Proceedings

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Energy for Survival

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SUMMARY

Severe energy problems plague the 16 member states* of the Economic Community of West African States (ECOWAS), including those exporting petroleum. Two particular problems are characteristic of the region. The first is deforestation (for fuelwood and charcoal production, slash-and-burn or shifting agriculture, and clearing of new agricultural land) which is leading to lower agricultural productivity, climatic changes, and reduced individual productivity because of the labor and time required to collect fuelwood. The second problem is the purchase of petroleum by countries, causing negative balance of payments, which in turn diverts financial resources from other development programs.

The objectives of the ECOWAS Energy Symposium** were to bring these problems to the attention of policy makers and to decide upon a course of action, beginning with a number of programs and projects. The symposium was a first step toward regional coordination of energy activities by the ECOWAS Commission on Transport, Telecommunications, and Energy. It, therefore, represents a milestone, both in mobilizing donor activities in the region and in bringing together concerned officials. Delegates came from all 16 ECOWAS countries as well as from a number of donor organizations. Technical experts helped three working groups develop proposals for projects related to industry, agriculture, and public infrastructure.

Some recommendations made by the working groups were similar. They are summarized below, subdivided by energy-related sectors.

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*They are: Benin, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, and Upper Volta.

**Funding for this workshop and for participation by representatives of the ECOWAS member states was provided by the U.S. Agency for International Development (AID).

Biomass Resources. The working groups recommended a series of projects intended to increase the substitution of biomass resources for commercial fuels, as well as to conserve existing wood resources for environmental reasons. At first glance, such programs appear to be a contradiction; however, carefully planned and implemented programs of replanting, research on improved cooking techniques, installation of gasifiers and wood-fired thermal equipment at power plants and in industry, upgrading of wood distribution systems, use of improved charcoal kilns, and reclamation of marginal agricultural land for energy plantations could begin to ease the crises mentioned above. Extensive land and biomass resource inventories, sufficient donor funds, as well as local political will were cited as necessary for successful programs.

Hydropower Resources. The working groups felt that hydropower resources, both large and small, should be exploited either for isolated systems or to connect to a grid network. This notion was questioned in terms of meeting the energy needs of rural, decentralized populations, particularly for subsistence and slash-and-burn farmers. Clearly, hydropower can make a large contribution. However, the capital costs for hydropower are two- to three-fold compared to those for thermal systems, and to avoid massive subsidization, ways must be sought to encourage the use of electricity to produce goods and services, or increase agricultural productivity. This should be given priority over its use for lighting and entertainment purposes, although political and social demands for lighting must be considered in the final equation. It was agreed that hydrologic resource and pre-feasibility investigations are urgently needed to identify investment opportunities and to secure financing. Continued coordination by ECOWAS will be necessary in the development of transnational distribution networks. Such coordination has already taken place, for example, among Ghana, Benin, and Togo.

Solar. The increased utilization of direct solar radiation for such purposes as crop drying, water heating, and industrial process heat was recommended by the working groups. Needs for hot water or steam in industrial plants should be partially met through solar energy. The manufacture of solar hot water equipment might be encouraged through special tax credits and other economic incentives. A number of photovoltaic water pumping systems are operating in ECOWAS countries. They should be evaluated and, if they are found to be economically viable, a large-scale program could be initiated to supply irrigation water, potable water, and water for livestock. Wind energy also has some potential in the ECOWAS region, particularly in Cape Verde and in some areas of the coastal states. This resource should be assessed to determine what contributions can be made to the energy balance.

Conservation. Although not technology specific, energy conservation is the quickest, and often cheapest, approach to lessening the import burden. Conservation measures, have been successful in several

developing countries; they include retrofitting industry with recuperators for heat recovery, upgrading public transportation systems to save energy, limiting the ownership and times of operation of private vehicles, establishing urban transportation patterns that optimize the use of fuel, switching truck fleets from gasoline to diesel, encouraging the use of navigable waterways and of railroads over trucks, enhancing the load factor on power systems fueled with diesel and fuel oil, and a host of other measures intended to lessen the demand for commercial fuels.

Policy and Coordination. In order to implement conservation measures, significant policy changes have to occur at the national government level as well as regionally. Steps must be taken to encourage energy savings and bring renewable energy sources into the mainstream. This could be accomplished by granting tax credits for new capital construction, by lowering subsidies on currently utilized fossil fuels, and by creating a government energy unit with the power to establish laws and take action. Since energy problems are similar in all ECOWAS countries, coordination by ECOWAS is essential. Policies carried out in a specific country should be monitored for applicability to other countries of the region with similar problems.

Information Systems. The three working groups agreed that ECOWAS must develop an energy information system accessible by member states. This system would include information on selected aspects of energy: supplies, consumption, resources, technologies, project activities, processing, etc. Regular publications available to member states would inform government ministries and other organizations of energy-related activities in the region.

Hydrocarbon and Uranium Exploitation. The working groups recommended active exploitation of the petroleum, coal, lignite, gas, and resources found in several ECOWAS states. Because this would require significant capital investment, outside expertise, and donor assistance, cooperation among member states in the exploitation of these resources should be encouraged. Some of the delegates felt that preferential prices should be proposed for fossil fuels found and consumed within the region.

This meeting did achieve its objective of increasing the region's awareness of its energy situation and highlighting the generic energy opportunities, although the participants did not identify specific projects or secure commitments from donor groups. ECOWAS, as an organization, is relatively young, and the energy commission was only created in May 1981. The November meeting, therefore, represented an initial attempt toward regional energy policy planning, and coordination. The individual countries, as well as the region, have a long way to go to realize decreased energy dependence and achieve more complete cooperation and coordination, but an important step in this direction has been taken.

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1.0 INTRODUCTION

The Treaty of Lagos, signed in May 1975, established the Economic Community of West African States (ECOWAS). The 15 regional member states were Benin, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, and Upper Volta. Cape Verde joined in 1977 (see Figure 1). The Executive Secretariat of ECOWAS, located in Lagos, Nigeria, has four special commissions which address issues of common concern to the member states. They are:

- Trade, Customs, Immigration, Monetary and Payments
- Industry, Agriculture, and Natural Resources
- Transport, Telecommunications, and Energy
- Social and Cultural Affairs.

In May 1981, the heads of state of ECOWAS countries added energy as a topic area for secretariat responsibility and assigned it to the responsibilities of the Transport and Telecommunications Commission. Commission Director Daniel Faux was charged with developing a "program for survival" in energy for ECOWAS. He requested assistance from the U.S. Agency for International Development's regional office in Abidjan, Ivory Coast (REDSO-WA). REDSO and AID/Washington's Office of Energy, Bureau for Science and Technology, then asked the Board on Science and Technology for International Development (BOSTID) to assemble a team of energy experts to serve as a resource panel for the workshop. In addition, AID provided financial support for three representatives from each ECOWAS member state to attend the workshop. The broad objectives of the symposium were to bring energy issues to the attention of ECOWAS members and to recommend projects--regional or site-specific--which could be undertaken under ECOWAS auspices. This report, prepared by Jack Fritz, Dennis Wood, and Carol Corillon of BOSTID, summarizes the observations and conclusions of working groups at the symposium.

The Symposium

The symposium was held in Freetown, Sierra Leone, November 2-6, 1981, with an attendance of approximately 130. Each of the 16 member states was represented, and delegates had a wide variety of background and work experience in energy.

Also attending the workshop were representatives of a number of other donor organizations: African Development Bank (ADB), United Nations Development Programme (UNDP), West African Economic Community (CEAO), U.N. Educational, Scientific, and Cultural Organization (UNESCO), European Economic Community (EEC), U.S. Agency for International Development (USAID), West African Development Bank (BOAD),

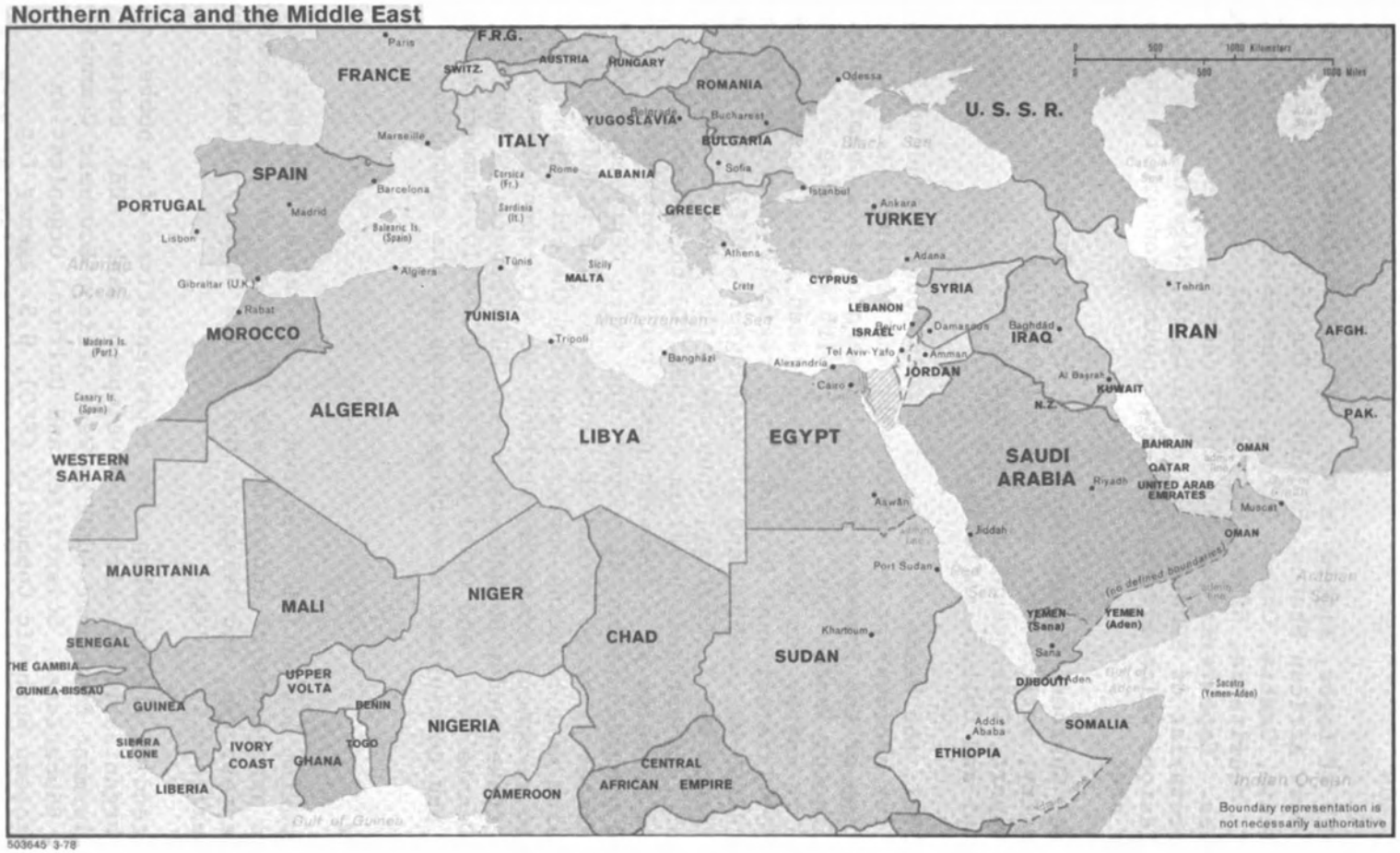

FIGURE 1 The 16 member states of the Economic Community of West African States.

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International Labor Organization (ILO), Canadian International Development Agency (CIDA), Permanent Interstate Committee for Drought Control in the Sahel (CILSS), and the Nordic Investment Bank.

The ECOWAS Secretariat invited a number of African specialists to present papers on regional background and country-specific energy profiles. In addition, BOSTID panel members prepared technical papers, a consultant to AID/W prepared a background document on energy project formulation, and a representative of the U.S. Geological Survey prepared a document on the hydrocarbon resources of the region.

As originally conceived, the objectives of the workshop were to:

- Create broader awareness of the nature of energy problems in the region
- Identify specific "survival" projects
- Recommend a plan of action to ECOWAS.

The Secretariat defined "survival projects" as projects that could be implemented within 3 years.

In October 1981, BOSTID staff and the Secretariat discussed the workshop objectives and how the Freetown meetings could be structured to achieve them. It was acknowledged that the format of the meetings, the diverse resources and political viewpoints in the region, and the large number of people attending reduced the likelihood that specific projects and a precise plan of action could be defined. Therefore, a more modest, two-fold objective was proposed:

- Educational: to create awareness among the ECOWAS member countries of the problems and constraints on development arising from the energy crisis and to identify possible ways of addressing them.

- Applicable: to make recommendations on a plan of action and to identify, to the extent possible, types of projects that could be implemented in the near future.

The Secretariat decided, for the purpose of discussion, to break the workshop into three working groups dealing with industry, agriculture, and infrastructure. Three ad hoc groups were established to discuss energy information, project finance, and educational and training needs. Summaries of the recommendations appear in section 3.0.

2.0 BACKGROUND

The energy crisis in the ECOWAS region can be characterized by the following:

o The population of the region is approximately 150 million and has a natural rate of increase of 3 percent or a doubling every 23 years. The annual per capita income is $550. Twenty-two percent of the population is urban, and urban areas are growing faster than rural areas (see Figure 2).

o Energy consumption on a per capita basis is among the lowest in the world. In Nigeria and the Ivory Coast, two of the more prosperous ECOWAS member countries, per capita consumption in 1978 was 6 percent of the average for the developed countries. However, financial resources required to pay for imported fuels as a percentage of total export earnings are among the highest in the world, ranging from 30 to 80 percent in the region (see Tables 1-3).

o On a regional basis, indigenous energy resources appear to be plentiful but poorly distributed in relation to population centers and demand patterns. Infrastructure for transportation is poor, and shipment of fossil fuels requires a large expenditure of energy.

o Exploitation of indigenous energy resources, with the exception of firewood, will require significant capital outlays. Development of the vast hydropower potential in the region will have to wait until financial resources have been mobilized. Also, there remains the political issue of providing electricity to rural households at low rates.

o Data indicate that noncommercial or traditional energy supplies, such as firewood, form the largest portion of energy consumed in the region. Substitution of indigenous energy resources for urban or industrial use may further exacerbate the fuelwood crisis.

o The ECOWAS region can be divided into three subregions: the tropical humid and semi-humid coastal states with sufficient hydropower and some biomass resources, the savanna zone with adequate rainfall for agriculture, and the Sahelian zone with very small amounts of water and biomass. The coastal states are being deforested by the demand for fuelwood and agricultural land. The interior states have already been deforested and will require a significant reforestation program to reverse the trend.

o Nigeria has indigenous oil resources and thus favorable balances of payment because of oil and agricultural exports. Other states, however, are actively searching for oil--there are some encouraging reports--but the heavy burden of paying for oil imports has led to negative balance of payments, reduced funds for development projects, and political friction between oil consumers and producers.

o Some states are densely populated; others are sparsely populated. For example, Nigeria has some 83 million people in an area of approximately 900,000 square kilometers (km^2), whereas Mauritania has only 1.4 million people within an area of approximately 1 million km^2.

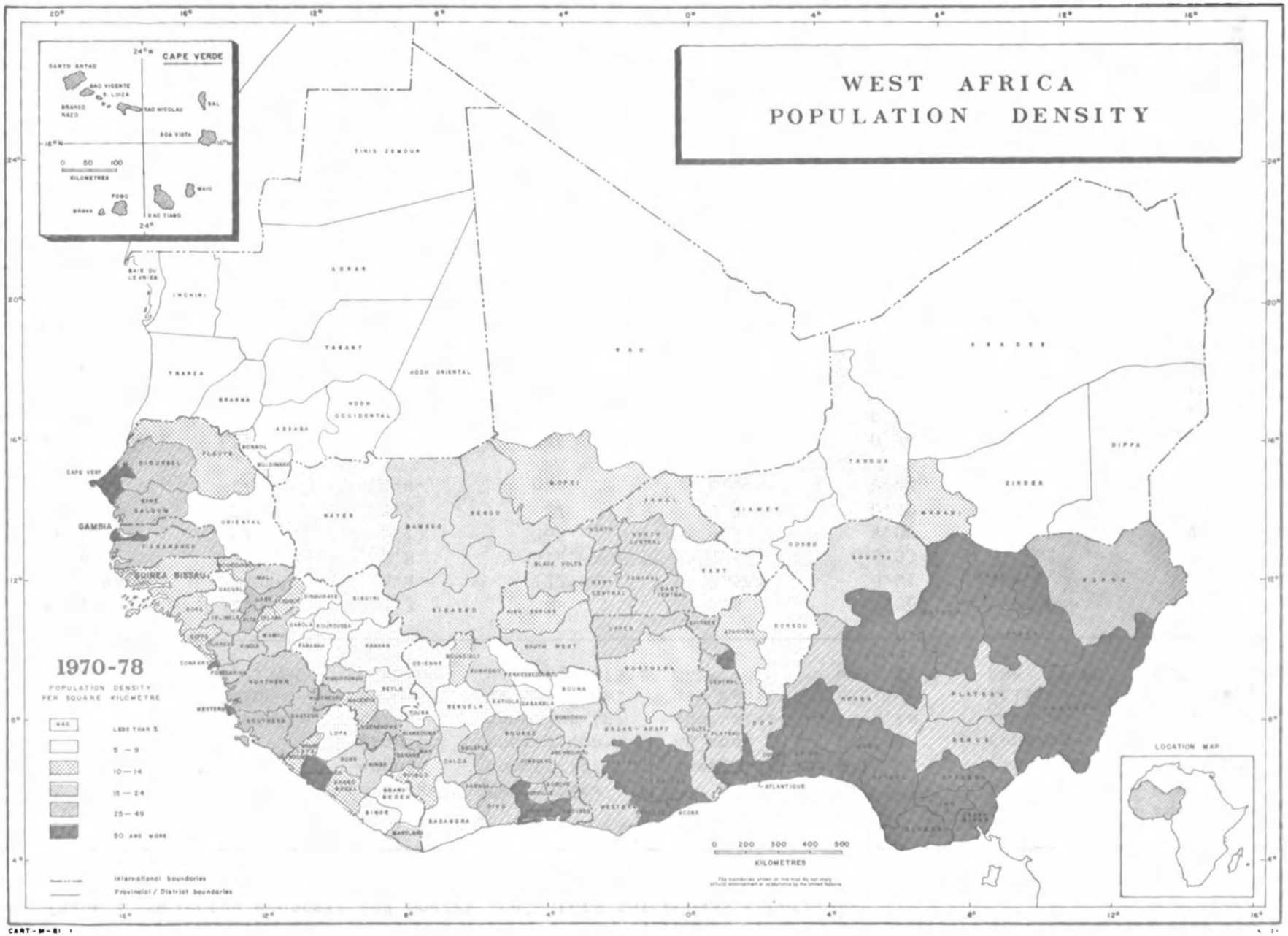

FIGURE 2 The population density of West Africa.

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TABLE 1 Selected economic and energy indicators for ECOWAS countries.

Country	Per capita GDP in US$, 1979	Average annual growth rate, 1970-79, percent	Per capita commercial energy consumption in kg coal equivalent, 1979	Energy in kg coal equivalent per capita GDP*	Electricity production in billion kWh, 1976	Electricity consumption in billion kWh, 1976	Per capita electricity consumption kWh, 1976
Benin	250	3.3	68	0.3	0.06	0.00**	19
Cape Verde	230**	n.a.	122**	0.5**	0.01	n.a.	23
Gambia	220	2.8	n.a.	n.a.	0.03	.03	52
Ghana	899	-0.1	265	0.3	4.08	4.23	396
Guinea	291	3.6	87	0.3	0.50	0.50	110
Guinea-Bissau	171	n.a.	n.a.	n.a.	0.02	n.a.	45
Ivory Coast	1113	6.7	234	0.2	0.96	1.12	191
Liberia	522	1.8	448	0.9	0.89	0.89	517
Mali	179	5.0	30	0.2	0.09	.09	16
Mauritania	293	1.8	185	0.6	0.10	.10	65
Niger	329	3.7	48	0.2	0.07	.07	15
Nigeria	910	7.5	83	0.1	3.40	4.28	53
Senegal	451	2.5	266	0.6	0.45	.45	88
Sierra Leone	232	1.6	89	0.4	0.20	.20	71
Togo	417	3.6	117	0.3	0.13	.05	58
Upper Volta	154	-0.1	29	0.2	0.06	.06	10

*Gross domestic product.
**1976 figures.
Sources: Accelerated Development for Sub-Saharan Africa, World Bank, 1981; World Energy Supplies, 1972-1976, United Nations, 1978; World Development Report, World Bank, 1978; Electricity Supply and Demand Forecast for Developing Countries, World Bank, 1979.

TABLE 2 ECOWAS energy trade statistics.

	Share of crude oil in merchandise imports, percent		Energy imports as a percent of export earnings		Energy imports and exports in million metric tons of coal equivalent, 1976	
Country	1960	1976	1960	1976	Imports	Exports
Benin	10	8		43	0.3	0.04
Cape Verde	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gambia	n.a.	n.a.	n.a.	n.a.	.05	0.01
Ghana	5	*	7	18	0.7	0.5
Guinea	n.a.	n.a.	7	n.a.	0.4	n.a.
Guinea-Bissau	n.a.	n.a.	n.a.	n.a.	n.a.	*
Ivory Coast	6	13	5	10	2.1	0.2
Liberia	4	n.a.	3	13	0.8	*
Mali	5	14	13	25	0.2	*
Mauritania	n.a.	n.a.	n.a.	n.a.	0.2	*
Niger	5	n.a.	n.a.	n.a.	0.2	*
Nigeria	5	3	*	*	1.5	125.3
Senegal	5	n.a.	8	15	2.3	0.2
Sierra Leone	12	n.a.	11	10	0.6	0.01
Togo	6	6	10	19	0.15	*
Upper Volta	4	n.a.	n.a.	19	0.1	*

*Approximated 0.0.

Source: World Energy Supplies, Series, J., Nos. 19-21, United Nations; World Bank Reports, World Bank, 1979.

TABLE 3 ECOWAS fossil fuel energy balances in 10^3 metric tons of coal equivalent, 1976.

Country	Production	Consumption	Balance
Benin	n.a.	157	
Cape Verde	n.a.	n.a.	
Gambia	n.a.	45	
Ghana	513.0	1,619	-1106
Guinea	10.0	419	- 409
Guinea-Bissau	n.a.	n.a.	
Ivory Coast	47.0	1,905	-1,858
Liberia	41.0	717	- 676
Mali	5.0	160	- 155
Mauritania	0.0	151	- 151
Niger	0.0	164	- 164
Nigeria	153,576.0	6,087	147,489
Senegal	n.a.	794	
Sierra Leone	0.0	315	- 315
Togo	0.0	194	- 194
Upper Volta	0.0	113	- 113
TOTAL	154,192.0	12,840	141,352

Source: World Energy Supplies, Series J., Nos. 19-21, United Nations.

These considerations form the backdrop for ECOWAS's efforts to develop a regional energy policy. A brief energy profile of each ECOWAS member state appears in Appendix A.

2.1 Coal, Oil, Gas, and Uranium Resource Opportunities

Coal resources are currently exploited only in Nigeria and Niger. Niger produces sub-bituminous coal and has reserves of lignite. Bituminous reserves are estimated to be 350 million tons and are found mostly in the Niger Delta region. This coal currently provides power for the uranium mines.

Senegal and Benin have recently discovered coal, primarily while searching for water. Sierra Leone has lignite deposits which were worked in the 1940s but since discontinued. In Senegal, at least 33 oil and water wells have intercepted lignite beds tens of meters thick at a wide range of depths. Benin has medium-quality lignite beds in 1-meter (m) layers, at depths of 60-100 m. Their quality, quantity, location, and ease of exploitation may enable some of these countries to meet their energy needs with indigenous resources.

In the ECOWAS region, hydrocarbon resources are found principally in the coastal basins of the Niger Delta, Togo-Benin, Ivory Coast, Ghana, Sierra Leone, Guinea, Mauritania, and the Senegal River, and in the inland basins of Niger, Nigeria, Mali, and Mauritania. Sediments of the coastal basins become thicker as they extend outward, increasing the prospects for petroleum deposits. Offshore exploration in these areas has been in full swing since the mid-1970s. Phillips Petroleum Co. has predicted that 500,000 barrels per day could be produced off the Ivory Coast by the late 1980s, although World Bank data indicate a reserve of 50 billion barrels for the Ivory Coast. Ghana's offshore oil production is expected to be 2,000 barrels per day during the 1980s. Liberia is also undertaking exploratory work under World Bank funding. In 1970, Union Carbide/Togo made a discovery that yielded only 40 barrels per day. Similar finds were made in Benin. However, by the end of 1980, some 20 foreign companies were active in the region. However, systematic exploration of both coastal and inland basins, including seismic surveys to determine the thickness of sediments, is required. Most exploratory work to date has been unorganized, with little regional cooperation.

Oil production in the ECOWAS region is substantial, amounting to some 25 percent of total African production, mostly from Nigeria. However, only that country produces in excess of consumption (data from 1976 indicate that roughly 5 percent of oil production was consumed locally). The prognosis for significant new discoveries in the other ECOWAS states is not too encouraging. Most exploratory finds are small, but may contribute significantly to relieving local shortages of transportation and utility fuels once refinery potential has been

established. A find similar to that of Nigeria, where substantial economic benefit could accrue to the country as a whole, is not predicted.

In Nigeria, natural gas is a by-product of oil production, and therefore, the emphasis will be on the use of this energy source. This potential has been discussed only in reference to Nigeria.

Uranium resources are being exploited in Niger (see Appendix A). Clearly, uranium will be used as a source of foreign exchange rather than as a resource for local use. Mali and Sierra Leone are also known to have small uranium deposits.

Upgrading of major transportation networks are necessary for full hydrocarbon resource development. Figures 3 and 4 show the limited rail and highway networks. It is clear that these networks must be better linked to possible hydrocarbon deposits. Appendix B, "Hydrocarbon Resources of the ECOWAS Region" by Robert Mattick, U.S. Geological Survey, gives more information on this subject.

2.2 Hydropower Resources and Regional Interconnections

The hydroelectric potential of West Africa, which is approximately 10 percent that of the continent as a whole, is estimated to be 21,400 megawatts (95 percent availability), most of which is found in Nigeria, Ghana, and the Ivory Coast. Where available, hydropower represents the most promising opportunity for development of electric power resources. However, its capital costs are considered high--$900 per kilowatt (kW) for high-head plants of large capacity and up to $2,500/kW for small plants requiring major civil works. These works may be 60 percent of capital costs. Thermal systems, in comparison, may be in the $600-$1,400/kW range. Thermal plants can often be standardized package designs, but hydro plants must be tailored to specific physical characteristics.

In West Africa, the average capital cost for power generation, according to World Bank figures, is approximately $1,600/kW. Figure 5 shows major hydropower and thermal power stations located in the region, and Figure 6 shows major river basins.

Each of the ECOWAS member states has some hydro potential, both mini and major. The major developments, in place and under study, are the Volta River Authority (VRA) serving Ghana, Togo, and Benin, and the Organisation Pour la Mise en Valeur du Fleuve Sénégal (OMVS), which will serve Mali, Senegal, Mauritania, and the St. Paul River Development in Liberia to cite a few. The Union of Producers, Conveyors, and Distributors of Electrical Energy in African Nations (UPDEA) is responsible for maintaining efficient cooperation in exchange for information among authorities responsible for production, transmission,

RAILWAYS WITHIN THE ECOWAS

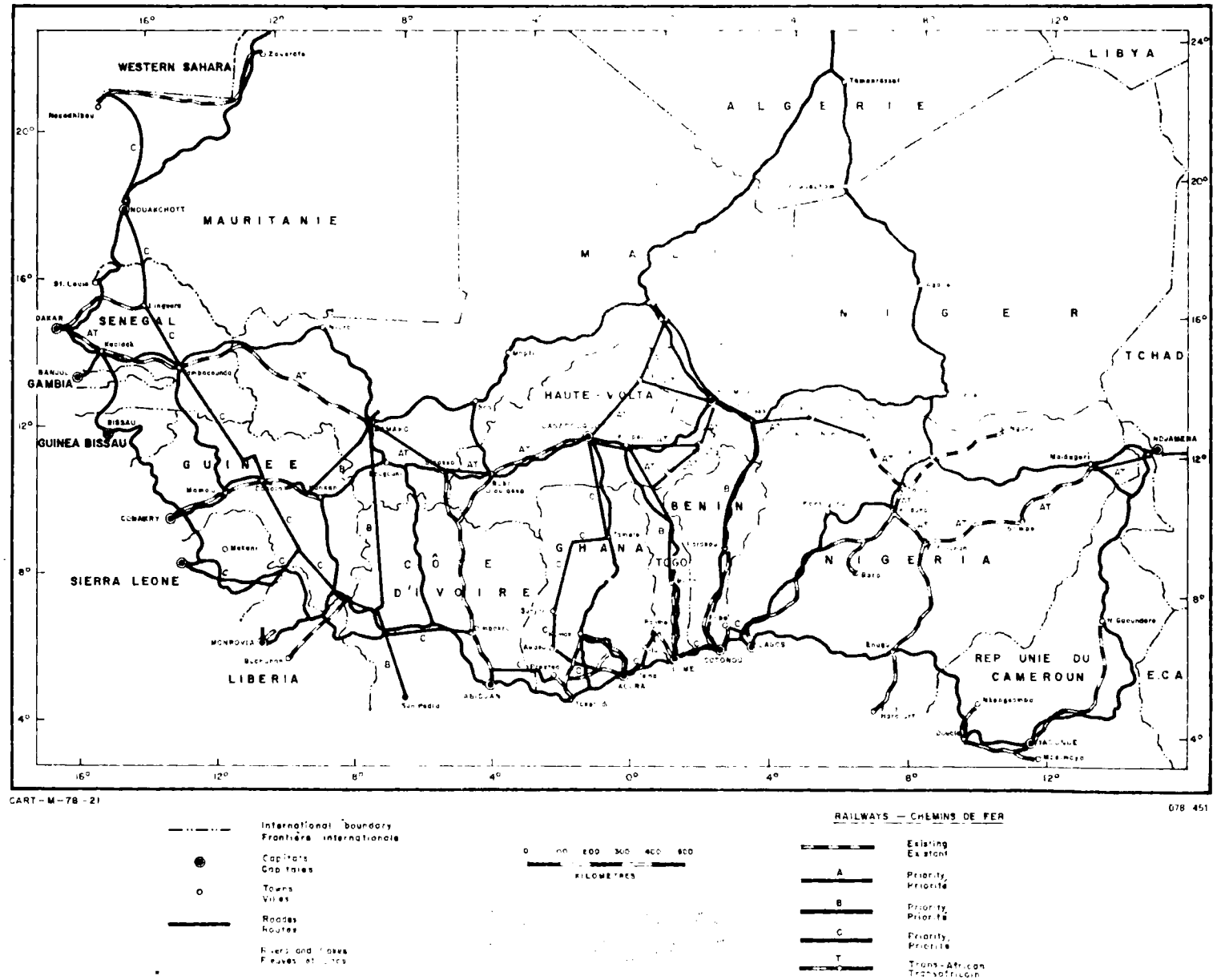

FIGURE 3 Railways within the ECOWAS region.

TRANS-WEST AFRICAN HIGHWAYS MASTER PLAN — PLAN DIRECTEUR DES AUTOROUTES EN AFRIQUE DE L'OUEST
ECA / ECOWAS — CEA / CEDEAO

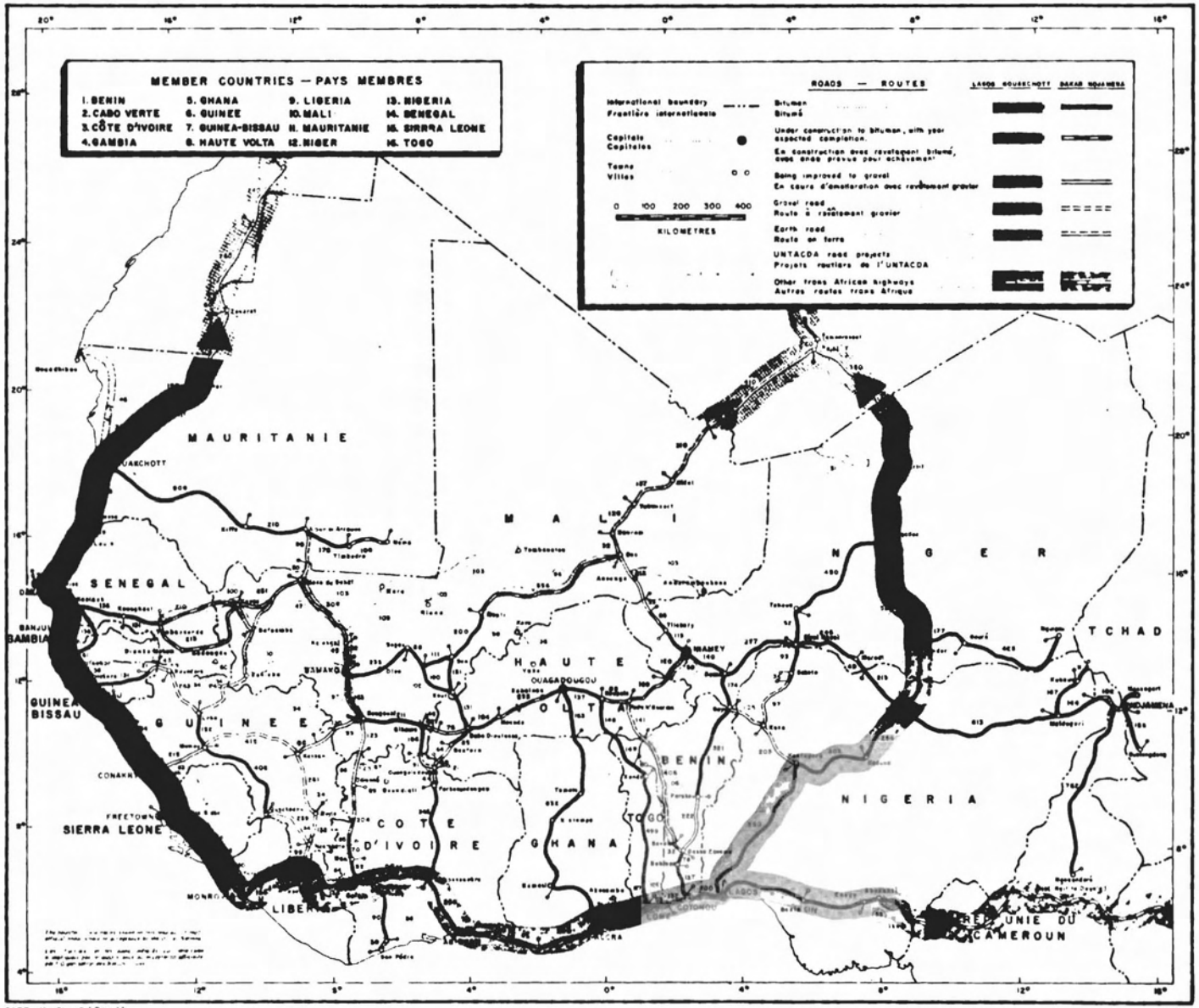

FIGURE 4 Trans-West African Highways Master Plan.

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and distribution of electrical energy. They are currently pursuing a number of studies on interconnection. Such regional links can effect savings through larger unit sizes, reduced system reserves, diversity of peak loads, higher load factors, hydro/thermal complementarity, and fuel savings. Small systems can be coordinated in much the same way. Liberia's use of 60 Hertz (Hz) makes interconnection a problem as hookups would require the use of rotating frequency converters or direct current converters/inverters. Much of Liberia's mining industry uses 60 Hz, whereas 50 Hz is standard throughout the rest of the ECOWAS region.

Regional meetings to facilitate interconnection have taken place. In May 1980, UPDEA held a seminar in Abidjan to determine specific courses of action, resulting in a number of general recommendations: (1) hydro resources will be fully exploited; (2) given the energy imbalance in the region, cooperation in the equitable distribution of electric power will be considered in all projects; and (3) an attempt will be made to reduce continued dependence on oil for thermal power generation. At this time, it is not yet clear if and how these recommendations will be acted upon by the various national power authorities or by the donor community.

2.3 Renewable Energy

Within the region, development of renewable sources of energy is the most pressing task for governments. Depletion of firewood resources in all ECOWAS countries is well documented and was a recurring theme during the workshop. A brief summary of the situation in each country is described in Appendix A. Implementation of specific projects, which are only partial solutions, has been slow and sporadic, and has met with limited success. Such projects have concentrated on (1) photovoltaic water pumps in a number of countries, all very expensive and not readily replicable in economic terms; (2) improved cooking stoves, which are believed to make more efficient use of wood or charcoal; (3) solar water heaters in urban areas (which may not be needed); and (4) fuelwood plantations which have yet to reach maturity. In addition, a number of solar research institutes have been established in various capitals and universities to test both imported and locally manufactured systems.

A brief review of the biomass depletion cycle, as it affects a typical ECOWAS country, follows. Deforestation involves the interaction of people, animals, drought, and floods, in such a way as to deplete the soil of nutrients and reduce its ability to hold water. During years of heavy rain, better than usual pastures, scrub brush, and crop yields occur, and farmers and pastoralists increase their herds and put more land into cultivation. Families are healthier and become larger. At the onset of a dry spell (which are inevitable and regular features of the West African monsoon-regulated climate), the carrying capacity of the land is reduced, and those living on it put greater than normal stress on

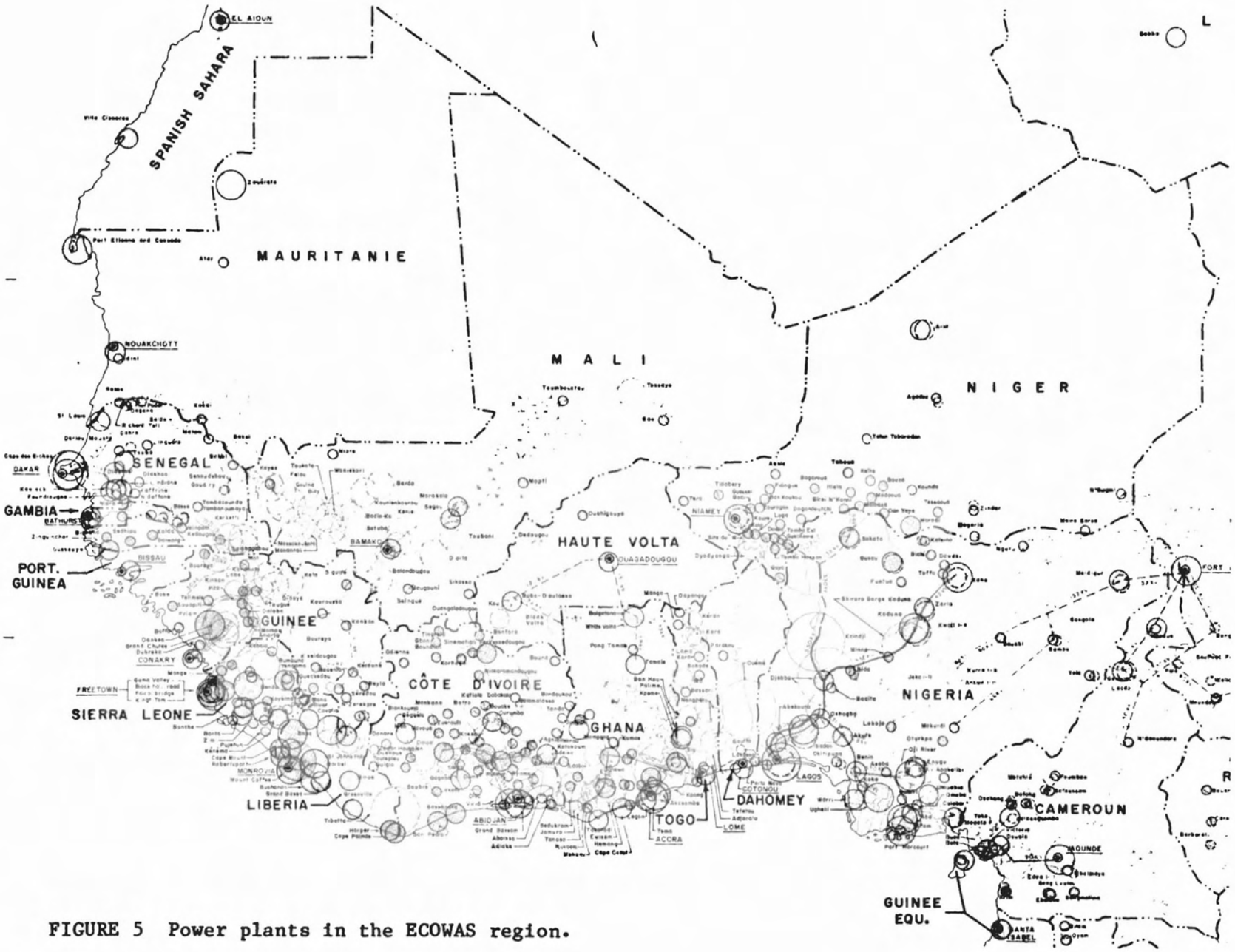

FIGURE 5 Power plants in the ECOWAS region.

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HYDROPOWER PLANTS
CENTRALES HYDRAULIQUES

	Existing En Exploitation	Under Construction or Proposed En Construction ou en Projet
Less than Moins de 1 MW		
1 — 10 MW		
11 — 100 MW		
101 — 300 MW		
301 — 500 MW		
501 — 1000 MW		
Over Plus de 1000 MW		

THERMAL POWER PLANTS
CENTRALES THERMIQUES

Less than Moins 1 MW		
1 — 10 MW		
11 — 100 MW		
101 — 300 MW		
301 — 500 MW		
501 — 1000 MW		
Over Plus de 1000 MW		

TRANSMISSION LINES
LIGNES DE TRANSMISSION

Less than Moins de 70 KV	———	- - - - -
70 KV – 220 KV	———	- - - - -
Over Plus de 220 KV	———	- - - - -

SCALE / ECHELLE

0 200 400 600 800

KILOMETRES

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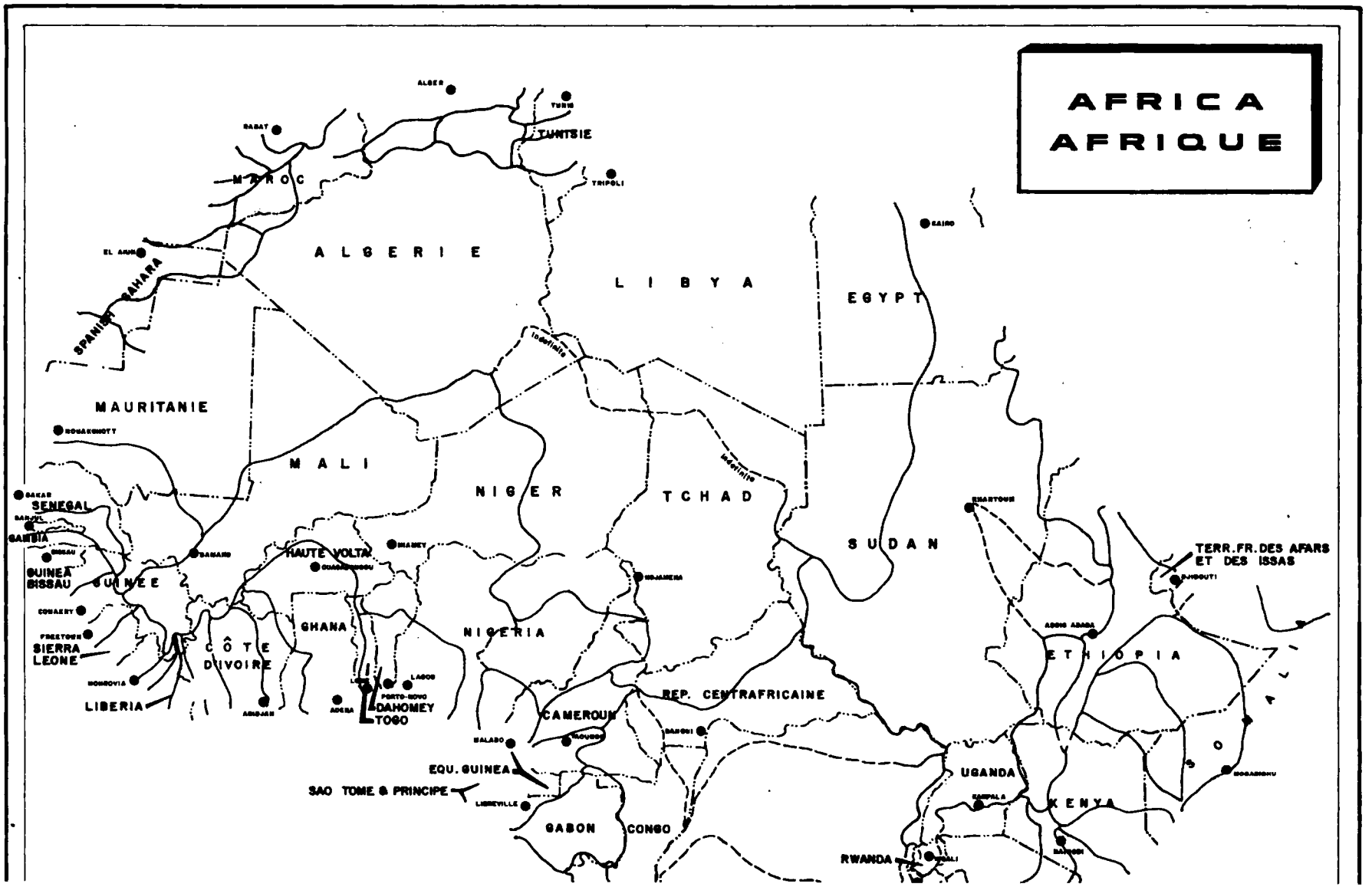

FIGURE 6 Major river basins in the ECOWAS region.

soil, water, and biomass resources. People remove young trees and scrub brush, and their herds strip remaining vegetation. Marginal areas undergo greater stress, which in turn reduces their carrying capacity. Winds erode topsoil layers so that when the rains finally return, the capacity of the land to retain water has been diminished. Further erosion results as river banks are flooded. This scenario clearly illustrates how deforestation reduces the carrying capacity of the land to a point where families must migrate to more prosperous areas or starve. Such migration further aggravates the existing rural exodus. The increasing cost of fossil fuels exacerbates the situation by encouraging urban families and enterprises (such as hotels and restaurants) to switch from electricity, LPG, and kerosene to charcoal and firewood for cooking, increasing the pressure on rural fuel supplies.

Remedial measures to stem deforestation/desertification include soil conservation, fuelwood plantations, water retention schemes, improved cooking stoves, training, and management. An integrated approach to the problem involving cooperation among several government entities is required. Discussions regarding specific proposals follow.

3.0 WORKING GROUP AND AD HOC COMMITTEE REPORTS

3.1 Working Group on Industry

This working group discussed energy and its implications for the industrial and commercial sectors in ECOWAS countries. It was agreed that energy inputs clearly have the most significant impact on the production process, from heavy industry such as mineral extraction to light commercial industry such as bottling. ECOWAS delegates were invited to give their views with respect to:

- The present energy situation in each country and its impact on industrial production (see Appendix A)
- Current energy usage in industry
- Opportunities to substitute renewable energy sources for existing fossil fuels
- State of the art of applicable technology
- Regional cooperation for training, energy audit methodologies, data banks, energy sharing, and power grid interconnection
- Financing and donor opportunities
- Investments in short-, medium-, and long-term priority energy projects, both on-line and planned.

The energy problems in the industrial and commercial sectors have brought further industrial development or expansion to a near standstill. In those states with no oil or ready coastal access and minimal transportation infrastructures, such as Mali, Upper Volta, Niger,

and Mauritania, the energy cost component in the price of goods is extremely high, which discourages investment in energy-intensive industries. However, those industries and businesses necessary for economic development require significant energy inputs, such as gas or oil for cement kilns; firewood, gas, or oil for brickmaking or baking; process heat for brewing, bottling, and food processing; acetylene for welding; and electricity for metal shops, lights, water pumping, mining, and aluminum extraction from bauxite.

The amount of energy required by all industrial and commercial processes is, in general, inversely proportional to the labor component--for example, in petrochemical refineries and electronic assembly plants. This relationship, and the location-specific factors affecting it, should be clearly defined so that industrialization follows an optimum path of low energy consumption, maximum labor utilization, and high productivity.

A number of possible actions were discussed during the working group sessions. Long- and short-term recommendations were put forward involving major process and hardware modifications, fuel substitution, and policy approaches through government or the marketplace. Some short-range approaches included energy audits of major industries found in each of the ECOWAS countries, e.g., cement production, mineral extraction, bottling, brewing, small workshops, agricultural processing, on-site electricity generation, and water lifting and treatment. These processes are generically similar within the region and well known in the developed countries. Measures to conserve fuel and alter the unit processes have been instituted in most developed countries; that expertise could be tapped rapidly through various bilateral programs.

Government policy options to bring about conservation in industry can range from rationalizing energy prices to granting various tax credits for new, energy-efficient process hardware. A tariff/duty structure could be devised to encourage the manufacture of products requiring little energy, making it easier to purchase high energy input products abroad.

The industry group recommended the implementation of "survival" projects in two phases, short term and long term.

Short-term Program

The short-term program is intended to give ECOWAS member states time to develop long-term solutions, provide relief from currently severe balance-of-payments problems, and slow the rate of fuelwood depletion to manageable levels.

Energy Data Bank. Because of the dearth of energy statistics for the ECOWAS countries, a regional data bank should be established in a member country, accessible to all ECOWAS members. Data collected would include sources and uses of traditional and commercial forms of energy, natural resource information, world market prices, and electrical power production figures. State-of-the-art reviews of various energy conversion technologies should also be included in the data base.

Conservation Measures. Immediate action should be taken to reduce energy consumption in the industrial sector. Energy audits previously mentioned would begin with the assistance of foreign technicians and the establishment of in-country training programs. Various tax penalties and credit incentives would be proposed to reduce gasoline use, encourage the construction of hydropower plants instead of thermal plants, and reduce fuelwood use by making lignite or peat available.

Substitution of local energy resources using various forms of biomass and direct solar radiation should be encouraged in all industrial processes, e.g., solar preheating, or preheating of fuel oil used in cement kilns. This can reduce oil consumption by 10 percent but will require tax credits to make the additional capital costs worthwhile.

Conservation in the transportation sector must be sought through enlightened public transportation policies that encourage greater use of more energy-efficient modes. Truck fleets should be diesel instead of mixed gasoline-diesel. Urban planning should be altered to encourage smooth-flowing traffic patterns. Taxes on gasoline for private cars should be raised and the proceeds used to fund various energy programs and public transportation systems.

Industrial Renewal. Efforts should be made to replace outdated, energy-intensive process equipment with more modern systems that take full advantage of the labor-energy tradeoff. Again, the use of peat and lignite should be encouraged in the process industries. The use of recuperators and equipment that utilize waste heat should be encouraged through liberal tax benefits. Working hours should be adjusted to maximize energy efficiency. Cooling of thermal equipment during nighttime shutdown should be discouraged by urging around-the-clock operations. Waste products should be more fully utilized in industry as is the case with groundnut shells in Senegal.

Training. Technical training for those who will institute the various policy options is necessary before long-term solutions can be implemented. Various donor agencies such as UNESCO, USAID, and the U.N. Industrial Development Organization (UNIDO) should consider cooperative training programs with ECOWAS members.

Long-term Program

Solutions that will carry the ECOWAS members into the next century require long-range planning and guarantees of adequate capital. Significant changes in the regional energy balance must occur. An overall, long-term plan will have to involve major shifts from imported fossil fuels to indigenous energy resources, both fossil and renewable. Perhaps the greatest challenge will be to provide energy for rural households and increased agricultural productivity.

Exploration of Fossil Fuel Resources. From Appendix A, it is clear that further mapping and exploration of the ECOWAS region is necessary to uncover the lignite, uranium, and oil deposits, and hydrologic resources awaiting analysis and development.

Development of Small Hydropower Resources. Development of large hydropower resources will be difficult in the capital-deficient ECOWAS environment. However, the development of small sites in conjunction with both urban and rural industrial needs and irrigation can proceed rapidly with new economic incentives and new sources of financing. These small sites must either be tied to an existing rural grid or powered by a diesel. If small hydro is only used to meet lighting needs, then cost-effectiveness is impossible and significant subsidization will be required.

A major small hydropower program could lead to the development of a local industry in hydro equipment manufacture and capital construction. A regional center could be established for research, development, repairs, and training.

Biomass Energy Systems. A shift from imported fossil fuels to biomass sources will require the establishment of "energy farms," including appropriate management systems and institutional models. The choice of biomass resources, whether trees for firewood, sugar cane for alcohol production, or palms or vegetables for transportation fuel, should be made wisely, based upon an assessment of needs and biological resources. Studies on the potential for cultivation of these crops and required conversion and distribution systems should begin.

Industrial sector studies should be made to identify the types and quantities of biomass-derived fuels that could be easily utilized, thus pointing to specific paths of resource development. Country development plans must be reviewed to determine the thrust of individual member programs. Opportunities for regional cooperation in biomass energy development may arise with one country exchanging the raw material for transportation fuel or electricity.

Large Hydropower and Grid Interconnection. Studies are currently under way to determine the feasibility of extending the various high

voltage grids already in existence. However, their expansion and the development of large hydropower systems will require significant capital from donor organizations. Choices must be based on optimal allocation of funds and electricity, which will require the cooperation of all ECOWAS members.

3.2 Working Group on Public Use and Infrastructure

This working group was divided into four subgroups: (1) rural and urban households, (2) buildings and other physical structures, (3) transportation, and (4) telecommunications.

Rural and Urban Households

Problems related to fuelwood and charcoal scarcity were discussed earlier. The production of biomass resources is linked to the management of public land, public access, the level of productivity, and the existence of squatters. Afforestation may offer a partial solution to the rural and periurban fuelwood crisis; however, as mentioned, planning and coordination among competing government agencies and an interim cooking fuel are prerequisites for a successful program.

Buildings and Other Physical Structures

Some 40 percent of the electrical energy produced in the ECOWAS countries is reportedly used for air conditioning, lighting, and water heating. Appropriate architectural design and new building materials could reduce electricity consumption. For example, passive solar designs have been used in Near Eastern countries to naturally cool and ventilate buildings. Solar-powered air conditioning systems, although a sophisticated technology, are also well known and used in parts of the American Southwest. Solar water heating, an old and mature technology, should be widely applied in the ECOWAS region in all public buildings. Imported air conditioners should be high-efficiency units.

This group recommended that:

- Public and commercial buildings should be designed to minimize the need for air conditioning systems. Performance standards for imported units should be established.
- All hot water systems should be solar assisted.
- In-country research and development activities should be undertaken to test and disseminate these technologies.

Transportation

Transportation systems are major consumers of imported petroleum. A number of policy shifts are suggested to reduce oil consumption in this sector:

- Significant freight and passenger transportation should be shifted to coastal and navigable waterways. The Niger and Senegal rivers appear particularly suited for a multinational river transport system.
- The development of rail networks should be given priority over highway systems because of rail's higher energy efficiency.
- ECOWAS should coordinate refinery capacity to meet regional market needs.
- Energy efficiency standards for imported automobiles should be published on a regular basis and enforced by member states through taxation.
- Locally, policies that encourage conservation should be developed for urban areas, for example, staggered working and driving hours, speed limits, restricted automobile zones, greater bicycle use.
- Design standards for highways and their location that maximize energy efficiency should be developed and enforced.
- ECOWAS transportation experts should coordinate these efforts and make staff available to member countries.

Telecommunications

An efficient telecommunications system is necesssary in developing countries, primarily for transportation and emergency purposes. Some 70-80 percent of communication failures result from power outages. The working group therefore recommended:

- Encouraging the use of equipment that has low power requirements. Various renewable energy options such as photovoltaics, wind, and micro-hydro should be encouraged.
- Reducing or eliminating the use of air conditioning by using more naturally ventilated structures.
- Implementing appropriate maintenance programs and establishing an ECOWAS information system on telecommunications equipment specifications that are appropriate for the region.

3.3 Working Group on Energy for Agriculture

Increased agricultural productivity is the number one development priority of each member state. Agriculture is primarily practiced at the subsistence level with the exception of a few commercial crops like

coffee, cocoa, and rubber. Increased agricultural productivity requires increased energy in the form of fuel, fertilizers, and pesticides. Thus the group sought ways to improve the efficiency of current energy sources in the agricultural process.

The committee recognized some basic facts concerning agriculture within the region:

- Agriculture is practiced largely at the subsistence level where individual farmers operate small farms of 2-5 hectares. Some large-scale commercial farms exist and are increasing.
- Agriculture within the region is location specific. Three ecological zones were identified: the humid to sub-humid coastal areas, the Guinea savanna, and the Sudan Sahel dry areas.
- The chief products of the region include tree crops, arable crops, and livestock. Crops are largely seasonal, following the prevailing rainfall pattern in the ecological zones of the region.
- The average farmer in the rural areas spends significant time in search of firewood for cooking, which results in lower agricultural productivity. The nomadic livestock herder also spends significant time in search of pastures and water.

As a starting point, the group reviewed the various agricultural operations in detail, identifying those that consume energy and the energy sources used. Of the preharvest operations--land clearing, land preparation, planting, weeding, fertilization, and plant protection--land clearing, land preparation, and weeding were identified as the most energy-intensive operations. The significance of fertilizers in improving productivity was also recognized. Postharvest operations--harvesting, drying, and processing--are generally carried out manually using traditional methods.

The principal energy sources used by rural farmers include human and animal labor, fire, direct solar, organic wastes, and oil and other fossil fuels. Because fuelwood is the predominant energy source, the committee group considered ways of improving efficiency of fuelwood utilization. Suggestions included guaranteeing the supply of fuelwood by reforestation and converting farm waste into briquettes to be used both as fuel and animal feed.

Specifically, the working group recommended:

Expansion of Agricultural Areas

- Irrigation is a necessity for increased productivity in the dry ECOWAS areas. Efforts should be made to assess the rivers and to construct multipurpose dams and reservoirs to realize the full potential of water resources. In arid areas, high costs

have impeded the use of solar or diesel pumps for drawing water from wells; therefore, water harvesting and conservation techniques must be employed.

- Mechanization is more desirable than traditional burning for land clearing, but care must be taken to prevent the soil erosion problems attendant to use of heavy equipment. It is recommended that small hand-operated machines ranging from 2 to 5 horsepower and animal-drawn machines be used. Modern machines require liquid fuels, and methanol, ethanol, and gas derived from biomass feedstocks are being substituted in various regions of the world. It is recommended that the prospects for substitution be carefully investigated in the ECOWAS region.

Intensification of Production

- Additional energy and fertilizer inputs are necessary to achieve increased agricultural productivity . Priority should be given to the optimum use of fertilizers with emphasis on the use of nitrogen fixation, organic fertilizers, and integrated pest management practices.
- Wastes of imported fertilizers in the ECOWAS region due to inefficient planning, handling, and distribution have been reported. Often, only a small fraction of the purchased fertilizers actually reaches the crop, and even then the timing may be wrong. Member governments should address this issue immediately.
- ECOWAS should pursue the feasibility of regional self-sufficiency in fertilizer manufacture by exploiting local raw materials, e.g., flare gas and phosphate deposits.

Harvest to Postharvest Practice

- Mechanization is recommended for harvesting to minimize losses. Harvesting techniques should be studied with a view toward adapting existing technologies to suit certain local crops where existing equipment may not have direct applicability.
- Food grain losses of 30 percent are common as a result of inappropriate and inadequate storage facilities and incomplete drying. Efforts should be made to improve traditional storage and drying methods. The introduction of modern storage techniques and facilities is recommended.
- Food processing is an excellent starting point for expanding industrialization within the ECOWAS region.
- Energy sources for processing could be derived from agricultural residues and waste and, where appropriate, from hydropower and solar energy.

Forest Management

- o Forest management and reforestation efforts should be pursued with emphasis on integrating programs into agricultural production systems or village community systems (agro-silvo-cultural, village woodlots). Particular attention should be devoted to reforestation or revegetation of marginal lands.
- o Industrial reforestation programs should be emphasized in order to meet the urban or periurban needs in fuelwood.

Marine and Aquatic Resources

- o Little information is available in the ECOWAS region on the exploitation of aquatic environments for food, feed, and fuel. It is recommended that ECOWAS investigate the potential of aquatic resources by supporting specific projects such as fish farming, biomass production, resources mining, etc.

3.4 Ad hoc Group on Energy Information

This group recommended that information gathering by a regional data center focus on specific project areas, with special attention given to the type of information needed and methodologies for data gathering and dissemination. The collection of such information, on a limited scale, will entail gathering macroeconomic data and establishing a centralized reporting and dissemination system. It was suggested that such a regional data center also include a training capacity for a minimum of 25 representatives from each country.

It was noted that various existing data collection efforts could be exploited or coordinated by ECOWAS. Other suggestions included obtaining advice on data collection needs from overseas experts and assembling a committee of representatives from all member countries to study information gathering.

3.5 Ad hoc Group on Project Finance

Donor organizations require information on funding levels and project implementation schedules. The group agreed that since the final list of projects had not been prepared, it would be premature to set funding levels and timetables. The ECOWAS Fund itself will constitute an important financial source for project identification and studies.

It was noted that funding for projects not considered cost effective in the short term, such as reforestation in the Sahel, is also

available. Certain financial organizations will invest in such projects if they are long-term, integrated development projects of priority to the country. ECOWAS should familiarize itself with the procedures and priorities of each financial organization.

A number of funding organizations made presentations. The West African Development Bank, which includes six member countries, can fund regional projects, including studies, with the condition that one of the countries involved be a member of the West African Monetary Union.

Sources of funding within the EEC include the European Development Fund (FED), the European Investment Bank (BEI), and in certain cases, the European Community for Coal and Steel (CECA). Although the EEC does not solicit requests, it accepts applications from countries. It also cofinances technical assistance or investment projects. Risk capital is available to signatories of the Lome Convention.

The Caisse centrale de coopération économique of France reported that it could also finance projects.

The U.S. Agency for International Development indicated that it is willing to finance certain feasibility studies; short-term training programs; long-term, upper-level university training; and workshops such as the ECOWAS symposium; as well as short- and long-term technical assistance, primarily in areas of planning and project conceptualization. Because AID's budget for activities in the energy sector in all Africa is limited, it emphasizes institution building rather than financing projects. However, AID intends to make a loan to ECOWAS to enable it to support small- and medium-sized enterprises (if the loan is approved, it will be effective from fiscal year 1983). AID also supports the private sector in undertaking feasibility studies that might result in joint operations.

The absence of the World Bank, by far the largest lender, was noted. However, other lending organizations were invited by the participants to use their limited resources to lay the groundwork for eventual World Bank funding. The West African Development bank was created to resolve, in part, the problem of bank financing. However, the general tendency of financial institutions to give loans on a bilateral basis rather than on a regional basis was stressed by the donor participants. Financial institutions should be encouraged to consider the region as a whole and to give high priority to regional projects sponsored and negotiated by ECOWAS in the name of its members. Consequently, it was decided that ECOWAS should clearly formulate its priority projects prior to presentation to any financial institutions for funding. The group concluded that good studies are indispensible for project identification. Funding from major donors is only available on the condition that the project is well designed and presented in an acceptable manner for easy analysis.

3.6 Ad hoc Group on Education and Training

This group recommended that ECOWAS members define the training and educational needs in the energy field, particularly in energy production and demands at the village level. Required levels of expertise include technicians with a secondary education and mechanical aptitude, engineers with a supplementary year in a specialized energy area, and masters-level scientists. As scientists, engineers, and technicians in member states are often untrained in appropriate areas or are too specialized, it may be necessary to consider additional training along more practical lines.

It was recommended that courses in energy planning, policy, and technology be organized. They might include seminars of less than one week to focus attention on specific energy problems. Six- to eight-week courses for middle- and upper-level energy planners should be developed, as well as 1-2 year courses for university graduates in energy technology. In addition, introductory courses should be organized in the immediate future, in both English and French, for 30-40 middle- and upper-level staff. The organization of further courses would depend on the success of initial efforts.

It was also recommended that volunteer groups be formed for rural areas and that nongovernmental organizations be encouraged to form similar groups made up of country nationals who might instruct at the village level.

4.0 HIGHLIGHTS AND OBSERVATIONS

Both participants and observers felt that the symposium succeeded in meeting the objectives set out by ECOWAS: to heighten awareness of energy problems and needs from both the national and regional perspectives, and to make recommendations for priorities and types of projects that would benefit ECOWAS members, particularly in the short term.

The first objective was met through interaction among the symposium's participants, and a spirit of regional cooperation emerged. A variety of disciplines was represented, resulting in lively exchanges and varied approaches to energy problems. Most participants and observers were either scientists/engineers or policy makers/administrators. As a result, a dichotomy of views was expressed which at times could not be synthesized into specific recommendations. Because the three working groups approached their tasks differently, recommendations were often not uniform and tended to overlap. However, similar actions were recommended by all three groups.

For example, the most critical crisis facing the ECOWAS members is a lack of fuelwood, charcoal, and the high cost of petroleum. Long-range

implications in terms of food production, water availability, and rural-to-urban migration problems will be disastrous if serious, well-planned actions are not implemented immediately. ECOWAS must recommend policies to its members that are not contradictory (e.g., make full use of biomass energy resources to displace imported petroleum while attempting to begin reforestation programs) and seek funding for long-term projects (not quick fixes intended to finance further importation of petroleum). The national political will must also be mobilized in such a way that competing local interests are included in project development to the maximum extent possible.

In the electricity sector, it was obvious that further expansion must be made through the development of hydropower sites, both small and large scale. Existing petroleum-fired thermal capacity must be replaced gradually with hydroelectric facilities. This approach was agreed upon by all participants, but the fundamental questions raised by this decision were not dealt with adequately. For example, water resources for small hydropower and rural electricity demand have not been identified through hydrologic assessments or feasibility studies. Increased electricity availability may or may not have an impact on fuelwood depletion. Clearly, the initial users of electricity will be industries and municipalities for processing, irrigation, water supply, lighting, small workshops, etc; rural households remain too poor to purchase electricity without massive subsidization. The investment in hydropower must be compared to the foreign exchange savings realized through reduced oil importation. Small hydropower is not a panacea for the energy crisis in the ECOWAS region, but it may offer a partial solution.

The development of alcohol fuels from agricultural residues and wastes was stressed. There was some confusion as to whether ethanol or methanol is the more appropriate. Considering present technical difficulties and unfavorable economics, perhaps neither is. For example, food production versus fuel production, fluctuating world sugar and molasses prices, and mobilization of political will were not adequately considered; however, the picture changes when agricultural residues and wastes rather than sugar are used as raw materials. The prognosis for conversion of cellulosic wastes to liquid fuels remains good and R&D efforts should continue to be applied. For ECOWAS members, alcohol production does not yet appear to be a feasible solution to the problem of transportation fuels.

In general, the symposium was considered successful. However, for logistical improvement of future meetings of this type, it might be useful to:

- Provide formal resource papers from each member country summarizing the energy situation in accordance with the working group division. This would obviate the need to present this

information in a haphazard and repetitive fashion during the meeting and in each working group.

- o Arrange additional or different working groups for less duplication and more specificity. The fuelwood crisis and hydropower potential surfaced within each working group. Perhaps the establishment of working groups on technology, rural versus urban issues, fuelwood, electricity, etc. would have been more practical.
- o Make more use of expert technical consultants. Clearly, all policy discussions should be led by country delegates; however, technical experts have often dealt with similar problems in other regions.

The BOSTID panel and staff were impressed with the quality of the ECOWAS Secretariat and their ability to organize diverse interests, which bodes well for future administration of ECOWAS energy projects.

APPENDIXES

APPENDIX A

Energy Profiles of ECOWAS Member States

BENIN

Benin (area, 112,600 km^2; 1980 population, 3.6 million) is wedged between Togo to the west and Nigeria to the east. Its commercial energy is derived principally from hydroelectric power imported from Ghana: approximately 90 million kilowatt-hours (kWh) annually. A supplementary 120-km line from Ghana is under construction to bring in an additional 60 million kWh annually. The other major source, a 20-megawatt (MW) thermal plant, will be enlarged by 20 MW because peak use has been reached. Pre-feasibility studies have been completed for eight hydro sites with a total estimated capacity of 80 MW. The economy is based on agriculture, services, and light industry. Industry consists of textiles, sugar processing, palm oil, and two cement plants.

CAPE VERDE

The Cape Verde islands (area, 4,000 km^2; 1979 population, 275,600) off the coast of Senegal are small and densely populated, with an arid climate and rocky terrain. Because fuelwood has all but disappeared from the islands, there is little opportunity for development of indigenous energy resources with the exception of wind. There is no hydropower potential because there is little water. Limited amounts of fuelwood, expensive butane, and kerosene barely meet household energy needs. The standard of living and energy use per capita in the Cape Verde islands is higher than most other ECOWAS states, giving rise to an unfavorable balance of payments due to the importation of most goods and services.

THE GAMBIA

In The Gambia (area, 11,300 km^2; 1979 population, 584,500) energy supplies consist primarily of fuelwood, groundnut shells, and imported

oil. In terms of the national energy balance, firewood accounts for 84 percent of total consumption or approximately 320,000 tons of oil equivalent; groundnut shells, 4 percent; and imported oil, 12 percent. Per capita commercial energy consumption is therefore among the lowest in the region--84 kg of coal equivalent per capita (in the Ivory Coast it is 380 kg). Fuelwood, the preferred fuel in rural areas, is consumed at the rate of 1.5 m^3 per capita per year. More efficient stoves are being introduced, and a briquetting plant under construction will provide 7,500 tons of rice husk briquettes per year to 10,000 residents. A master energy plan has been formulated which defines an investment program for resource development, energy conservation, energy pricing, and taxation.

GHANA

Ghana (area, 238,500 km^2; 1980 population, 11.5 million) has high per capita electrical energy consumption due largely to hydro-generated electricity from the Volta River. The Volta River Authority (VRA) has 15 years of experience in power generation, primarily with the 912-MW Akosombo project of which 60 percent goes to the VALCO aluminum smelter. VRA electric power is also sold to Togo and Benin. Downstream from Akosombo at Kpong is a 160-MW plant under construction. New and smaller sites, of which only five will be developed, are being surveyed to provide a total of 1,000 MW. Although electricity is plentiful, only 20-22 percent of Ghana's population has access to electrical power distributed by the Electricity Corporation of Ghana (ECG). Wood remains the main source of energy in rural areas, whereas charcoal is used in urban areas. On a national energy balance basis, 37 percent comes from electricity, 33 percent from wood and charcoal, and 30 percent from petroleum.

Oil exploration by foreign companies started in the mid-seventies, and in 1979 the first well off the continental shelf began production at 3,000 barrels per day. Proven reserves stand at 6 billion barrels. Prior to 1979 Ghana imported crude from Nigeria and refined it locally for exportation. Some 50 percent of petroleum products are used in the transportation sector, followed by the industrial sector. Relatively little petroleum is used to generate electricity because of available hydropower.

Renewable energy research is conducted by the Council for Scientific and Industrial Research (CSIR), with principal interest in solar heaters and dryers and testing of wind energy systems.

GUINEA

Energy statistics for Guinea (area, 245,900 km^2; 1978 population, 4.8 million) are scarce; however, 40 percent of the commercial energy (electricity) is provided by the Kamaroto project, with a capacity of 17.5 MW. Several other hydropower projects are currently being planned or are under way, such as Souapiti with 750 MW and Fomi with 50 MW.

GUINEA-BISSAU

As is the case with Guinea, scarce energy information is available for Guinea-Bissau (area, 36,100 km^2; 1979 population, 777,200). Approximately 12,000 kVa of installed diesel-electric exists, with 8,440 kVa in the Bissau public utility. This system produces 20,000 kWh per year and uses 5,500 tons of diesel fuel, primarily for air conditioning.

Petroleum was imported at a cost of $10 million in 1981 and was used mainly to generate electricity (40 percent) and for transport (50 percent).

Renewable energy projects are under way. The Dutch are building two biogas plants and AID, in cooperation with the Swedish International Development Agency, is funding a photovoltaic installation. The applicability of hydropower is not well established since the country is relatively flat.

IVORY COAST

The Ivory Coast (area, 322,500 km^2; 1979 population, 7.9 million) is one of the most prosperous countries in the ECOWAS region. It has a thriving economy and a variety of energy resources, such as hydropower, biomass, and some petroleum. Proven oil reserves are estimated to be 50 billion barrels, and the hydro potential is 220 MW which could produce 343 gigawatt-hours (GWh) per year. The largest current producer is the Kossou project, brought on line in 1972, with a capacity of 174 MW. Total installed capacity is 614 MW in hydropower and 214 MW in thermal generation. Some 10 new sites are under investigation which could produce a total of 10,000 GWh per year. Interconnection with the VRA in Ghana is now in progress.

Tariff and management structures were established in the mid-1970s to compensate for the escalating cost of energy inputs in manufacturing and agriculture. Petroleum exploration also began at this time. A variety of industries have been encouraged to invest in the Ivory Coast by liberal tax credits and government cooperation, even though there is an energy tariff system which does not subsidize energy costs. As a result, agro-industry makes full use of residuals, for example, coffee husks equivalent to 500,000 tons of oil are used each year in thermal processes.

LIBERIA

The marketplace for commercial energy in Liberia (area, 97,800 km^2; 1979 population, 1.8 million) consists of petroleum-based transport and residential consumption. Firewood, charcoal, and kerosene are used for household cooking. The cost of imported oil has risen from $5.5 million, or 6.3 percent of total imports in 1970, to over $115

million, or 20 percent of total imports, in 1979. The Liberian Electricity Corporation (LEC) provides electric power for Monrovia and seven other urban areas. Installed capacity consists of four gas turbines, four small hydro units, and seven diesels totalling 173 MW and producing approximately 400 million kWh annually. Studies are being carried out to develop the St. Paul and Mano rivers for large-scale hydropower. The St. Paul River has a potential of 1,200 MW; feasibility studies will be completed in 1982. The first stage will be the installation of a $600 million dam and power system with a capacity of 400 MW.

Significant data have been collected on wood and forest resources in Liberia. Some 43 percent of the country is forested, representing an available annual potential of 1 million m^3 of wood waste. However, wood is a commercial commodity in and around urban areas and is thus expensive. Charcoal manufacture is on the rise and becoming the preferred cooking fuel because of rising kerosene prices. Data on other renewable energy opportunities in Liberia will remain scarce until more in-depth studies are conducted.

MALI

Mali (area, 1.2 million km^2; 1976 population, 6.3 million) has the lowest annual gross domestic product (GDP) and per capita energy consumption in the ECOWAS region, $91 and 27 kg of coal equivalent respectively. It is land-locked and arid or semiarid and has few natural resources. Ninety percent of the commercial energy is from imported petroleum, contributing to a negative balance-of-payments ratio of 1.74. Wood is the major energy source, followed by imported petroleum and small hydropower. Two small-hydro sites, a 500-kW and a 5,400-kW installation, and a thermal plant of 25 MW supply the Bamako area with electricity. The two hydro plants produce approximately 3 million and 35 million kWh per annum, respectively. There are also 10 smaller thermal stations around the country. A new dam at Selingire on a tributary of the Niger River has just been completed with a capacity of 24 MW, and it will produce 100 million kWh per year. Mali is participating with Mauritania and Senegal in the development of the Senegal River for irrigation, navigation, hydropower, and flood control through the Organization pour la Mise en Valeur du Fleuve Senegal (OMVS). In Mali, the project consists of a dam at Manantali for irrigation and hydropower that has 200-240 MW capacity. The dam will produce 180 GWh per year, which will be used in the Bamako area. The lack of inexpensive electrical energy in Mali has been the primary obstacle to exploitation of lucrative bauxite deposits.

Mali's Solar Energy Laboratory was established in 1964. It carries out studies on wind, biomass, and solar technologies. Despite these efforts, desertification and fuelwood scarcity continue. In the Bamako area the current annual fuelwood demand of approximately 200,000 tons is

expected to rise to 500,000 tons by 1990. Yearly increases in the price of firewood are approximately 15 and 40 percent for Bamako and Mopti, respectively.

The government is attempting to implement a balanced energy strategy consisting of continued hydropower development, oil exploration, fuelwood plantations and conservation.

MAURITANIA

The energy situation in Mauritania (area, 1.0 million km^2; 1979 population, 1.4 million) is similar to that of Mali, aggravated by the lack of natural resources. Mauritania is mostly sparsely settled desert, thus having considerable solar energy potential. Electricity consumption is low, approximately 100 million kWh annually, produced by thermal plants around the capital of Nouackchott with a capacity of 40 MW. Development of some 2,000 MW of hydropower potential along the Senegal River is being considered in concert with OMVS.

It is estimated that within 10 years fuelwood will disappear entirely along the Senegal River where much of the wood is being converted to charcoal. Renewable energy activities are under way through French and American bilateral programs. Wind and direct solar assessments have been completed, and solar thermal water pumps have been installed on a demonstration basis. However, pressure on wood and water resources is accelerating at such a fast pace that only a major rural development effort will postpone disaster.

NIGER

In Niger (area, 1.3 million km^2; 1979 population, 5.4 million), some 4 million tons of coal near Agadez is currently being exploited, with production estimated to reach 120,000 tons per year in 1982. The coal is being used to provide fuel for the uranium mines which have proven reserves of 200,000 tons and another 200,000 tons reasonably assumed. Niger has some 15 percent of the world's uranium resources. The first uranium mine was opened in 1971, a second in 1978, and a third in 1980.

Niger has no installed hydropower. Electricity is generated by a coal-fired thermal plant of 20 MW capacity, and purchased from Nigeria. A 132-kV line extends from Niger to the Kainji dam in Nigeria with 30 MW of capacity allocated for Niger. In 1975, Niger's annual consumption of electricity was 70 million kWh with a per capita consumption of 15 kWh, making Niger one of the lowest consumers in the region.

Again, fuelwood remains the major energy source. The equivalent of 25 kg of coal per capita is consumed annually, representing 93 percent of the annual energy budget. As in other countries of the region, the

fuelwood situation is critical. The Office de l'Energie Solaire (ONERSOL) is conducting research, demonstration, and training activities in other renewables. ONERSOL has a factory for producing solar water heaters, 100 experimental photovoltaic-powered educational televisions, a French solar water pump using the SOFRETES engine, solar cookers, and various other alternative energy activities.

NIGERIA

Nigeria (area, 923,800 km^2; 1980 population, 83.0 million) is rich in energy resources, primarily coal, oil, gas, and hydroelectric power. It is the eighth largest oil producer in the world with proven reserves of almost 17,000 billion barrels. Daily production is approximately 2.1 million barrels with national consumption reaching 150,000 barrels. Growth in the consumption of refined products is about 14 percent annually and is expected to reach 260,000 barrels per day by 1985 although policies are currently being considered that would reduce this figure. In addition, natural gas, equivalent to 350,000 barrels of oil per day, will be exploited in conjunction with oil production. Natural gas alone represents 15 times the current electrical power consumption in Nigeria. A recent decree states that by 1984 no oil company will be allowed to flare gas. Gas-consuming projects and searches for additional reserves are under way.

The Nigerian Electric Power Authority (NEPA) produces 98 percent of Nigeria's electric power. Existing installed capacity is 1,600 MW (1978) which includes a 520-MW Kainji hydro project, 407 MW thermal, and 20 MW diesel. The government and NEPA have launched a 10-year expansion plan which includes development of the 600-MW Shirora Gorge, the 545-MW Jebba project, and the 1,200-MW Lokoja project. Construction of a 1,000-MW steam plant in Lagos, to be fueled by gas from the oil fields, is also planned. Total installed capacity by 1986 is expected to be 3,245 MW in hydro, and 1,516 MW in gas turbines. In rural areas, as of 1977, NEPA was operating 25 diesels with a capacity totalling 36 MW, most of which will be discontinued by grid extension as part of Nigeria's rural electrification program.

The National Sciences and Technology Development Agency (NSTDA) supervises renewable energy research with emphasis on solar water heaters, crop drying, irrigation systems, and potable water systems. Currently, no solar water heaters are being produced privately, although demonstration units exist. The country's priorities are clearly on industrial development using available fossil fuel resources and not on renewable energy systems.

SENEGAL

Senegal (area, 196,700 km^2; 1979 population, 5.5 million) had a 1980 oil import bill totalling 42 percent of export earnings,

approximately half the revenues from groundnuts, their principal export crop. Much of the imported petroleum is refined to jet fuel to accommodate the increasing number of aircraft that come through Dakar. Additional refined petroleum products, including jet fuel, diesel fuel, and kerosene, are exported to neighboring Mali and Mauritania.

In rural areas, fuelwood is the major energy source, roughly 60 percent of the national energy balance. Statistics for fuelwood and charcoal production vary widely. Senegal's Fifth National Plan for Development indicates that 931,000 metric tons of charcoal were produced in 1975, whereas the U.N. Economic Commission for Africa cites that only 93,100 metric tons were commercially authorized. Clearly, substantial amounts of both firewood and charcoal are marketed outside the formal sector and therefore few firm data are available.

Electricity generation is exclusively thermal with a total installed capacity of approximately 140 MW. As discussed in reference to Mali, hydropower is being developed along the Senegal and Gambia rivers. Through the OMVS the 150-MW Manantali dam will soon begin producing electrical power. Additional sites are under study; the Galougo and Gourbassi will yield a combined capacity of 300 MW. Of the imported oil, 27 percent is used for electricity generation, 29 percent for transportation, and 25 percent for mines and industries. The two major electric companies in Senegal are the Société d'Electricite and the Société Senegalaise de Distribution Electrique which have eight thermal stations. Sixty-four percent of the electricity in Senegal is consumed in Dakar with a per capita consumption of 94 kWh per year. The thermal plants are both diesel and steam turbine. By the 1990s, the government hopes to double installed electrical capacity and achieve an energy balance of 30 percent biomass, 30 percent petroleum, 20 percent hydro, 2 percent solar, and 20 percent wood and peat.

SIERRA LEONE

As in other ECOWAS countries, Sierra Leone (area, 71,700 km^2; 1980 population, 3.4 million) is suffering from both a fuelwood crisis and a severe economic imbalance due to the cost of imported oil. To compensate for the lack of natural resources, 30 percent of export earnings are used to finance petroleum imports. Some 70-80 percent of the national energy balance consists of fuelwood, which is rapidly being depleted, even along traditionally forested areas on the coast. Fuelwood consumption is approximated at 2.5 million m^3 annually, with forest reserves estimated at less than 6 million m^3. Simple mathematics would lead one to conclude that in 3 years there will be no forests left. Steps to arrest this trend, such as more efficient charcoal manufacture, improved stoves, and substitution of agricultural and animal wastes for commercial fuels, are being considered by the government.

The generation and distribution of electricity is carried out by the Sierra Leone Electricity Corporation. Imported petroleum is their primary energy source. Three plants are located near Freetown, the capital: a 2.4-MW hydro unit at Suma, a 35-MW marine diesel at Kingtown, and five medium-speed diesels at Falconridge which have a maximum demand of 23 MW. In the rural areas, there are three diesel installations which provide power for local grids. The only existing hydropower plant is at Suma, a 2.5-MW Francis unit that operates only during the rainy season. A second unit of 4 MW is also under construction at Suma, and a feasibility study is under way for a 35-MW project at Bumbana.

While future power generation will be primarily through hydropower, the possibility of exploiting lignite deposits for thermal power generation is also being considered.

TOGO

Togo (area, 56,000 km^2; 1979 population, 2.5 million) is wedged between Ghana and Benin, and its energy future is linked to that of its neighbors, particularly through the purchase of electricity from the Volta River Authority in Ghana. The development of the 60-MW Mono River Hydro Project, in collaboration with the Communaute Electrique du Benin, will provide additional electricity to Togo. Local installed capacity is only 105 MW, 90 percent of which is diesel and over half of which is used by light industry. The purchase of power and petroleum contributed to an export/import balance-of-payments ratio of 1:3.

UPPER VOLTA

Upper Volta (area, 274,200 km^2; 1979 population, 6.7 million) is landlocked and composed of semiarid savanna. Population pressure has decimated most fuelwood resources and is causing significant rural/urban migration, particularly since the drought in the 1960s. Some 94 percent of the energy consumed by Upper Volta comes from fuelwood consumed at the rate of 3 million tons annually. All petroleum requirements are met through imports. Installed electrical capacity is approximately 18 MW thermal. No hydropower sites have been developed, although possibilities exist along the extensive irrigation works and headwaters of the Red, Black, and White Volta valleys. Several projects are in the planning stages, in particular a hydro plant on the Black Volta that will produce 60,000 kWh annually.

Upper Volta has also experimented with other renewable energy projects. In Tangaye, a photovoltaic-powered pump provides electricity for water pumping and grain grinding. The system delivers 3,000 gallons of water per day for a village of approximately 2,200 people. The final costs, benefits, and applicability of this AID-financed project have yet to be evaluated to determine if widespread use of this technology is justified economically.

BIBLIOGRAPHY

Checchi and Company (1980) Senegal Food and Energy Study. Washington, D.C.

National Research Council (1981) Environmental Degradation in Mauritania. National Academy Press, Washington, D.C.

U.S. Department of Energy (1978) Solar Energy Commercialization for African Countries. Washington, D.C.

U.S. Department of State (1980) Draft Environmental Report in Niger, U.S. Man and the Biosphere Program, Washington, D.C. (Same report available for The Gambia, Ghana, Mali, Upper Volta, Senegal, Cape Vere, and Liberia.

World Bank (1979) Energy Options and Policy Issues in Developing Countries. Staff Working Paper No. 350, World Bank, Washington, D.C.

World Bank (1979) Prospects for Traditional and Non-Conventional Energy Sources in Developing Countries. Staff Working Paper No. 346, World Bank, Washington, D.C.

World Bank (1979) Urban Growth and Economic Development in the Sahel. Staff Working Paper No. 315, World Bank, Washington, D.C.

World Bank (1980) Energy in the Developing Countries. World Bank, Washington, D.C.

World Bank (1981) Accelerated Development in Sub-Saharan Africa. World Bank, Washington, D.C.

World Bank (1981) World Development Management 1981. World Bank, Washington, D.C.

APPENDIX B

"Hydrocarbon Resources of the ECOWAS Region"

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The ECOWAS region can be divided into 13 basins or geographic areas, according to an analysis of the geologic framework of Africa. These 13 basins can be grouped into eight categories based on similarities of stratigraphy and suspected hydrocarbon potential. A brief summary of the hydrocarbon potential of each of the eight stratigraphic categories follows (see Figure 7).

Rocks of the basement complex. The basement complex consists of crystalline or highly metamorphosed sedimentary rocks of Precambrian age and younger volcanic rocks. These rocks have little or no permeability, and any hydrocarbons that they may have contained were destroyed long ago by high-temperature thermal alteration.

Paleozoic and upper Precambrian sedimentary rocks. These rocks are found in the Taoudeni, Bove, and Volta basins, and the northern parts of the Niger and Chad basins. The only sedimentary rock formations that have the potential for containing hydrocarbons are of Paleozoic and upper Precambrian age. In the Niger and Chad basins and to a much lesser extent in the remaining basins, the Paleozoic and upper Precambrian sedimentary rocks have been explored by drilling. With the exception of a few minor shows of oil and gas, the results have been negative.

"Continental Intercalaire" rocks. Over much of the Niger and Chad basins, rocks of the "Continental Intercalaire" unconformably overlie the basement surface. "Continental Intercalaire" refers to rocks younger than last dated Paleozoic sedimentary rocks and older than overlying marine Cretaceous deposits. In the Niger and Chad basins, this section consists chiefly of Cretaceous age continental red-bed facies, 0-2,000 m

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*Not officially with the BOSTID panel.

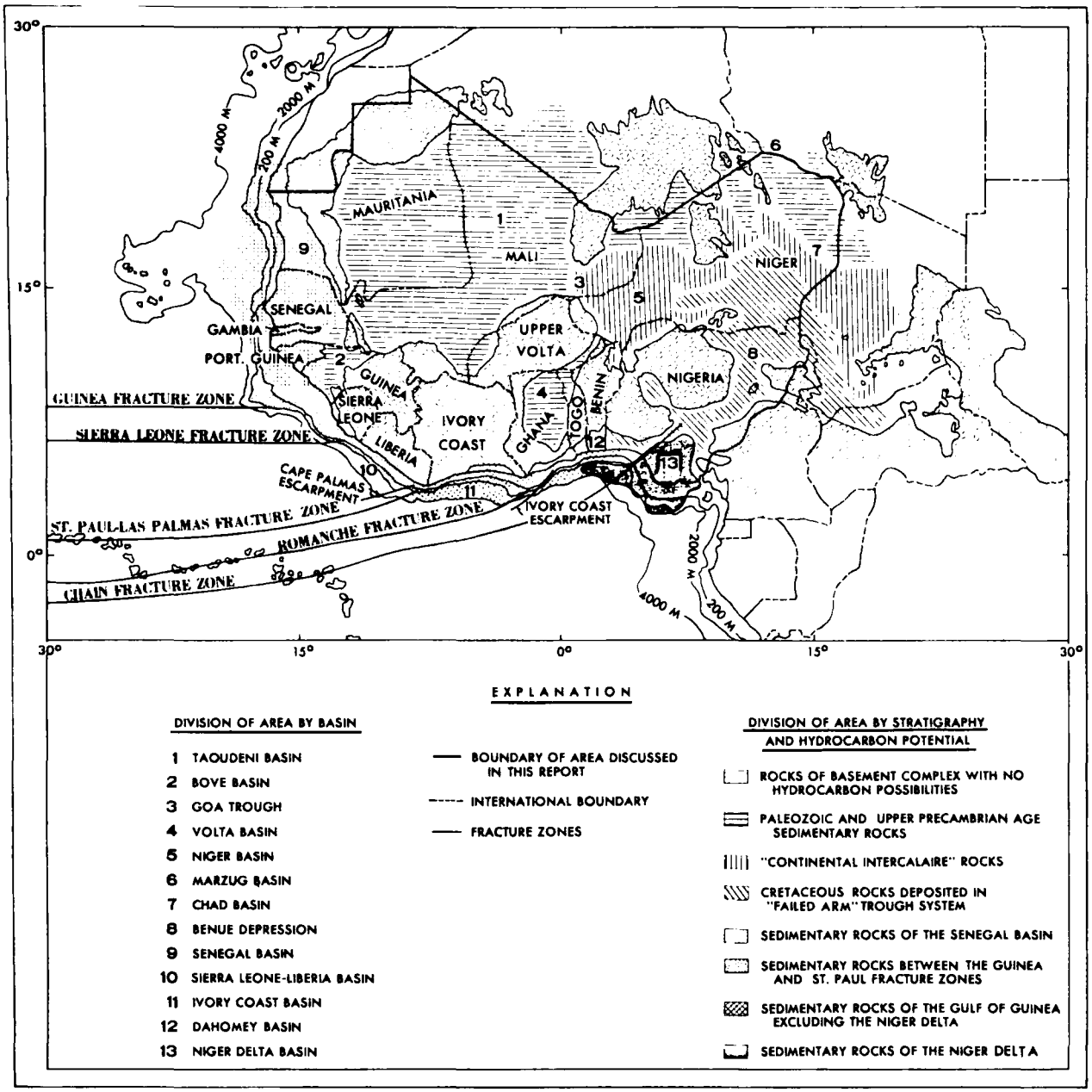

FIGURE 7 Hydrocarbon potential of the eight stratigraphic categories in West Africa.

thick, and is overlaid by 500-1,000 m of Middle and Upper Cretaceous sandstones and shales that reflect alternating marine and nonmarine conditions. Prospects for finding significant quantities of oil or gas in rocks of the "Continental Intercalaire" are considered poor.

Benue depression. Cretaceous sedimentary rocks in the Benue depression represent deposition in a failed arm trough system initiated by opening of the South Atlantic Ocean. The trough was filled by over 3 km of sediments of Albian to Coniacian age. This section contains shallow- and deep-water marine shales with limestones and sandstones deposited at the margins of a marine embayment. Many parts of this relatively poorly understood trough system could contain significant deposits of hydrocarbons. Although the results of exploration in the lower Benue depression were negative, oil and gas discoveries were made in the Lake Chad area of Chad and in southern Chad near the Central African Empire boundary.

Senegal Basin. The Senegal Basin is related to the opening of the North Atlantic Ocean and contains more than 7 km of sedimentary rock. The sedimentary fill consists of sandstones, siltstones, shales, carbonate rocks, and evaporites chiefly of Triassic to Miocene age. The basin represents a typical Atlantic-type marginal basin. In general, analogous type basins off the coast of North America have proved to be poor prospects for discoveries of oil and gas.

Guinea Fracture Zone to St. Paul Fracture Zone. In the area between the Guinea and St. Paul Fracture Zones, the Continental Shelf narrows from over 140 km wide in northern Sierra Leone to an average width of 35 km off Liberia. The thickness of Cretaceous sedimentary rocks on the shelf range from an average of 2 km off Sierra Leone to less than 1/2 km off Liberia. A much thicker sedimentary section underlies the lower slope and rise, however.

No hydrocarbon shows of any kind have been reported from the Continental Shelf off Sierra Leone and Liberia, and industry has shown little interest in the area, probably because of the thin sedimentary section. Four wells drilled in 1971 off Liberia were located in an area of the shelf where thick sedimentary rocks occupy a small fault-controlled basin to the north and to the south by major faults at the shelf edge and on the rise, respectively.

A recent discovery, Ivory Coast's Espoir field, will probably spur deep-water exploration in the area. The discovery well is reported to be capable of producing 20,000 barrels of oil per day, and the field could have producible reserves of 500 million barrels of oil. Water depths above the field range from about 250 to 730 m.

Niger Delta. In the Niger Delta, oil and gas are produced from a Tertiary delta system that prograded across the continental margin in the

lower Benue depression. The thickness of Tertiary sedimentary rocks probably exceeds 8 km. From a petroleum exploration viewpoint, the geology of the Niger Delta is quite similar to that of the Mississippi Delta of the U.S. Gulf Coast. Much is known about the Niger Delta area as a result of over 30 years of intensive exploration for oil and gas.

In 1977, the proven reserves of Nigeria (Niger Delta) were 12.6 billion barrels of oil and 51.42 trillion ft^3 of natural gas. The U.S Department of Energy and the U.S. Geological Survey estimate that from 1.8 to 22.8 billion barrels of recoverable oil and 26 to 130 trillion ft^3 of recoverable natural gas remain to be discovered.

Nigeria's oil development may have peaked, as 13 of 14 giant oil fields were discovered prior to 1969, and the greatest number of fields were discovered in 1965-67. Most of Nigeria's oil fields are small to medium by world standards, and future oil discoveries are likely to reflect this trend.

The natural gas resources of Nigeria, unlike its oil resources, are comparatively underdeveloped. Total natural gas production in 1977 was an estimated 757 billion ft^3 of which approximately 739 billion ft^3 was flared or not marketed.

Coal Resources

Of the ECOWAS countries, only Nigeria and Niger produce coal. Niger produces subituminous coal and has reserves of lignite. On the basis of extensive drilling, reserves of bituminous coal are estimated at 350 million tons. The lignite deposits of the Niger Delta appear to be large but have not been developed.

Geothermal Resources

Published literature contains almost no information pertaining to heat flow values in the ECOWAS region. It is speculated, however, that these values are low because the region is part of a Precambrian shield area located far from any plate boundaries and does not contain any areas of recent volcanism.

A search of published literature found no reports of hot springs in the ECOWAS region.

APPENDIX C

Agenda

Sunday, November 1, 1981	Arrival and registration
Monday, November 2, 1981	
9:30 a.m.-12:30 p.m.	Plenary Session, Official Opening
	Welcoming Address Honorable A.G. Sembu Forna Minister of Energy and Power, Sierra Leone
	Address Dr. Aboubakar Diaby-Ouattara Executive Secretary of ECOWAS
	Address Dr. Thomas B. Reed Chairman, National Academy of Sciences Panel
3:00 p.m. - 6:00 p.m.	Presentation of Papers
	Mr. Gilbert Grant Nigerian National Petroleum Corporation
	"Towards the Efficient Development and Utilization of Petroleum in the West African Sub-Region"

Mr. E.A.K. Kalitsi
Volta River Authority, Ghana

"Demand, Supply, and Distribution of Energy in West Africa--The Need for Regional Cooperation"

Prof. Djibril Fall
University of Dakar, Senegal

"Conventional and Nonconventional Energy Resources of the Subregion: Present Situation and Future Prospects"

Dr. Morton Gorden
Development Sciences Inc., United States

"The ECOWAS Energy Team Report in the First Steps for Formulating Energy Projects for West Africa"

Dr. Charles E. Backus
Arizona State University, United States

"Photovoltaic Technology"

Dr. David W. Brockensha
University of California at Santa Barbara, United States

"Wood Fuels in West Africa"

Dr. Wesley K. Foell
University of Wisconsin - Madison, United States

"Transportation Systems Planning and Energy Management: An International Perspective"

Dr. William Ramsey
Resources for the Future, United States

"Industrial Energy Conservation in the Developing Areas"

Dr. Thomas B. Reed
Solar Energy Research Institute,
United States

"Firewood and Biomass Energy for the West African States"

Mr. Gninimi Mansak
Togo

"The Consumption and Production of Energy in Togo"

Mr. Ogunlade Davidson
University of Sierra Leone, Sierra Leone

"Assessment of Energy Potential in Sierra Leone"

Mr. Sesan Ayodele
Nigerian Institute of Social and Economic Research, Nigeria

"ECOWAS Energy Development and Utilization: The Issues of Appropriate Technology and Its Transfer"

Mr. Kenneth Small
Center for Strategic and International Studies, Georgetown University,
United States

"The Establishment of a Turnkey Model, Information Clearing House for the ECOWAS Region"

Mr. S.S. Labor
Sierra Leone Electricity Corporation,
Sierra Leone

"The Generation and Distribution of Electricity in Sierra Leone"

	Mr. Bede Okigbo IITA, Nigeria "Alternative Energy Options in ECOWAS Countries in Relation to Food and Agricultural Production"
6:00 p.m. - 6:30 p.m.	Organization of Work (Working Groups)
7:30 p.m.	Reception Minister of Energy and Power, Sierra Leone

Tuesday, November 3, 1981

9:00 a.m. - 12:30 p.m.	Working Groups
3:00 p.m. - 7:00 p.m.	Working Groups

Wednesday, November 4, 1981

9:00 a.m. - 12:30 p.m.	Working Groups
3:00 p.m. - 6:00 p.m.	Working Groups
7:00 p.m.	Reception Executive Secretary of ECOWAS

Thursday, November 5, 1981

9:00 a.m. - 12.30 p.m.	Working Groups
3:00 p.m. - 5:00 p.m.	Drafting of Working Group Reports
5:00 a.m. - 7:00 p.m.	Meeting of Synthesis Group on Policy and Planning

Friday, November 6, 1981

9:00 - 12:30 p.m.	Completion of Report
4:00 - 6:45 p.m.	Plenary Session, Presentation of Working Group Reports

o Industry Group

Mr. Oousame Diallo, Guinea

o Agricultural Group

Mr. Djibo Abdou Karimou, Nigelec, Niger

o Energy for Public Use and Infrastructure

Mr. Gilbert Grant, Nigeria National Petroleum Corporation, Nigeria

Adoption of Reports

7:00 p.m. Formal Closing

Remarks
Mr. Michael W. Bassey
Chairman, Energy Symposium

Remarks
Mr. Aboubakar Diaby Ouatara
Executive Secretary, ECOWAS

Remarks
Ms. Patricia Wyndham,
Minister of Energy, Sierra Leone

APPENDIX D

List of Participants

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*This list represents the best information available to the BOSTID staff at the time the symposium was held, but is not necessarily complete. It was not possible to verify many of the names and affiliations of participants.

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