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ENERGY ASSESSMENT OF IVORY COAST, MOROCCO, NIGERIA, AND SENEGAL

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Energy Assessment of Ivory Coast, Morocco, Nigeria, and Senegal

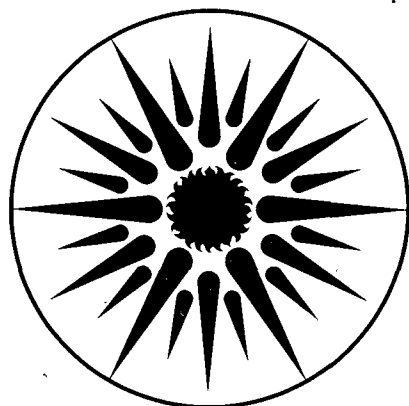
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ENERGY ASSESSMENT OF IVORY COAST, MOROCCO, NIGERIA, AND SENEGAL

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Energy Assessment of Ivory Coast, Morocco, Nigeria, and Senegal

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INTRODUCTION

This report is an overview of the energy market in four West African countries: The Ivory Coast, Morocco, Nigeria, and Senegal. We feel these countries are representative of the West African region. Together they account for 75% of the total energy use in West Africa, 78% of GDP, and 76% of population. The purpose of the study is to analyze the evolution of energy demand in the context of the general socio-economic background of the region. The study also examines energy supply and trade related to the energy sector. The analysis focuses on the study of commercial fuels. Although we have reviewed studies of wood, solar, wind, and agricultural residues, we leave out detailed discussions of these non-commercial energy forms.

The first part of the report is an assessment of the trends in energy demand in the four study countries. We discuss the main factors driving energy demand sector by sector. This is followed by a review of the primary energy resources of the countries, and of the capacity for production of secondary fuels. The last section looks at energy trade, with particular emphasis on the role of the United States.

The sections on demand are based on the energy and economic data prepared for the Developing Country Data Series, developed at IES-LBL. The data and relevant information were obtained from local sources during visits to each of the four countries surveyed. We contacted government offices (ministries and statistical bureaus), academic research institutions, and private companies (oil refineries and distributors, electric utility companies). Record keeping in these countries is far from perfect, and although the data are the best available, there may be inaccuracies and omissions. Although some of the numbers may be unreliable, after careful analysis and cross-checking, we are confident of the accuracy of the trends they show. The sections on supply are based on a literature review done by the International Energy Studies Group at Lawrence Berkeley Laboratory (IES-LBL),¹ as well as on information from our country contacts.

ENERGY DEMAND

This section contains an overview of the trends in energy demand in West Africa since the mid-1970s, and an assessment of the likely future trends in energy demand. The analysis is based on the link between the demand for various fuels and the level of activity in the main sectors of the economy: industrial production, household activities, transportation, and electricity generation. The dwindling supply of fuelwood throughout the region, coupled with massive increases in urban population, combine to create a fast-growing demand for commercial fuels. Since most commercial energy in the region is provided by petroleum products, most imported, we give

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¹We include the following countries in the region: Burkina Faso, Cameroon, Ghana, Guinea-Bissau, Ivory Coast, Liberia, Mali, Morocco, Niger, Nigeria, Senegal, Sierra Leone.

special emphasis to oil based fuels.

Urbanization

The demand for commercial fuels in West Africa is determined, to a large extent, by the disproportionate growth of population in the main urban centers of the region. Although the level of urbanization in West Africa is low compared to that of Latin America, the overall growth has been remarkable, and many observers find the rate of urban growth since the 1950s alarming. The estimated addition to the urban population between 1950 and 1970 is equivalent to an average annual rate in excess of 6 percent. In the period 1973-1984, the average growth rates in the four countries surveyed was between 3.8 and 8.3 percent (Table 1). That corresponds to a doubling of the urban population in the region by the turn of the century. Urban population growth rates were well above total country population growth rates, and rural-urban migration accounts for at least half of the overall population growth in urban centers (Figure 1).²

Table 1
Average Annual Growth of
Urban Population
1973-1984

<i>Country</i>	<i>%</i>	<i>Doubling Time (yrs.)</i>
Ivory Coast	8.3	8
Morocco	4.2	17
Nigeria	5.2	13
Senegal	3.8	18

The primary functions of West African cities continue to be administration, commerce, and transshipment; no industrial city has yet emerged, and only a few of the less populous centers are focused on mining. In most cases, administration and commerce in West African countries are concentrated in seaports that are also the capital cities; the urban systems of many West African countries are characterized by the absence of towns of intermediate size.

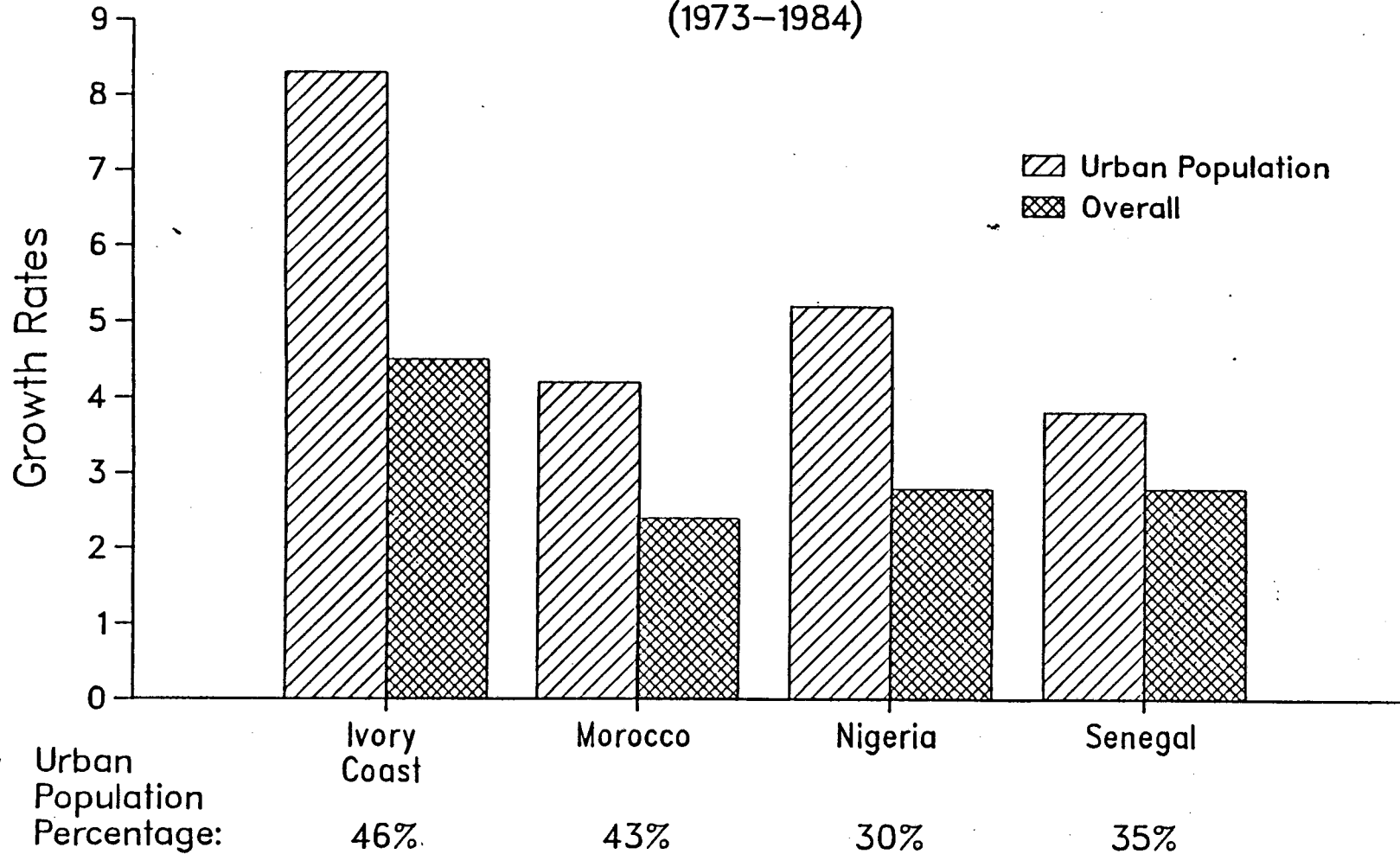
The concentration of population in urban areas has put continuous upward pressure on the demand for commercial fuels, especially petroleum products. Due to the decreasing availability of fuelwood, households gradually switch to kerosene and LPG for cooking and lighting. Demand for gasoline and diesel oil also grows at unusually high rates, in response to the increasing number of vehicles needed to provide personal and freight transport in urban areas.

The most salient characteristic of this pattern of demand is that it is rather independent of the overall performance of the economy. While in other parts of the world the energy use per capita is closely related to economic output, the recent recession that afflicted West Africa has had a relatively small effect on the average energy use.

Continued urban growth will have extreme consequences on the aggregate energy demand over a relatively short time. At the current growth rates, average per capita energy use in West Africa will have doubled by the turn of the century, reaching levels comparable to that observed in Brazil in the early 1970s. In a few decades, the West-African market could easily be accounting for a significant share of world demand for petroleum and energy in general.

Figure 1

Population Growth Rates (1973-1984)



Energy Use

Total commercial energy use in the four countries surveyed was 21 million TOE in 1983. Although this level is small when compared with some Asian or Latin-American countries, the average growth rate of energy demand (10 percent) is one of the highest in the world (Table 2).

Table 2
West-African Energy Demand in Context

	<i>1983 Commercial Energy Consumption (1000 TOE)</i>	<i>Avg. Annual Growth in Energy Consumption 1974-83</i>
West Africa, 4 Countries	21,310	10%
Ivory Coast	1247	7.1%
Morocco	4865	2.8%
Nigeria	14409	15.6%
Senegal	789	3.6%
Latin America**	353,000	4.0%
Japan**	342,000	-0.2%
Western Europe**	1,221,000	-0.1%

** From 1985 BP Statistical Review of World Energy.

Quite significantly, and in agreement with the general characteristics of the local market, this extreme growth of energy demand took place during a period of slow economic growth. Total GDP for the group grew from 22.7 to 26.4 billion dollars from 1974 to 1983, corresponding to an average yearly rate of 1.7 percent. However, between 1977 and 1983 GDP decreased in Nigeria and Senegal, and GDP per capita decreased in all the countries (Table 3). Yet, there is a generally increasing trend for energy use per capita, which is evidence of the importance of urban growth in the determination of total energy demand in the region. Much of West Africa's GDP is generated in the primary sector (especially agriculture and mining) which is relatively low in energy intensity. On the other hand, the explosive growth of urban population has continued unabated, creating a rapidly growing market for commercial fuels for household use and for transportation.

Historical Trends

Due to the dynamic nature of the residential and transportation energy markets, the trend for commercial fuels in West Africa is one of sharply increasing demand. Adverse weather conditions and poor economic performance have, in some cases, interrupted that increase in the last three years. Nevertheless, given the continuous influx of population into urban centers, that appears to be a temporary disturbance in a strong upward trend.

Total energy use in the countries surveyed increased an average rate of 11 percent, that is nearly doubling in the five-year period 1977-1982, going from 13.1 to 22.4 million TOE. By 1984 demand had declined to 19 million TOE, reflecting the adverse economic conditions prevailing throughout the region. Use of coal and natural gas increased significantly, but was limited to Morocco (coal) and Nigeria (natural gas). There was some use of coal and natural gas in the Ivory Coast, but the country remains largely dependent on oil. Senegal relies exclusively on oil for commercial energy supply.

Table 3
GDP Total and per Capita
(1980 US \$)

	Per Capita			Total		
	1977	1983	AAGR	1977	1983	AAGR
Ivory Coast	1125	1025	-0.2%	8235	9205	1.9%
Morocco	795	781	-0.3%	14580	17846	3.4%
Nigeria	1021	736	-5.4%	80270	68905	-2.5%
Senegal	350	384	-3.5%	1833	1734	-0.9%
Average	958	743	-4.2%			

The upward trend in demand is due mostly to Nigeria, where energy use increased four-fold from 1974 to 1983. Although not as strong, energy demand in the other three countries also increased quite substantially during that period (Table 2).

Energy use per capita for the group of countries grew at 5.2 percent in the period 1977-83 (Table 4). At that rate, energy demand per capita would double between now and the end of the century. Growth of energy per capita was highest in Nigeria, nearly doubling from 1977 to 1982, and showing an average growth rate of 7.8 percent in the period 1977-83, despite a significant contraction in demand from 1982 to 1983. The energy market in the other countries was less dynamic, and did not keep up with population growth in the recent past. Energy use per capita declined for several successive years after peaking in 1979 (for Morocco and Senegal), and 1980 (for Ivory Coast).

The share of oil in primary energy use increased from 83 to 88 percent from 1977 to 1983, reflecting mostly the growth of petroleum demand in Nigeria, and Senegal's complete dependence on petroleum for commercial energy supply. The share of petroleum products increased in Morocco, due mostly to the need to increase fuel oil use in power generation in the period 1977-1984. The recent alleviation of the drought conditions allowed a substantial decline in oil use per capita in the Ivory Coast, as hydroelectric power plants were able to resume full operation.

Table 4
Energy and Oil Demand per Capita
(TOE per 1000 persons)

	ENERGY			OIL			HYDRO		
	1977	1983	AAGR	1977	1983	AAGR	1977	1983	AAGR
Ivory Coast	124	139	1.9%	115	98	-2.7%	8	41	27.2%
Morocco	219	217	-0.2%	172	184	1.1%	172	184	1.1%
Nigeria	98	154	8.1%	64	115	9.8%	3	4	2.1%
Senegal	133	129	-0.5%	134	129	-0.6%			
Average	119	163	5.2%	89	126	5.8%			

Energy and oil use per unit of GDP increased constantly from 1977 to 1982, remaining virtually unchanged from 1982 to 1983 (Table 5). While the average GDP per capita for the region declined constantly since 1977. The energy/GDP ratio nearly doubled in that period, increasing at an average yearly rate of 9.4 percent.

Table 5
Energy and Oil Demand per GDP
(TOE per million US \$ of 1980)

	ENERGY			OIL		
	1977	1983	AAGR	1977	1983	AAGR
Ivory Coast	110	136	3.5%	102	96	-1.0%
Morocco	276	279	0.2%	217	236	1.4%
Nigeria	93	209	13.5%	63	156	15.1%
Senegal	382	455	2.9%	382	455	2.9%
Average	125	219	9.4%	93	170	10%

Comparing Energy Intensities

Due to differences in exchange rates, economic structure, and relative commodity prices, it is difficult to do inter-country comparisons of E/GDP ratios. The E/GDP indicator may be useful for identifying trends within countries.

Although growth of urban population seems to be the main determinant of energy demand in West Africa, the energy and oil intensities of the region were also subject to variations due to economic output and climate. West-African countries are largely dependent on commodity exports as a source of foreign exchange. In recent years, the continued decline in the price of some of their basic export commodities caused declines in GDP that were not accompanied by a proportional decline in energy use. Typical of that pattern was the decline in the price of peanuts, one of the main Senegalese exports, and phosphates, which account for much of Morocco's exports. Nevertheless, energy and oil intensities continued to increase throughout the 1970s in Senegal, and remained fairly high in Morocco, despite a stagnant economy.

The primary energy mix and the petroleum intensity of several countries in the region were also influenced by a series of severe droughts that have affected the region since 1979. The years of lean water supply have caused the shutdown of some hydroelectric units and led to an increase in the demand for fuel oil for power generation. This has caused abrupt fluctuations in the oil intensity of several of the local economies, especially Morocco and the Ivory Coast. Whereas the Ivory Coast is approaching self-sufficiency in petroleum (mostly since 1983),³ Morocco is not, and has suffered severe financial consequences from its increased oil-import bill. The drought conditions subsided in 1985, after prevailing through most of the 1979-1984 period. An important aspect of this substitution process is that it is largely reversible, and that under regular rainfall conditions, fuel-oil intensities will be suddenly and substantially reduced.

Sectoral Breakdown

The sectoral breakdown of energy use for the period 1977-1984 gives evidence of the potential of the regional energy market and of the importance of the transportation and residential and commercial sectors (Table 6,7 Figure 2). First, the slowest sectoral growth rate for energy use was still an impressive 6.0 percent, registered by the industrial sector. Second, the transportation sector alone accounted for more than half of total commercial energy use, and that share appears to be increasing. Third, the residential energy market for commercial fuels outgrew all other sectors in that period, increasing at an average annual rate of 11 percent. Energy use for power generation grew only slightly faster than the average, increasing its share only slightly. The rate of oil use in electricity generation exceeded the average growth of total energy use in the sector due to the effect of the droughts.

Table 6
Sectoral Shares of Energy Demand
(percent)

Sector	1977	1984
Industrial	28	19
Transportation	50	57
Resl/Comml	12	13
Power Generation	10	11

Table 7
Energy and Oil Demand by Sector
(1000 TOE)

	ENERGY			OIL		
	1977	1983	AAGR	1977	1983	AAGR
Industrial	3118	4464	6.0%	2380	3308	5.5%
Transportation	5708	9905	9.2%	5676	9892	9.3%
Res/Comml	1333	2532	10.7%	972	1928	11.4%
Power Generation	1181	1798	7.0%	857	1486	9.2%

The Industrial Sector

Total energy demand of the industrial sector of the four-country aggregate grew at an average yearly rate of 6% between 1977 and 1983 (Table 8). Oil demand grew at nearly the same rate (5.5%), as the sector relies on petroleum products for three-quarters of its total energy use.

Industrial energy intensity, measured as energy use per unit of value added, showed mixed behavior (Table 9).

Oil and Structure Growth Rates (Ivory Coast, Morocco, Nigeria, Senegal)

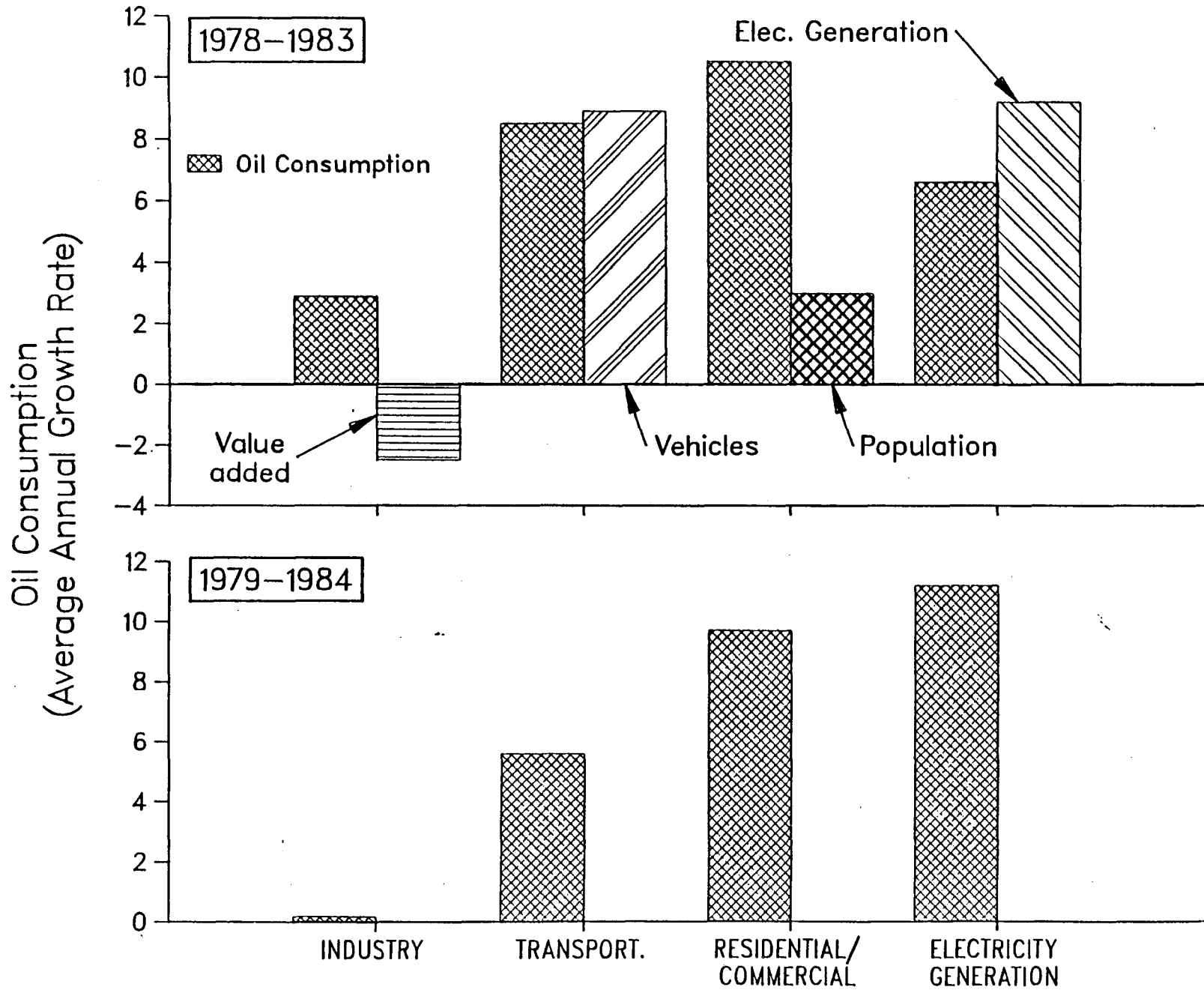


Figure 2

Table 8
West-African Industrial Energy Demand

	1977		1983	
	MTOE	%	MTOE	%
Oil	2380	76	3309	74
Coal	112	4	187	4
N.Gas	311	10	482	11
Electricity	315	10	487	11
Total	3118	100	4464	100

Table 9
Industrial Energy and Oil Intensity
(TOE per million US \$ of 1980 of Value Added)

	ENERGY*			OIL		
	1977	1983	AAGR	1977	1983	AAGR
Ivory Coast	50	50	0.0%	36	31	-2.5%
Morocco	217	244	2.0%	175	175	0.0%
Nigeria	29	63	12.9	21	48	13.7
Senegal	219	252	2.3%	189	210	1.8

* Industrial GDP for 1983 based on share of the sector for the most recent year.

In Nigeria there was an extreme increase in both energy and oil intensity of industrial output. Both those indicators more than doubled, growing at an average rate in excess of 12 percent during the period observed, as the Nigerian industry increased its use of the country's large oil and natural gas reserves. The development of local refineries and cement plants contributed to this increase in intensity. Despite this considerable growth, the average energy content of industrial output in Nigeria is still low compared to that of other countries in the region. In Senegal, where the petroleum refinery S.A.R. accounts for a substantial fraction of industrial output, industrial energy intensity in 1983 was 252 TOE per million dollars, which is much greater than that of Nigerian industry. On the other hand, if the trend of the last decade is maintained, Nigerian industry could be the most energy intensive of the group by the turn of the century

In the other three countries the changes in industrial energy intensity were slight, growing at a rate of about 2 percent in Morocco and Senegal, and remaining unchanged in the Ivory Coast. Oil intensity remained stable in Morocco, and declined at an average 2.5 percent in the Ivory Coast.

The Transportation Sector

The aggregate vehicle fleet in the countries surveyed increased at an average yearly rate of 8.3 percent from 1977 to 1983 (Table 10). That is nearly 2.5 times the population growth rate for the same period, and corresponds to an average growth of 5.2 percent for the number of vehicles per capita. Automobiles account for over half of the total fleet, and their number has increased at nearly the same rate as the total vehicle population. At those rates the number of cars per capita in West Africa will have doubled before the turn of the century.

Table 10
Composition of Vehicle Fleet
(in thousands)

	1977	1983	AAGR
Cars & Pickups	780	1216	7.4%
Total vehicles	1372	2260	8.3%

Energy Demand 1977-83

Aggregate energy demand for transportation in the four countries increased from 5.7 to 9.9 million TOE from 1977 to 1983. That corresponds to an average growth rate of 9.2 percent. Petroleum products account for virtually all the energy use in the sector.

The oil price increase of 1978-79 generated different responses in the region, as well as in the market of gasoline and diesel within each country (Table 11). In Nigeria, demand for both gasoline and diesel continued the strong growth of previous years, increasing at average rates in excess of 10 percent both for gasoline and diesel. In the Ivory Coast, there was a decline in demand for both fuels. In Morocco and Senegal gasoline demand declined, while demand for diesel increased significantly.

Table 11
Fuel Use in Transportation
(in 1000 TOE)

	GASOLINE			DIESEL		
	1977	1984	AAGR	1977	1984	AAGR
Ivory Coast	278	209	-4.0%	308	260	-2.4%
Morocco	409	367	-1.6%	859	1025	2.5%
Nigeria	2020	4144	10.3%	973	1968	10.1%
Senegal	112	96	-2.2%	90	132	5.5%
Total	2819	4816	7.7%	2230	3385	6.0%

Transportation oil intensity, measured as the sum of diesel and gasoline use per vehicle, remained nearly unchanged for the group as a whole. It underwent a significant decline in the Ivory Coast, going from 3.1 to 1.6 TOE per vehicle from 1977 to 1983. There were also declines in Morocco and Senegal. This decline in intensity was brought about mostly because of fuel price increases in these petroleum importing countries after the oil price shock of 1979. The decline in

intensity was sufficient to outweigh the increase in vehicle fleet and lead to the decrease in total energy use in the sector in these three countries. In Nigeria there was a small increase with respect to 1977 levels, which had been the lowest of the decade.

Table 12
Transportation Oil Intensity
 (Gasoline plus Diesel per Motor Vehicle)
 (TOE/Vehicle)

	1977	1983	AAGR
Ivory Coast	3.1	1.6	-11.0%
Morocco	2.3	1.9	-3.2%
Nigeria	4.7	5.0	1.0%
Senegal	2.5	2.0	-3.7
Total	3.5	3.7	1.0%

It should be noticed that while the oil intensities of Senegal, Morocco, and the Ivory Coast are clustered in a range from 1.6 to 2.0 TOE per vehicle, the annual average in Nigeria is much higher, approximately 5 TOE per vehicle (Table 12). This rate is similar to the figure for Venezuela, where domestic supply and price conditions were similarly favorable. These oil intensities in transportation are one of the the highest among LDCs.

Due to the weight of the Nigerian market, in 1983, the average use of gasoline plus diesel in the region was 3.7 TOE per vehicle, that is approximately 4411 liters per vehicle.

The Residential/Commercial Sector

The average growth rate for the four countries studied was 3.2 percent from 1977 to 1983. The highest rate was observed in the Ivory Coast, 3.4 percent, and the lowest Senegal, 2.6 percent.

However, the most important feature from the standpoint of commercial energy use were the rates of growth for the urban population. The average for the group was close to 5 percent, ranging from 8.3 percent in the Ivory Coast to 3.8 percent in Senegal.

The average is heavily weighted by the population of Nigeria, which accounted for 69 percent of the total for the four countries in 1983. The net inflow of people into Lagos during the 1970's was 50 thousand per year. In 1972 it was estimated that the city would need 48 thousand new houses to alleviate the problems of overcrowding-- and this number assumed an occupancy rate of 20 persons per house. The metropolitan area of Lagos experiences chronic power failures, horrendous traffic jams, water rationing, and a growing crime rate. Lagos' population exploded from 300 thousand to three million in one decade. Similar trends and problems are found in Ibadan, the largest city in Nigeria (and in Africa), with a population estimated to be between 5 and 8 million people.

In those cities, demand for additional (energy-using) infrastructure is required not only by those newly-arrived from rural areas, but also by the millions who live at the margin of the commercial market. Even assuming that rural-urban migration could be attenuated, the natural growth of the existing urban population would continue to propel demand for commercial energy. As fuelwood availability decreases and charcoal prices increase, more urban households switch to kerosene and LPG as fuels for lighting and cooking, resulting in the increasing energy (and oil) intensity for the sector.

Energy Demand 1977-1983

Total energy demand of the residential/commercial sector increased from 1.33 to 2.53 million TOE in the period 1977-1983, corresponding to an average yearly rate of 10.7 percent, which is the highest among the sectors studied (Table 13). An even higher rate (11.4 percent) was achieved by demand for petroleum products, which increased from 0.97 to 1.93 million TOE.

Kerosene and LPG accounted for 75 percent of total (commercial) residential energy use in 1983, electricity accounted for 24 percent, and the remaining one percent were divided between diesel, fuel oil, and coal. Demand for kerosene outgrew that of any other fuel, increasing at an yearly average of 12.4 percent. The small use of coal in the residential/commercial sector was restricted to Nigeria.

Table 13
Breakdown of Commercial Fuels
for the Residential/Commercial Sector
(1000 TOE)

	1977	1983	AAGR
Electricity	350.6	597.6	8.9%
LPG	271.7	464.6	8.9%
Kerosene	690.4	1449.3	12.4%
Diesel	3.9	4.7	3.1%
Fuel Oil	6.1	9.6	7.6%
Coal	9.8	6.5	-6.8%
Total	1332.5	2532.3	10.7%

The residential/commercial sector is the only one where both energy and oil intensities increased in all countries. The average growth rates for energy and oil use per capita were 7.5 and 8.3 percent respectively (Tables 14, 15).

Nigeria was the only country where oil intensity outgrew energy intensity in the residential sector, due largely to the increase in the demand for kerosene, which more than doubled between 1977 and 1983. In the other three countries, the highest rate of penetration was that of electricity (Table 16). In Morocco, for example, the rate of growth of residential electricity demand was twice the rate observed for petroleum products.

Table 14
Residential/Commercial Oil Intensity
(TOE per 1000 persons)

	1977	1988	AAGR
Ivory Coast	7.7	10.2	4.7%
Morocco	16.8	19.8	2.7%
Nigeria	7.0	15.0	12.7%
Senegal	3.4	4.1	3.1%
Total	9.7	15.9	8.3%

Table 15
Residential/Commercial Energy Intensity
(TOE per 1000 persons)

	1977	1988	AAGR
Ivory Coast	12.3	17.9	6.3%
Morocco	22.5	27.8	3.5%
Nigeria	10.0	18.0	9.8%
Senegal	5.3	6.8	4.2%
Total	12	19	7.5%

In general, residential energy demand shows the expected correlation with the level of economic output. The countries with higher GDP per capita also have higher commercial energy use. The exception is Nigeria which has a GDP per capita comparable to that of Senegal, but consumes three times as much energy per capita (Table 17).

Electricity Generation and Sales

Total electricity generation in the countries studied increased at an average yearly growth of 9.1 percent (Table 18). The highest growth rate was observed in Nigeria (10.4 percent), and the lowest in Senegal (4.8 percent). With the exception of Nigeria, electricity generation increased at a rate faster than total energy use.

The most extreme difference was observed in Morocco, where electricity generation increased at an average 8.3 percent, while total energy use increased at 2.8 percent. *Fuel Demand 1977-1988*

Table 16
Residential/Commercial Electricity Intensity
(TOE per 1000 persons)

	<i>1977</i>	<i>1983</i>	<i>AAGR</i>
Ivory Coast	4.7	7.7	8.2%
Morocco	5.7	8.0	5.7%
Nigeria	2.9	4.0	5.4%
Senegal	1.9	2.7	5.9%
Total	3.5	4.9	5.6%

Table 17
Residential/Commercial Energy Demand
and GDP per Capita in 1983

	<i>Energy/capita</i> <i>(TOE/1000 persons)</i>	<i>GDP/capita</i> <i>(1980 US\$)</i>
Ivory Coast	17.9	1103
Morocco	27.8	789
Nigeria	20.4	804
Senegal	6.8	306

Table 18
Total Electricity Generation
(GWh)

	<i>1977</i>	<i>1983</i>	<i>AAGR</i>
Ivory Coast	1243	1988	7.8%
Morocco	3754	6185	8.3%
Nigeria	4674	6185	10.4%
Senegal	487	648	4.8%
Total	10158	17534	9.1%

Total fossil fuel demand for electricity generation increased from 1874 to 3382 thousand TOE from 1977 to 1983, corresponding to an average growth rate of 9.8 percent.

Oil demand in that sector increased at a somewhat slower pace, from 883 to 1494 thousand TOE, averaging 8.8 percent per year. There were, however, large differences in the general trends of petroleum intensity (Table 19). While it decreased in Nigeria and in the Ivory Coast, it increased sharply in Morocco and only slightly in Senegal. The reduction in oil intensity in Nigeria was due to the rapid penetration of natural gas, which accounted for 96 percent of total fuel use for electricity generation in that country.

Table 19
Power Sector Fuel Oil Intensity
(TOE per TWh)

	1977	1983	AAGR
Ivory Coast	218.3	103.0	-12.5%
Morocco	81.6	155.0	10.7%
Nigeria	13.6	1.5	-36.7%
Senegal	301.2	336.8	1.9%

Climate was the most important factor determining the oil-intensity of electricity generation in other countries. Due to the prolonged drought, hydroelectric generation in Morocco in 1983 was 466 GWh, that is, only 30 percent of the 1574 GWh generated in 1979. Morocco is also the country that makes most use of coal for generation, with that fuel accounting for 29 percent of total sectoral fuel use in 1983. Accordingly, the share of fuel oil in total petroleum use in Morocco was 46 percent in 1983, compared to 38 percent in 1977.

The effects of the drought were also felt in the Ivory Coast. Although there is a decline in oil-intensity in 1983 with respect to 1977, due to additions to capacity, total hydroelectric generation has declined continuously since 1982. In 1984, due to the intense drought, only one of the Ivory Coast's three hydroelectric plants was able to operate, and only at 30 percent capacity.

ENERGY RESOURCES AND PRODUCTION*

The energy situation in West Africa is similar in many respects to that in other low-income developing regions. The availability of wood, which dominates household energy consumption, is threatened by deforestation. The most widespread indigenous non-wood energy source is hydro power and, although a few countries are large oil exporters, most are heavily dependent on imported petroleum. Energy is linked to concerns about, among other things, the satisfaction of basic needs, the balance of trade, shortages of investment capital, relations with multinational companies, and public sector management problems.

*This section draws heavily from Kahane and Lawakabamba, ref. 1

Primary Energy

The four West African countries have substantial energy resources, including stocks of oil, gas, coal, uranium and biomass, and flows of sun and water, but they are distributed unevenly. The most plausible estimates of the "economically recoverable" resources of conventional fuels in each country are shown in Table 20.

Table 20
Potential Energy Resources

	Crude Oil (Barrels $\times 10^6$)	Natural Gas (Cubic Meters $\times 10^9$)	Coal (tonnes $\times 10^6$)	Hydropower (Megawatts)
Ivory Coast	108	162d	-	3000
Morocco	0.25	1.0	10	n.a.
Nigeria	21513	3615	600	12400
Senegal	p	s	-	1400n

Unless otherwise specified, oil, gas and coal reserves are defined as those recoverable with existing technology and under existing economic conditions, and hydro as the technically exploitable potential.

p Potential existence of resources.

n Resource is shared between countries, so the ultimate share obtained is subject to negotiation.

s Small quantity of resources (less than 1 unit).

d Definitions of resource potential may be different from the ones given above

Petroleum and Natural Gas

Estimates of proven oil reserves are highest in Nigeria at approximately 17 billion barrels, followed by the Ivory Coast at 100 million. Much smaller fields are also reported as possible in Morocco and Senegal.

Most of the large proven oil fields are being produced. In 1984, oil production in Nigeria was about 1400 thousand barrels per day (kbd) and accounted for about 98% of the group's production (Table 21). Smaller amounts were produced in the Ivory Coast (30 kbd). Nigerian production climbed from the early 1970s to a peak in 1979⁴ but has since declined, following the decline in world oil demand. By contrast, production since 1980 has increased ten-fold in the Ivory Coast.

Natural gas reserves are found in all the oil-producing countries. Proven reserves are around 1,000 billion cubic metres in Nigeria, and 85 billion cubic meters in the Ivory Coast. Much smaller deposits are reported in Morocco and Senegal.

Natural gas production historically has been important only in Nigeria, where in 1984 production was above five billion cubic meters. The amount of gas flared has steadily declined since 1979 and was to be eliminated entirely by 1985 (except with written government permission), according to a revised 1979 decree, but this deadline has been admitted to be unrealistic.⁵ The

Table 21
Crude Oil Production
(Thousands of barrels per day)

	1970	1980	1981	1982	1983	1984
Ivory Coast	0	2	8	15		
					24	27
Nigeria	1087	2090	1428	1279		
				1294	1241	1377

Other countries: no significant production.

amount marketed has more than tripled since 1979; in 1981 final consumption was evenly divided between industry and power plants.⁶ A number of schemes have been proposed to use more gas, including LNG and petrochemical plants, use in steel works and pipelines to serve potential urban residential markets.

Table 22
Natural Gas Production in Nigeria
(Millions of cubic Meters)

	1979	1980	1981	1982	1983	1984
Gross	30049	24552	16572	15127	15181	-
Marketed	1378	1070	2155	1413	2298	4929
Flared	28761	23482	14346	12821	12515	-
Re-Injected	0	0	71	893	368	-

Source: OPEC, Annual Statistical Bulletin

The Ivory Coast is moving to exploit offshore gas deposits and plans to promote substitution of gas into refining, power generation, and industry.⁷ In Senegal, at least until 1981, a small amount was produced and burned in the dual-fired Cap des Biches power station.⁸

If oil production continued at 1984 rates, currently estimated proven oil reserves would be exhausted in about 30 years in Nigeria and about 10 years in the Ivory Coast. Of course, this calculation ignores additions to the proven reserves. As of November 1984, there was exploration for new oil and gas fields in the Ivory Coast (2 rigs) and Nigeria (10 rigs). Six of the ten Nigerian rigs were onshore, with all of the remaining exploration in offshore fields.⁹ Exploration has tapered off in the last few years: the number of rigs in each of the countries has declined since 1982 (from 6 the Ivory Coast and 28 in Nigeria).¹⁰ Exploratory drilling was expected in 1985 in Senegal and Morocco, offshore in both cases.

Coal and Uranium

Coal deposits in West Africa are generally not as large as those in the southern and southeastern parts of the continent. There are reserves in Nigeria and Morocco, however, estimated at around 600 million and 10 million tonnes (50 to 60 tons probable) respectively. In Nigeria, 1981 coal production was 114 thousand tonnes, mostly for use in industry.^{11,12} Production has fallen sharply since the late 1950s due to very low mine productivities and decreased coal demand for rail transport and power generation. In Morocco; 1984 production was approximately 800 thousand tonnes, up substantially from previous years. Morocco is planning further expansion in the future.

There are substantial peat deposits in Senegal in the "Niayes" region near Dakar. Peat reserves are estimated at 9.8 million dry tons (3.7 million toe). Studies are underway that examine the use of peat in households, industry, or as a fertilizer with phosphates. Initial indications are that the high ash content (35%) will preclude the use of peat in industry and power generation.¹³

Although there is some uranium in Nigeria it is not used as an energy resource in the region. Morocco is reported to be investigating the possibility of acquiring a nuclear power plant from France.¹⁴

Hydro Resources

Hydro is the most widely distributed energy resource, with some estimated potential in every country in the group. There are three general reasons why the actual installed capacity given in Table 23 is so far below the potential. First, the estimates noted in Table 21 generally refer to technical and not necessarily economic exploitability. Many of the sites would be expensive to develop and, even if total generating costs would be lower than from oil-fired plants, financing of the large construction costs has been difficult. Second, projected industrial and household demand is often too low to justify exploitation.^{15,16} Finally, local engineering manpower is often insufficient for either detailed resource surveys or for construction.¹⁷

Regional hydro development is a promising solution to many of these problems, although inter-country negotiations have been complicated by considerations related to flooding and to joint power/irrigation use. Many of the projects recently proposed are either on hold or no longer under consideration. More attention is now being given to proposals for regional integration and for interconnection of existing facilities.

Secondary Energy

Electricity Generation

Of the primary fuels other than wood, all of the hydro, most of the gas, and some of the oil and coal are used to generate electricity. Installed electrical generating capacity in 1984 is shown in Table 23. Hydro makes up most of the capacity in the Ivory Coast, the remaining capacity is oil-fired except in Morocco (coal) and Nigeria (coal and natural gas). Industrial autoproduction is important in the Ivory Coast.

Electricity production in 1975 and 1982 is shown in Table 24. In general, there has been an increase in production reported with a shift from oil to hydro in the Ivory Coast. Some of the year-to-year variation in hydro generation is related to water availability, as was the case during the recent drought-induced electricity shortages the Ivory Coast.¹⁸

Table 23
Installed Electric Generating Capacity, 1983
(Megawatts)

	Total	Thermal	Hydro
Ivory Coast	1163	278a	885
Morocco	1815	1208	607
Nigeria	4020	2120b	1900
Senegal	182	182	0

a Significant portion owned by autoproducers.
b Most of this is natural gas.

Serious technical inefficiencies in the electric sector are widespread. In Nigeria, for example, frequent power outages have resulted from a lack of spare parts (partly because of foreign exchange constraints), inadequate operational supervision and poor maintenance.¹⁹ In some cases, tariffs have not been adequately adjusted after oil price increases to allow a surplus for maintenance. In Senegal²⁰ by contrast, overall maintenance is reported to be good.

Table 24
Production of Electricity
(Millions of kWh)

	1975			1984		
	Thermal	Hydro	Total	Thermal	Hydro	Total
Ivory Coast	579	383	962	1280	351	1809
Morocco*	2398	1356	3754	6049	352	6401
Nigeria	1129	2341	3470	7796	1181	8976
Senegal	406	0	410	695	0	695

* values are for 1977 instead of 1975

Petroleum Refining

There are eight refineries in the four countries, with total capacities ranging from 30 thousand barrels of crude oil a day in Senegal up to 250 thousand in Nigeria (Table 24). One problem with the refineries is that, with limited cracking capacity they are severely limited in their ability to meet the demand for middle distillates, which has generally grown much faster than the demand for heavier fuel oil. This shift in demand mix is the result of rapid growth in household and transport consumption along with stagnation in oil-fired electric generating capacity, and is expected to continue through 1995.²¹

Restructuring of refining capacity in the region has been suggested both because of problems in the output-demand mismatch and because of chronic underutilization. In 1983 the Ivory Coast completed a \$450 million expansion of its Abidjan refinery that included the addition of cracking capacity. Initially the expected domestic market did not materialize and the refinery was operating far below capacity. In March 1984, however, the Ivory Coast signed a contract to process 400 thousand tons of crude for Gulf Oil, and exports of petroleum products to neighboring countries has been expanding.²² Nigeria has tentative plans to build a 100,000 bsd refinery to decrease petroleum product imports from offshore refineries.

Table 25
Petroleum Refinery Capacity
 (As of January 1, 1985)

	Number of Plants	Capacity (Barrels per day)
Ivory Coast	2	90,000
Morocco	2	160,000
Nigeria	3	250,400
Senegal	1	29,800

Source: Oil and Gas Journal; Country sources

ENERGY TRADE

This section examines trade and its relation to the energy sector. Special attention is given to the prospect for trade between the United States and the study countries.

Table 26 show the trade in non-wood fuels in various years (the most recent years complete figures were available). The net balance of energy trade (in Btu terms) is negative for Morocco and Senegal, and strongly positive for Nigeria. Energy trade in the Ivory Coast is improving and the country is approaching energy self-sufficiency. Trade in fuel wood has not been reported and is probably small compared to consumption in all countries; exports of charcoal from the Ivory Coast to Burkina Faso, ^{23,24} have been considered, however, and there are some charcoal exports from the region to Europe.

The dominant commodity in energy trade is petroleum. Petroleum is Nigeria's primary export commodity (over 95% of foreign exchange earnings) and the oil market will be the primary factor determining the course of the country's future development. Morocco and Senegal are heavily dependent on imported petroleum and have been running large trade deficits in part because of the oil import burden. Ivory Coast has benefited from recent discoveries of oil and gas, but the size of the reserves and their exploitability is uncertain.

Crude oil is imported into all the countries, except Nigeria. Petroleum products are imported into almost all countries, including those with refining capacity, because of the refinery output mix problem mentioned above. Indeed, several countries record both imports and exports of petroleum products.

Most of the crude oil imported by group countries comes from outside of West Africa, that is, from countries other than Cameroon and Nigeria. This is related both to particular payment conditions and crude quality requirements. The Ivory Coast has recently begun refining substantial quantities of crude for Gulf Oil (the first such agreement in West Africa). Suggestions of concessionary intra-African sales have generally not been adopted. Another proposal ²⁵ has been to arrange for direct exchange of minerals and other export commodities for petroleum.

Petroleum import costs, measured as a percentage of export earnings, have risen from generally less than 10% in 1970 to as high as 44% in 1984 in Morocco (Table 27). ²⁶ Nigerian oil exports presently provide almost all the country's export earnings, which has made the economy highly vulnerable to external oil demand fluctuations.

Table 26
Trade in Non-Wood Fuels
(Thousand tonnes of oil equivalent)

Oil	Imports			Exports		
	Crude Products	Petroleum Coal	Oil	Crude Products	Petroleum Coal	
Ivory Coast (1982)	1427	207	0	97	275	0
Morocco (1983)	4250	241	186	0	0	18
Nigeria (1984)	0	2730	00	55400	710	0
Senegal (1984)	384	623	0	0	126	0

Source: Country Sources

There may also be electricity trade over the interconnections between Ghana and the Ivory Coast, and between Nigeria and Niger.

Electricity converted at consumption value (1kWh = 0.08 kgoe).

Electricity trade in the region is confined to Nigerian exports to Niger (non-firm hydro-generated power). Ghana is also interconnected with the Ivory Coast.

Table 27
Petroleum Trade

	1970	1975	1980	1981	1982	1983	1984
Crude Petroleum imports as a percentage of total exports							
Ivory Coast	3	12	14	17	17	12	7
Morocco	5	14	25	46	53	43	44
Senegal	6	13	43	35	37	42	44
Crude Petroleum exports as a percentage of total exports							
Nigeria	57	96	97	95	98	96	97

Source: IMF

Morocco and Senegal are overwhelmingly reliant on imported petroleum as a commercial energy source (85% and 99% respectively of commercial energy in 1984). Morocco is making an effort at replacing imported oil with coal in both electric power generation and industry. Morocco is developing its indigenous coal reserves, but because of constraints in mining capacity and coal quality the rising demand for coal will be met with foreign imports. Coal imports now account for over thirty percent of coal use, having risen from less than 30,000 tons at the beginning of the decade to 450,000 tons in 1985.^{27,28} There have also been reports of Senegal considering the importation of coal to displace oil in industry and possibly power generation. The governments of both of these countries have expressed interest in renewable energy sources, especially decentralized solar energy, but little has been done besides demonstration projects by various foreign groups.

Trade in Energy Equipment and Services

All the countries under study have plans to increase reliance on domestic energy sources in an attempt to meet the rapid growth in demand for commercial energy. Expansion is planned for oil, gas, and coal production facilities, gas distribution networks, electrical power plants, and electrical distribution networks. Virtually all the equipment and materials, as well as the technical expertise for these planned expansions need to be brought in from outside. American companies have aided in past expansions and may be able to increase exports of goods and services in the future. However, corporations from many different countries are active in the region and competition for contracts is likely to be intense.

Oil and gas exploration by consortia of multinational oil companies in partnership with individual country governments is continuing in Nigeria, the Ivory Coast, and Morocco. However the currently soft international oil market has depressed exploration activities, and slowed development of newly discovered reserves. The Ivory Coast is pursuing expansion of its gas pipeline network in order to utilize newly discovered gas reserves. There are plans to construct a 60 kilometer gas pipeline to connect off-shore gas fields with Vridi (near Abidjan). The gas will be in the refinery and power station at Vridi. There are also plans to add up to 300 MW of gas-fired generating capacity and an ammonia plant. Nigeria is also adding pipelines to attempt to bring a halt to the flaring of natural gas. As mentioned above, Nigeria may also attempt to expand its refinery capacity to meet the domestic demand for middle distillates.

Electricity demand, as discussed above, is increasing rapidly, and all four countries are planning additions of electrical generating capacity. Morocco and Nigeria, the two big electricity users, in particular are pursuing the construction of new power plants. Morocco is proceeding with feasibility studies for the addition of up to 1800 MW of new coal-fired capacity and the current five year plan calls for the addition of 1500 MW of hydroelectric power at 15 different sites. ²⁹ Nigeria is currently constructing 1100MW of hydro capacity, and is considering the addition of additional hydro, gas and coal electrical generating capacity. Whether these ambitious plans will come to fruition will be highly dependent on the future financial situations of the countries. This is discussed further below.

Despite the trends toward increasing urbanization, the majority of citizens of the study countries still live in small rural villages. Rural electrical distribution is generally poor, especially in Nigeria, and Senegal. Continued expansion of the electrical distribution network is a stated goal of all the governments and is an important political issue. Fulfillment of the present Nigerian government's promises of rural electrical development may be important in maintaining the fragile political stability. The Ivory Coast is going ahead with plans for electrical grid expansion in 150 villages.

Existing electrical distribution networks are woefully inadequate and transmission losses are high. Officials in the electrical companies and in the governments are aware of the need for improved maintenance and upgrading of the network, but are constrained by a lack of capital, and in some cases, technical expertise. International aid organizations are also starting to push investments in efficiency improvements. It is likely that investment in imported electrical distribution equipment will be important in the near future in all of the study countries.

All of the countries could benefit from improvements in the efficiency of energy use. There will be a market for energy-conserving equipment and services related to energy conservation.

Constraints on Energy Sector Expansion

Energy sector expansion could be severely constrained by the shortage of foreign exchange that all of the countries are now experiencing. Trade balances, debt restructuring, commodity prices, exchange rates, and the health of the world economy, will all be factors that influence the energy development plans of these countries.

The situation in each country reflects differences in historical development patterns and economic structure. A brief review of each of the study countries is given below. Further data on the economies and trade of these nations is contained in the tables in the appendix. After discussing each country, prospects for United States trade in the energy sector are discussed.

Nigeria

Modern Nigeria has been shaped by the petroleum boom and political turmoil. The struggles between rival political factions, divided primarily along tribal lines, that were at their height during the 1967-1970 civil war are still key factors in determining Nigeria's future. Current austerity measures and cutbacks in government services brought about by the drastic fall in oil revenues are straining the fragile political equilibrium of the country. Two coups in the last three years have left the country in the hands of Major General Ibrahim Babangida and his Armed Forces Ruling Council. He has attempted to reform the civil service, discourage imports with tariffs and a proposed devaluation of the naira, and move the country toward agricultural self-sufficiency by favoring the rural poor at the expense of the urban wage earner. Future trade and development policies are difficult to predict and could change quickly in the potentially explosive political environment of Nigeria today.

Nigeria is totally dependent on petroleum exports as a source of foreign exchange (97-98% of exports, Table A-3). In the late 1970s Nigeria borrowed heavily against future oil export earnings to finance ambitious development projects. The World Bank estimated outstanding public debt at almost 12 billion US dollars in 1984 (Table A-2). The total is much higher when private debt is included. It is difficult to say how much higher due to chaotic financial record keeping and corruption. Debt service was 25% of exports in 1984. During the oil boom Nigeria became dependent on imported foods, spending 23% of export earnings on food in 1983 (Table A-4). An increase in oil prices and domestic reforms could improve the trade situation but Nigeria will be saddled with high debt service and food imports for the near future.

Many of the vast array of capital improvement projects started in Nigeria during the height of the oil boom have been slowed or abandoned since the collapse of oil prices. It is unlikely that Nigeria will be able to finish many existing projects, let alone start new ones, as long as oil prices stay at current levels.

Morocco

Economic growth in Morocco will be severely constrained by a huge foreign debt, and reliance on imported petroleum and food. Since the late 1970s Morocco has been weakened by a combination of factors. Prices for phosphates, Morocco's main export commodity, fell in the mid-70s and have remained at depressed levels. Agricultural exports, another important foreign exchange earner have been negatively affected by higher import tariffs imposed by the expanded European Economic Community. A costly war in the Western Sahara has been a steady drain on the economy, with defense spending accounting for 40-50% of the state budget. In the early 80s the worst drought of the century forced already substantial food imports even higher and required higher oil imports to replace lost hydroelectricity.

Morocco's economic woes resulted in rising foreign debt and trade deficit (Tables A-1 and A-2). Public debt was over 10 billion US dollars in 1984 and Morocco has had a high negative trade balance for the last ten years.

The autocratic regime of King Hassan II has provided relative political stability but a growing disparity in the distribution of wealth promises to cause increasing problems in the future. Morocco possesses a bigger and more diversified industrial base than most African countries, but more than half the population is still engaged in traditional agriculture and unemployment is between 35-40%.

Morocco needs to invest in hydroelectricity and coal to alleviate the oil import bill, but new investment funds will be hard to secure. Even after a recent rescheduling, debt service still accounted for 38% of exports in 1984 (Table A-2). An increase in phosphate and agricultural prices would help, but it appears that Morocco will require substantial foreign assistance in order to pursue much needed investment programs in the energy sector.

Ivory Coast

The Ivory Coast, once regarded as model of political stability and economic growth, has also experienced problems recently due to drought and falling commodity prices. The Ivory Coast's agriculturally based economy is dependent on coffee and cocoa exports. Starting in 1979, a serious drought caused a fall in agricultural production, and from 1977-1979 the world price for coffee and cocoa dropped 31% and 10% respectively. In 1984 another drought restricted agricultural output and caused severe power shortages. Existing industrial problems, particularly in the sugar industry, were exacerbated by the drought and oil had to be imported to make up for the lost hydroelectricity. By 1985 normal rains and new discoveries of oil and gas had moved the economy on a path to recovery.

The difficulties of the early 80s left the country with a large debt (4.8 billion dollars in 1984) the service of which will continue to divert foreign exchange revenues away from capital investment (Table A-2). Throughout its difficult years the Ivory Coast managed to maintain a positive trade balance (although a negative total reserve balance, Table A-1), and recent austerity measures are likely to insure that imports remain low. Ambitious plans to expand energy and transportation infrastructures will undoubtedly be affected by world prices for the Ivory Coast's main agricultural export commodities.

Senegal

The story in Senegal is a familiar one; falling commodity prices and severe drought coupled with a high energy import bill led to severe economic difficulties and high foreign debt (Tables A-1-A-3). Recovery will be difficult. Two thirds of the country lies in the arid Sahel zone and much of this area is experiencing severe environmental degradation. Between 1981-1985, Senegal was forced to reschedule its debt five times, which amounts to a 100% rescheduling. Despite the poverty of a majority of its citizens Senegal has been forced to adopt austerity measures and plans call for new grants and loans of 500 million US dollars per year between now and 1990. Investments in the energy sector aimed at reducing oil imports and alleviating the fuel wood crisis will have a high priority in future development plans.

United States Trade in the Energy Sector

The United States trades with all four countries supplying electrical generation equipment, electrical distribution equipment, and industrial machinery among other things (Table A-5). The total value of goods in these categories sold to the four study countries has not been large (about 100 million dollars in 1985) and represents a small fraction (estimated 10 %) of U.S. exports to these countries (Table A-6). In addition to energy equipment the U.S. has recently begun to supply coal to Morocco. Coal trade with Morocco is likely to expand, and there is the possibility of future sales to Senegal as well.

The percentage of imports by the four study countries originating from the United States has been declining in all cases except Morocco, and in 1983 was between 5% and 10% in Nigeria, Senegal, and the Ivory Coast, and about 13% in Morocco. The high value of the dollar during this period undoubtedly contributed to an erosion of the U.S. trade position and a lower valued dollar may reverse the trend. The EEC is a major trading partner of all the countries with typically 40% to 50% of the market. Although connections between the countries and the old colonial powers (Great Britain and France) have been weakening the trading ties remain quite strong. These past ties are a barrier to the expansion of U.S. trade.

Future trade prospects will be highly dependent on the evolution of the foreign debt in these countries. Further rescheduling and new loans will be needed. All of the countries have been negotiating with the IMF in an attempt to improve their borrowing status. Nigeria has resisted suggested IMF reform measures, particularly the devaluation of the naira. In 1985 United States Secretary of the Treasury James Baker proposed a plan that would coordinate rescheduling and new loans to major debtor countries in Latin America and Africa, including Morocco, Nigeria, and the Ivory Coast. The plan proposed a coordinated regional approach as opposed to the IMF's country by country approach. The plan met with a cool reception in debtor countries and with major European banks. The plan was criticized as primarily serving the interest of major U.S. banks. While all parties agree on the need for rescheduling and new loans to promote economic growth, no agreement has been reached. Investment capital continues to be in short supply in all of the study countries.

Another United States initiative, known as the Bilateral Investment Treaty Program, has been more successful. The program attempts to set up conditions favorable to U.S. private investment. Signatory countries provide capital investment guarantees, and agree on procedures for reimbursement in the case of expropriation, and for settling disputes, in the hopes of attracting private U.S. investment capital. Senegal has already signed such accords and Morocco was reported to be close to signing. ³⁰

Multilateral and bilateral development aid is likely to be an important source of investment capital in the study countries in the near future (with the probable exception of Nigeria). The energy sector will be an important focus of aid programs, although improvements to existing systems may be favored over large new projects. The United States provides substantial assistance to Morocco and Senegal (153 and 44 million dollars respectively in 1984, Table A-7) and United States suppliers may be favored in these countries.

CONCLUSION

The commercial energy market in the four West-African countries surveyed has two salient characteristics: a) it is among the fastest growing in the world; b) it is driven primarily by the demographic explosion in urban centers.

Throughout the 1970s and early 1980s, the growth of energy demand in the region has been fast and nearly continuous. The aggregate energy use more than doubled from 1974 to 1983, increasing at an average annual rate of 10 percent. During the same period, energy use per capita grew at an average 5 percent. Although all countries of the group showed substantial growth potential, the most dramatic increase in energy demand occurred in Nigeria, reflecting the abundance of domestic petroleum supply, and the relatively low prices of petroleum products.

The growth of urban population has been the major determinant of energy demand in West Africa. In the period 1970-82, the average growth rate of urban areas was 5.2 percent, which would result in a doubling of the urban population by the turn of the century. Accordingly, demand for commercial fuels has also increased dramatically in the residential and transportation sectors, at an yearly average of 10 percent. The decreasing availability of fuelwood has forced households to switch to kerosene and LPG for lighting and cooking. At the same time the need for personal and freight transport in urban areas has triggered an unusually high growth in the vehicle fleet, as well as in the demand for gasoline and diesel.

At current growth rates, the average per capita energy use in West Africa will have doubled by the turn of the century. The West-African market will soon account for a substantial share of world energy demand.

Energy resources in the region are adequate, although unevenly distributed and developed. Heavy reliance on imported petroleum will continue to cause problems for Morocco and Senegal. Nigeria and the Ivory Coast should be able to provide adequately for domestic energy needs and Nigeria will continue to be a petroleum exporter. Natural gas represents a large potential resource in Nigeria and the Ivory Coast, provided the investment for infrastructure investment can be found. The hydropower resources in the region are large and could help solve certain energy problems. Exploitation of these resources has been constrained by lack of capital and by international disputes over shared resources.

Although all the countries have refineries, capacity is not well adapted to the domestic markets. Demand for middle distillates will continue to be higher than can be satisfied internally. Nigeria especially has to import petroleum products.

West Africa is a potential market for United States coal exports (in Morocco and possibly Senegal) and for American manufactured equipment related to energy conversion and distribution. The United States trading position in these countries has been declining, and there is stiff competition from Europe.

Trade in the region will be hampered by the large foreign debt of all the countries and by balance of trade deficits. Morocco and Senegal in particular are saddled with huge debts and economic recovery in these countries will be a long slow process. The future policies of Nigeria will depend on the international oil market and on internal politics. International aid may be the only source of much needed capital for energy sector improvements in the majority of countries.

References

1. Kahane A., Lawakabamba S., "Energy in West Africa: A Literature Survey", IES/LBL, November 1985.
2. Gugler, Josef and Flanagan, William - **Urbanization and Social Change in West Africa**, Cambridge University Press, 1978.
3. OPEC - "Ivory Coast: Country Profile", OPEC Bulletin, April 1985.
4. International Energy Agency/OECD - **Energy Balances of Developing Countries 1971-1982**. Paris, 1984.
5. The Economist Intelligence Unit. **Quarterly Energy Review: Africa**. Various Issues, 1984.
6. United Nations Development Program/World Bank - "Nigeria: Issues and Options in the Energy Sector". Washington, August, 1983.
7. UNDB/World Bank "Ivory Coast ..." op. cit.
8. United Nations Development Program/World Bank - "Senegal: Issues and Options in the Energy Sector. Washington, July 1983.
9. **Oil and Gas Journal**. Various Issues, 1984 and 1985.
10. World Bank - **The Energy Transition in Developing Countries**. Washington, 1983.
11. World Bank - "Nigeria...", op.cit.
12. Iwayemi, Akin - "Energy in West Africa: Issues and Policy Approaches". **Energy Policy**, September 1983.
13. UNDB/World Bank, "Senegal..." op. cit.
14. **La Vie Economique**, March 6, 1986
15. Iwayemi, Akin, op.cit.
16. United States Agency for International Development - "An Assessment of Energy Options for Liberia". Final Report of the Initial Phase of the National Energy Assessment for Liberia. Washington, June 1983.
17. Konan, Lambert - "Hydropower Development in Sub-Saharan African Countries". Workshop on Small-Scale Hydropower in Africa, March 1-5, 1982.

18. The Economist Intelligence Unit, op.cit.
19. UNDP/World Bank - "Nigeria..."op.cit.
20. United Nations Development Program/World Bank - "Senegal: Issues and Options in the Energy Sector". Washington, July 1983.
21. Wijetilleke, Lakdasa and Anthony Ody. - **World Refinery Industry: Need for Restructuring**. World Bank Technical Paper no. 32. Washington, 1984.
22. OPEC, op. cit.
23. Chauvin, Henri - "When an African City Runs Out of Fuel". *Unasylva*, (FAO), Vol.33, No.133, 1981.
24. United Nations Development Program/World Bank - "Ivory Coast: Issues and Options in the Energy Sector". Washington, November 1984.
25. Economic Community of West African States (ECOWAS). Final Report from the Seminar on Energy Cooperation within ECOWAS, Lome, October 24-29, 1983.
26. The Economist Intelligence Unit, op.cit.
27. UNDP/World Bank, Morocco Issues and Options in the Energy Sector, Washington D.C.,1984
28. **Almaghrib**, February 14, 1986.
29. **La Vie Economique** March 7, 1986
30. **Marches Tropicaux**, October 26, 1984.

APPENDIX 1. DATA RELATED TO TRADE

Table A-1
Balance of Payments
Millions of U.S. Dollars

	77	78	79	80	81	82	83	84	85
<i>Ivory Coast</i>									
Merchandise Exports	2412	2616	2722	3012	2435	2453	2092	2591	2883
Merchandise Imports	(1597)	(2043)	(2233)	(2613)	(2101)	(1847)	(1506)	(1314)	(1400)
Trade Balance ^(a)	875	573	489	399	334	606	585	1277	1482
Net Service & Other Income	(693)	(994)	(1300)	(1519)	(1407)	(1108)	(1155)	(1172)	(1129)
Total Change in Reserves ^(b)	138	227	(321)	(133)	(374)	(123)	(120)	15	(31)
<i>Morocco</i>									
Merchandise Exports	1283	1488	1937	2414	2283	2043	2058	2161	
Merchandise Imports	(2821)	(2629)	(3245)	(3770)	(3840)	(3815)	(3301)	3569	
Trade Balance ^(a)	(1538)	(1141)	(1308)	(1356)	(1557)	(1772)	(1243)	(1407)	
Net Service & Other Income	(878)	(957)	(1146)	(1181)	(1373)	(1107)	(635)	(519)	
Total Change in Reserves ^(b)	26	29	(135)	(277)	(303)	(430)	(163)	(129)	
<i>Nigeria</i>									
Merchandise Exports	12431	10508	16774	25741	17961	12123	10488	11948	
Merchandise Imports	(9723)	(11685)	(11862)	(14636)	(18872)	(14801)	(11393)	(8940)	
Trade Balance ^a	2708	(1177)	4912	11105	(911)	(2679)	(905)	3008	
Net Service & Other Income	(3543)	(2336)	(2860)	(5428)	(4429)	(14102)	(2890)	(2146)	
Trade Change in Reserves ^(b)	(947)	(2343)	3663	4686	(6341)	(2283)	(623)	472	
<i>Senegal</i>									
Merchandise Exports	667	402	527	481	433	458	569	548	
Merchandise Imports	(773)	(744)	(852)	(973)	(913)	(858)	(880)	805	
Trade Balance	(106)	(342)	(305)	(492)	(480)	(400)	(311)	(257)	
Net Service & Other Income ^(a)	(69)	(13)	(31)	(66)	N.A.	N.A.	N.A.	N.A.	
Trade Change in Reserves ^(b)	4	(43)	(8)	(48)	(49)	(34)	N.A.	N.A.	

Source: African Development Bank Group, *Selected Statistics on Regional Member Countries 1985*; IMF, *International Financial Statistics*

(a) Trade Balance = Exports-Imports; (Imports and Exports F.O.B.)

(b) Total Change in Reserves = Trade balance + Service and Other Income + Unrequited Transfers + Capital other than Reserves + Errors and Omissions + Counterpart Items + Liab. Const. Fgn. Author. Reserves

Table A-2
External Public Debt

	<u>79</u>	<u>80</u>	<u>81</u>	<u>82</u>	<u>83</u>	<u>84</u>
<i>Ivory Coast</i>						
Total External Public Debt 10 ⁶ US	\$3647	4265	4497	4861	4824	4835
Interest Payments 10 ⁶ US \$	225	296	413	476	413	404
External Debt Service as percent of Exports	15	24	22	37	31	21
<i>Morocco</i>						
Total External Public Debt 10 ⁶ US \$	6227	7098	7879	9030	9445	10,169
Interest Payments 10 ⁶ US \$	411	618	631	615	510	494
External Debt Service as Percent of Exports	22	28	30	37	38	38
<i>Nigeria</i>						
Total External Public Debt 10 ⁶ US \$	3744	4997	4652	6085	11757	11,815
Interest Payments 10 ⁶ US \$	205	394	495	722	974	1,172
External Debt Service as Percent of Exports	2	2	5	10	19	25
<i>Senegal</i>						
Total External Public Debt 10 ⁶ US \$	786	906	944	1329	1496	1,555
Interest Payments 10 ⁶ US \$	43	57	41	64	31	53
External Debt Service as Percent of Exports	14	-	-	-	-	-

Definitions:

Total External Public Debt - Amount of public and publicly guaranteed debt disbursed, net of repayment, at year end.

Interest Payments - Actual payment of interest on total external debt.

Debt Service as a Percent of Exports - Sum of actual repayment of principal and interest as a percentage of total exports of goods and services.

() - indicates net outflow from country

Table A-3
Percent Share of Major Commodities In Value of Exports

	75	76	77	78	79	80	81	82	83	84
<i>Ivory Coast</i>										
Cocoa	19	18	19	31	21	25	29	22	20	15
Coffee	24	34	38	25	31	21	18	22	20	34
Wood	14	16	13	10	13	15	11	9	9	7
<i>Morocco</i>										
Citrus Fruit	7	11	11	13	11	11	9	9	8	6
Phosphates	55	39	36	33	29	31	31	27	20	24
<i>Nigeria</i>										
Cocoa	4	3	4	6	4	1	1	1	2	-
Crude Petroleum	96	93	93	90	94	97	95	98	96	97
<i>Senegal</i>										
Groundnuts & Oil	33	46	38	18	24	13	5	18	20	17
Phosphates	22	13	10	14	14	16	13	11	9	11
Petroleum Products	7	5	8	14	13	19	28	25	20	18
Fish & Shellfish	4	4	6	12	11	14	13	10	10	12

Source: IMF, *International Financial Statistics*.

Table A-4
Food Trade

	Food Imports as a Percentage of Total Exports						
	75	77	79	80	81	82	83
Ivory Coast	11	10	13	-	17	16	14
Morocco	41	31	26	28	36	37	24
Nigeria	6	10	9	-	-	-	23
Senegal	28	-	37	46	41	-	-

Source: African Development Bank Group.

Table A-5
**Value of United States Exports of Energy-Related
Equipment**

Value in Thousands of U.S. Dollars

Export Category	1980	1983	1985
Heating & Cooling Equipment & Parts			
Total	35592	19593	15757
Morocco	1062	145	291
Senegal	178	-	-
Ivory Coast	8672	438	78
Nigeria	25680	19010	15388
Power Generating Equipment & Parts			
Total	33140	15484	18217
Morocco	3156	2028	1830
Senegal	1190	394	-
Ivory Coast	5230	1727	153
Nigeria	23564	11335	16234
Pumps			
Total	9618	7561	20756
Morocco	369	248	762
Senegal	270	672	166
Ivory Coast	550	116	64
Nigeria	8429	6525	19764
Electric Power Machinery			
Total	498	18563	1772
Morocco	-	-	85
Senegal	-	-	-
Ivory Coast	-	75	-
Nigeria	498	18488	1687
Electrical Distribution Equipment			
Total	9221	4752	1117
Morocco	-	-	-
Senegal	-	213	-
Ivory Coast	389	-	-
Nigeria	8832	4539	1117

Table A-5
**Value of United States Exports of Energy-Related
Equipment**

Value in Thousands of U.S. Dollars

Export Category	1980	1983	1985
Electric Current Devices, Circuit Boards, Resistors			
Total	3900	1083	973
Morocco	937	158	-
Senegal	76	-	-
Ivory Coast	-	-	64
Nigeria	2887	861	909
Mineral Fuels, Lubricants, & Related Materials			
Total	17248	93233	45554
Morocco	337	1089	8919
Senegal	107	870	12042
Ivory Coast	1304	11569	20382
Nigeria	15500	69705	4211

Source: *U.S. Exports Schedule E, Commodity by Country*, U.S. Department of Commerce

Table A-6
United States Balance of Merchandise Trade

Millions of U.S. Dollars

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>
<i>Ivory Coast</i>						
U.S. Exports To	128	185	130	97	61	65
U.S. Imports From	363	288	344	303	343	469
Balance	(235)	(103)	(214)	(206)	(282)	(404)
<i>Morocco</i>						
U.S. Exports To	271	344	429	397	440	526
U.S. Imports From	40	35	36	45	31	34
Balance	231	309	393	352	409	492
<i>Nigeria</i>						
U.S. Exports To	632	1150	1523	1295	862	577
U.S. Imports From	8161	11105	9249	7045	3736	2508
Balance	(7529)	(9955)	(7924)	(5750)	(2874)	(1931)
<i>Senegal</i>						
U.S. Exports To	44	45	49	-	-	-
U.S. Imports From	1	1	1	-	-	-
Balance	43	44	48	-	-	-

Source: United States Department of Commerce, *Statistical Abstract*
Data for Senegal are from *U.N. Handbook of International Trade Statistics*. (due to definitional differences Senegal data is not comparable with other countries).

Table A-7
United States Aid
Millions of U.S. Dollars

	Public Assistance		Military Assistance	
	1983	1984	1983	1984
Ivory Coast	0.1	0.1	3.0	5.0
Morocco	150.3	152.6	26.0	36.0
Nigeria	0	0	6.0	6.0
Senegal	40.9	44.1	0	2.0

Source: *Marches Tropicaux* 26 Oct. 1984.

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