6.20 The many technical assistance activities identified in this report have been grouped in this section according to priorities agreed with the government. In view of the limited counterpart resources available, the projects were selected taking into account their expected impact as well as the absorptive capacity of the institutions concerned.

First Priority Activities:

(1) ENERGY EFFICIENCY IN ELECTRIC SECTOR:

Institution: SBEE

Objective: Evaluation of the potential for reducing physical and financial losses in power generation, transmission and distribution. The study is to include both the Atlantic system and the isolated centers.

Cost: Requires four man-months of consulting services.

(2) MANAGEMENT INFORMATION SYSTEM:

Institution: SBEE

Objective: Design of a statistical system to provide management with adequate information to monitor performance in this rapidly expanding public utility.

Cost: Project to be incorporated in the technical assistance package associated with Nangbeto.

(3) IMPROVED STOVES:

Institutions: Direction de la Recherche Scientifique and Groupement de Femmes

Objectives:

(a) review of the ongoing program by an outside consultant and exposure of Beninoise to the Bank's stove program in Niger.

(b) basic analytical work, including survey of energy use in households; measurement of stove efficiency; training of stove manufacturing artisans; and improvement of current market information campaign.

Cost: This program is to be executed conjointly with Togo. It is to be phased over three years at a total cost of US$200,000.

4. USE OF AGRICULTURAL RESOURCES IN BOHICON:

Institution: SBEE - Ministry of Rural Development.

Objective: Evaluation of use of surplus residues available at sawmill and cotton plant in Bohicon, for generation of steam and/or electric power. Rapid action is required if individual disposal decisions are to be avoided.

Cost: 2 man-months of consulting services, including evaluation of long term availability of residues.

5. DENDRO POWER PLANT - PHASE I

Institution: Ministry of Rural Development.

Objective: Evaluation of the ecological, technical and economic feasibility of producing fuelwood for a DENDRO power plant to be built in Parakou.

Cost: Two man-months of consulting services.

6. ENERGY SECTOR PLANNING - PHASE I

Institution: Ministry of Finance and Economy.

Objective: Establishment of a core unit for data collection and handling, of energy demand and supply variables. Project includes training in Benin and set up of a micro-processing facility.

Cost: about US$50,000.

Second Priority Projects

7. ENERGY SURVEY OF ARTISANAL SECTOR:

Institution: Ministry of Rural Development - Direction de la Recherche Scientifique.

Objective:

(a) Evaluation of energy consumption in oil palm processing, dolo, akassa and salt production and other artisanal activities.

(b) The palm oil industry merits special consideration. The mission estimates that only 25% of all palm fruits are processed in industrial plants, the rest being processed in the cottage industry which uses fuelwood. If the capacity of the three modern industrial units were utilized, energy savings on the order of 45,000 toe could be achieved. The mission suggests a survey be carried out to examine the minimum price that would have to be established to induce a transfer to industrial processing; analysis of energy use in the cottage industry; production cost; and employment.

Cost:

(a) General survey: US$20,000, including one man-month of external consultant services and 10 man-months of local consultant services.

(b) Palm oil survey: two man-months of external technical assistance (one for cottage industry, one for industrial palm oil sector) and the services of four local consultants.

8. SUPPLY AND DEMAND OF LPG:

Institution: SONACOP

Objective: Evaluation of the economic advantages to be derived from replacing gasoline and diesel in the transport and small industrial sector with imported LPG. Assistance would also consist of evaluating Nigeria's willingness to enter into a firm and long-term supply commitment, of analyzing SONACOP's investment requirements, and designing a strategy of market penetration.

Cost: Estimated at about two months consultancy work.

9. ENERGY EFFICIENCY IN TRANSPORT - PHASE I:

Institution: Ministry of Transport.

Objective: Evaluation of energy efficiency in the government owned fleet. Includes evaluation of consumption and use of fleet, driving conditions and engine efficiency audits.

Cost: Two man-months consultant services.

10. RENEWABLE ENERGY RESOURCES:

Institution: Ministry of Rural Development, Ministry of Higher Education.

Objective:

(a) Evaluation of decentralized agricultural residues. Chinese assistance is being sought by Benin for the dissemination of biogas technology.

(b) Evaluation of the wind regime survey and formulation of a windmill dissemination plan.

(c) Pre-feasibility studies for retrofitting industries and institutions with solar water heaters. The mission estimates potential savings of about 1,800 toe of commercial fuels by 1988. To determine the technical and economic feasibility, it is suggested that a study be made of the breweries in Cotonou and Parakou, the soap factory in Porto Novo, the hotels and the hospitals.

Cost: Technical assistance consisting of two man-months of services is required.

Annex 1.1

POPULATION BY PROVINCE, 1979

Province	Area	Population (000's) Total	Rural	Urban	% Urban/ Total	Population Density Persons/ km^2	Number of Households '000	Average Size
	(km^2)							
Southern	11,700	1,796.9	1,145.6	651.3	36.3	153.6	352.6	5.1
Ouémé	4,700	627.1	435.1	192.0	30.6	133.4	122.8	5.1
Atlantique	3,200	693.3	304.3	389.0	56.1	215.2	148.0	4.7
Mono	3,800	476.5	406.2	70.3	14.8	125.4	81.8	6.8
Central: Zou	18,700	569.5	478.4	91.1	16.0	30.5	118.4	4.8
Northern	82,200	971.8	756.7	215.1	22.1	11.8	142.9	6.8
Borgou	51,000	490.3	356.3	134.0	27.3	9.6	68.1	7.2
Atacora	31,200	481.5	400.4	81.1	16.8	15.4	74.8	6.4
Total	112,600	3,338.2	2,380.7	957.5	28.7	29.6	613.9	5.4

a/ Defined as population living in centers of 10,000 or more inhabitants.

Sources: Population Census, March 1979, preliminary estimates, INSAE, 1982. Bank mission.

Annex 1.2

PROJECTION OF POPULATION GROWTH TO 1998
(in thousands and %)

	Population in 1979	Average Annual Growth Rate 1979/83	Population in 1983	Average Annual Growth Rate 1983/98	Population in 1998
		(%)		(%)	
Cotonou-Porto Novo	459.6	7.2	607	6.0	1,450
Abomey-Bohicon, Parakou, Djougou	165.4	6.0	209	6.0	500
Other semi-urban areas a/	332.5	5.0	404	5.6	920
Rural areas	2,380.7	2.1	2,582	2.1	3,533
Total	3,338.2	3.34	3,807	3.53	6,403

a/ Between 10,000-20,000 inhabitants.

Source: UN population projections and Mission estimates.

PROJECTED REGIONAL POPULATION DISTRIBUTION

	Population in							
	1979			1983			1998	
	Number of People	Relative Share	Growth Rate 1979/83	Number of People	Relative Share	Growth Rate 1983/98	Population	Relative Share
	('000)	(%)		('000)	(%)		('000)	(%)
South	1,797	54	3.8	2,085	55	3.2	3,345	52
Center	570	17	2.7	635	17	2.8	962	15
North	971	29	2.9	1,087	28	4.5	2,096	33
Total	3,338			3,807			6,403	

Source: Mission estimates.

Annex 1.3

PROJECTED REGIONAL DISTRIBUTION OF POPULATION

	Population in 1983	Average Annual Growth 1988/83	Population in 1988	Average Annual Growth 1998/88	Population in 1998
	('000's)	(%)	('000's)	(%)	('000's)
South: a/	2,085	4.06	2,544	3.60	3,622
Urban	607	6.99	851	5.47	1,450
Semi-Urban	233	6.01	312	5.28	522
Rural	1,245	2.10	1381	1.80	1,650
Center: b/	635	2.88	732		992
Urban	96	6.09	129	6.0	231
Semi-Urban	19	6.47	26	5.64	45
Rural	520	2.10	577	2.18	716
North: c/	1087	3.11	1,267	3.51	1,789
Urban	113	5.97	151	5.98	270
Semi-Urban	152	6.06	204	5.61	352
Rural	822	2.10	912	2.50	1,167
Total	3,807	3.60	4,543	3.49	6,403

a/ Includes the provinces of Mono, Atlantique and Oueme.

b/ Includes the Zou.

c/ Includes the northeastern province of Bourgou and the northwestern province of Atakora.

Source: Mission estimate.

Annex 2

BENIN: ENERGY BALANCE, 1982
(in tons of oil equivalent)

	Primary Energy			Secondary Energy								
	Fuelwood	Agricultural Residues	Conversion Losses	Charcoal	LPG	Gasoline	Kerosene	Gas/Diesel Oil	Fuel Oil	Electricity	Total Energy	Relative Share %
Gross Supply												
Domestic Production	663,660	69,000	--	--	--	--	--	--	--	--	732,660	--
Official Imports	--	--	--	--	640	69,264	59,313	82,738	20,114	12,731	244,800	--
Illegal Imports	--	--	--	--	--	12,226	--	4,060	--	--	16,286	--
Export to Neighboring Countries	--	--	--	--	--	40,445	24,973	40,317	12,170	--	117,905	--
International Bunkers	--	--	--	--	--	--	16,315	2,877	1,153	--	20,345	--
Change in Stocks - Statistical Errors	--	--	--	--	--	131	1,006	1,055	368	--	2,560	--
Net Supply	663,660	69,000			640	40,914	17,019	42,549	6,423	12,731	852,936	--
Relative Share in Net Supply (%)	77.8	8.0	--	--	0.1	4.8	2.0	5.0	0.8	1.5	100	
Conversion Processes												
Charcoal Manufacture	43,920	--	32,940	10,980	--	--	--	--	--	--	--	--
Electric Generation	--	--	3,164	--	--	--	--	(4,513)	--	1,349	--	--
Losses in Transmission & Distribution	--	--	--	--	--	--	--	--	--	(3,119)	(3,119)	--
Inefficiency in Conversion	--	--	36,104	--	--	--	--	--	--	--	(36,104)	--
Available to Final Consumers	619,740	69,000	--	10,980	640	40,914	17,019	38,036	6,423	10,961	813,713	100.0
Household and Cottage Industry	619,740	54,900	--	10,980	548	--	16,617	--	--	4,469	707,254	86.9
Commerce and Administration		--	--	--	84	--	20	476	--	2,445	3,025	0.4
Industry and Construction	--	14,100	--	--	8	--	377	4,868	6,208	4,047	29,608	3.6
Transport	--	--	--	--	--	--	--	--	--	--	73,826	9.1
Road	--	--	--	--	--	40,833	5	29,676	--	--	70,518	--
Railway	--	--	--	--	--	--	--	2,706	--	--	2,706	--
Air	--	--	--	--	--	77	--	--	--	--	77	--
Water	--	--	--	--	--	--	--	310	215	--	525	--

Source: Mission estimate. Assumptions explained in note.

ENERGY BALANCE, 1982 - EXPLANATORY NOTE

Methodology and Sources of Information

1) Gross Supply:
   (a) Fuelwood: as indicated in Annex 5
   (b) Residues: as indicated in Annex 5
   (c) Petroleum Imports and Exports: 1982 Statistics of "Port Autonome De Cotonou -- Statistiques Mensuelles -- December 1982.

These statistics are given in tonnes as follows:

Total Imports:	229,476 tonnes
To Benin	112,823 tonnes
To Niger	103,475 tonnes
To Mali	46 tonnes
To Togo	5,427 tonnes
To Upper Volta	7,581 tonnes
To Others	124 tonnes

The qualitative composition of petroleum imports and exports is as follows:

Type of Product	Imports	Exports
Gasoline (m^3)	93,880	55,329
Kerosene (m^3)	75,270	31,691
Gasoil (m^3)	100,900	49,167
Fuel Oil (tons)	20,715	12,677

2) Conversion Processes

Charcoal Conversion: assumed 10 steres of wood per tonne of charcoal (One stere of wood = 1 m^3 stacked wood = 0.6 m^3 of solid wood).

Electricity (thermal): efficiency 28.5%
Thus: 1 GWh = 0.86 Tcal (at 100% efficiency)
1 GWh = 3.018 Tcal = 3.018 x 10^9 kcal
1 1 kg of Gasoil = 10,700 kcal
= 282.06 grs. of gasoil/kWh
= 343.97 lts/kWh.

The average gasoil consumption was 0,355 lts/kWh in 1983.

Electricity Imports are stated at substations. Losses in transmission and distribution average 22%.

3) Final Consumption:

(a) Petroleum Products
Source of information: SONACOP - Statistical Bulletin of Sales - and mission estimates derived from direct interviews with major energy consumers.

(a1) Gasolines: As indicated in Annex 5, petroleum products are sold at service stations and to wholesale consumers. The mission assumed that all gasoline sales are used for transport.

(a2) Kerosene: Sales in retail outlets were allocated to the household and cottage industry sector, where it is used mostly for lighting. Sales to wholesale customers were allocated: (i) to industry, the sales to public enterprises; (ii) to commerce, sales to other customers; (iii) to international bunkers, sales to aviation.

(a3) Diesel oil: The allocation of diesel oil sales to individual sectors of consumption poses difficult statistical problems and will have to be revised. According to SONACOP's Statistical Bulletin, diesel oil sales were as follows:

	m^3
SONACOP - total sales - Calendar Year 1982:	48,805
To:	
Gas Stations	10,277
State Enterprises	16,079
Public Services	581
Other Consumers	2,885
Construction	15,097
MARITIME - Internal Bunkers	378
" - International Bunkers	3,508

The demand of the various consumer groups was estimated by the mission as follows:

	m^3
Total Demand (1982 - Calendar Year):	52,936
International Bunkers	3,509
Internal Demand	49,427
Power Generation	5,500
Identified Industrial Use	4,059
Railroads	3,300
Internal Bunkers	378
Road Transport Requirements	36,190

The comparison of the two tables indicates that actual demand is about 10% higher than sales. The difference could be due to private imports from Nigeria.

The mission opted to allocate actual sales according to the demand estimates, deducing the deficit from the transport sector.

A large portion of diesel oil sales to the industrial sector is used for transport purposes. The sales to the construction sector appear very large and should be carefully revised by SONACOP.

(A4) Fuel Oil: The fuel oil sales reported by SONACOP do not include direct imports made by the cement plant at ONIGBOLO. The overall balance estimated by the mission is as indicated below:

Fuel Oil Balance	
Total Sales:	7,583 tons
Less exports (Bunkers)	1,188
Internal Sales	6,395
Less transport	221
Industrial Sales	6,174
Industrial Consumption	9,273
Direct Imports by ONIGBOLO	3,099

Annex 2.2

BENIN: EFFECTIVE END-USE ENERGY CONSUMPTION IN 1982
(in tons of oil equivalent)

	Biomass	Oil Products	Electricity	Total	%
Households & Cottage Industry	87,154	5,287	4,022	96,463	75
Commerce & Administration	-	338	2,201	2,539	2
Industry & Construction	4,935	5,867	4,047	14,849	11
Transport	-	15,588	-	15,588	12
Total	92,089	27,080	10,270	129,439	
%	71	21	8		100

Source: Mission estimates based on Annex 2 and the following efficiency factors in energy utilization:

Sector	Energy Form	Efficiency Factor %
Household & Cottage Industry	Fuelwood	13
	Agricultural Residues	7
	Charcoal	25
	LPG	55
	Kerosene	30
	Electricity	90
Commerce & Administration	LPG	55
	Kerosene	35
	Gasoil/Diesel	60
	Electricity	90
Industry & Construction	Agricultural Residues	35
	LPG	80
	Kerosene	15
	Gasoil/Diesel	30
	Fuel Oil	70
	Electricity	100
Transport		
Road	Gasoline	20
	Gasoil/Diesel	25
Railways	Gasoil/Diesel	30
Air	Gasoline	20
Water	Gasoil/Diesel	30
	Fuel Oil	20

BENIN: ENERGY BALANCE, 1984
(In tons of oil equivalent)

	Primary Energy				Secondary Energy								
	Crude Oil	Fuel-wood	Agricul-tural Residues	Conver-sion Losses	Char-coal	LPG	Gaso-line	Kero-sene	Gas/Diesel Oil	Fuel Oil	Electri-city	Total Energy	Relative Share %
Gross Supply													
Domestic Production	360,000	708,730	69,000	--	--	--	--	--	--	--		1,137,730	
Official Imports	--	--	--	--	--	707	51,013	39,214	54,391	14,414	8,337	168,076	
Exports	(360,000)	--	--	--	--	(4)	(5,738)	(6,847)	(8,531)	(2,730)	--	(383,850)	
International Bunkers	--	--	--	--	--		--	(16,725)	(4,890)	(1,542)	--	(23,157)	
Inventory Change and Statistical Error						(144)	584	(126)	(1,367)	196		(857)	
Net Supply	--	708,730	69,000		--	559	45,859	15,516	39,603	10,338	8,337	897,942	
Relative Share in Net Supply (%)		78.9	7.7			All Petroleum Products, 12.5%					0.9		
Conversion Processes													
Charcoal Manufacture		(46,900)		35,174	11,726							--	
Electric Generation				12,651					(16,120)	(1,690)	5,159	--	
Losses in Transmission & Distribution											(2,573)	(2,573)	
Inefficiency in Conversion				47,825								(47,825)	
Available to Final Consumers		661,830	69,000	--	11,726	559	45,859	15,516	23,483	8,648	10,923	847,544	
Household and Cottage Industry		661,830	54,900		11,726	450		15.230	--	--	4,766	748,902	88.4
Commerce and Administration						101		22	500		2,616	3,239	0.4
Industry and Construction			14,100			8		260	5,923	8,648	3,541	32,480	3.8
Transport												62,923	7.4
Road							45,740		16,763			62,503	
Railway								4				4	
Air							119					119	
Water									297			297	

Annex 4.1

BENIN: ENERGY BALANCE PROJECTION TO 1988
(In tons of oil equivalent)

	Fuelwood	Agricultural Residues	Conversion Losses	Charcoal	LPG	Gasoline	Kerosene	Gasoil	Fuel Oil	Electricity	Total Energy	Relative Share
												%
Gross Supply												
Domestic Production	795,870		71,300								867,170	
Imports					1,213	56,972	46,673	71,210	51,236	12,731	240,035	
International Bunkers							21,705				21,705	
Exports										422	422	
Net Supply	795,870	71,300			1,213	56,972	24,968	71,210	51,236	12,309	1,085,078	
Relative Share	73.3	6.6	-		0.1	5.3	2.3	6.6	4.7	1.1	100.0	
Conversion Processes												
Charcoal Manufacture	(42,840)		27,540	15,300								
Electric Generation			16,105					(9,300)	(15,236	8,431		
Losses in Transmission and Distribution										(2,528)	(2,528)	
Inefficiency in Conversion			(43,645)								(43,645)	
Final Consumption	753,030	71,300		15,300	1,213	56,972	24,968	61,910	36,000	18,212	1,038,905	100.0
Household & Cottage Industry	753,030	54,900		15,300	1,047		24,968			7,863	857,078	82.5
Commerce & Administration					166		30	715		4,826	5,737	0.6
Industry & Construction		16,400						14,000	36,000	5,523	71,923	6.9
Transport											104,167	10.0
Road						56,885		41,500			98,385	
Railway								3,290			3,290	
Air						87					87	
Water								2,405			2,405	

Source: Mission estimates.

ENERGY BALANCE PROJECTION TO 1998
(In tons of oil equivalent)

	Fuelwood	Agricultural Residues	Hydropower	Conversion Losses	Charcoal	LPG	Gasoline	Kerosene	Gasoil	Fuel Oil	Electricity	Total Energy	Relative Share
													%
Gross Supply													
Domestic Production	1,011,460	94,900	8,347									1,114,707	
Imports						3,444	122,924	94,493	150,791	85,850	24,536	482,038	
International Bunkers								45,376				45,376	
Exports													
Net Supply	1,011,460	94,900	8,347	-	-	3,444	122,924	49,117	150,791	85,850	24,536	1,551,369	
Relative Share	652	6.1	0.5			0.2	7.9	3.2	9.7	5.5	1.6		
Conversion Processes													
Charcoal Manufacture	(73,370)			47,160	26,210							-	
Electric Generation			(8,347)	19,157					(21,900)	(5,520)	16,610	-	
Losses in Transmission and Distribution											(4,469)	(4,469)	
Inefficiency in Conversion				(66,317)								(66,317)	
Final Consumption	938,090	94,900	-	-	26,210	3,444	122,924	49,117	128,891	80,330	36,677	1,480,583	100
Household & Cottage Industry	938,090	76,900			26,210	2,973		49,057			12,854	1,106,084	74.7
Commerce & Administration						471		60	1,405		9,493	11,429	0.8
Industry & Construction		18,000							30,225	80,330	14,330	142,885	9.7
Transport												220,185	14.9
Road							122,813		89,595			212,408	
Railway									5,261			5,261	
Air							111					111	
Water									2,405			2,405	

Source: Mission estimates.

FUELWOOD AND CHARCOAL CONSUMPTION IN HOUSEHOLD AND COTTAGE INDUSTRY

Data:

1. Very little field work has been done in Benin to measure actual consumption of fuelwood and charcoal. A quick survey made by Uhart in 1976 indicated that households used two sacks (25 kg each) of charcoal per month and that fuelwood consumption averaged one stere per month. Assuming a six person household, this represents a unit consumption of 100 kg/capita per year for charcoal and 840 kg of fuelwood/capita/year. We believe that these estimates are considerably biased upwards. A main problem is the lack of definition of the measurement units used in surveys.

2. Von Aufsess, Marsch and Mueller in 1979, following Bourguignon, estimated that consumption per household in Cotonou would fall to about 0.66 steres per month in the future.

3. In 1978, A. Bertrand measured the volume of forestry products entering Cotonou at 100,000 tons of fuelwood and 4,100 tons of charcoal. At that time, the city had a population of 300,000 people.

4. In 1982, a socio-economic survey carried out in Cotonou by Gigg indicated that already an important fuel substitution process had taken place. Fuelwood was used by 54.2% and charcoal by 20.5% of households. The remaining 25% of households were using other commercial fuels for cooking.

5. Assuming that the substitution process had accelerated in recent years and that in 1978 75% of households used fuelwood and 15% charcoal, Bertrand's survey can be translated into effective per capita consumption rates of 444 kg per year for fuelwood and 91 kg for charcoal.

6. These figures are relatively close in line with the results that can be arrived at by estimating minimum useful energy requirements at 2500 kcal/day for a household (Table 1). The minimum level is inferred from: (a) Siwatibau (1981), who estimated the minimum gross energy consumption for cooking one meal in Fiji at 1464 kcal, using a kerosene stove with a 29% efficiency; (b) Prasad arrived at a similar result using a theoretical approach. He estimated minimum useful energy requirements at about 500 kcal for cooking one meal and 2 liters of tea. In practice, cooking energy requirements in Africa are considerably higher than these theoretical values because of the custom of stewing food over long periods of time to obtain special quality sauces. Therefore the minimum caloric requirements were doubled in Table 1.

Table 1: MINIMUM FUELWOOD AND CHARCOAL REQUIREMENTS

Fuelwood

Minimum useful energy requirements per household	2500 kcal/day
Wood Stove efficiency	10%-15%
Gross energy input per household	25,000-16,670 kcal/day
Size of household	5.19 persons
Calorific value of fuelwood	3,500 kcal/kg
Average per capita consumption	1.38-0.92 kg/day
Average per capita consumption	504-336 kg/year

Charcoal

Useful energy requirements per household	2500 kcal/day
Charcoal stove efficiency	20%-25%
Gross energy requirements	12,500-10,000 kcal/kg
Calorific value of charcoal	7200 kcal/kg
Average per capita consumption	122-98 kg/year

7. In this report, per capita fuelwood consumption in households is taken as 1.21 kg/day (or 440 kg/year) in urban areas, and 20% higher in rural areas (528 kg/year); the equivalent charcoal consumption has been estimated at 110 kg/year. 1/ These figures compare with other data available for the region (Table 2). However, caution has to be expressed in the sense that many surveys have not actually measured consumption, and arbitrary mass/volume/calorific conversion factors have been used. The surveys indicate that in the dryer areas rural fuelwood consumption tends to be lower than urban, whereas in more humid countries the reverse is the case.

1/ In the energy balance, total fuelwood consumption is increased by 10% to take into account artisanal consumption.

Table 2: WEST AFRICA: PER CAPITA FUELWOOD AND CHARCOAL CONSUMPTION
(kg/capita/day)

Countries	Fuelwood	Charcoal
Upper Volta	1.1(R)-1.5(U)	
Mali	1.0-2.54 a/	0,047
Niger	0.76(R)-1.44(U)	
Nigeria	0.86(R)-1.09-1.24(U)	0,0236
Senegal	1.49(R)-1.14(U)	--
Tunesia	0.7(U)-1.5(R)	--
Congo	1.8	--
Ivory Coast	1.5	0,330
Liberia	2.0	--
Togo	1.13-4.5	0,148-0,225

Notes:
a/ includes space heating and the preparation of Dolo (millet beer).

Source: Consommation et utilisation des combustibles ligneux en Afrique Occidentale et Centrale, Centre Technique Forestier Tropical - April 1979.

8. Fuelwood consumption can also be correlated to the availability of wood. A recent FAO study has assessed gross consumption as shown in Table 3.

Table 3: FUELWOOD CONSUMPTION IN AFRICA

	GJ/hab/year	kg/cap/year
Sahara zone countries	5- 6	341-409
Sahel zone countries	6- 8	409-546
Sudanese zone countries	8-10	546-680
Guinean zone countries	10-14	680-955

Source: FAO 1983.

Fuelwood Substitutes Used in Households

9. In the Southern region, the coconut hulls are widely used as a fuelwood substitute. To measure the impact of this energy source, it can be estimated that coconut production is about 11,000 cocos/year/ha and that each hull weighs one kilo. On the basis of 11,000 ha of coconut plantations, total supply of coconut hulls is 121,000 tons. Assuming a calorific value of 4,300 kcal/kg and that 50% of all available resource

is used for energy, coconuts are estimated to replace 74,000 tons or 100,000 m^3 of fuelwood per year.

10. In the North, millet stalks are widely used as a cooking fuel. Although there have been no actual measurements of the extent to which this resource is being used, a survey made in Upper Volta can illustrate its importance. According to Ernst, 2/ consumption is 80 kg/person/year, which is equivalent to 30,000 tons (40 m m^3) of fuelwood, assuming a 3,200 kcal/kg calorific value and that 50% of the rural population of the two northern provinces used this resource.

Cottage Industry Fuelwood Consumption

11. Fish smoking, salt production, baking and food preparation are some of the major fuelwood using cottage industries. In this report, it is conservatively estimated that about 260,000 m^3 of wood, the equivalent of 10% of total fuelwood consumption, is used for these activities. This figure should be validated through a survey because in some African countries the share of cottage industry equals 50% of household consumption.

Fish Smoking

12. In South Benin, fishing is an important economic activity. Bertrand has estimated that about 30% of the catch is preserved through smoking the fish on a fuelwood and herb fire. On the average, this process requires about 2 steres of wood per ton of fish. Estimating the fish production at about 21,000 tons/year, fuelwood consumption would amount to 12,600 steres or 7,600 m^3 of solid wood per year.

Bakeries

13. Bread baking as a cottage industry is a traditional means of increasing the household revenue. On the average 100 kg of flour per week are processed by individual bakers. It can be estimated that in Benin approximately 10% of all flour is processed in family bakeries, or 2,900 tons per year. Assuming an energy consumption level of 2 steres per week per baker, total annual consumption could be estimated at about 35,000 m^3 of solid wood.

2/ E. Ernst, Fuelwood Consumption among Rural Families in Upper Volta, Ouagadougou, July 1977.

Annex 6

TOTAL PETROLEUM SALES - ENERGY PRODUCTS
(in Cubic Meters)

	Gasoline		Kero-				Aviation	Total
	Super	Regular	sene b/	Gas Oil	Fuel Oil	LPG a/	Gasoline	Sales
Fiscal Year								
1975/76	8,589	32,090	27,474	32,922	—	676	--	101,751
1976/77	8,490	32,312	26,456	34,302	—	611	--	102,171
1977/78	9,634	36,012	29,176	34,191	—	730	--	109,743
1978/79	12,857	44,405	34,968	48,473	—	833	--	141,536
1979/80	12,360	34,067	18,605	40,466	—	927	--	106,425
1980/81	8,995	23,941	37,019	46,554	8,778	1,023	375	126,685
1981/82	10,398	27,182	48,107	50,860	7,663	1,114	30	144,742
Calendar Year 1982	11,431	25,424	41,112	48,805	8,067	1,129	105	136,073
1983	12,396	22,825	34,191	42,987	9,919	1,087	162	123,567
1984	19,723	42,002	40,203	54,260	11,578	987	157	168,910
Average Rate of Growth (%)								
FY76/79	14.4	11.4	8.4	13.8		7.2		11.6
FY80/79	(3.9)	(23.3)	(46.8)	(16.5)		11.3		(24.8)
FY81/80	(27.2)	(29.7)	99.0	15.0		10.4		
FY82/81	15.6	13.5	30.0	9.2	(12.7)	8.9		
CY83/82	8.4	(10.2)	(16.8)	(11.9)	23.0	(3.7)	54.3	(9.2)
CY84/83	59.1	87.6	17.6	26.2	16.7	(9.2)	(3.1)	36.7
CY84/82	72.5	65.2	(2.2)	11.2	43.5	(12.6)	49.5	24.1

a/ Original information expressed in kg. For conversion density = 0.54.

b/ Includes Jet A-1 fuel.

Annex 7

PETROLEUM SALES BY TYPE OF OUTLET - 1982 CALENDAR YEAR
(in cubic meters)

	Gasoline						
	Super	Regular	Kerosene	Gasoil	Fuel Oil	LPG	Total
Gas Stations	10,190	23,256	21,087	10,277	-	969	65,779
Ouémé	690	819	78	662	-	62	2,311
Atlantique	8,294	12,627	4,715	4,047	-	836	30,519
Mono	304	2,464	5,898	872	-	10	9,548
Zou	376	1,990	3,302	1,002	-	21	6,691
Atacora	188	2,297	3,545	1,128	-	8	7,166
Borgou	338	3,059	3,549	2,566	-	32	9,544
Wholesale	1,346	2,168	20,025	38,528	8,067	160	70,294
Public Enterprises	423	982	277	16,079	6,385	4	24,150
Public Services	-	629	14	581	-	16	1,240
Other Consumers	134	300	18	2,885	183	131	3,651
Construction	684	257	202	15,097	-	9	16,249
Internal Maritime	-	-	-	378	235	-	613
International Maritime	-	-	-	3,508	1,264	-	4,772
Aviation	105	-	19,514	-	-	-	19,619
Total	11,536	25,424	41,112	48,805	8,067	1,129	136,073

Annex 8

PETROLEUM SALES BY TYPE OF OUTLET - 1984 CALENDAR YEAR
(in cubic meters)

	Gasoline Super	Gasoline Regular	Kerosene	Gasoil	Fuel Oil	LPG	Total
Gas Stations	19,138	40,551	19,332	13,873	-	798	93,692
Ouémé	2,098	3,314	214	927	-	33	
Atlantique	14,898	24,271	3,639	4,850	-	676	
Mono	550	3,324	6,668	2,125	-	11	
Zou	874	3,667	3,142	1,409	-	28	
Atacora	230	2,713	3,967	1,503	-	11	
Borgou	488	3,262	1,702	3,059	-	39	
Wholesale	742	1,451	20,871	40,387	11,578	189	75,218
Public Enterprises	380	970	276	25,268	9,656	4	
Public Services	11	291	6	1,571	-	22	
Other Consumers	126	181	39	5,865	196	162	
Construction	68	9	46	1,358	-	1	
Internal Maritime	-	-	-	362	-	-	
International Maritime	-	-	-	5,963	1,726	-	
Aviation	157	-	20,504	-		-	
Total	19,880	42,002	40,203	54,260	11,578	987	168,910

Source: SONACOP Direct Information.

PETROLEUM PRODUCT PRICES - 1983
(FCFA/liter)

	BENIN a/										TOGO b/							
	Gasoline										Gasoline							
	Premium	%	Regular	%	Kerosene	%	Gas Oil	%	Fuel Oil c/	%	Premium	%	Regular	%	Kerosene	%	Gas Oil	%
Retail Price (Jan. 82)	165.	100.	162.	100.	100.	100.	132.	100.	114,70	100.	205.	100.	200.	100.	135.	100.	180.	100.
Fob Cost	78,21		74,63		78,67		78,84											
Other Import Costs (Freight)	60,38		59,30		63,76		66,65											
Total Landed Cost	84,25	51,1	80,56	49,7	85,05	85,1	85,50	64,8	73,5	81,6	95,20	46,4	91,84	45,9	96,53	71,5	93,36	51,9
Taxes	36,82	22,3	36,22	22,4	9.573	9,6	22,39	17,0	11,64	10,1	68,26	33,3	67,36	33,7	31,29	23,2	32,91	18,3
Storage Cost	1,63		1,50		1,50		1,00				1,45		1,45		1,45		0,85	
Stabilization Price Fund	10,00	6,1	10,0	6,2	10,0	10,0	6,00	4,5			16,7	8,1	16,22	8,1	(15,31)	(11,3)	31,59	17,6
Stabilization Transport Fund	1,50		1,50		1,50		1,50											
Expenditures	6,314	3,8	6,054	3,7	4,461	4,5	4,461	3,4	8,405	7,3	9,871	4,8	9,709	4,9	8,719	6,5	8,992	5,0
Profits for Company(ies)	1,183	0,7	1,13	0,7	1,179	1,2	1,089	0,8	20,11		1,51	0,7	1,42	0,7	1,32	1,0	1,31	0,7
Gains or Losses	16,097	9,8	17,829	11,0	(21,57)	(21,6)	0,365	0,3										
Distribution Costs	2,21	1,3	2,21	1,4	3,31	3,3	4,69	3,6	1,045	0,9	6,0	2,9	6,0	3,0	6,0	4,4	6,0	3,3
Distribution Margin	5,00	3,0	5,00	3,1	5,00	5,0	5,00	3,8			6,0	2,9	6,0	3,0	6,0	4,4	6,0	3,3

a/ June 1983 levels - as established by regulation dated Jan. 1982.
b/ June 1983 levels - as established by regulation dated Oct. 1981.
c/ October 1982 - Fuel Oil 1500 with maximum 3%S.

WEST AFRICA - PETROLEUM PRODUCT CONSUMPTION -1981

	LPG	Gasoline	Motor Gasolines	Kerosene	Jet Fuel Bunker	Jet Fuel Internal Demand	Diesel Oil Bunker	Diesel Oil Internal Demand	Fuel Oil Bunker	Fuel Oil Internal Demand	Total Consumption Bunker	Total Consumption Internal Demand	Total
Angola	23		80	21	68	12	80	195	260	200	408	531	939
Benin		--	30	20	8	--	--	40	--	8	8	98	106
Cape Verde	1		2	8			60	20	15	3	75	34	109
Congo	2	1	40	2	10	5	--	30	--	5	10	85	95
Equatorial Guinea			4	6				12			--	22	27
Gabon	4	10	35	20	15	--	20	200	70	220	105	489	594
Gambia	--		22	5			--	24	--	--	--	51	51
Ghana	8		210	105	40	--	30	185	--	50	70	558	628
Guinea		1	46	19	2	--	--	44	--	173	2	283	285
Guinea Bissau	1		7	1	--	5	--	15	--	--	--	29	29
Ivory Coast	18	40	225	57	7	68	5	285	--	79	52	732	784
Liberia	1	1	69	6	53	1	10	115	45	300	108	493	601
Mali			50	10	5	--	--	45	--	22	5	127	132
Mauritania	3		30	3	10	--	--	120	--	35	1-	191	201
Niger		1	36	4	--	14	--	100	--	5	--	160	160
Nigeria	23	5	2,900	1,185	--	65	40	1,780	60	840	100	6,848	6,948
Senegal	5	3	125	18	105	5	100	240	200	390	405	786	1,191
Sierra Leone		1	45	30	10	5	60	44	60	90	131	214	345
Togo			55	--			--	124	--	46	--	225	225
United Republic of Cameroon	6	2	146	68	30	10	--	60	--	90	30	382	412
Burkina			56	11			--	68	--	15	--	150	150
Western Sahara	--	1	5	2	2	--	--	32		13	3	52	55
Zaire	1	8	180	80	90	20	--	360	30	150	120	799	919
Total (in '000 tons)	96	74	4,398	1,684	455	210	405	4,138	740	2,784	1,642	13,339	14,981

Annex 11

WEST AFRICA PETROLEUM MARKET - HISTORICAL TRENDS

	1970		1978		1981	
	Bunkers	Internal Demand	Bunkers	Internal Demand	Bunkers	Internal Demand
Angola	266	516	287	823	408	531
Benin	7	93	12	111	8	98
Cape Verde	452	9	76	31	75	34
Equatorial Guinea	--	12	77	574	105	22
Gabon	63	284	77	574	105	489
Gambia	--	15	--	44	--	51
Ghana	36	720	71	752	70	558
Guinea	2	249	3	278	2	283
Guinea-Bissau	--	20	--	28	--	29
Ivory Coast	23	737	10	1,326	52	732
Liberia	57	431	108	438	108	493
Mali	7	66	5	122	5	127
Mauritania	4	128	8	179	10	191
Niger	--	66	--	143	--	160
Nigeria	--	1,620	45	6,038	100	6,848
Senegal	1,226	344	491	683	405	786
Sierra Leone	141	230	125	202	131	214
Togo	--	85	--	141	--	225
United Republic of Cameroon	47	202	50	464	30	382
Burkina	--	47	--	114	--	135
Western Sahara	2	23	4	56	3	52
Zaïre	170	549	100	756	120	799
Total	2,506	6,560	1,480	13,402	1,642	13,324
Total excluding Nigeria		4,940		7,364		6,476

Growth Rates:

Total Demand, including Bunkers:	1978/70 = 6.4%/year	1981/78 = 0.19%/year
Internal Demand	1978/70 = 9.3%/year	1981/78 = 0.19%/year
Internal Demand, excluding Nigeria	5.1	-4.2
Internal Demand, Nigeria	17.9	4.3
Bunkers	5.1	3.5

Source: United Nations - J Series.

Annex 12

WEST AFRICAN REFINING CAPACITY (MB/CD)
(January 1, 1983)

	Crude Distillation	Cat. Reform	Cat. Crack	
Mauritania	20.00	5.16	0.00	Somir - Nouadhibou
Senegal	18.00	1.90	0.00	Ste. Africaine de Raf. - Dakar (M'bao)
Sierra Leone	10.00	0.00	0.00	Sierra Leone Petr. Ref. Co. - Freetown
Liberia	15.00	2.00	0.00	Liberia Petr. Ref. - Monrovia
Ivory Coast	80.00	14.60	0.00	Ste. Ivoirienne de Raffinage - Abidjan
	10.00	0.00	0.00	Ste. Multinationale de Bitumes - Abidjan
Ghana	26.60	6.18	0.00	Ghanian Italian Petroleum Cl - Tema
Togo	20.00	4.40	0.00	Ste. Togolaise des Hydrocarbures - Lomé
Nigeria	100.00	17.50	21.00	Nigerian Petr. Refining Cl - Kaduna
	100.00	0.00	26.00	" - Warri
	60.00	6.00	0.00	" - Port Harcourt, Alesa Eleme
Cameroon	43.00	6.50	0.00	Sonara - Pointe Limboh
Gabon	20.00	1.40	0.00	Ste. Gabonaise de Raf. - Port Gentil
Zaire	17.00	3.50	0.00	Ste. Zairo - Italienne de Raf. - Muanda
Angola	32.10	1.90	0.00	Petrangol - Luanda
Total	571.70	70.04	47.00	

Source: Petroleum Encyclopedia and Bank staff estimates

SOMIR = Ste. Mauritanienne des Industries de Raffinnage
SONARA = Ste. Nationale de Raffinage

Annex 13

HYDRO RESOURCES OF TOGO AND BENIN

River Basin		Dam Site a/	Average Flow	Max. Head	Installed Capacity	Average Output	Cost b/	
			(m³/s)	(m)	(MW)	(GWh)	(US$x10⁶)	($/kW)
TOGO								
Mono	10	Nangbeto	85	32	63	148	89	1,410
	12	Tetetou	99	24	24	115	85	3,540
	16	Adjarala	101	34	20 c/	80 c/	40 c/	2,000
Oti	28	Oti III	20	50	6	23	36	6,000
	29	Tchaléa	37	50	20	86	94	4,700
	37	Keran VIII	34	52	13	51	72	5,540
		Total energy potential Togo				503		
BENIN								
Ouémé	34A	Beterou	65	35	30	120	163	5,430
	24	Olougbé	93	36	42	133	135	3,210
	25A	Assanté	124	37	36	160	186	5,170
	20A	Ketou	180	48	72	271	229	3,180
Mono	16	Adjarala	101	34	20 c/	80 c/	40 c/	2,000
Oti	49	Batchanga	12	55	15	36	51	3,400
Mékrou	55	Dyodyonga	34	43	26	39 d/	18 d/	1,380
		Total energy potential Benin				839		
Variants								
Ouémé	24	Olougbé	93	36	60	164	140	2,330
	20A	Ketou	180	48	122	411	243	1,990
		Total energy potential Benin including variants				1,010		

a/ Sources: Site 10 (Nangbeto) Engineering to tender documents stage.
Sites 12, 16, 29, 24, 25A, 20A, 49: Pre-feasibility studies.
Sites 28, 37, 34A, 55: Inventory.

b/ Consultant's estimates in FCFA of January 1983 converted at US$1.00 = FCFA 350. Transmission is not included.

c/ Total installation, output and cost (40 MW, 159 GWh and US$80.00 million) split 50/50 between Togo and Benin for the purpose of discussing the resource base.

d/ Total output and cost (77 GWh and US$35.00 million) split 50/50 between Benin and Niger for the purpose of discussing the resource base.

BENIN: ELECTRIC DEMAND PROJECTIONS

	1981/82			1988			1998			1982/88	1988/98
	Sales	Gross Demand	Peak Demand	Sales	Gross Demand	Peak Demand	Sales	Gross Demand	Peak Demand	Annual Growth Rates Gross Energy Demand	
	(GWh)	(GWh)	(MW)	(GWh)	(GWh)	(MW)	(GWh)	(GWh)	(MW)	(%)	
A. World Bank: a/											
Interconnected System		151	28		258	48		595	106	8.6	8.7
SBEE- Distribution Coastal		137	24		217	38		484	85	7.3	8.4
Low Voltage	67			109			239				
Medium Voltage	45			73			177				
Bohicon-Abomey					11	2		35	7	14.0	12.3
Low Voltage	-	-		5.5			15				
Medium Voltage	-	-	-	3.5			15				
Wholesale customers											
Onigbolo		14	4		30	8		70	12	12.4	8.8
Lokossa Textile	-	-	-	-	-	-	-	6	2	-	-
Isolated Centers		13.7	3.0		22	5		84	19		
Zou-(Abomey-Bohicon)	3.7	4.7	1.0	-	-	-	-	-	-	-	-
Low Voltage	2.6						INTERCONNECTED				
Medium Voltage	1.1										
Borgou:		8.0	1.7		18	4	56	67	14	13.3	14.0
Parakou	6.5			14			43				
Other towns	-	-	-	1	-	-	8.6				
Atacora	-	1.0	0.3	-	4	1		17	5	23	16.2
Total Benin		165	31		280	52		679	120	8.5	9.2

(a) Source: Power Sector Memorandum

Assumptions:
(1) Abomey-Bohicon to be connected by 1986.
(2) Losses: Interconnected Systems - 17% in 1982; 16% in 1988; 14% in 1998
Isolated centers - 19% in 1982; 17% in 1988; 16% in 1998
(3) Load Factors: Distribution: Interconnected system 0.65; Isolated Centers: Zou-Borgou: 0.54; Atacora 0.38.
Wholesale customers: Onigbolo: 0.66
(4) Lokossa textile: As indicated in Table 2.4 - Energy Assessment mission considers that the energy requirements will be significantly lower than estimated in Power Sector Memorandum.

TOGO: ELECTRIC DEMAND PROJECTIONS

	FY81/82			1988			1998			1982/88	1988/98
	Sales	Gross Demand	Peak Demand	Sales	Gross Demand	Peak Demand	Sales	Gross Demand	Peak Demand	Annual Growth Rates Gross Energy Demand	
	(GWh)	(GWh)	(MW)	(GWh)	(GWh)	(MW)	(GWh)	(GWh)	(MW)	(%)	
Coastal Interconnected	304	329	74	470	520	108	875	980	189	7.3	6.5
Low Voltage	82	209	41	156	372	70	363	777	145		
Medium Voltage	102			166			309				
Wholesale Customers											
SNS	14		4	18		8	20		8		
OTP	60		14	60		14	100		20		
CIMAO	46		15	70		16	83		16		
Isolated Centers	15.5	18.5	4.3	29.6	35.3	8	108	127	29.5	10.5	13.7
Lama Kara	11	13	3	26	31	7	95	112	26		
Others	4.5	5.5	1.3	3.6	4.3	1.0	13	15	3.5		

Assumptions: CEET Distribution

Distribution Losses: Coastal system: 13.5% throughout the period - does not incude supply of wholesale customers. Isolated systems: 17% in 1988; 15% in the 1990's.

Transmission Losses: Coastal system 4% included in gross demand.

Load Factors: Coastal system: 0.61 and isolated centers 0.50 throughout period.

Wholesale Customers: Production to increase as indicated in Table 2.12.
Load factors around the following values: SNS: 0.30
OTP: 0.57
CIMAO: 0.59

Source: Power Sector Memorandum: Table 3.1: Adjusted to target years of energy assessment.

Annex 16

TOGO-BENIN: INTERCONNECTED SYSTEM - PROJECTION OF GENERATION REQUIREMENTS

	1981/82	1988	1998
Energy (GWH)			
Togo	329	520	980
Benin	151	258	595
Total	480	778	1575
Transmission Losses (4%)	20	31	63
Generation Requirements	500	809	1638
Non-Coincident Peaks (MW)			
Togo			
CEET Distribution	41	70	145
SNS	4	8	8
OTP	14	14	20
CIMAO	15	16	16
Benin			
SBEE Distribution (includes Abomey- Bohicon)	24	40	92
Onigbolo	4	8	12
Lokossa Textile	-	-	2
Total	102	156	295
Coincidence Factor	0.87	0.87	0.93
Coincident Peak	89	136	274
Losses (6%)	-	8	17
Generation Requirements	89	144	291
Implied Load Factor	0.64	64	64

Source: WB-Power Sector Memorandum and Mission estimate.

TOGO-BENIN: ESTIMATE OF PETROLEUM REQUIREMENTS FOR POWER GENERATION

	Generation Requirements				Specific Energy Consumption	Oil Consumption					
	1984 b/ (Real)	1984 a/ (Est.)	1988 a/	1998 a/		1984		1988		1998	
						Diesel	Fuel Oil	Diesel	Fuel Oil	Diesel	Fuel Oil
		(GWh)			(gm/kWh)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
Interconnected System:											
Demand	398	604	707	1,254							
Togo	219	417	492	839							
Benin	146	187	215	415							
Supply											
Imports	247	252	500	575							
Domestic:	117	352	207	679		49,180	64,130	10,107	44,291	31,586	91,263
SBEE-Cotonou-Old }	47	3	-	-	275	988	-	-	-	-	-
Cotonou-New }		30	469	25	230	-	7,420	-	17,065	-	6,183
CEET-Lomé)		76	-	-	235	21,389	-	-	-	-	-
Lomé-Diesel)		83	135	259	240	5,964	16,065	9,700	26,130	18,610	50,130
Lomé-)	70										
Gas Turbine)		140	2	197	360-680	15,090	40,645	407	1,096	12,976	34,950
OTP-Self-Generation		20	-		(240)	5,749	-				
Isolated Systems:		36	60	134	300	12,934	-	21,557	-	48,144	
Togo	20	20	29	61		7,186	-	10,419	-	21,916	
Benin	14	16	31	73		5,746	-	11,138	-	26,228	
Total Oil Consumption						62,114	64,130	31,664	44,291	79,730	91,263
In Togo						55,378	56,710	20,526	27,226	53,502	85,080
In Benin						6,736	7,420	11,138	17,065	26,228	6,183

a/ Based on Mission's low demand estimate.
Losses estimated at: Interconnected System: 17% in 1982; 15% in 1984; 13% in 1988; 11% in 1998.
Isolated Centers: 20% during the entire projection period.

b/ Actual, provisional figures for 1984 indicate considerable slowdown with repect to estimated figures due to curtailment of imports.

Annex 18

INSTALLED ELECTRIC POWER CAPACITY

Systems	Installed Capacity (kW)	Peak Demand (kW)	Fuel Used	Efficiency (%)
Interconnected				
Cononou - SBEE	16,260	33,000	Gasoil	30.
	16,000 d/		Fuel Oil	
Isolated	5,700			
Bohicon-Abomey b/	1,500	2,200	Gasoil	26.3
Allada	220		Gasoil	28.0
Parakou	3,000	1,500	Gasoil	30.0
Natitingou	600	300	Gasoil	25.5
Lokossa a/	380			
Self-Producers	17,600			
Bohicon-SONICOG	500		Cotton hulls	
Parakou-IBETEX	2,700	(closed)	Gasoil	
Save - Sugar Mill c/	14,400		Bagasse-Gasoil	
Other Oil Factories	n.a.			

a/ Lokossa has recently been interconnected. Units are kept as stand-by.

b/ SBEE has decided to transfer from Parakou two units with a total capacity of 2 MW. There are 4 x 300 kVA groups in Parakou which eventually could also be transferred to Bohicon. SBEE considers these solutions provisional and stresses the need to interconnect Bohicon with Atlantic system.

c/ There is a hydro site (25A) located near Savé. It has been proposed to develop this site and supply the mill during the off-harvest season (April-October).

d/ Projected to become operational in mid-1984.

Annex 19

1982 ELECTRIC TARIFFS

1. Energy Bought from CEB (From April 1982)	
US$	
Fixed monthly charge	16,667.
Peak Power (per monthly kVA)	8.52
Energy (per kWh)	0.0127
2. Energy Sold by SBEE	
	FCFA
a. Medium Voltage	
Energy (per kWh)	22
Monthly fixed charge	
- shedding	0
- no shedding	2000/kVA
- partial shedding	2000/kVA
Average price during FY81/82	24.16/kWh
b. to ONIGBOLO	
Fixed monthly charge:	40 million (for amortizing transmission line)
Peak power	1986/kVA month
Energy	4.5/kWh
Regional tax	1/kWh
Average price paid in 1982:	19.93/kWh
c. Low Voltage - Energy segments	
Tariff 1 - Commercial lighting	
1 segment - 20 kWh	36/kWh
4 segments	43.5/kWh
Tariff 2 - Households	
20 kWh	27/kWh
(15n a/ - 20) kWh	32/kWh
15n a/ 2 kWh	41/kWh
rest	37/kWh
Tariff 3 - Motor power	29/kWh
Tariff 4 - Household and Air-conditioning	
20 kWh	36/kWh
(15n - 20) kWh	42/kWh
(100P b/ - 15n) kWh	37
rest	29.5
Tariff 5 - Air conditioning	29.5
Tariff 6 - Public lighting	29.0

a/ Number of rooms in the house.
b/ Power subscribed in kW.

Annex 20

PROPOSED TARIFF - MEDIUM VOLTAGE
(in FCFA of 1982)

General Tariff	
Fixed annual charge	none
Energy (FCFA/kWh)	
Peak	49.85
Above average	33.81
Off-peak	23.02
Tariff for Extended Use	
Annual fixed charge (FCFA/kW subscribed)	17,700
or (FCFA/kW subscribed at the peak)	28,704
Energy (FCFA/kWh)	
Peak	42.62
Above average	28.91
Off-peak	19.65

LOW VOLTAGE

Household Uses	
General Tariff (P_s = 1 kW)	
1st segment (20 kWh/month)	43.92
2nd segment (" ")	27.29
3rd segment	17.73
Tariff for Large Consumers (P_s > 2 kW)	
1st segment (40 hr/month) -	49.61
2nd segment (" ")	34.67
3rd segment	23.90
Professional Uses	
1st segment (40 hr/month)	50.39
2nd segment (" ")	35.45
3rd segment	23.90
Public Lighting	
Energy	44.87

ENERGY POTENTIAL OF AGRICULTURAL WASTE PRODUCTS

Regions	Corn b/	Sorghum Millet	Oil Palm: Industry c/	Oil Palm: Cottage Industry c/	Oil Palm: Leaves d/	Cotton: Stalks	Cotton: Husks	Ground-nut	Rice	Coconut Hulls f/	Animal Waste g/	Total
Mono	27,000 to 45,000		3,800 to 7,000	12,300 to 16,500	69,500	2,000		300 to 400		12,000		126,900 to 152,400
Atlantique	46,000 to 125,000		3,800 to 7,000	12,300 to 16,500	77,500			200 to 1,000		16,100		143,300 to 243,100
Zou	28,000 to 47,000	3,000 to 5,000				9,000	1,300 to 2,000	1,700 to 2,400	300 to 600			43,300 to 66,000
Atacora	9,000 to 15,000	26,000 to 53,000				2,000		300 to 400	1,600 to 2,800		2,500	41,400 to 75,700
Borgou	15,000 to 25,000	17,000 to 35,000				39,000		300 to 400	900 to 1,700		7,500	79,700 to 108,600
TOTAL	199,000 to 334,000	46,000 to 93,000	11,400 to 21,000	36,900 to 49,500	204,000	52,000	1,300 to 2,000	3,500 to 4,900	2,800 to 5,100	52,000	10,100	61,900 to 827,600
Current Use	192,000	13,000 to 26,000	4,500 to 9,000	5,400 e/			600 + 100 a 500			26,000		69,000 to 86,700
Volume to be left on the field a/	78,900	20,300										99,200
Potential Avail-ability	100,900 to 235,900	12,700 to 46,700	6,900 to 12,000	31,500 to 44,100	204,000	52,000	400 to 900	3,500 to 4,900	2,800 to 5,100	26,000	10,100	450,800 to 641,700

ASSUMPTIONS:

a/ Recycling of 750 kg/ha of stalks and leaves to the soil in the case of corn, sorghum and millet.
b/ 20% of corn cobs are already being used as an energy source.
c/ Refers to fibers and shells and it has been assumed that industrial and artisanal production is distributed in equal proportions in each of the three southern provinces.
d/ Palm leaves were estimated in proportion to the areas of each province.
e/ Assuming that 20% of husks are used in the artisanal sector.
f/ Coconut groves are located along the coast. Regional distribution according to their coastal extension.
g/ According to the Direction de l'Elevage, animal draft agriculture is located 75% in Borgou and 25% in Atacora.

ANALYSIS OF THE ENERGY POTENTIAL OF AGRICULTURAL RESIDUES

Foreword

1. In Annex 21, the energy potential of agricultural subproducts has been estimated at 450-640 Ktoe. All the values developed in this annex are theoretical and require field testing in Benin. The following provides a detailed explanation of how these potentials were estimated.

Corn

2. This crop is mainly planted in subsistence agriculture, in exploitation units of less than one hectare. Thus, only relatively small scale projects can be envisaged at this time to use the energy potential of this crop.

Estimate of Energy Potential

Volume of corn production (agricultural year 1982/83)	273,000 tons
Weight of cobs	273,000 tons
Weight of stems and leaves (varies from 1.5 to 3.5 times the weight of corn)	409,500-955,500 tons
	682,500-1,228,500 tons

Theoretical Energy Potential:	Ktoe
Cobs (3,500 kcal/kg, 15% MC)	96
Stems and leaves (2,500 kcal)	100-230
Total	196-326

Current Use

3. Corn cobs are available at the level of the farms and villages where the corn is shelled. According to local sources, a significant amount of cobs already is being used as fuel in households, and in the southern provinces as fuel for drying and smoking fish.

4. Corn stems and leaves are now usually burned on the field. Only very small amounts are used to kindle fuelwood stoves. To make it an acceptable fuel, this material has to be densified.

Sorghum and Millet

5. Sorghum and millet are planted mainly in the two northern provinces of the Atacora and Borgou. Fuelwood is scarce in the Atacora; therefore sorghum stems frequently are used. In areas better endowed with fuelwood, stems are used to build fences, doors and other woodwork.

6. Stems are collected in the following manner: during harvesting, the stems are cut down and left on the land. The leaves dry rapidly. Farmers burn the field, but only the leaves burn while stems are protected by their water content. Once cooled down, stems are collected and easily bundled. The plantations of sorghum and millet consist of small areas, due to the land tenure system. Therefore, mechanical collection of stems does not appear possible at present.

7. The energy use of stems should be viewed in terms of alternative uses. One important potential use would be to recycle them to the field, digging them under. Research is needed to determine their value in replenishing the organic material of the soil. The opportunity cost of this resource has to consider other applications such as cattle feed and as construction material.

8. In addition to the stems, the sorghum and millet ears also have an energy potential. In the following table the theoretical energy value of this crop is estimated.

THEORETICAL ENERGY CONTENT IN SORGHUM AND MILLET

1982/83 Production of Sorghum and Millet:	69,000 tons
Weight of stems (twice the weight of grains) a/	138,000 tons
Weight of ears (3 x weight of grains) b/	34,000 tons
Theoretical energy content:	
Stems (2,500 kcal/kg)	33,800 toe
Ears (3,500 kcal/kg)	11,800 toe
Total	45,600 toe

Notes:
a/ Lower end value. Some sources estimate it four times the weight of the grains.
b/ Lower value: varies between 0.5 and 1 times the weight of grains.

Source: Mission estimate.

Oil Palm

9. Palm oil is processed in industrial plants and in small village units in the volumes indicated in the table below.

OIL PALM PRODUCTION
(in thousand tonnes per agricultural year)

	1978-79	1979-80	1980-81	1981-82 a/
Fruits collected by State-owned Industries	58.4	69.3	76.1	90.0
Industrial Oil Production	11.9	13.4	14.9	18.0
Fruits collected by artisans	201.5	260.0	267.2	n.a.

a/ Estimated by the mission.

Source: IBRD - Benin: Recent Economic Developments.

Industrial Processing of Oil Palms

10. At present, only fibers are used as an energy source. Stems are incinerated, and ashes, rich in potash, used to make soap. Hulls are not used. The total energy surplus is as follows:

1981-82 Oil Production:		18,000 tonnes
Fruit Input:		90,000 tonnes a/
Energy End Products:		
Stalks:	27,000-41,000 tons x 1,300 kcal/kg	= 2.0-5.0 Ktoe
Fibers:	4,500- 9,000 tons x 2,500 kcal/kg	= 4.4-8.8 Ktoe
Shells:	9,000-18,000 tons x 4,000 kcal/kg	= 3.5-7.1 Ktoe
Total		9.9-10.9 Ktoe
Energy Used		4.4- 8.8 Ktoe

a/ Oil yield is about 18-20% in weight according to the Grand Hinvi plant manager.

Artisanal Processing of Oil Palm

11. There is no direct information on the volume of palm oil fruits collected by the rural population. The mission estimated this volume at 267.2 Mtoe for 1980/81, based on the sales of areca (Palmiste) to SONICOG (26,300 tons) and assuming a ratio of areca to palm oil fruit of 9%.

This percentage is much larger for the palm oil species Dura grown in natural palm groves than for the selected palm oil species planted in the large state-owned groves, where the percentage of areca/fruit is only 3-4%.

THEORETICAL ENERGY CONTENT OF OIL PALM SUBPRODUCTS
(Artisanal Sector)

Volume of fruits processed	267,200 tons	
	Volume (KT)	Energy Potential (Ktoe)
Associated Subproducts		
Stalks	80-100	10.3-15.0
Fibers	12-15	3 - 4
Shells a/	59-75	23 -29
Total		35.3-48

a/ In the Dura palm variety, the amount of shells is larger than that of fiber. The selection of varieties has emphasized the increase of the volume of the pulp to increase oil output.

Palm Leaves

12. According to a FED study, 1/ the annual production of leaves equals three times the production of fruits. Thus, for the year 1980/81 the amount of leaves produced is 1,020 Ktons, equivalent to 200 Ktoe (assuming a calorific value of 2,000 kcal/kg). To use the energy value of these leaves directly, they must be cut and bundled, or ground and bound into briquettes.

13. Present use of subproducts in the artisanal oil palm sector: There is no data on their use in Benin. In other West African countries (specifically Ivory Coast), these are as follows:

(a) The stalks are used as fertilizer, and eventually to kindle wood fires.

(b) The fibers are pressed into cakes, and dried. Occasionally these cakes are used for lighting.

(c) The nuts are dried and then opened. The shells are sold to blacksmiths.

1/ Conseil de l'Entente - FED: "Valorisation des résidus végétaux dans les pays du Conseil de l'Entente." LBTB, Apavé, Abidjan, 1981.

Fuelwood Use in Artisanal Palm Oil Processing

14. Artesial 2/ indicates that fuelwood consumption has been measured in the field at 0.5 steres per 150 kg of fruit. 3/ Thus, for processing the 1980/81 production, fuelwood consumption would be about 128 Ktoe. Because of the magnitude of this figure, the mission strongly suggests that a survey of this artisanal sector be made.

Measures to increase the efficiency of the Oil Palm Sector

15. The artisanal processing of the oil palm fruit appears to make poor use of the energy potential of the associated end products. Furthermore, the oil yield in artisanal extraction is about 50% of that obtained by industrial processing.

16. On the other hand, the industrial sector has a processing capacity of about 210 K tons in three modern plants, but processes only about 90 Kt or 43%. Should the recommended survey of the artisanal sector confirm such a large demand for fuelwood in palm oil processing, it would be necessary to envisage a two-pronged policy:

(a) Inducing the transfer of artisanal activities to the industrial sector.

(b) Increasing the energy efficiency in the artisanal sector.

17. Transfer of Processing to the Industrial Sector. In the following table, the energy savings resulting from a transfer of artisanal to industrial processing are estimated at 45 Ktoe per year. The estimate is based on the assumption that industrial capacity is equipped to handle the natural variety of the oil palm fruit and that total installed capacity is used; and additionally, that an economic price for the fruit can be established that would give an incentive to sell the fruit to SONICOG and cover the transport costs. Further, it will be necessary to assess the economic effects of this transfer on the level of employment and on the production costs.

18. Improving Energy Use in the Artisanal Sector. The artisanal activity can be improved by: (a) improving the efficiency of the stoves and promoting the systematic use of all end products of the oil palm fruit; and (b) introducing more efficient processing units.

2/ Artesial - Ministère Français de la Coopération et du Développement - 1982.

3/ Assumption: 1 stere = 0.6 m^3 of solid wood = 0.42 ton.
1.4 tons of wood/ton of fruit or 0.48 Toe/ton of fruit.

PRESENT OIL PALM PROCESSING STRUCTURE AND ENERGY USE
SAVINGS FROM TRANSFER OF PROCESSING FROM THE
ARTISANAL SECTOR TO INDUSTRIAL UNITS

	Quantity of Fruit Processed (KT)	Energy used in Process (Ktoe)	Energy Potential of Subproducts (Ktoe)	Energy Source Used	Energy Balance Surplus (Deficit) (Ktoe)
Present Situation					
Industry	90	6.8	16.2	Fibers	9.4
Cottage Industry	267	128.0	43.2	Fuelwood	(84.8)
Total	357	134.8	59.4		(75.4)
Maximum Transfer					
Industry	200	15.1	34.0	Fibers	18.9
Cottage Industry	157	75.4	25.4	Wood	(50.0)
Total	357	90.5	59.4		(31.1)
Deficit Reduction:			75.4 - 31.1	=	44.3

19. At this time, and given the uncertainty of the oil palm plantation itself, the mission suggests that only the first set of measures be envisaged.

Groundnut

Total production 1982/83:	35,000 tons
Shells (25-35%)	9,000-12,000 tons
Energy Potential (Calorific Value - 4,000 kcal/kg)	3.5-4.7 Ktoe

20. Official production figures indicate a decline in production, probably induced by the low price paid by official commercial channels. The most important production is obtained in the Zou province (50%) and Oueme (20%), part of which is probably exported to Nigeria. Processing in industrial plants represents about 10% of total production. (In 1983, SONICOG will produce 1,000 tons of oil, with an input of 2.5-4.0 Ktons).

21. Artisanal processing involves manual shelling, roasting, grinding and extraction. The yield of oil (oil/nut) is about 30% (50% in industries). The cake is used for human consumption. The process requires heat and mechanical energy. Probably fuelwood is used to

supplement the energy derived from shells, and gasoline and diesel motors are used for grinding.

22. Unless prices for groundnut are increased, inducing farmers to sell their product to industrial units, there will be no energy surplus available from this crop.

Cotton

In 1982/83 cotton ball production	31,000 tons
cotton seed production	17,000 tons
of which: Borgou	13,000 tons
Zou	4,000 tons

Waste material with an energy potential is produced at:

Energy Potential	Volume KT	Calorific Value kcal/kg	Energy Potential Ktoe
Field: Stems and Stalks	127	4,100	50
Ginning and Delinting Units			
Installed Capacity:			
Kandi 15 Kt/y			
Glazone 18 Kt/y			
Parakou 18 Kt/y			
Agoumé 18 Kt/y a/			
Savalou 8 Kt/y a/			
Linter	1.7-2.1	3,500	0.6-0.7
Seed Shelling Units			
Bohicon 34 Kt/y			
Shells			
(30% of seeds) b/	3.9	3,900	1.5
Total			52.1

a/ Not in operation.
b/ Approximately 4000 T of seeds are directly exported. Thus, only 13 KT are shelled in Benin.

Current Use of Waste Products

23. SONICOG, in its oil processing unit in Bohicon, uses part of the shells (600 toe) as an energy source. Thus, a surplus of about 900 Toe is available. Linters are used in other parts of the world to make felt, or are employed in explosives (fulmiton). In Benin, delinting takes place during shelling, and linter is stored at Bohicon awaiting the development of a market.

Rice

1982/83 production: 9,000 tons of paddy rice.

Produced in the Atacora (60%)
Borgou (31%)

Energy Potential	Volume KT	Calorific Value kcal/kg	Energy Potential Ktoe
Straw (1-2 x weight of grain)	9 -18	2,500	2.2-4.4
Husks (20-30% weight of grain)	1.8-2.7	3,000	0.5-0.8
Total			2.7-5.2

24. The regions where rice is produced north of Borgou and the Atacora are those that have the most important fuelwood shortage. There are two husking plants in that region, each with an installed capacity of 2,000 tons/year (Natitingou and Malanville), but which operate at about 25% of capacity. They use diesel engines as their energy source.

Cashew Nut

25. In Benin there are about 10,000 ha planted with cashew nut trees, of which 5,500 are under the management of the CARDER's and about 4,700 ha in the hands of peasants.

26. The cashew nut industrial processing unit is located in Parakou. It lacks feedstocks and in 1983 was practically closed. During 1977/78 it processed 971 tons of feedstock, while in 1981/82 only 497 tons.

27. The energy balance below shows that there is an opportunity to reconvert this industrial unit to using the associated waste material. However, this should not be envisaged until the main problem of the plant - lack of raw material - has been resolved and the plant proves to be economical.

Energy Balance

Processing of feedstock		497 tons	
Production:	Nuts	69 tons	
	Balsam	22 tons	
Water Loss (6%)		30 tons	
Waste Material - shells		376 tons	
Energy Content (3000 kcal/kg)			111 toe
Energy Requirements:			35 toe
Fuel Oil (cooking of nuts)		20 m^3	18 toe
Gas Oil (steam for washing & drying)		20 m^3	17 toe
Energy Surplus			76 toe

Animal Waste Products

28. Traditionally, cattle breeding has been an itinerant activity, and only recently has emphasis been placed on rearing draft animals for agriculture. According to Government sources, some 20,000 pairs of oxen have already been introduced. Theoretically, the energy potential from these animals' waste is on the order of 10 Mtoe 4/ that could be used in biodigestors at the farm level.

4/ 6 tons of fresh cow dung per animal/year.
50-110 m^3 of gas per ton of fresh cow dung with an average of 80 m^3. Calorific value of gas is 5,500 kcal/m^3.

29. However, given the cultural and technical constraints, the mission suggests that biodigesters be envisaged only at those breeding stations, where there is a large concentration of animals. There are four centralized breeding farms: 5/

Okpara:	which raises 700 animals in an area of 33,000 ha. This farm is almost closed.
M'Betecoucou:	has more than 1,000 animals.
Samiondji:	500 animals over 4,000 ha.
Kpinnou:	concentrated pig raising (300 animals).

30. At this stage, only Kpinnou could be considered a potential place to install a biodigestor. Biogas production could be around 5-8 toe/year.

Assumptions: 6/

Organic material cast:	180 kg/year/pig
Gas production:	280 lt/kg of material
Calorific Value	5,500 kcal/m^3

31. Also, consideration should be given to installing biodigestors in the slaughterhouse of Cotonou (50 toe/year) and in the future slaughter station in Parakou (12.5 toe/year).

5/ According to Mr. Guillaume Doussoyouvo, Adjoint Director of Cattle Breeding.

6/ Date of yields obtained from the experience at the Ranch Maya in the Philippines, which produces 371 toe/year from 22,000 pigs.

SUGAR MILL (SSS) ENERGY BALANCE
(excluding mobile equipment)

	Production (thousand tons)				Energy Needs (thousand toe)			
	Cane	Refined Sugar	Bagasse (tons)	Bagasse (10^3 Toe)	Irrigation	Sugar Production a/	Total	Net Deficit
1982/83	102	8	34	(7.8)	4.8	5.6	10.4	2.6
1983/84	150-195	12-15.6	50-65	(11.5-14.9)	6-6.5	8.4-10.9	14.4-17.4	2.5-2.9
1984/85	300-338	25.5-28.7	100-113	(23-26.0)	8-9	17.8-20.1	25.8-29.1	2.8-3.1
1988/89	390	35	130	(30.0)	10.0	24.5-34.5	34.5-44.5	4.5-14.5

a/ Assuming .7 toe/tonne of refined sugar. In fact some heavy oil is also used in boilers (1,000-2,000 tonnes).

EVALUATION OF NON-CONVENTIONAL RENEWABLE ENERGY TECHNOLOGIES

Use of Agricultural Waste

1. The theoretical energy balance drawn in the foregoing indicates that there is considerable potential for increasing the use of agricultural waste products. The introduction of some of these technologies would make it possible to reduce the demand for fuelwood and charcoal in the household sector and the consumption of petroleum products and electricity in the industrial sector. It would further make available more convenient forms of energy to the rural population.

2. The present retail price and economic cost of commercial energy sources will serve as comparators in making an economic feasibility analysis of the various technologies:

COST OF COMMERCIAL FUELS
(in '000 FCFA per toe)

	Households		Industry	
	Economic Cost	Retail Price	Economic Cost	Retail Price
Fuelwood: Cotonou		30		
Bohicon		15		
Charcoal		72		
Kerosene		125.7		
Diesel Oil			121	158
Fuel Oil			95.1	125.9
Electricity (isolated centers)			830.2	640.1

Small-Scale Use of Agricultural Residues

Briquetting

3. Briquets from corn, rice, cotton straw, sawdust, linters, husk, shells, etc. can be envisaged. The cost estimate is made for manual and mechanical operations.

Manual Briquetting

Assumption: Production of 1.4 tons of briquets/day
Operations 320 days/year
Total Output: 450 T/y x 2,500 kcal/kg - 110 Toe/year

Investment		
Pressing Machine (Terstaram Standard = Belgium)	FB	42,350
3 Double Moulds	FB	23,760
2 Grinders (manual choppers)	FB	58,400
Packing Material	FB	5,850
Subtotal	FB	130,360
Conversion: 7,5 FCFA/F.Belge	FCFA	977,700
Transport, Commission, Installation	FCFA	300,000
Shed (for operations, stocking of input and briquets)	FCFA	2,000,000
Total	FCFA	3,277,000

Costs	Total FCFA/year	Unit Cost FCFA/toe 100% Operation	Unit Cost FCFA/toe 50% Operation
Capital Recovery (10 years, 10% interest)	553,000	5,030	10,060
Labour (5 persons - 12,600 FCFA/per month each)	756,000	6,870	6,870
Cost of Input [a/]	180,000	1,640	1,640
Total	1,489,000	13,540	18,570

a/ Assuming a payment of 1 FCFA/2 kg of waste material, to give an incentive to the farmer to collect it in the field. The briquets also require a binding material, which could consist of mud (lowering the calorific value), dung, soda silicate (subproduct from soap factories), etc.

Mechanical Briquetting

Assumption: 1000 tons per year of material, such as corn stalks. Annual production 245 toe.

Investment		'000 FCFA
Grinder Gondart	fob	1,250
(capacity 500 kg/h)	cif	1,625
Press-Bavaria Briquette		
Press BP 500 - DM 35,000	fob	5,785
	cif	7,520
Shed		5,000
Total		14,145

Annual Costs	Total '000 FCFA/year	Unit Cost FCFA/toe 100% Operation	50% Operation
Capital Cost		7,798	15,596
Grinder (10 years, 10%)	264.5	1,080	2,160
Press (15 years, 10%)	988.7	4,035	8,070
Shed (15 years, 10%)	657.4	2,683	5,366
Maintenance		1,694	3,388
Grinder (10% of fob investment)	125.0	510	1,020
Press (5% of fob investment)	290.0	1,184	2,368
Operational Labor		1,176	1,176
Grinder (2 persons x 1 shift)	288.0		
Press (1 person x 2 shifts)	288.0		
Electricity		9,290	9,290
Grinder (7.5 kW x 2000 hr/year x 54 FCFA/kWh)	810.0		
Press (10 kW x 5000 hr/year x 54 FCFA/kWh)	2,700.0		
Total		24,994	49,990

4. The preceding rough estimates indicate that only manual briquetting of agricultural waste products is competitive with fuelwood if such a project is established in an area near main consuming centers and where a wide variety of agricultural waste products is available, guaranteeing operation during the whole year.

5. The mission recommends that the economic feasibility of such a project be tested in the maritime area where there is ample access to corn stalks, palm leaves and other waste products. However, before a decision is made, a soil analysis of the area has to be made to assess the need for waste recycling in the field and to avoid soil exhaustion. A briquetting system would drain agricultural waste products from an area of between 300-2000 ha.

Small-Scale Gasifiers (20 kW)

6. The Twente University of Technology introduced 20 kW gasifiers in Tanzania to partly fuel (dual fuel mode) existing diesel engine driven corn mills in villages by produce gas generated from corn cobs. The design was based on research and development work at THT, but adapted to local technical and socioeconomic conditions. They were designed for milling performances of 380-570 kg of corn/hr. The actual mill output was in practice considerably lower, due to long-term engine idling stemming from irregular corn supply. Yearly operations varied between 1,000 and 2,200 hrs/year. The average load factor of the mills during operation hours was on the order of 65-75%. Corn cobs were provided by either

transporting field shelled cobs to the mill site or by shelling close to the mill. About 40% of the corn cobs produced are needed to provide the power to drive the mill. Diesel oil savings were only on the order of 50% due to low load factors.

7. The investment costs of the gasifier built in Tanzania, including shelter for storing maize cobs, and training and installation, was on the order of 90,000-120,000 T.shillings or the equivalent of US$460-620, which is approximately twice the cost of equipment purchased from international manufacturers. Under those circumstances and given the low level of operations, the gasifier alternative is not economical.

Industrial Use of Agricultural Residues

8. Wood fired and combined wood-agricultural residues power systems can be commpetitive with traditional power schemes. The technology of steam systems is commercially available and has been truly proven. Gasification systems are in the developmental and demonstration stage and offer substantial efficiency advantages, especially in the small sizes of less than 1 MW. Gasification/internal combustion engine systems can easily be in the 18 to 25% range even down in the 100 kW size range. While some efficiency is gained by increasing size, the rate of increase vs. size is relatively small with gasification systems. Steam systems would have at best a 5% efficiency at 100 kW and not reach the 20% mark until 15 MW. However, the rate of increase with size is both steady and relatively greater. The efficiency difference provides a lower raw material resource cost for gasification systems as less fuel is required; however, gasification systems require fuelwood to be processed to a higher degree (less moisture allowed and smaller/consistent feedstock particle size required), hence, a compensating higher processing cost. At some kW output rating, the compensating costs balance, leaving the only potential advantage of gasification systems to be the conservation issue, as less fuelwood is required for a given kWh output. The overall cost balance point can be shown to be at a size as low as 500 kW which will be lower than the fuel cost balance point because of the capital cost advantage for steam fired plants.

9. At 500 kW capacity, a wood-fired steam system would be expected to have an overall efficiency of one half of that of a gasification system. To operate properly, the gasification plant would require the addition of the following wood processing equipment above and beyond that required by the steam plant:

(a) Wood Chipper with 5-year useful life and maintenance requirement of 10 percent of invested cost per year.

(b) Wood Dryer with 10-year useful life and maintenance requirement of 5 percent of invested cost per year. The dryer dries the wood from 50 percent MC to 20 percent MC wet basis.

(c) Add fuel operating and capital costs of $18.86 per tonne to base of $44.44 per tonne of wood consumed.

10. The operations and investment costs for these additions would result in the fuel costs increasing by 42 percent for a gasification system compared to a steam system. However, as only half the fuel is consumed because of twice the efficiency in a gasification system, the difference still favors the gasification system with its fuel costs being roughly 25 to 30 percent below that of steam plants. The capital cost (turnkey installed) of a 500 kW steam plant is estimated as $1200 per kW Dun Heilborn GmbH of Rosenheim, West Germany compared to $1800 per installed kW of gasification system obtained by extrapolation from DECON provided cost data, all based on an exchange rate of 2.7 DMK = 1 US$.

11. Assuming a 10 percent, 20-year capital recovery period for a steam plant compared to a 10 percent, 10-year recovery for gasification plant, and operating at a 55 percent load factor, the capital recovery cost advantage for a steam plant essentially balances the fuel cost advantage for gasification plants. Steam plants above 500 kW would have a definite cost advantage, while the cost advantage for those below 500 kW would steadily shift toward gasification systems.

12. The above is actually a moot analysis for present consideration. It only has value if, and when, gasification systems have been commercially proven. For present consideration, down to as low as 100 or 200 kW, steam plants represent the only commercially proven alternative for wood use in power generation. Gasification systems have great potential for power applications of up to 500 kW when reliability and safety have been satisfactorily demonstrated. The mission therefore cautions Mifor to go ahead at present with its gasification project.

13. According to the data provided by the company, power can be generated at a cost comparable to that of SBEE's marginal cost in isolated centers, assuming no opportunity cost for the wood waste.

Cost Analysis:

Gasification Project -Mifor-Bohicon

		10^3 FCFA	
Cost of equipment, including diesel groups		200,000	
Peak demand:	500 kW		
Economic Life:	12,000 hours - 4 years		
Annual Operation:	2,880 hours		
Annual Costs:			
Capital (10% interest, 4 years)		63,100	
Maintenance (10% of capital cost)		20,000	
Diesel Oil (20% of normal consumption)		11,500	
Labor (1 person at 25,000 FCFA/173 hr)		500	
Lubricants		5,800	
Total		100,900	
Output		1,444,000	kWh/y
Unit Cost		70	FCFA/kWh

14. As an alternative to Mifor's gasification project, the mission proposes to process the total amount of agro-industrial residues available in the area of Abomey-Bohicon (SONICOG's oil mill and Mifor's sawmill) and use it in a central station to generate electricity for SBEE's system and/or steam for a brewery to be established in Abomey.

TOTAL WASTE MATERIAL AVAILABLE IN BOHICON

	Tonnes	Energy Value toe
Cotton Shells	1000-2300	400-900
Sawdust and Shavings	1100	400
Total	2100-3400	800-1300

Power Generation

15. The present amount of residues available allows the possibility of installing a 500 kW steam unit that has a thermal efficiency of 8%. The investment cost of the packaged unit is US$1,200/kW. Total capital costs were increased by 35% to take into account internal transport costs and the construction of a shed and a storage area. Thus, power could be generated at a cost of FCFA 41.44, assuming no opportunity cost for residues and total animal generation of 1.25 GWh (2500 hours/year).

Annual Costs	Total Annual (10^3 CFA)
Capital Cost (20 years, 10%)	35,200
Maintenance (5% of Investment)	15,000
Labor (4 men, 25,000 FCFA per 173 hr/man)	1,600
Total	51,800
Unit Cost FCFA/kWh	41.44

Source: Mission estimate based on Heilbron price quotations.

16. It has to be stressed that the unit cost is sensitive to the load factor, and that if the available feedstock amounts to 2000 Toe/yr, annual production can increase to 2100 MW, reducing the unit cost to FCFA 25/kWh. These costs can be compared with a fuel cost alone in isolated thermal plants of FCFA 40/kWh.

Cogeneration: Electric Power and Low Pressure Steam

17. For this assumption, quotations were obtained from Compagnie Générale de Chauffe and Worthington. Thermal equipment consists of a multifuel boiler with a capacity of 4 tons of steam at 300°C and 20 Atm. The electric group (counter-pressure) has a capacity of 300 kW. Steam exhaust available: 4 T/h at 1 Atm. relative (2 Atm. absolute). The quantity of energy input to the boiler is equal to 1060 Toe. Annual operation 2,800 hours, and a power output of 840 MWh.

	'000 FCFA
Investment Costs:	
Building, storage, feedstock, handling, boiler and associated equipment	222,500
Turbo-Alternator	25,000
Transport, Installation (35%)	86,600
Total	334,100
Annual Costs:	
Capital Cost (10%, 20 years)	33,410
Maintenance (5% of investment)	16,700
Labor (4 men, 25,000 FCFA/173 h/man)	1,600
Total	51,710
Assuming electricity is sold to SBEE at FCFA 54/kWh	45,360
Cost of Steam	6,350

18. The cost of the associated steam can be compared to its generation cost in a classic boiler (based on fuel oil). Such a plant, with a recycling system for the condensates and an efficiency of 85% for the boiler, would have a cost of FCFA 72,000,000. This assumes that fuel requirements to produce 4 T/hr of steam are equal to 0.27 Toe and an economic cost for fuel oil is FCFA 95,000/toe.

19. To clarify the benefits of cogeneration to the brewery La Beninoise, the following table presents the utility costs if La Beninoise would build a fuel oil boiler and buy electricity from SBEE.

Total Costs for La Beninoise:

Assumptions:

Annual Operations: 2800 hr.
Electricity: 840 MW, at 54 FCFA/kWh.
Cost of Steam: (calculated assuming a capacity cost factor of:

$$Cost = x\ (capacity)^{0.6}$$

	'000's FCFA/year
Capital Cost (Annual)	3,600
Maintenance	700
Labor	400
Fuel	95,180
Electricity	45,360
Total	145,240

Comparison with Cogeneration from Waste:

	'000 FCFA
Total Industry Cost (Conventional Boiler - purchased power)	145,240
Cogeneration from Waste	51,710
Net Benefits	93,530

Maximum Valorization of Waste Products: 71.95 FCFA/toe

Steam Generation Alone:

Comparison of Multifuel Boiler versus Fuel Oil Boiler

The comparison is made between a boiler using 1050 Toe of cotton hulls and sawmill waste and a classic fuel oil boiler.

Capacity:	4 tons of steam/hour, 10 Atm	
Efficiency:	Agricultural Waste Boiler:	75%
	Fuel Boiler:	85%
Energy Requirements:	Agricultural Waste Boiler:	0.32 Toe/hr.
	Fuel or Boiler:	0.28
Annual Operations:	3,300 hours (Based on availability of waste products in Bohicon-Abomey)	
Cost of fuel:	FCFA 95,100/Toe - economic cost of fuel oil.	

COST COMPARISON OF ALTERNATIVE BOILERS
('000 FCFA)

	Agricultural Waste	Fuel Oil
Investment:	115,000 a/	23,000 b/
Annual Capital Charges (20 years, 10%)	13,500	2,700
Maintenance:		
5% of investment per year	5,800	
3% of investment per year		700
Labor (3,300 hrs/year)		
2 men	1,000	
1 man		500
Fuel	———	87,900
Total Annual	20,300	91,800

a/ Cost fob. FCFA 75 million + storage FCFA 10 million; Transport, commission, installation: 35% of fob price.
b/ Cost fob. FCFA 17.5 million. Transport, commission and installation: 30% of fob price.

Source: Quoted by Lardet Babcock - France.

Maximum Valorization of Waste Products in this case:

$$\frac{\text{FCFA } 91{,}800{,}000 - \text{FCFA } 20{,}300{,}000}{1{,}050} = \text{CFA } 68{,}100/\text{toe}$$

Biogas Technology

20. Although this technology has a potential for alleviating the problems of lack of energy, fertilizers, poor public health and deforestation, up to now only their application in intensive animal rearing and in industries has seemed financially viable. Widespread dissemination to rural households and communities is limited because of their capital cost, the availability of freely collected fuelwood, the constraints in meeting the users' energy needs, social and cultural habits, etc. The mission considers that the introduction of biodigesters should be limited in Benin to those financially viable applications. Current research efforts are oriented towards more efficient biogas technologies and a better understanding of the socioeconomic environment. These efforts hopefully will permit in the future a more economic and effective dissemination of biodigesters in rural areas of the developing countries, including Benin. On the other hand, the mission does not recommend proceeding with the project of building a biogas plant in Cotonou based on

septic tank waste material. In the following, these projects are evaluated.

21. Economic Analysis of Biodigesters in Benin

(a) Ranch Kpinnou:

Data:	
Number of animals	300
Potential energy production	5-8 toe
Construction Cost	FCFA 305,500-1,000,000/toe/year 1/
Energy Substituted:	Diesel Oil at the economic cost of FCFA 121,000/toe.

Investment	FCFA	4,242,875
Assuming average construction cost of FCFA 657,750/Toe/year and average production of 6.5 Toe/yr.		
Annual Capital Charge: (10%, 10 years)	FCFA	690,510
Cost of energy replaced		786,500
Saving	FCFA	95,990

This simple comparison indicates that there are savings to be achieved where there is a use for the gas and investment costs are realistic.

(b) Slaughterhouse in Cotonou:

Slaughtering capacity	50 heads/day
Capacity of cattle holding Pens	500 heads
Potential production of biogas	50 toe/year Assuming the existence of 200 heads e·ery day
Cost of Building the digester	FCFA 652,750/toe/year.

Comparison	FCFA
Annualized Capital charges (10%, 10 years)	5,310,121
Cost of Replaced Diesel Oil	6,050,000
Savings	739,879

1/ Based on cost figures obtained by mission in Togo.

(c) Slaughterhouse in Parakou: (under construction)

Capacity	50 animals/day
Biogas production	12.5 toe
Savings	FCFA 174,428

(d) Analysis of a biogas plant project in Cotonou based on Human Waste Material

22. This project has been presented at the Table Ronde Conference in 1983, by the Government of Benin, for financing.

Description of Project:

Collection: 300 m^3/day of material obtained from cleaning septic tanks, with 5% content of dry material.

Production: 5,000 m^3 of biogas/day and 40 T of stabilized muds, with 20% content of dry material. The 5,000 m^3 of biogas are to be used for generating 8,200 kWh/day.

Construction Cost: The Government indicated a projected cost of FCFA 280 million (1981 prices). In addition, the cost of the prefeasibility study was estimated at FCFA 58 million; the cost of the detailed feasibility study at FCFA 14 million. Total project cost: FCFA 352 million.

Cost Evaluation	'000 FCFA/year
Annual Capital Charges (10% opportunity cost of capital and 10 year economic life)	52,270
Other Annual Costs (According to project proposal)	21,300
Total Annual Cost	78,570
Total Annual Revenues (According to project proposal)	65,200
Losses	13,370

23. The mission thinks that this project should not be considered for implementation at present, not only because its financial viability is questionable, but more so because there are no experiences in other countries of running a successful operation and because the operation of a digester of this size requires a high level of technical expertise.

24. The biodigesters currently in operation cannot be fed with sewer water due to their low concentration of solid material. The construction of a biodigester to treat the material of emptying septic tanks is therefore incompatible with the projected construction of a sewer system.

25. It is necessary to maintain a constant temperature in the digester to obtain a constant production of gas, otherwise storage costs would become prohibitive. The monthly average temperatures in Cotonou vary between 21°C and 33°C. In the project brief no consideration was given to a system for regulating the temperature of the digester, which would require significant amounts of energy.

Solar Energy

26. Research on solar energy is only beginning in Benin. Theoretical estimates of solar irradiation (by the Physics Laboratory of the National University of Benin) indicate values similar to those of Togo; i.e., average of 3.3 kWh/m^2/day to 5.0 kWh/m^2/day depending on location, increasing towards the north. Potential applications range from flat plate collectors to photovoltaic cells in industry, agriculture and households.

Solar Water Heating

27. Flat plate collectors for industrial water heating have a good potential for substituting for oil. They can be used to supply hot water (to 95°C) or to preheat water entering a boiler. In the latter case, these systems become economical if the industries use process steam. Where the condensates are recycled to the boiler, the advantages of solar heating becomes marginal. According to a recent study, solar energy could become an important source of industrial process heat by 1990 in developing countries.

1990 - POTENTIAL SUBSTITUTION OF INDUSTRIAL HEAT BY SOLAR ENERGY
(in %)

	Egypt	Tunisia	Kenya	Sudan
Food Industries		38	52	40
Edible Oil Extraction				47
Textiles	39	48	51	44

Source: Market Potential of Solar Industrial Process Heat in Developing Countries by D. Costello-Alea. January 1983 - Study prepared for IBRD.

28. For Benin, the mission recommends that the application of solar water heating systems be studied in the following industries:

- Breweries of Cotonou and Parakou
- The soap factory of Porto Novo
- The oil factories at Cotonou and Bohicon
- The palm oil factories
- Industrial textile plants
- Larger Hotels - Sheraton - PLM.

Economics of Solar Water Heaters

Cost Data: 1/	FCFA
Solar Collector	40,000/m^2
Piping, Storage, Installation	250,000 (for 6 m^2 collector)
	175,00 (for 3 m^2 collector)
	120,000 (for 2 m^2 collector)

Assumptions: Increase 1 m^3 of water/day from 20°C to 60°C.

Energy Requirements:	40,000 kcal/day (46.5 kWh/day)
Average Solar Radiation:	4.2 kWh/m^2/day
Efficiency:	40%
Surface of Solar Collector:	$\frac{46.5 \text{ kWh}}{4.2 \times 0.4} = 28 \text{ m}^2$

	FCFA
Investment Cost:	1,568,000
Annualized Charges (10%, 10 years)	255,000
Cost of Conventional Energy:	1.43 Toe
Fuelwood in Cotonou b/ (13% efficiency)	330,000
Kerosene (30% efficiency)	599,170
Electricity b/ 90% efficiency)	660,000

a/ Source of information: Haentjens, A. Sema-Energie; Comes-Sid; and Ministére de la Coopération. Comes-Sema: Evaluation of renewable energy sources in developing countries. Collection Technologies et Développement N-1, 2nd Edition, 1981

b/ Based on retail price.

29. This very rough estimate indicates that the solar water heating option can be competitive in Benin. Of course, there are economies of scale in solar systems, which make small-scale solar applications non-competitive, especially if the substitute is fuelwood.

30. In most potential applications (hotels, hospitals, etc.), the solar water heating system will have to be backed up with conventional heating systems.

Photovoltaic Cells

31. The most interesting application of PV cell panels is in water pumping. It has been estimated 1/ that at present the break even point for the various water pumping systems in the Sahel countries is as follows:

- to 500 W: hand pumps
- 500 W: PV pumps
- above 3 kW: Conventional motor pumps.

32. In Benin, there are few irrigation projects and all of them are based on gravitation. The mission recommends that PV based systems be considered in the future when and if larger scale irrigation projects are required. At this stage, it is not recommended to introduce PV panels in the Save Sugar plantation, because of the very basic technical and economic problems that confront this agro-industrial complex.

33. The mission also studied the potential application of PV cells to refrigeration in areas where no electricity is available. The following comparison indicates that solar refrigerators and freezers should not be considered at this time.

Comparison Between a Kerosene and a Photovoltaic Refrigerator

Kerosene Refrigerator: type SIBIR, capacity 230 lt.

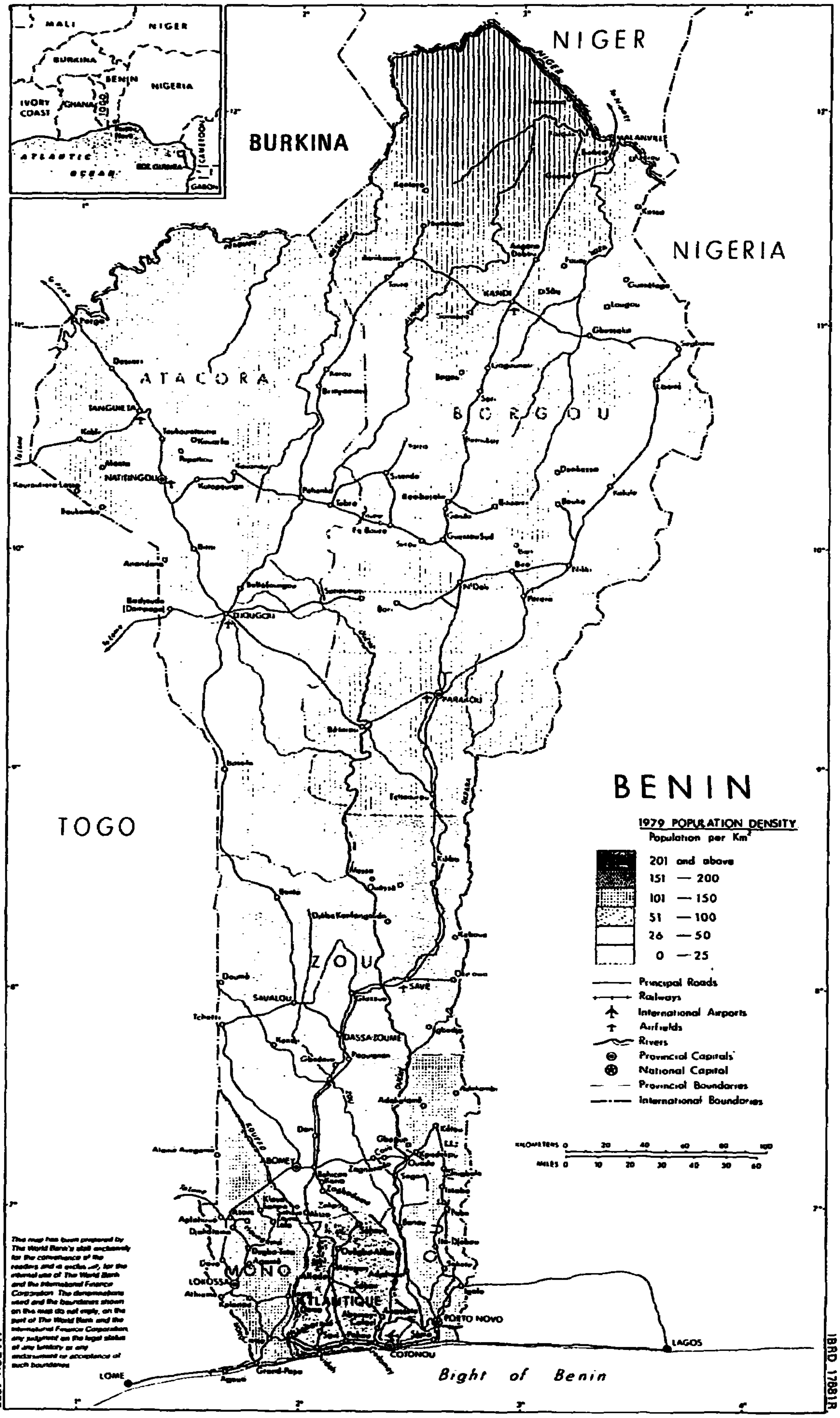
Price: fob France:	FCFA 344,500
Energy Consumption:	Estimated at 5 lt/week by the manufacturer. Fuel storage capacity 15 lt.
Cost of kerosene:	FCFA 100/lt.

Photovoltaic Refrigerator: type LEROY SOMMER, capacity 200 lt.

Price of unit fob France:	FCFA	802,950
Price Photovoltaic Panels: 144 W peak (Ref. G.144):		623,350
Two supports of Anodized Aluminium		45,000
Total	FCFA	1,471,300

1/ According to information provided to the mission by A. Haentjens - Sema - Energie - France.

Cost Comparison	'000 FCFA	
	Leroy Sommer	Sibir
Investment	1,471.3	344.5
Transport	250.0	250.0
Total	1,721.3	594.5
Annual Capital Charges (10%, 10 years)	280.0	97.0
Fuel Cost	-	26.0
Annual Costs	280.0	123.0



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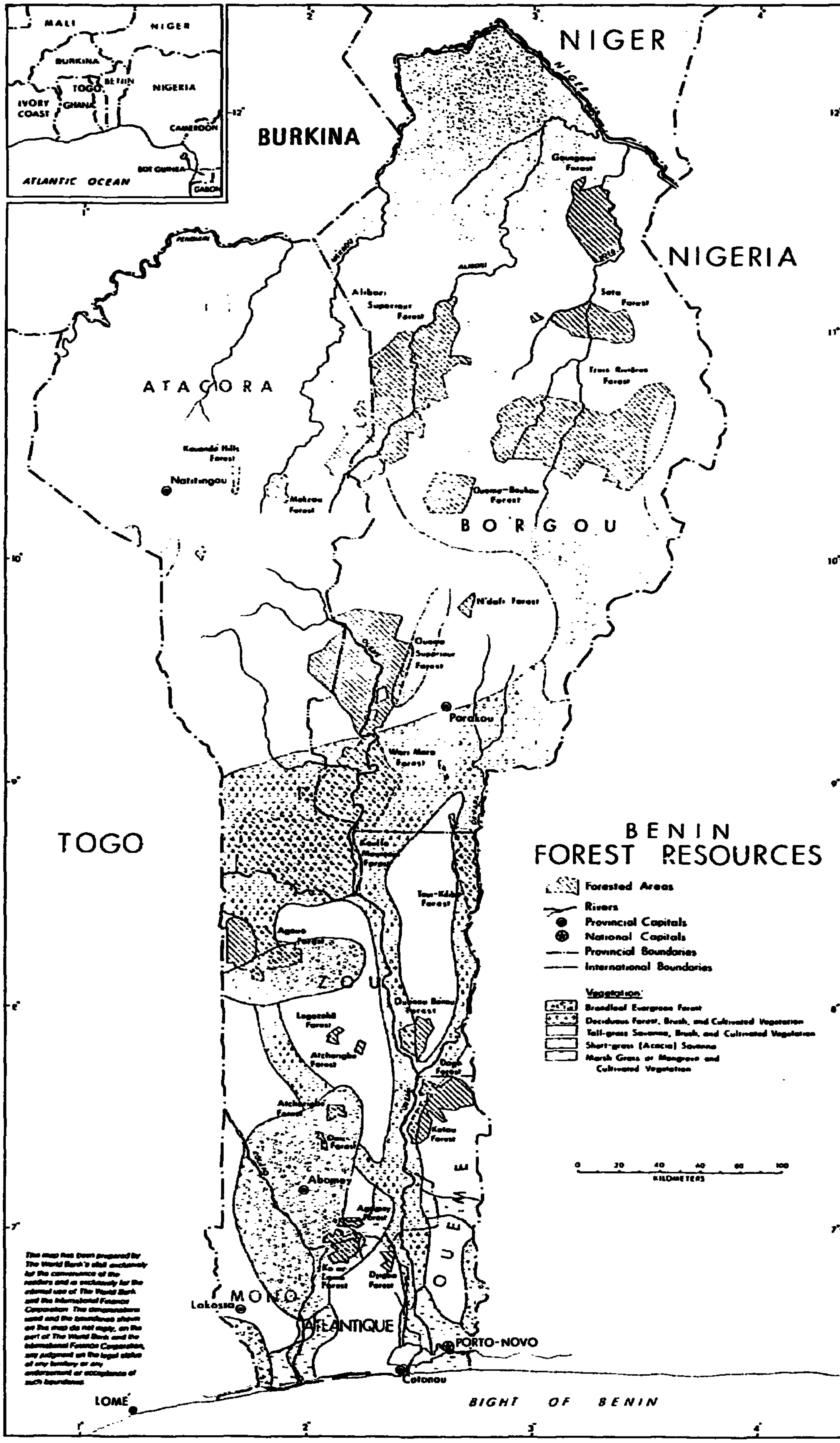

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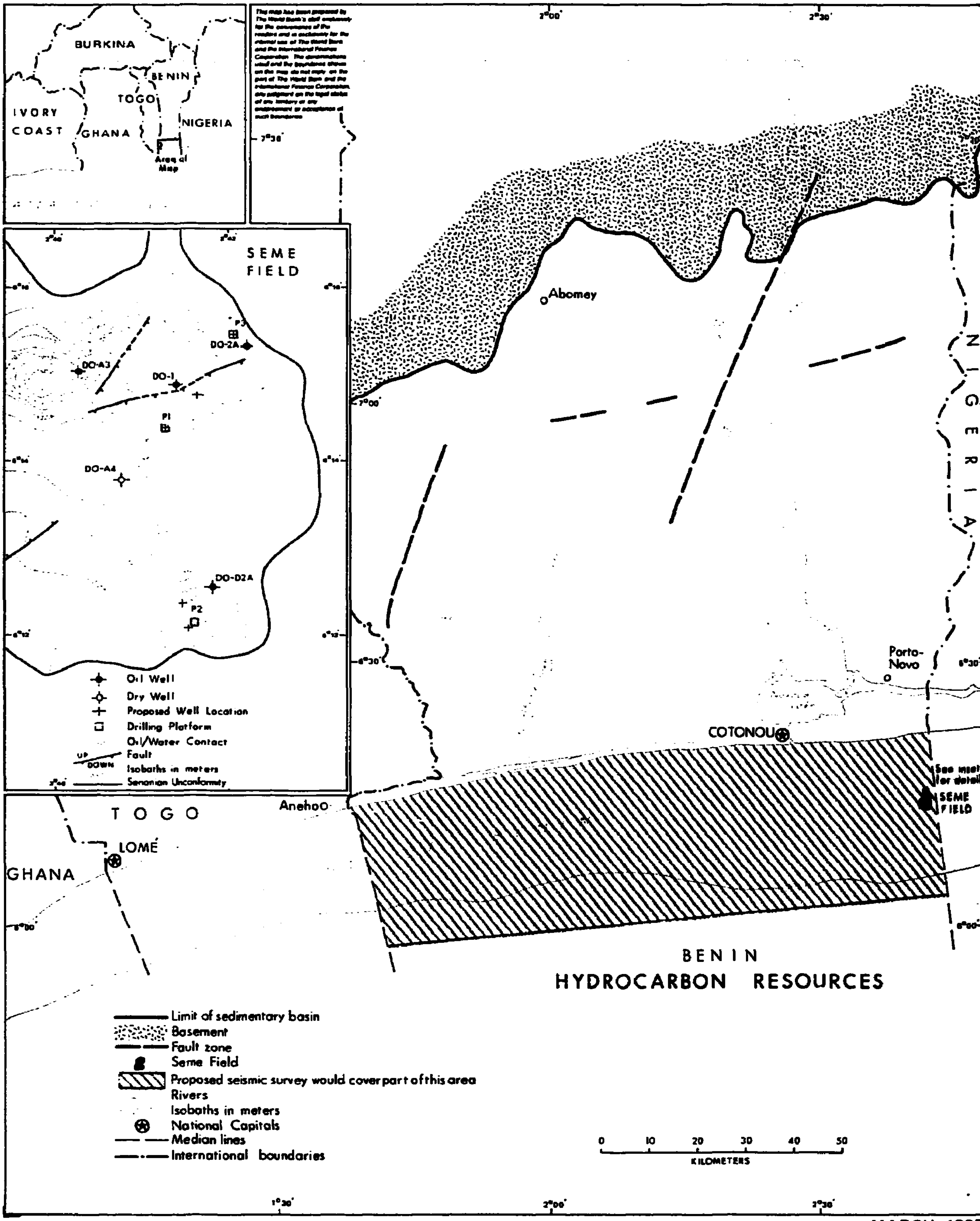

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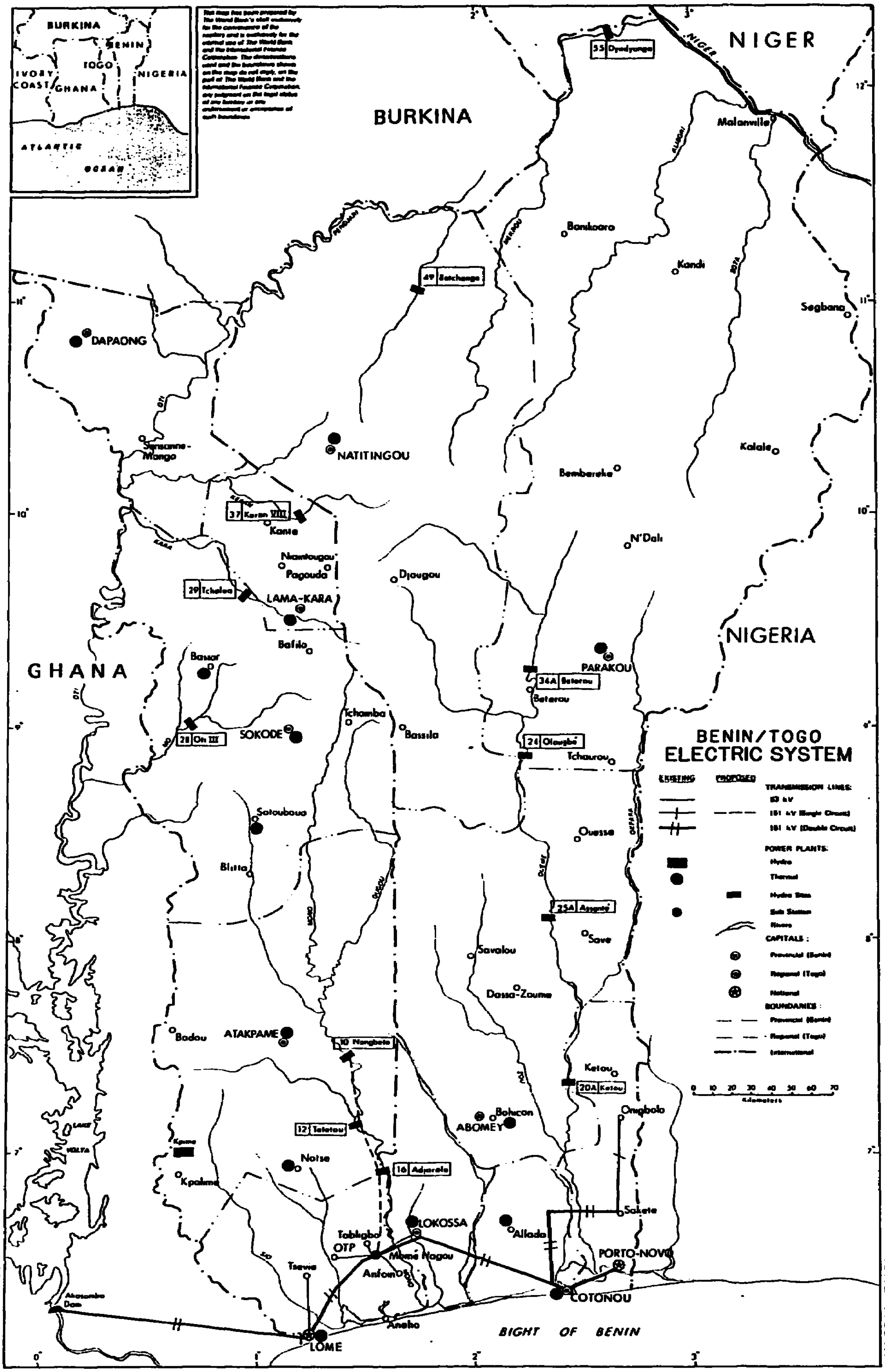

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