Report No. 3800-KE

Kenya: Issues and Options in the Energy Sector

May 1982

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

CURRENCY EQUIVALENTS

Currency Unit	Shilling (KSh)
Kenya Cents 100	KSh 1
KSh 20	Kenyan Pound (KL) 1/
KL 1	US$2.50 2/
US$1	Sh 8.0 2/

1/ The KL is not now used in Kenya as a unit of currency but is used in accounting, economics and reporting as a convenient measure of value or unit of account.
2/ The exchange rate has been changed since the mission was in Kenya and is now about US$1 = KSh10.

ENERGY CONVERSION FACTORS

Fuels	Physical Units per toe 1/
Liquid Fuels (cubic metres)	
LPG	1.85
Gasoline	1.38
Jet Fuel	1.34
Kerosene	1.25
Diesel Oil	1.19
Fuel Oil	1.06
Ethanol	1.38
Coal (tonne)	1.67
Hydro electricity (kWh)	4000
Biomass (tonnes)	
Charcoal	1.31
Wood	3.95

1/ 1 toe = 41 million Btu.

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KENYA

ISSUES AND OPTIONS IN THE ENERGY SECTOR

May, 1982

ABBREVIATIONS AND ACRONYMS

ACFC	Agro-Chemical and Food Company		
BBL	Barrel		
CBS	Central Bureau of Statistics		
CDC	Commonwealth Development Corporation		
CIDA	Canadian International Development Agency		
Danida	Danish International Development Agency		
EAOR	East African Oil Refineries Ltd.		
EAPC	East African Portland Cement Company Ltd.		
EAPL	The East African Power and Lighting Company, Limited		
EEC	European Economic Community		
GDP	Gross Domestic Product		
Government	Government of Kenya		
GWh	Gigawatt hour	=	1,000,000 Kilowatt hours
KCFC	Kenya Chemical and Food Corporation		
KPC	The Kenya Power Company Limited		
KSA	Kenya Sugar Authority		
kV	Kilovolt	=	1,000 Volts
kVA	Kilovolt Ampere	=	1,000 Volt Amperes
kW	Kilowatt	=	1,000 Watts
kWh	Kilowatt hour	=	1,000 Watt hour
LPG	Liquefied Petroleum Gas		
MMBtu	Million British Thermal Units		
MOE	Ministry of Energy		
MW	Megawatt		
SIDA	Swedish International Development Authority		
TOE (toe)	Tonne of Oil Equivalent		
tonne (t)	Metric Ton (1.1 short tons)		
TRDA	The Tana River Development Authority		
TRDC	The Tana River Development Company Limited		
UEB	The Uganda Electricity Board		
UNDP	United Nations Development Program		
USAID	United States Agency for International Development		

This report is based on the findings of the Energy Assessment Mission undertaken during March-April 1981. The composition of the mission was: Trevor Byer (Mission Chief), R. Deen (Loan Officer/Economist), G. Collins (Consultant), S. Smith (Power Consultant), and T. S. Tuschak (Renewables Consultant). A follow-up mission to discuss these findings visited Kenya in April 1982. Members of that mission were Trevor Byer (Mission Chief), H. E. Wackman (Deputy Division Chief, Energy Assessments Division), and J. Besant-Jones (Economist, East Africa Projects Department). Comments from the Government and other agencies have been incorporated into this report.

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I. MAJOR FINDINGS AND RECOMMENDATIONS

The Energy Problem

1.01 Kenya's known commercial energy resources are basically hydro and geothermal. While these resources are adequate for providing most of the country's need for electricity during this decade, Kenya is totally1/ dependent on imports for oil and other commercial fuels. Moreover, forest resources are being 'mined' to meet the large and growing demand for woodfuels, which, for the most part, are not sold commercially. Commercial energy use in Kenya amounted to 1.9 million toe in 1979, with petroleum, hydroelectricity and coal accounting for 79%, 19% and 2% respectively. The use of non-commercial energy, largely fuelwood and charcoal, was 4.7 million toe.

1.02 Kenya faces two major energy problems. First, the cost of imported energy is becoming an increasingly heavy burden on the balance of payments, accounting for 36 percent of exports in 1980 compared with 16 percent in 1978. And second, deforestation, though still not as serious a problem as in some other African countries, is worsening because woodfuels are being consumed at about four times the annual rate of incremental production.

1.03 A number of measures must be taken to deal with these problems. First, reducing the net cost of petroleum products to the country by encouraging a more economic mix of petroleum product imports and exports. Second, replacing the remaining thermal power generation through further development of indigenous hydroelectric and geothermal resources and, in the longer-term, possibly developing regional power projects. Third, encouraging large users of petroleum products to convert to coal (which must be imported but at a lower cost to the economy). Fourth, ensuring that energy in all sectors is used in the most efficient way. Fifth, strengthening efforts to discover indigenous petroleum resources and use, where feasible, renewable energy sources such as solar. And sixth, improving reforestation programs and developing programs for improving the efficiency of wood and charcoal-burning cookstoves and charcoal conversion techniques. In addition to these actions, the Government must develop an overall long-term strategy for the energy sector, a goal which can be accomplished only after completion of a number of studies which are underway or are recommended in this report.

1/ Two fuel alcohol production facilities are currently in the late stages of construction; however, when completed their contribution to liquid fuel supplies will be small. The economics of alcohol production from these plants is unattractive and discussed further in paras. 1.25 - 1.26.

Energy and the Economy

1.04 Kenya is a middle-income country with a GDP of US$420 per capita in 1980. Agriculture remains the principal source of income in rural areas where over 80% of the population of about 15 million lives and works. The country's first decade as an independent nation witnessed rapid growth, with GDP increasing, in real terms, at an annual rate of 6.5% between 1964-73. Since 1973, however, major fluctuations in the prices of both exports and imports have resulted in significant variations in the growth of GDP. For example, in 1974, the year following the first petroleum shock, GDP growth dropped to 2.6%, while in 1977, following the increase in coffee prices, the rate jumped to 8.6%, declining again to 3.8% in 1980 with the end of the coffee boom and the second petroleum shock.

1.05 Before 1973, demand for petroleum products grew at 10%/year, giving a GDP elasticity for petroleum of 1.54. Since 1973, as real GDP growth declined to an average of 4.7%/year, petroleum demand growth has dropped to 4.1%, giving an elasticity of 0.87. An important influence on this lower elasticity was the government's policy of allowing domestic prices of petroleum products to move upwards in line with international prices.

1.06 Meanwhile, the GDP elasticity for electricity increased from 1.57 in the period 1969-73, when demand grew[1/] at 10.2% annually, to 1.72 in the period 1973-80, when demand grew at 8.1% annually. This is partly because the growth of electricity consumption was from a low base, and partly because electricity tariffs have not increased as fast as petroleum prices; this in turn was largely due to the declining share of petroleum-based electricity generation in total power generation (from about 33% in 1970 to around 11% in 1979[2/]) and partly because of continued imports from Uganda, equivalent to up to 1/5 of total electricity supply, at relatively cheap rates.

1.07 During this decade, and especially during the period to 1985, it is unlikely that there will be major changes in the relationship between GDP growth and the growth of petroleum product and electricity demand. For petroleum products, the recent elasticity (0.87) has been low by international standards, and as the initial impact of the price rises wears off it will require substantial efforts in energy conservation and fuel substitution to reduce it further; for electricity, demand forecasts (which may not fully reflect further rapid urbanization and some planned industrial developments) suggest only a marginal reduction in the GDP elasticity.

1/ Sales from the interconnected power system.

2/ Although this increased to 21% of total generation in the dry year of 1980, the trend has been for a decreasing share of oil-fired generation.

1.08 Energy imports and exports play an important role in Kenya's external trade and balance-of-payments. Petroleum is imported mainly as crude oil and is refined at the Mombasa refinery (jointly owned by the government and the private oil companies), which has a capacity of some 95,000 bbls/day. About 40% of the refinery's production is then exported, either inland to nearby land-locked countries or off-shore.

1.09 Kenya's geographic position has meant that relatively high prices could be charged for petroleum products delivered to the land-locked countries and international airlines; this has helped cushion to some extent the impact of world oil price increases on its balance-of-payments and petroleum trade account. As Table 1.1 shows, up to 1973 Kenya's 'energy trade' was roughly in equilibrium, with exports of refined products roughly covering almost the entire cost of imported crude oil, coal and electricity. Since 1973, exports to the landlocked countries and international airlines have accounted for a progressively smaller share of refinery throughput and the effect on the net oil import bill has declined accordingly, especially since 1977. In the future, this trend is likely to continue as the landlocked countries increase their efforts to obtain petroleum products from other sources in order to provide some competition for Kenya. As such, except in years when export earnings from coffee are high, net energy imports are likely to increase as a proportion of non-energy exports in the future unless the Government takes urgent remedial action as recommended in this report.

TABLE 1.1

Energy and the balance of-trade (1972-80)
Kenya Pounds (millions)

	1972	1973	1974	1975	1976	1977	1978	1979	1980
1. Energy Imports	20.9	22.4	81.6	96.0	103.7	116.8	117.6	147.0	279.9
(of which coal/ coke/hydro)	(0.8)	(1.0)	(1.0)	(0.9)	(1.2)	(1.4)	(1.7)	(1.3)	(2.6)
2. Energy Re-exports 1/	19.4	21.3	45.6	58.5	68.6	83.0	68.9	76.9	160.9
3. Net Energy Imports	1.5	1.1	36.0	37.5	35.1	33.8	48.7	70.1	119.0
4. Non-Energy Exports	101.1	140.1	165.7	156.6	266.8	397.2	301.0	308.6	324.5
(3) as a % of (4)	1.5	0.8	21.7	23.9	13.2	8.5	16.2	22.7	36.4

1/ Petroleum products.

Source: Statistical Abstracts, Economic Survey.

The Energy Balance

1.10 Table 1.2 gives the commercial energy balance for 1979. It should be noted that information on energy demand by final user is very scanty in Kenya and is only available for this year.1/ The transport sector is the largest commercial energy consumer, accounting for 40 percent of domestic demand; the second largest is industry, at 38 percent. These are followed by residential/commercial energy demand (12 percent of the total) and agriculture (10 percent). Since transport has been growing rapidly and since there have been moves to replace heavy diesel and fuel oil used in power generation and industry by hydro, geothermal and coal, the mix of petroleum products in domestic demand has changed significantly, as is indicated by the figures in Table 1.3. The share of demand of heavy diesel and fuel oil declined from 37 percent in 1969 to 26 percent in 1980, while the share of gasoline and gasoil increased from 37 percent to 44 percent and the share of jet fuel increased from 19 percent to 23 percent.

TABLE 1.3

Consumption of Petroleum Products in Kenya

Product	1969	1973	1980	Average Annual Growth, % 1969-73	1973-80
	('000 m^3) 1/				
LPG	10.7	22.2	39.8	19.9	8.7
Gasoline 2/	212.2	322.1	416.3	11.0	3.7
Kerosene 3/	52.8	65.8	107.1	5.7	7.2
Jet Fuel 4/	202.9	341.8	464.4	13.9	4.5
Gasoil	183.9	302.5	486.5	13.3	7.0
Heavy Diesel	36.8	55.0	45.8	10.5	-3.6
Fuel Oil	354.6	435.3	489.8	5.3	1.7
Aviation Spirit	7.8	7.7	7.8	-0.4	0.3
Total	1,061.7	1,552.4	2,057.5	10.0	4.1

1/ Conversion factors are given in Annex I.
2/ Regular and premium gasoline.
3/ Illuminating and power kerosene.
4/ Kenya Airways consumed 13% of jet fuel in 1979; the remainder is for refuelling of foreign airlines paid for in foreign exchange.

Source: Central Bureau of Statistics, Statistical Abstracts.

1/ As a result of a 2 yr. US AID project.

TABLE 1.2

Commercial Energy Supply and Demand Balance for 1979 5/

('000 TOE)

Energy Source	SUPPLY: Production	Imports	Total Primary Supply	Supply After Transfor-mation	Thermal Electricity Generation	Transmission and Distribution Losses	Net Supply Available for Consumption	CONSUMPTION: Residential	Commercial	Industrial	Transport 4/	Agriculture	Total Kenya Demand	Export
Coal	-	40	40	40	-	-	40	-	-	40	-	-	40	-
Crude Oil	-	2,739	2,739	-	-	-	-	-	-	-	-	-	-	-
LPG	-	-	-	21	-	-	21	12	5	3	-	-	20	1
Gasoline	-	69	69	437	-	-	437	-	-	-	292	11	303	134
Aviation Spirit	-	12	12	12	-	-	12	-	-	-	5	-	5	7
Kerosene-Jetfuel	-	179	179	610	-	-	610	66	2	16	32	2	118	492
Gasoil	-	20	20	457	(4)	-	453	-	19	34	191	100	344	109
Heavy Diesel	-	10	10	122	-	-	122 }	{						
Fuel Oil	-	-	-	1,215	(91)	-	1,124 }	{ -	11	382	49	30	472	774
Electricity	322 1/	40	362	121	17	21	117	25	32	57	-	3	117	-
Total	322	3,109	3,431	3,035			2,936	103	69	532	569	146	1,419	1,517
Conversion Losses				396 2/	78		495 3/							
Total				3,431			3,431							

1/ Production consists entirely of hydroelectricity.
2/ Losses in the refinery and theoretical losses from hydroelectricity based on thermal generation at 4000 kWh per TOE. For consumption, electricity is converted at 1 toe = 12,000 kWh.
3/ Includes (2) and transmission and distribution losses plus losses in thermal generation.
4/ Excludes international aviation as estimated by Schipper.
5/ Assumes no change in stock levels.

Note: Bank Staff estimates based on data from MOE, CBS, EAOR, EAPL and Schipper et al.

1.11 As is indicated by Table 1.2, the industrial sector accounts for 37 percent of the domestic demand for petroleum products, with 88 percent of its demand being for fuel oil for use in boilers, etc. It also accounts for all Kenya's demand for coal, which is imported from Swaziland and primarily used in the cement sector. About half of Kenya's demand for electricity comes from industry. The main commercial fuels used in the residential/commercial sectors are kerosene (40 percent) and electricity (32 percent), the former largely for cooking and lighting, the latter primarily for lighting and appliances in high income households, while in the agricultural sector over two thirds of demand for commercial fuel is for gasoil for tractors and farm machinery.

1.12 Electricity is provided mainly from hydroelectric plants with additional supply from oil-fired steam turbines, gas turbines, diesel generators, and purchases from the Uganda Electricity Board. In particularly dry years, such as 1980, the hydro shortfall is made up by increased output from the thermal plant (at Mombasa) and by higher imports from Uganda. Major load centres are Nairobi and Mombasa, but the market in Western Kenya has been growing at a faster rate. Although total electricity sales were 1468 GWh, or 92 kWh per capita in 1980, only 6% of the population is connected to electricity, mainly in the urban areas where 13 percent of the population lives.

1.13 Excluded from the commercial energy balance are fuelwood and charcoal, which most households use for cooking. Total annual consumption of wood for energy purposes is estimated at about 25 million tonnes, or annual per capita consumption of about 1.5 cubic metres. This compares with an annual regrowth of trees of about 6 million tonnes. While fuelwood is still generally available within reasonable distances of consumers, and they can collect it at minimal cost, several areas are already beginning to show signs of widening deforestation, and commercialization of these woodfuels is beginning to emerge in some urban areas.

Energy Demand Issues

1.14 While accurate forecasts for energy demand growth in the main consuming sectors are not possible given the data constraints, and have not been attempted in this report1/ owing to the absence even of historical trend data, it is clear that the main scope for restraining the growth of energy demand in the coming years is in a few specific activities in the transport, industrial and household sectors.2/ In the transport sector, there are several opportunities for increasing the efficiency of energy use and fuel substitution. The Government has already increased import duties on larger private cars, and this will increase the efficiency of private transport over the long term. The

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1/ A projection of total demand for energy in 1985 is given in Table 1.5 including a rough estimate of the sectoral breakdown.

2/ The conservation potential in agriculture is lower than in the other sectors, especially for commercial energy.

mission suggests that an additional measure which could reduce gasoline and gasoil consumption by 10-15 percent, especially in Nairobi, is improved traffic management, including no parking zones, one-way streets, etc. (para. 4.14). A program to introduce diesel-fuelled matatus (small buses serving urban and surrounding areas) is being studied, but the mission warns that this program may not be consistent with the future product mix from the refinery (para. 4.15). Indeed, the mission recommends that relatively higher import duties on diesel-fuelled passenger cars than on petrol-driven cars should be considered as well as a realignment of the sales taxes on transport fuels which currently favour use of diesel oil.

1.15 To reduce fuel consumption in freight movement the Government should encourage the transfer of as much freight as possible from the highways to the railway (paras. 4.16-4.19). A recent study[1] estimated that in 1979, 1.75 million tonnes of freight were carried by heavy trucks on roads paralleling the railway. It is the operational delays on the railway rather than costs which lead to this situation and studies to be financed under Loan 1976-KE will identify problems and formulate measures for improvement as well as review the tariff structure. Kenya Railways also needs to determine its optimal long-term source of motive power (including electrification), and to improve its capacity for carrying containerized goods. Improvements in the switching system are necessary as a first step but longer term options include twinning the line from Mombasa to Nairobi as traffic increases. Diversion of one million tonnes of freight from the roads to the railway, which the mission considers feasible and which could be done without investment in new capacity[2], could save an estimated 12 million litres of diesel oil per year, or about 2.5 percent of the total consumption of this product in 1980.

1.16 In the industrial sector, the main potential for saving petroleum is in the conversion of cement plants to use imported coal instead of fuel oil. Two cement plants, Bamburi Cement and East African Portland Cement (EAPC), consume 23 percent of all domestically-used fuel oil, and, despite the surplus of fuel oil which is produced by the Mombasa Refinery and the fact that imported coal is subject to a 20% import duty while the fuel oil is not taxed, there is still a clear cost advantage to the firms in the use of coal[3] (EAPC is also considering converting its plant from the wet process to the dry process and the mission expects that this will provide further substantial cost savings through lower energy use[4]). Substitution of fuel oil by coal seems also

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1/ Study of Road Use Charges and Axle Load Limits, December 1980, Kamsax International A/S, for Danida.

2/ The Kamsax study includes the details of the types of products (mainly bulk products) which would be involved.

3/ The import duty was reduced from 30% to 20% in July 1981.

4/ The mission considers that the expansion of the EAPC plant using the dry process may obviate the need for a third cement plant.

to be feasible at the pulp and paper mill, and a study to confirm this should be done in the near future. Indeed, the mission recommends that the Ministry of Energy carry out a full survey of all potential coal users, as well as a study of the port, railway and other infrastructure facilities required to handle larger quantities of imported coal. (The Bamburi Cement plant already has capacity to handle the increased volume of coal it would require). The mission understands that a Norwegian-financed study of coal transport was completed in late 1981 but is not sure that all aspects of this recommendation were addressed. The import duty on coal should also be removed completely to ensure that it does not deter further substitution of oil by coal in industry.

1.17 Most of the larger industrial companies, especially those with international ties, have already made efforts to increase the efficiency of energy use. However, recent studies suggest that in small and medium sized industries also energy consumption could be reduced by 20 to 30% per unit of output without large expenditures, while hotels could reduce their consumption of electricity and petroleum products by as much as 50% by promoting simple conservation measures and making greater use of solar water heating. The mission therefore recommends that MOE launch a program to provide technical assistance to medium and small establishments for achieving a reasonable target reduction of energy consumption of, for example, 15 percent in three years. To assist in determining priorities in this program data on energy inputs per unit of output should be collected in a systematic manner.

1.18 Solar water heaters appear to offer good potential for reducing electricity consumption in the residential sector, where electric water heating accounts for at least 20% of household electricity consumption. There are some 19,000 residential water heaters in Kenya which are specially metered with an electronic signal interruptor to ensure that consumption is only off-peak and can be interrupted independently of the rest of the supply to these households. There are also an unknown number of residential electric water heaters which are metered at the normal tariff. Solar water heaters which could replace these electric water heaters are assembled in Kenya and cost about KSh 9,500 installed (40-gallon tank, 3 collectors, thermo-syphon), though without the 15% sales tax and import duties on components which the mission recommends be abolished, the cost would be about KSh 6,600 (US$825). Based on the current standard residential tariff a solar water heater of this size and cost would have an attractive payback period of about 2.5 years. The present differential between normal and off-peak tariffs is very high, and therefore discourages replacement of electric water heaters by solar water heaters. However, EAPL have proposed to reduce this differential from July 1982 as well as increase tariffs to finance the local cost components of the power investment program during the 1980's. The mission recommends that the Government approve the proposed increases in tariffs (para. 5.15).

1.19 It is also recommended that the Government should undertake a comprehensive study of the economic benefits and costs of a solar water heater program. If justified, the Government should establish a program of technical assistance for solar water heaters installations once the capabilities of local manufacturers have been assessed and performance standards for solar collectors have been determined (para. 4.10).

1.20 There are two methods for reducing the growth of fuelwood and charcoal demand if substitution by other fuels is not possible: improving stoves and improving charcoal conversion efficiencies. The stove improvement program requires a large effort through extension services, and in the first instance should be directed towards charcoal stoves in the urban areas. Several agencies and organizations in Kenya are addressing the issue of improved stove efficiencies and these deserve continued support. About 40 percent of the 20-25 million tons of wood consumed per year ends up as charcoal, whose use amounts to some 1.4 million tons/year. With such a low conversion efficiency (10 to 14 percent), any measures to improve it could thus have an important impact on decreasing the level of wood demand. The mission recommends the creation of one or more new institutions, such as a "Charcoal Corporation," or a series of charcoal co-operatives, whose objective would be to introduce modern efficient charcoal producing technology into the rural areas. Such an institution, which could be linked with afforestation programs, could build efficient kilns, purchase wood from those who currently produce charcoal inefficiently, and sell charcoal to existing distributors (paras. 4.26-4.28). Efforts in this area will have little effect in the short term but are essential to ensure that wood resources are used more efficiently in the longer term. The results of the Beijer Institute's Study of the fuelwood cycle can be used as input for this program.

Energy Supply Issues

Petroleum

1.21 Although exploration for petroleum is being encouraged in Kenya, and, indeed, is crucial to the long-term energy prospects of the country, it is expected that all of this decade's needs will have to be imported. Meeting the demand for light products in Kenya and land-locked countries will require different amounts of crude oil, depending on the type of crude, the refinery configuration and the pattern of demand. Table 1.4 gives an example using two basic alternatives. Since the present configuration does not match current or projected demand and since the surplus of residual fuel oil must be exported at a lower price than the price of crude, it is highly likely that investment in secondary refining facilities would have a high rate of return (see para. 3.39). The mission therefore recommends the Government urgently commission a study of the options for ensuring that Kenya can obtain the petroleum products it is likely to need at the minimum cost, taking into account potential exports and comparing all options with importing refined products directly from abroad.

TABLE 1.4

Comparison of Alternative Refinery Yields and Demand Pattern
(% by weight)

	Gasoline and Distillates	Residual Fuel Oil	Losses, Other
Refinery Output: Current	48	46	5
With secondary refining	64	28	7
Demand Pattern: 1980	71	23	5
Projected 1985	77	17	5

Electricity

1.22 The East African Power and Light Company (EAPL) has plans to add 345 MW of generating capacity by 1990, giving total installed capacity of nearly 800 MW. This plan is basically designed to increase the use of indigenous power resources and thereby reduce the use of oil-fired thermal generation by developing geothermal and hydro resources, and by strengthening the transmission lines to Mombasa. These objectives are supported by the mission.

1.23 EAPL (through the Kenya Power Company) is developing the Olkaria geothermal field. To date, the drilling program has been limited to one portion of the field, though an expanded deep drilling program designed to outline the limits of the field has been proposed. The consultants to KPC are optimistic that this program would identify at least an additional 170 MW of economic potential, and could possibly lead to development of over 500 MW. The mission therefore recommends that high priority be given to this expanded program.

1.24 Together with the geothermal potential, Kenya's hydro-power resources are adequate to meet most of the increased demand during the 1980s. The Masinga dam project on the Tana River is now onstream and will have 40MW of capacity, though more importantly it will provide necessary storage to impound the run-off from the long rains and allow the existing downstream hydro plants to generate up to an additional 100 GWh by taking advantage of the controlled flow. The Kiambere 140MW hydro project is planned to be on-stream in 1986 and the Turkwel 120MW project, is planned for 1988. The mission considers that it is vital to maintain this hydro-power program sequence since any significant delay would lead to the need for additional thermal capacity at Mombasa. The mission therefore recommends that EAPL ensure that the preparatory engineering studies for Turkwel are completed as a matter of urgency. The mission also urges that the option of importing more electricity from neighbouring countries, especially for the longer term, be given greater emphasis (para. 2.26).

Ethanol

1.25 There are currently two ethanol plants under construction which will use molasses as feedstock, and by mid-1982 the ethanol supply will be about 36,000 m^3 annually. A third project using sugar cane juice as feedstock is also under consideration. However, the mission concluded that the Government has not dealt systematically with the economic, technical, organizational, and financial issues relating to the introduction of fuel alcohol in Kenya, including high capital costs, transport costs for molasses, external energy costs (particularly at one plant where there is a lack of bagasse), the profitable molasses export markets, and above all the fact that gasoline landed at Mombasa at US$1.10/US gallon still has a highly competitive price relative to substitutes. Even if the capital investment in the two existing plants are treated as sunk costs one of them will be a drain on the budget and the other will be only marginally profitable. Moreover, there appears to be no economic or financial justification for construction of the third plant.

1.26 The mission therefore recommends first, that no further investments be made in the fuel alcohol program, second, that a course of action be developed to maximize cash flow from the KCFC plant, and third that a program of technical assistance for the Ministry of Energy should be developed for rationalizing and monitoring the production and use of alcohol (para. 2.44-49).

Woodfuels

1.27 Forests currently cover almost two million hectares in Kenya, most of which are under public ownership and management, and current yield is low, at about 3 m^3 per hectare. To meet the demand for wood fuels, these forests should yield 20 m^3 per hectare or the area under forests should be increased. In doing this, efforts should continue to be made to find tree species that can thrive in the semi-arid areas of Kenya, where competition with other crops will not be significant, and to promote general rural afforestation -- farm woodlots, etc. It is clear that considerable investment (of the order of $25 million annually) would be required for this program, and a program of this size would require substantial improvement in institutional and management capabilities (see paras. 2.39-43).

Other Renewable Energy Sources

1.28 Bagasse is already used as a fuel within the sugar industry and though some potential exists for generating surplus electricity for sale to the grid, this is unlikely to be competitive with geothermal or hydropower (para. 2.50). The same is likely to hold in the near future for mini hydro schemes though less is known about these. While not urgent, a survey to determine whether mini hydro could contribute substantially to future rural electrification programs would be useful (para. 2.11-12).

1.29 Wind energy is already used for pumping water in some areas of Kenya, and the mission considers that its use could be extended. Windmills appear to compare favorably with diesel pumps at 4000 gallons per day (though less favorably at 20,000 gallons per day). The Ministry of Energy and the Meteorology Department are currently updating a study which evaluated wind potential and more metering stations are to be installed. The mission supports these efforts (para. 2.30-31).

1.30 Because of the large livestock population in Kenya (over 30 million cattle, sheep, and goats), biogas from anaerobic digesters offers a promising source of energy for rural areas. There are currently about 100 digesters in Kenya and the size of the animal population suggests that up to 200,000 four cubic metres/day digesters could be built. However, factors such as ownership, colonization patterns and cooking habits need to be evaluated before the widespread introduction of digesters is attempted. The Government should first attempt to gain general acceptance for digesters on livestock farms, or in other communities where there is a sufficiently concentrated animal population (paras. 2.51-56).

1.31 To consolidate the various research and demonstration efforts in new and renewable energies, the mission recommends that an energy research institute be established, with support from MOE and the University of Nairobi (paras. 6.12-6.14). Its program would include identification of solutions to rural energy problems, adaptation of new technologies to Kenya's situation, and analysis of the impact which alternative development paths would have on energy use and the economy. The mission supports the basic organization which the EEC consultants have recently recommended to the MOE but it does not agree that either a special fund or a separate Development Bank needs to be established for funding renewable energy projects since competent banks of this type already exist (paras. 6.16-6.19). In general, there is a need for greater coordination and a clearer direction of aid for renewable resources, and the mission recommends that the various programs now being implemented by various Ministries should be placed under the responsibility of MOE.

Future Energy Balance and Investments

1.32 A feasible energy balance for 1985 is given in Table 1.5. The table, which is based on assumptions given in Chapter 3, indicates that commercial energy use would be about 2.6 million toe, of which imported petroleum would provide 69% (compared with 79% in 1979).1/ Contributions to the replacement of oil would come from coal and renewables, which would provide 7% and 2% of primary energy respectively, and primary electricity (including geothermal) which would provide 22%. Even in such a scenario, however, crude oil imports would be ten percent higher than

1/ This assumes that the refinery modification will be completed.

in 1979, thus adding to the balance of payments problem even with optimistic assumptions about oil and non-oil exports and no real rises in the world price of oil. Without real price increases, imports of oil and coal could cost US$770 million (1981$) in 1985 while petroleum product exports could amount to US$430 million giving net energy import costs of about US$340 million.

1.33 Table 1.6 presents a preliminary comparison of selected energy projects, which are either under construction or being considered, on the basis of total capital cost per unit of oil displaced, and also on foreign exchange benefits. It suggests that the foreign exchange benefits from the hydro and geothermal projects as well as the refinery conversion and cement plant modifications appear to be quite high, while the ethanol projects will actually increase foreign exchange costs to the economy.

Summary of Major Recommendations

1.34 The major recommendations constituting a program of action to address development of domestic energy supply, improve demand management (conservation and fuel substitution), and strengthen the energy sector institutionally, are summarized below:

(a) Development of Domestic Supply

(i) Study and execute improved refinery configuration (para. 3.40);

(ii) Attach high priority to expanded hydropower program (para. 2.27), including study of longer term link-up to neighboring countries (para. 2.26)

(iii) Study and stimulate afforestation and commercialization of fuelwood and charcoal supply (para. 2.43, 4.28); improve demand/supply data for charcoal (para. 3.27);

(iv) Review the ethanol program (para. 2.49);

(v) Expand exploration for oil/gas (para. 2.03);

(vi) Expand exploration for geothermal power and develop investment program (para. 2.15);

(vii) Study expansion of solar water heating (para. 2.32, 4.10), and utilization of bagasse (para. 2.50), wind energy (para. 2.30) and biogas digestors (para. 2.53).

TABLE 1.5

Illustrative Commercial Energy Supply/Demand Balance, 1985
('000 toe)

Energy Source	Production	Imports	Total Primary Supply	Supply Supply After Transformation	Thermal Electricity Generation	Transmission and Distribution Losses	Net Supply Available for Consumption	Residential	Commerci.	Industrial	Transport 5/	Agriculture	Total Kenya Demand	Exports
Coal	-	180	180	180	-	-	180	-	-	180	-	-	180	-
Crude Oil	-	3020	3020	-	-	-	-	-	-	-	-	-	-	-
LPG	-	-	-	32	-	-	32	19	8	5	-	-	32	-
Gasoline	-	-	-	470	-	-	470	-	-	-	321	12	333	137
Aviation Gasoline	-	12	12	12	-	-	12	-	-	-	8	-	8	4
Middle Distillates	-	-	-	1376		-	1376	106	34	80	359	164	743	633
Heavy Diesel	-	-	-	121	-	-	121 }	{ -	10	340	44	26	420	497
Fuel Oil	-	-	-	846	(50)	-	}	{						
Solar Energy 1/	15	-	15	5	-	-	5	4	1	-	-	-	5	-
Ethanol 2/	26	-	26	26	-	-	26	-	-	-	26	-	26	-
Electricity				190	17	32	1	37	48	85	-	4	174	-
o Hydro	432	-	432	-	-		-							
o Geothermal	75	-	75	-	-		-							
o Imports	-	63	63	-	-		-							
Total	548	3275	3823	3258			3215	166	101	690	758	206	1921	1271
Conversion Losses				565 3/	33		645 4/							
Total				3823			3823							

1/ Equivalent to 60 GWh substituted for electricity.
2/ Ethanol production of 36 million litres considered equivalent to gasoline.
3/ Same as 2/ on Table 1.2
4/ Same as 3/ on Table 1.2
5/ Same as 4/ on Table 1.2

(b) Demand Management/Conservation

(i) Modernize the oil refinery (para. 3.38-3.40);

(ii) Develop program to encourage conservation in small/medium enterprises (para. 4.23), with coordination between various donors;

(iii) Miscellaneous measures, including improved consumption data base through surveys and audits (para. 4.23), approval for proposed increases in power tariffs (para. 5.15), reduction of normal/off-peak power tariff differentials (para. 5.15), installation of residential/commercial solar water heaters (para. 2.30, 4.10), extension service for stove improvement (para. 4.25), realigned sales taxes on some fuels (para. 5.05), diversion of long-haul freight to railway (para. 4.18); review of small diesel bus ("matatus") program (para. 4.15);

(c) Fuel Substitution

(i) Complete studies, project preparation and execute coal conversion (and possibly wet/dry process conversion) at East African Portland Cement plant (para. 4.06);

(ii) Study coal conversion in other industries, including the pulp and paper plant (para. 4.20);

(iii) Review import duty on coal (para. 5.18);

(d) Institutional/Organizational

(i) Place all energy-related programs under Ministry of Energy and strengthen its structure and staffing (para. 6.02-6.09);

(ii) Merge Kenya Power Company and Tana River Development Company (para. 6.10-11).

(iii) Establish energy development institute (para. 6.12-6.15);

(iv) Study organization of charcoal production and marketing (para. 4.29).

TABLE 1.6

Comparison of Projects in the Energy Sector

Project	Capital Cost US$, Million	Oil Displaced Barrels per day	Additional Imported Energy Required per Year	Capital Costs per Unit Energy 1/	Total Net Foreign Exchange Savings US$, Million per year 3/
Bamburi Cement - Coal Conversion & Uprating	16.0	1,050	91,000 tonnes coal	$ 19,600	1.4
East African Portland Cement: Coal Conversion	10.0	1,320	124,000 tonnes coal	$ 7,600	1.9
Ethanol-Approved Projects (Kenya Chemical and Food Co., and Agro-Chemical and Food Co.)	60.5	520	-	$114,000	- 1.5
Ethanol - Proposed Project (Riana - Cane Juice distillery)	76.0	650	-	$115,000	- 2.0
Kiambere - 140 MW Hydro	300.0	3,260 2/	-	$2143/kW	13.2
Geothermal - 30MW, Olkaria	89	1,010 2/	-	$2967/kW	4.4
Refinery Conversion	103.0	20,000 4/	19,250 5/ barrels of fuel oil	$5150	32.3

1/ Per daily barrel of oil displaced except where kW are specified.
2/ Based on 4000 kWh per tonne of oil equivalent.
3/ Projects amortized at 11% over 10 years except for the power projects which are amortized over 25 years.
4/ Reduction in crude throughput.
5/ Annual foregone exports of fuel oil.

II. ENERGY RESOURCES AND SUPPLY

2.01 Kenya's proven energy resources are relatively small. Hydroelectricity is currently the major supplier of primary electricity for the grid and the geothermal resources of the Rift Valley are being developed for electricity generation. Fossil fuel resources have not so far been proven; interest in petroleum exploration is increasing in prospective onshore and offshore sedimentary basins though limited surveys for coal and peat deposits have been disappointing.

2.02 As to wood, recent reports indicate that its consumption is exceeding annual regrowth, and in certain areas deforestation is becoming serious. Kenya is endowed with significant solar energy which is fairly constant year-round. This resource can be utilized directly for water-heating and crop drying, or indirectly through efficient use of biomass such as bagasse or other agricultural wastes.

Oil and Natural Gas

Exploration

2.03 Kenya has no identified reserves of oil or gas. However, the sedimentary basins have not been fully-explored and potential exists for future discoveries. Evidence from drilling in Kenya1/ and neighboring countries indicates that gas and oil have been generated, and that there are abundant source rocks and prospective reservoirs. In the past exploration was held back because identified structures are small, the offshore shelf area is limited, and the prospects for finding gas are higher than for oil. Now, because the value of gas is increasing, potential gas discoveries are less of a deterrent to exploration. At present an exploration permit covering 12,420 km^2 is held by Cities Service, Union Oil, and Marathon. The Government has received a proposal for offshore exploration and many requests concerning contract possibilities. The Bank has approved a $4 million loan to provide technical assistance in petroleum, exploration promotion, and for legal consultants, in order to evaluate the existing data and to attract private investment for exploration. The mission supports these efforts; indeed they are crucial to the long term energy prospects of the country; however, because exploration is at a very early stage, the analysis in this report has assumed that there will be no commercial production of oil or gas in Kenya during this decade.

Supply

2.04 The international oil corporations operating in Kenya import crude oil from Middle East countries through their affiliates. This

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1/ A list of exploratory wells drilled appears in Annex III.

practice may change somewhat during the 1980s, as the National Oil Company recently formed in Kenya exercises its mandate to enter into contracts with foreign governments to purchase crude oil directly. This may reduce the unit cost of crude oil to Kenya, and if the contracts are with diversified suppliers, increase the security of supply. The crude oil processed by the marketing companies at the East African Oil Refinery, (EAOR), in Mombasa meets most of Kenya's petroleum product demand with the exception of aviation gasoline which is imported.

2.05 The proportion of refinery products consumed inside Kenya has increased during the period 1969-1980, as Table 2.1 shows, while Table 2.2 shows that the volume of gasoline and middle distillates exports changed very little in 11 years, fuel oil exports have increased somewhat, and heavy diesel oil exports have declined. Neighbouring land-locked countries (Uganda, Rwanda, Burundi, and Zaire) buy almost 80% of the total exports of clean products (gasoline, kerosene, jet fuel, and gasoil). By contrast, only 4.5% of the exports of heavy fuel oil end up in these countries, with the remainder being sold offshore or as bunker fuel for ships. Further discussion of the refinery issues, especially the product mix, is given in Chapter 3.

TABLE 2.1

Domestic Consumption as a Percentage of Refinery Production

Product	1969	1973	1980
LPG	64.4	75.5	89.2
Gasoline	51.8	72.6	70.8
Kerosene/Jet Fuel 1/	71.7	85.4	99.5 2/
Gasoil	51.0	67.8	78.0
Heavy Diesel	24.1	28.8	45.9
Fuel Oil	33.0	31.8	32.7
Total	44.8	52.6	60.0

1/ Includes international aviation up-lift.

2/ Provisional data, subject to revision. On the basis of CBS' data for exports by country, this figure would be 75.2%.

Source: CBS, EAOR

TABLE 2.2

Exports of Petroleum Products from Kenya
('000 toe)1/

Product	1969	1973	1980
LPG	3	4	-
Gasoline	142	88	136
Kerosene/Jet Fuel2/	77	53	108
Gasoil	149	120	145
Heavy Diesel	99	115	37
Fuel Oil	680	879	943
Total	1,150	1,259	1,369

1/ Conversion factors (see Annex I)

2/ Kerosene and jet fuel reported together by EAOR.

Coal and Peat

Reserves and Supply

2.06 A survey of peat resources was done in late 1980 by a Finnish consulting company, EKONO, at the request of the Ministry of Energy of Kenya. No peat deposits were located in the swamps surveyed, but a sample from a swamp not visited during this work was considered worth following up. The mission supports the consultants' recommendation to continue prospecting, particularly at higher elevations, in mangrove swamps, and in areas which are thought to contain peat.

2.07 No coal reserves have been discovered and so Kenya's major coal consumer, the Bamburi Portland Cement Company, imports all of its coal (60,000 tpy) from Swaziland, and has already opened discussions for increased supplies. The origin of the remaining imports is unknown.

Electricity

Hydropower Resources

2.08 Hydroelectric and geothermal resources which can be considered as proven and capable of development amount in total to 1,075 MW, or about twice the current installed capacity.

2.09 Between 1978 and 1981 hydropower stations in Kenya provided between 60% and 83% of the electricity currently generated in Kenya, and

East African Power and Light (EAPL) would like to increase the use of this resource as far as possible. The potential theoretical generation available from rivers in Kenya has been estimated to be 30,000 GWh per year, with 15,000 GWh accounted for by the Tana River, though not all of this will be economically exploitable.

2.10 Studies indicate that by the end of the century, 560 MW of installed capacity of hydropower could be added to the present 350 MW. At a capacity factor of 55%, hydropower's total installed capacity of 910 MW would then generate about 4380 GWh per year, compared with the 1981 figure of 1,362 GWh.

Small Scale Hydropower Resources

2.11 The potential for small scale hydropower development in the Tana River Basin was studied by consultants financed by ODA during 1978 (the maximum installed capacity per site was 300 kW). The study confirmed that the Upper Tana Basin contains many sites where small scale hydro development would be technically feasible. However, relatively few of the sites in the Upper Tana Basin are situated more than 15 km from existing EAPL grid supply lines, and therefore they cannot be considered as remote. The study concluded that connection of isolated load centers in this area to the existing grid supply would be more economic than development of the sites, and that small scale hydro is only likely to be more economic than grid connection when the grid distance from the sites exceeds 45 km, based on grid energy supplies being obtained from hydrogeneration. Similar conclusions to the ODA study were obtained by Finnish consultants in a survey of Western Kenya around Lake Victoria conducted in 1981.

2.12 Three conditions need to be fulfilled generally for development of small scale hydropower to be economic, namely the sites and load centers should be remote from existing or planned national grid supplies, streams need to be perennial and relatively fast flowing, and loads should be of sufficient size and duration to result in economic plant factors. Such a combination does not appear to exist much in rural Kenya. However, further survey work for small scale hydro development is currently being undertaken in Kenya, particularly in the Athi River Basin (mainly for water supply purposes rather than power).

Geothermal Resources

2.13 Geothermal areas in Kenya are located in the Rift Valley which runs from the Kenya - Tanzania border in the south to Ethiopia in the north. There are three major areas of geothermal activity: Olkaria, which is under development, and Eburru and Lake Bogoria, which are currently being explored.

2.14 Exploration started in the early 1950s at Olkaria and the first well was drilled in 1956. A second well was drilled in the field but exploration activity dropped in the early 1960s due to the expansion of hydropower. Interest later revived, and further exploration in 1967 identified several anomalous areas which were recommended for drilling. Through the 1970s exploration and drilling work, financed partially by the UNDP, continued and a feasibility study completed in 1977 indicated that development of the Olkaria field was feasible. Bank loans helped finance development, which consisted of additional drilling and the construction of two 15 MW generating units. The first was brought onstream in July 1981 and the second will be completed by January 1983.

2.15 Exploration is continuing in the Olkaria field, with plans for further drilling to establish the limits of the field. Based on geophysical work, the field is estimated to cover 100 km^2 with generating capacity estimated conservatively at 170 MW and optimistically at 1,000 MW. In view of the fact that the full potential of the Olkaria geothermal field is still unknown, the deep drilling program to define the limits of the field needs to be pursued as a matter of highest priority so that an investment program for additional geothermal capacity can be developed. Identified projects of 70-100 MW are likely to be determined soon and this new capacity could be absorbed by the system by 1986-87. The Olkaria field and the transmission system are shown on map IBRD 16389.

2.16 The other two areas, Eburru and Lake Bogoria, have not been evaluated to the extent that estimates of power capacity and their development costs can be made, though results to date are encouraging. The exploratory work in progress is being financed and supported by the Japan International Cooperation Agency (Eburru) and the UNDP and the Ministry of Energy is now evaluating the prospects before committing itself to full-scale development.

Existing Power Facilities

2.17 The East African Power and Lighting Company Limited (EAPL) is the sole distributor of electricity which is generated by EAPL, the Kenya Power Company Ltd. (KPC), the Tana River Development Company Ltd. (TRDC), and the Tana River Development Authority (TRDA). In addition to hydropower, oil-fired steam turbines, gas turbines, diesel generators, and purchases from the Uganda Electricity Board (UEB) provide electricity. The interconnected system extends from the Ugandan border through Nairobi to Mombasa. Isolated diesel generator sets provide electricity to the larger towns lying outside this corridor.

2.18 The installed and effective capacity in Kenya is shown, by source, in Table 2.3. An additional 30 MW is available from UEB under a long-term agreement bringing the total available capacity to 538.1 MW on the interconnected system.

TABLE 2.3

Available Generating Capacity, 1981
East African Power and Lighting
(MW)

	Interconnected Installed	Interconnected Effective	Isolated
Hydro	348.5	339.0	-
Steam	98.0	90.5	-
Diesel	31.5	18.7	1.9
Gas Turbine	30.1	21.8	-
Total	508.1	470.0	1.9

Source: EAPL

2.19 The three largest hydroelectric power stations --- Gitaru (145 MW), Kamburu (91.5 MW), and Kindaruma (44 MW), all owned by TRDC --- are located on the Tana River about 70 miles east of Nairobi. These three stations are interconnected through Nairobi to the EAPL steam and gas turbine plant (110.2 MW) at Kipevu (Mombasa) by means of 132 kV single circuit transmission lines. A 220 kV transmission line between Kamburu and Mombasa is under construction with financial assistance from the Canadian International Development Agency. This additional interconnection will permit reduced operation of the thermal station in Mombasa.

2.20 Other installations include seven small hydroelectric developments, the largest of which are Tana (14.4 MW) and Wanjii (7.4 MW), both run of river schemes on the Tana River,owned by KPC. The remaining five hydroelectric installations together with seven diesel-electric power stations, including Nairobi South, and the gas turbine generating plant are owned by EAPL. All of this plant, including the larger power stations described above, is interconnected by means of 132 kV and 33 kV transmission and subtransmission lines. This system is linked to Uganda by a 132 kV double-circuit transmission line for the transfer of the bulk power. EAPL also operates five isolated diesel electric power stations aggregating 1.9 MW.

2.21 In recent years, EAPL has expanded the area served by the interconnected system, particularly in Western Kenya. In response to the Government's decision to make Kisumu and Eldoret industrial centers, EAPL has reinforced transmission lines and connected several towns which were previously served by diesel generators. Rural electrification is proceeding in a slow but systematic manner by extension of the distribution system, or by installing diesel generators in the larger isolated centers.

2.22 As the system is currently configured, the hydropower stations are base load plants and provide as much electrical energy as possible, taking into account the available storage and irrigation demands. However, the existing transmission line to Mombasa limits the amount of electricity which can currently be supplied to that area from the hydro plants and, consequently, the thermal plant is operated as a base load plant serving the Mombasa area. During the dry season (January-March) of years with low rainfall, such as 1980, this plant is operated at a high plant factor and electricity is transmitted in the opposite direction -- from Mombasa to Nairobi -- to supplement energy output from the hydro plants. Additionally, in dry years the gas turbines at Nairobi South and the diesel stations which are connected to the grid are used to supplement energy requirements, and as peaking plants.

2.23 The data for generation by source for 1975 to 1981 are given in Table 2.4, which clearly shows the fluctuations in thermal generation resulting from dry years (1976 and 1980), and the large increases in hydro generation in 1978 and 1979 due to the commissioning of the Gitaru project which was completed during 1978.

TABLE 2.4

East African Power and Lighting
Electricity Generation by Source 1/
(GWh)

Year	Hydro	UEB	Thermal	Geothermal	Total
1975	634	261	254	-	1149
1976	563	240	479	-	1282
1977	785	272	348	-	1405
1978	1053	217	259	-	1529
1979	1288	160	207	-	1655
1980	1040	315	380	-	1735 2/
1981	1362	194	284	39	1879

1/ Interconnected system only.

2/ In 1980 there was load shedding of approximately 40 GWh due to restricted supply. The true demand is therefore estimated to be 1775 GWh.

Source: EAPL

Prospects and Policies

2.24 EAPL has recently drawn up a tentative plan for development to meet the increased demand from now until the year 2000. Three scenarios were developed, but the differences only materialize after 1990. The plan calls for the addition of 315 MW of generating capacity by the year 1990, giving a total installed capacity of nearly 800 MW. Some projects in the plan are already completed or near completion; these include, in particular, the first 30 MW of geothermal at Olkaria, the 40 MW Upper Reservoir Masinga project, and the 220 kV transmission line to Mombasa to increase delivery of hydroelectric supplies to displace oil generation at Kipevu. In addition to increasing installed capacity, the Masinga dam will also impound the run-off from the rain and allow the existing downstream plants to generate up to an additional 100 GWh by taking advantage of the controlled flow. These projects will reorient the system, so that the thermal generating stations can be used for back-up and peaking purposes primarily, with some base load operation only during the dry season. A comparison of effective capacity and expected maximum demand at the stations is shown in Table 2.5 for 1980-1990.

TABLE 2.5

East African Power and Lighting
Projected System Installed Capacity & Maximum Demand, 1981-90
(MW)

Year	Installed Capacity	Effective Capacity 1/	Maximum Demand	Increase From
1980	468	432	290	
1981	523	485	313	Upper Reservoir, 40 MW (On-stream late 1981)
1982	523	485	332	Olkaria 1, 15 MW (On-stream July 1981)
1983	538	500	355	Olkaria 2, 15 MW
1984	538	500	380	
1985	553	515	406	Olkaria 3, 15 MW
1986	678	640	435	Kiambere, 140 MW (less 15 MW Thermal Retirements)
1987	678	640	465	
1988	783	745	498	Turkwel, 120 MW (less 15 MW Thermal Retirement)
1989	783	745	533	
1990	783	745	570	

1/ Excluding 30 MW bulk supply from UEB.

Source: EAPL

2.25 There have been proposals to introduce a 90 MW combined cycle oil-fired generation station in 1988, consisting of two or three gas turbines and a waste heat boiler steam generator. The argument turns on delaying the construction of a second 220 kV circuit to Mombasa. It would only be used as standby capacity. The increased demand for oil created by this plant could be avoided by maintaining the hydro-power program sequence, and further reduction in oil consumption can possibly be achieved by retrofitting the two large Mombasa units (totalling 65 MW) to make them coal-fired, though this needs to be analyzed further. EAPL have concluded that the second transmission line is more economic than the proposed combined cycle plant and, therefore, the latter project has been dropped.

2.26 A suggestion often made for East Africa is cooperation amongst the countries to develop the region's hydroelectric potential. For example Tanzania plans to develop significant additional hydroelectric capacity on the Rafiji River, and could have surplus power available in the second half of the 1990s. Restoration of the transmission inter-tie between Mombasa and Tanga in Tanzania at 220 kV (formerly 33 kV) would greatly strengthen both systems, increasing reliability of power supplies and allowing purchases of additional blocks of economic power by Kenya in the future. This option should be pursued by Kenya, as well as the option of further purchases from Uganda. In this respect the Ayago project in Uganda, which has a capacity of 500 MW could be developed jointly by the two countries. Because of the political aspects of these projects and the longer lead time for regional projects, it is important that the Government and EAPL initiate action soon so that these projects could be completed in the 1990's when more capacity will be required.

2.27 Based on the forecast of average demand and the development and investment plan described above, a forecast of generation by source can be made for the next five years. This forecast (Table 2.6) shows the importance of bringing the Kiambere hydro plant onstream at the earliest possible time and certainly by 1986. Otherwise, the electricity which could be provided by Kiambere would have to be generated by thermal plant, resulting in an increase in fuel oil required. Beyond 1986, the Turkwel hydro project must be completed at the earliest possible date, and the mission recommends that the relevant pre-investment studies be completed as soon as possible.

TABLE 2.6
Forecast of Generation by Source, GWh

Year	Hydro1/	UEB	Geothermal	Thermal	Total
1981	1362	194	39	284	1879
1982	1393	252	100	264	2009
1983	1478	252	200	220	2150
1984	1668	252	200	180	2300
1985	1729	252	300	180	2461
1986	1882	252	300	200	2636

1/ For an average hydrological year.

Source: EAPL data supplied to the follow-up mission.

Solar and Wind Energy

Solar Resources

2.28 Kenya's entire area lies within 5 degrees north and south latitude. Consequently, solar radiation is high and fairly regular throughout the year. Historical meteorological data are available for more than thirty stations throughout the country, and include daily sunshine hours, mean solar insolation, and, in some cases, wind velocities. The average annual insolation for the country is estimated at 5.5 $kWh/m^2/day$. There are portions of the country which enjoy higher levels of radiation consistently through the year, while others experience cloudy conditions during the rainy season. However, even the diffuse component of radiation under cloudy conditions could be utilized by flatplate thermal collectors.

2.29 The contribution of solar energy to the national energy supply is minimal at present. It is currently being used for water heating and crop drying. Crop drying is widespread, but still fairly rudimentary. The open sun drying of crops and fish often reduces product quality, and increases storage and transportation losses.

Wind Resources

2.30 An analysis of Kenya's average annual wind speeds and average available power identified two portions of the country as particularly suitable for wind pumping or power generation1/. One small area was in the highlands near Eldoret, while the second area is a band extending from Malindi and Lamu through the Lake Turkana area. The seasonal and diurnal wind variations were also analyzed to the extent possible, given the quality and type of data available. The Ministry of Energy and the Meteorological Department have initiated a project to update this analysis and it is now thought that the potential for windpower may be equally good in other parts of the country.

2.31 Windmills have been used for water pumping in Kenya for decades, but their use is most prevalent on large farms or ranches in the northern central region. At least two Kenyan companies currently manufacture windmills and several imported models are available. A cost comparison of locally-manufactured windmills versus diesel pumps performed for USAID showed a payback period for windmills of two to seven years depending on the output2/.

1/ Chipeta, G. B., "A Study of Wind Power Availability in Kenya", University of Nairobi, M. Sc. Thesis, 1976.

2/ USAID, Kenya Renewable Energy Development Project, Project Paper 615-0205, August 1980.

Prospects

2.32 In addition to domestic use, which is discussed in Chapter 4, solar water heating systems are also being installed in hotels and other institutions and this should continue to be encouraged. One other potential application of solar water heating is in the industrial sector, though the water may often require further heating by conventional energy systems. The net liquid fuel saving could still be significant, however, and the current tax system encourages their installation once the industrialists have been made aware of their benefits.

2.33 As for solar crop drying, several programs are underway to introduce more effective methods, and interest is high in cooperative societies as well as commercial concerns such as the British-American Tobacco Company (B.A.T.). Solar drying could substitute for fossil fuels or fuelwood currently used to dry cash crops such as tea, coffee, pyrethrum and tobacco. Proposals have been made to replace diesel driven driers with solar powered ovens, and these schemes, having been tested and approved by B.A.T., deserve to be financed, either directly or through external assistance.

2.34 Experiments have been underway for some time to use solar power, both photovoltaic and systems based on temperature differential, for water pumping. However, the units installed so far, at Turkana and Wajir, cost far more than recent installations in other countries and substantial cost reductions would be required to make them economic.

2.35 An interesting but limited use for solar power is in electric fencing for range lands. Photovoltaic cells can be used to generate an electric pulse for the fences.

2.36 Photovoltaic electric generation is not yet established nor competitive in Kenya. Present costs of up to $10 per peak watt are clearly an inhibiting factor, although it may be competitive for certain uses in remote areas such as telecommunication and refrigeration of medical supplies. Future cost reductions are certainly to be expected and so action should be limited to demonstration projects until there are significant reductions in costs of this technology.

2.37 The University of Nairobi's Engineering Faculty is involved in research and experiments in solar application, although on a limited scale. There are also plans to initiate teaching programs in this field by both the University of Nairobi and Kenyatta University College.

2.38 Increased use of windpumps will depend on the availability of financing for the higher initial costs, and also on the presence of aquifers at depths shallow enough for efficient pumping. The recent increases in fuel prices have generated renewed interest in windpumps and, to the extent that diesel powered pumps are replaced, demand for petroleum will be reduced marginally.

Woodfuels

Resources

2.39 Concentrated in the central part of the country, where rainfall is comparatively high, forests cover almost 2 million hectares, or about 4% of Kenya's total land area. Forest resources are almost completely under public ownership and management. Indigenous forest reserves account for some 88% of the forests, with forest plantations, mostly of exotic species, and privately owned forests accounting for another 6% each. Private forests consist mainly of small farm woodlots and shelterbelts.

2.40 The Bank Group has supported establishment of these plantations in the past with two projects and a third project has been negotiated[1/]. In addition to providing for 6400 hectares of industrial plantations p.a., the new project envisages strengthening the Rural Afforestation Extension Service (RAES) which currently operates 125 nurseries throughout the country. (The Governments of Switzerland and Italy are cofinancing the project.) These nurseries would be expanded and 30 new ones created. Seedling production in 1981 was 13.0 million and the objective is to increase production to 52.5 million by 1986. Seedlings are currently sold at about one tenth of production cost and survival rate is less than 30% and the project will attempt to improve survival tc 40%. The area of the rural woodlots created through this program has not been estimated although some 90,000 hectares of land have been set aside by Councils for afforestation.

2.41 The Forest Department estimated the 1978 forest yield as follows:

Forest reserves	168,000 tonnes
Private agricultural land	200,000 tonnes
Rangeland, government, and trust land	5,600,000 tonnes
Total	5,968,000 tonnes

Prospects

2.42 Since wood will continue to be a major energy source over the next couple of decades, it is crucial to assure that this does not

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1/ The total project costs are estimated to be US$74.1 million. The Bank Group financing will include a US$21.5 million IBRD loan and a US$16 million IDA credit.

increase deforestation. Several international agencies are already providing aid for forestry as well as for improving the efficiency of the use of wood, but their programs need to be coordinated.

2.43 There are three basic approaches to increasing wood supplies, all of which are currently being tried to some extent and all of which the mission believes need to be followed in the appropriate areas of the country:

(1) Large-scale plantations to serve urban and industrial demand. These projects should be implemented by professional organizations, such as the Forest Department, in collaboration with local authorities and/or private industry who should identify:

   a. areas suitable for plantation;
   b. species;
   c. a management plan for plantations and their financing;
   d. costs, yields and revenues;
   e. methods to spread plantations and the regulations, laws, taxation measures, etc. required.

(2) Large-scale afforestation in arid and semi-arid areas. Efforts should be made to find appropriate species which can survive in these areas (e.g., present experiments with euphorbia trees financed by Belgian aid) and locate them so as to support the dual objective of soil conservaton and contribution to fuelwood supplies. The projects should be designed and managed by the Forest Department.

(3) General rural afforestation - woodlots and agroforestry. The general atmosphere for dramatic increases in this area is right. As wood is now getting scarce, farmers are becoming increasingly conscious of the need for farm woodlots. The plantations should be multipurpose to yield wood, food and fodder and help in soil conservation. While professional guidance from the Forest Department is critical, a major role for NGOs (Non-Governmental Organizations) exists in this area in organizing the farms, and providing extension services, as well as at least part of the funds needed.

Other Renewable Resources

Ethanol

2.44 The viability of the fuel alcohol program in Kenya is closely linked to other aspects of the agriculture sector. Kenya has about 12 million ha of medium to high potential land (20% of the total area), about 6.2 million ha of which are farmed. A wide variety of crops is produced, but in recent years Kenya has imported significant quantities of agricultural products, mainly maize, wheat and edible oils, and a significant portion of the unfarmed medium/high potential land is forest land in the Central Highlands and Western Kenya. Before converting this land to crops, the effects on future wood supply and erosion with attendant siltation of hydro dams must be studied.

2.45 Sugar production and consumption in Kenya have grown rapidly in the past decade as shown in Table 2.7, and the Kenya Sugar Authority (KSA) has forecast continued strong growth in sugar production during the 1980s. Table 2.8 shows four alternative production estimates by KSA, two of which show that Kenya would need to import sugar in 1990 and the other two show that it would export sugar. In the first two cases there appears to be little a priori justification for ethanol production from sugar; in the second two, the key issue is what maximises Kenya's net foreign exchange earnings - exporting sugar/molasses or production of some ethanol to substitute partially for gasoline.

TABLE 2.7

Sugar Production, Consumption and Imports
(tonnes)

Year	Production	Consumption	Imports 1/
1970	125,156	162,375	38,672
1972	92,284	194,612	113,617
1974	164,208	223,661	81,814
1976	167,371	197,013	31,815
1978	237,529	251,186	44,495
1980 2/	401,251	299,514	(93,192) 3/

1/ For 1972-77, the International Sugar Organization reported net imports about 90,000 tonnes greater than shown.

2/ Provisional.

3/ Net Exports.

Source: Kenya Sugar Authority.

TABLE 2.8

Forecast of Sugar Production and Surplus or Deficit
('000 tonnes)

	CASE I		CASE II		CASE III		CASE IV	
Year	Without Rehabilitation or Expansion		With Rehabilitation		Full Rehabilitation and Expansion of Existing Factories		Case III Plus New Projects	
	Production	Surplus (Deficit)	Production	Surplus (Deficit)	Production	Surplus (Deficit)	Production	Surplus (Deficit)
1981	426	113	426	113	426	113	426	113
1982	432	91	432	91	438	97	439	98
1983	457	91	457	91	481	115	482	116
1894	467	75	475	83	529	137	531	139
1985	471	52	491	72	572	153	618	199
1986	472	23	504	55	604	155	724	275
1987	472	(11)	517	34	625	142	775	292
1988	472	(46)	521	3	645	127	846	328
1989	472	(82)	521	(33)	661	107	887	333
1990	473	(121)	522	(72)	670	76	931	337

Source: Kenya Sugar Authority.

2.46 Two projects are nearing completion and the Government is considering a third:

(i) Kenya Chemical and Food Corporation -the Kisumu plant owned by Kenya Chemical and Food Corporation (KCFC) is a molasses based ethanol production unit with a capacity of 20 million litres/year, a 3000 ton/year citric acid plant and a 1800 ton/year baker's yeast plant. The total investment was about US$122 million, of which about US$28 million was allocated for producing ethanol. The distillery is located 100 km from the molasses source and, not being across-the-fence from a sugar mill, power and steam are not available from bagasse. Instead the plant includes a digester to produce methane from the stillage to meet an estimated 40% of energy needs and will rely on a diesel power plant for the remainder. This operation will obviously be negative from an energy standpoint. Indeed, even if the investment costs are regarded as sunk, the cost of alcohol production (excluding transport) will be of the order of US$1.38 per U.S. gallon, well above the border price of petrol.

(ii) Agro-Chemical and Food Company - the second distillery, owned by Agro-Chemical and Food Company (ACFC), is about 100 kms south of Kisumu. This distillery has been built as an annex to the sugar mill at Muhoroni, and will be able to use surplus bagasse from the mill as the distillery's fuel source. The rated capacity of this plant is 18 million litres/year of ethanol. The project is estimated to cost some US$32.5 million and excluding the investment cost, production costs are about 93 U.S. cents per U.S. gallon, just competitive with imported petrol.

(iii) Riana - a third project for ethanol production is being considered by the Government. This project would be at Riana in Nyanza Province, and the distillery would be capable of producing 45 million litres of ethanol/year and is based not on molasses as the feedstock but cane juice. In addition, it would use bagasse as the fuel source and not commercial energy. The estimated investment for this project is US$76 million, which includes cane handling and transport equipment, but excludes agricultural development costs although 10,000 ha of land would have to be planted with cane. In Brazil an integrated facility of this size would cost some US$25-35 million. Total production cost for alcohol would be about US$1.16 per U.S. gallon.

2.47 Table 2.9, abstracted from a recent draft Bank report, shows a financial comparison of the three plants and indicates that production costs for alcohol will vary from KSh 2.71 per litre at ACFC to KSh 7.38 per litre at KCFC. It is clear that, with the economic price of gasoline even as high as 2.4 KSh/litre (US$1.15/US gallon), these projects are not viable. Indeed, the estimated financial return on investment is - 6% for KCFC, 11.7% for ACFC and 7.6% for Riana, which clearly reveal the tenuous nature of this program.

2.48 In all, the three ethanol projects are unlikely to make alcohol production for gasoline substitution an economic proposition in Kenya for the following reasons:

(a) High capital costs of the facilities;

(b) Transport costs for molasses;

(c) Use of commercial energy sources especially at one plant (Kisumu) due to unavailability of bagasse;

(d) Profitable molasses and sugar export markets and,

(e) The availability of gasoline at more competitive prices (about US$1/gallon border price) relative to alcohol production costs in Kenya in the facilities in question.

TABLE 2.9

KENYA - Fuel Alcohol Subsector Review

Comparative Financial Analysis

of Alcohol Projects

	Annual (KSh million)			KSh per 100 lt			% of Alcohol Sales		
	KCFC	ACFC	RIANA	KCFC	ACFC	RIANA	KCFC	ACFC	RIANA
Fixed Costs									
Depreciation	88.3	13.6	26.8	446	75	67	101	17	15
Plant Maintenance	10.9	3.6	5.3	55	20	13	13	5	3
Overhead	15.6	9.3	15.0	79	51	38	18	11	9
Sub-Total	114.8	26.5	47.1	580	146	118	132	33	27
Variable Costs									
Molasses	53.3	32.2	-	270	178	--	61	40	-
Cane	-	-	85.7	-	-	214	-	-	49
Chemicals	24.6	4.8	0.7	123	27	2	28	6	1
Utilities	22.9	5.7	-	116	32	-	26	8	-
Labor	9.1	1.8	3.6	46	10	9	10	2	2
Other direct costs	5.7	-	-	29	-	-	7	-	-
Sub-Total	115.6	44.5	90.0	584	247	225	132	56	52
Operating Costs	230.4	71.0	137.1	1,164	393	343	264	89	79
Other Products Credit	(84.3)	(22.0)	-	(426)	(122)	-	(97)	(28)	-
Alcohol Production Cost	146.1	49.0	137.1	738	271	343	167	61	79
Operating Profit/ (Loss)	(58.8)	30.4	39.3	(297)	170	98	(67)	39	21
Alcohol Sales	87.3	79.4	176.4	441	441	441	100	100	100

Industrial Projects Department
May 1981

2.49 The Government should therefore urgently review the entire ethanol program and the mission recommends first, that no further investment in alcohol should be made, second that a course of action be developed to maximize cash flow from the KCFC plant, and third, that a program be developed for rationalizing and monitoring the production and use of alcohol.

Bagasse

2.50 This by-product of sugar production is normally used to provide all the energy necessary for that industry. In some countries excess electricity is produced and sold back to the power company. In Kenya, however, there are some plants where fuelwood or commercial energy must be used to supplement the bagasse and only one sugar factor, Mumias, has offered to sell electricity to EAPL though no agreement has been reached so far. In any event it is unlikely that bagasse will be competitive with geothermal or hydro-power. It is possible to install driers using heat from boiler stack gases at the sugar plants so that bagasse can be stored for periods when there is no cane to be crushed. This would at least eliminate the need for purchasing other forms of energy to supplement the bagasse.

Biogas

2.51 One of the most promising forms of non-conventional energy is biogas. Undoubtedly, its success is a function of a number of often unique factors. The reported success in China is due in part to such aspects as population density, strong extension services and use of pig manure.

2.52 These factors combined with livestock inventory should determine whether family or community-size bio-digesters are more desirable. The 1978 Report of the Ministry of Agriculture gave the following animal census:

Cattle	16.7 million
Sheep & goats	15 million
Poultry	6 million
Pigs	69,400
Camels	607,000
Donkeys	135,000

Total manure production per day is estimated to be 862.6 million kg.

2.53 These numbers suggest that the volume of feedstock required to operate up to 200,000 four cubic meters per day bio-digesters, which could serve a rural population of up to 1.5 million, can be secured. The problem is that the numbers hide such critical factors as property ownership and colonization patterns which, combined with cash flow requirements (the initial cost of a digester is still around KSh 4,000), make it unlikely that the family-size bio-digester can spread quickly in the rural areas. Another problem is that since the majority of animals graze the whole day miles away from villages, only their nightly droppings can be easily collected. This should not impede, however, the adoption of bio-digesters by livestock farms and other operations, such as fattening operations, and these should be encouraged by the Government.

2.54 The basic economic viability of bio-digesters is closely linked to the value of fertilizer which, depending on one's viewpoint, can be considered either the main product or a by-product of the process. Table 2.10 assumes three (low, medium, high) values of the slurry. As can be seen in all but one case, the cash flow is positive even with zero slurry value assumed.

TABLE 2.10

Cash Flow for Biogas Digesters

Design	Size (M^3/day)	Capital Cost (K.shs)	Slurry Value (K.shs) Low	Med.	High	Net Cash Flow (K.shs) Low	Med.	High
I	5	1650	0	300	600	-130	170	470
	20	3850	0	1200	2400	305	1505	2705
II	5	750	0	300	600	140	440	740
	20	1500	0	1200	2400	900	2160	3360

2.55 At the present time, there are about 100 biogas digesters in Kenya. Only part of these are working continuously, most of them on large farms, such as the Lhoruho Estate in Eldoret. In 1979 the then formed Rural Energy Panel set up a subcommittee with a mandate to install bio-digesters on a pilot basis across the country in different ecological and climatic zones and analyze their performance from a technological as well as socio-economic aspect. However, there is no evidence that this has happened.

2.56 Agricultural and animal wastes can be burned directly and in parts of Kenya where fuelwood is scarce this is common. However, there are no estimates of how much of these wastes is used. To the extent that fuelwood becomes scarcer, this practice may increase with the attendant loss of nutrient value for the soil. Production of biogas as described above would be a better use of these wastes, since the slurry can be returned to the soil as a fertilizer.

Euphorbia Plants

2.57 Experiments done on selected species of euphorbia plants in Brazil, Mexico and Southern California have shown that the latex of these plants is very rich in hydrocarbon-like materials (polyisophrenes and sterols). Latex yields (net of water content) of up to 30 barrels/acre/year have been reported. One of the attractive features of these species is that they can be grown in semi-arid areas on land of low economic value -- a requirement of special relevance to Kenya. A technical assistance project sponsored by the Belgian Government is being undertaken through the Ministry of Natural Resources to investigate the yields of the most promising Euphorbia species under Kenya conditions. Very limited information was made available to the mission on this project.

III. ENERGY DEMAND

3.01 In 1979, Kenya consumed approximately 6.8 million toe of energy (see Table 3.1). Per capita energy consumption was about 444 kg. of oil equivalent; this compares with the world average of 1,500 kg, and an average for Africa of 300 kg. Non-commercial, traditional energy sources met about 71% of the total 1979 demand for energy, with commercial energy providing the other 29%. However, Kenya is more industrialized than many of its neighbours, as shown by the following estimates of their dependence on traditional fuels: Burundi (81%), Tanzania (93%), Rwanda (96%), Somalia (90%), Ethiopia (93%).

TABLE 3.1

Total Energy Consumption in 1979

	Urban		Rural		Total	
	Quantity (1000 toe)	% of Total Quantity	Quantity (1000 toe)	% of Total Quantity	Quantity (1000 toe	% of Total Quantity
Coal and Coke	40.2	1.7	-	-	40.2	0.6
Fuelwood	-	-	3,768.8	86.2	3,768.8	55.4
Charcoal	644.7	26.5	429.8	9.8	1,074.5	15.8
Petroleum Fuels 1/	1,388.2	57.0	171.6	3.9	1,559.7	22.9
Hydroelectricity	362.0	14.9	-	-	362.0	5.3
	2,435.1	100.0	4,370.2	100.0	6,805.2	100.0

1/ These data are slightly different than those in Table 1.2 which were compiled from different sources. The difference amounts to only 3%.

Source: Kenya Economic Survey 1981 for commercial energy statistics. Bank staff estimates for fuelwood and charcoal consumption and rural/urban energy consumption are based on data from T.S. Tuschak's "Kenya: Energy Situation and Options for the Future" - Interim report (August 1979).

Commercial Energy Consumption

3.02 Total commercial energy consumption in Kenya is estimated at 2.0 million toe in 1980, up from 1.9 million toe in 1979. The industrial, transport, and urban sectors have continued to depend heavily on petroleum. However, petroleum's share of primary commercial energy consumption declined from 85% in 1969 to about 79% in 1979, mainly because of the decrease in petroleum based electricity generation. This was due to the increased use of hydroelectricity, which rose from 12% of primary commercial energy consumption in 1969 to 19% in 1979.

3.03 Between 1969-73 petroleum consumption grew at 10%/year compared with GDP growth of 6.5%/year, resulting in an elasticity of demand for petroleum of 1.54. For the period 1973-1980, real GDP growth declined to 4.7%/year and petroleum demand growth fell to 4.1%/year so that the elasticity nearly halved, to 0.87. The main reasons for this change have been government policies which allowed the prices of petroleum products to move upwards with international prices and the increases in the percentage of electricity generated by hydropower.

3.04 For electricity demand the situation has been different. Sales of electricity on the interconnected power system increased at 10.2%/year between 1969-73, declining slightly to 8.1%/year from 1973-80. This means that the elasticity of electricity demand actually increased, from 1.57 during 1969-73 to 1.72 during 1973-80. There appear to be two reasons for this. First, the share of petroleum based electricity generation in total power generation declined during the 1970s from about 33% to 11%, so electricity prices have not had to follow completely the rise in international petroleum prices. Second, the contribution of electricity purchases from Uganda to total system demand in Kenya remained close to one fifth, and they have been available at very competitive and stable prices. These factors also help to explain why the share of electricity in commercial energy demand has increased after 1973.

Crude Oil and Petroleum Products

3.05 The demand for crude oil by the EAOR refinery derives from the demand for petroleum products within Kenya and also in neighbouring land-locked countries to which Kenya exports. Annual consumption of each product within Kenya, along with the growth rates, was shown in Table 1.3. Each of the products, except kerosene, shows the same reduced growth rate for the 1973-80 period as compared with 1969-73, and the share of the market taken by each product has not changed significantly.

3.06 Table 3.2 gives the GDP elasticity of demand for the various petroleum products, and shows that there was a decrease in elasticity for all products except kerosene. However, the GDP elasticities for LPG, jet fuel and gas oil were still greater than 1.0; for LPG this is because growth has been from a very small base, for jet fuel this is due mainly to increased up-lift by foreign airlines, and for gasoil the reasons are given below.

TABLE 3.2

Ratio of Growth in Petroleum Product Demand to Growth in GDP

Product	1969 - 1973	1973 - 1980
LPG	3.06	1.85
Gasoline	1.69	0.79
Kerosene	0.88	1.53
Jet Fuel	2.14	0.96
Gasoil	2.05	1.49
Heavy Diesel	1.62	-0.79
Fuel Oil	0.82	0.36
Aviation Spirit	-0.06	0.06
Total	1.54	0.87

Source: Central Bureau of Statistics.

3.07 The changing pattern of petroleum product use within Kenya is shown in Figure 3.1, which charts the volume of each product used per unit of GDP. Most noteworthy is the declining importance of heavy diesel and fuel oil and the increasing importance of gasoil (except for 1976, 1977 and 1980, when hydro reservoirs were low, and fuel oil use per unit of GDP increased as EAPL's consumption increased.) This reflects partly the efforts of major industrial users to reduce their consumption of residual fuel oil and heavy diesel oil per unit of output, and partly increased highway freight transport, the switch from fuel oil to gasoil by the railway and, possibly, some switching to diesel powered rather than gasoline powered private automobiles.

Sectoral Consumption

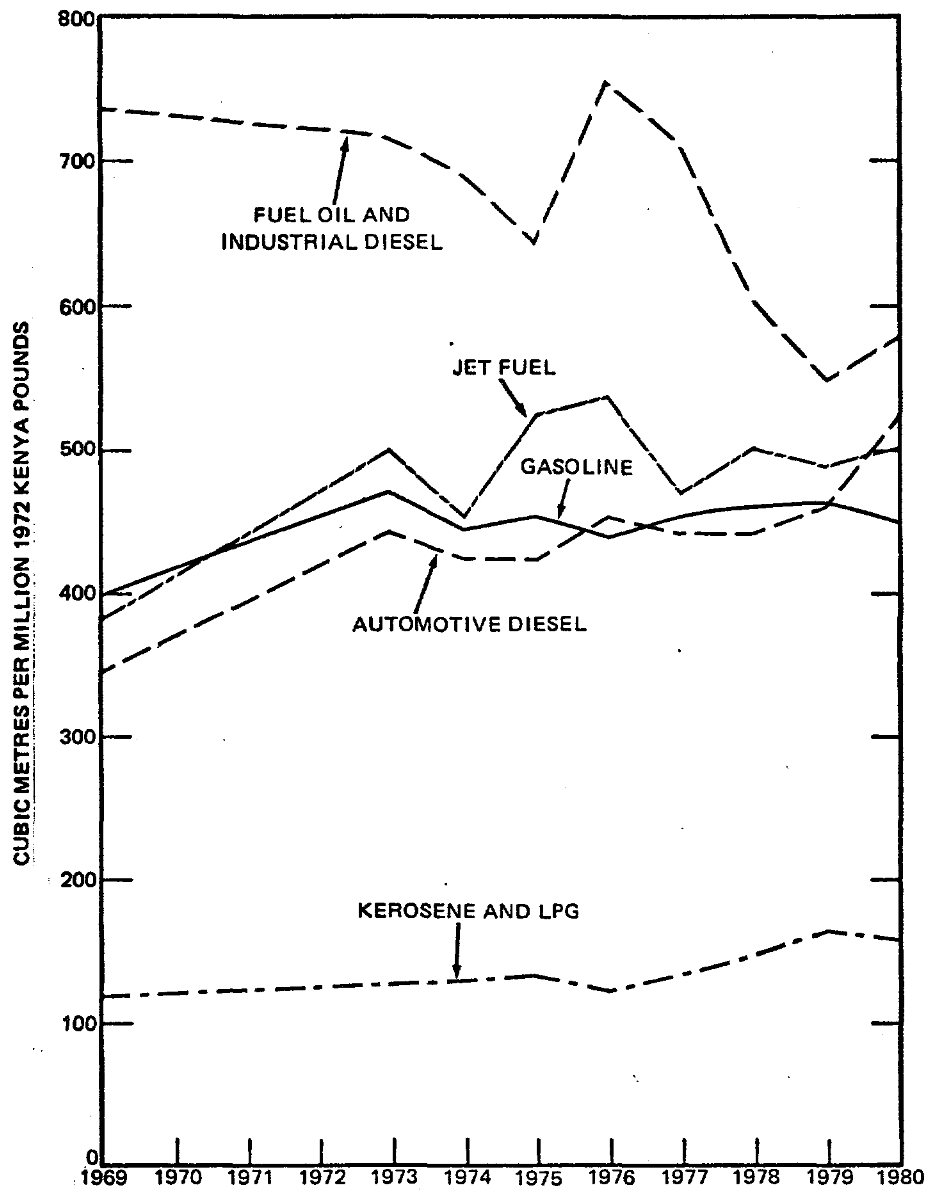
3.08 Few data are available on end uses of petroleum products. However, a recent study 1/ allocated consumption by sector by supplementing available information with the following assumptions:

1. Gasoline is assigned to transport except where sales are to agricultural institutions.

2. Gasoil (automotive diesel) is divided among transport, agriculture, industrial, and commercial sectors. Of the retail volume, 80% is transport, 20% agriculture.

1/ L. Schipper et al, Report to USAID and Resources for the Future, July 1981.

FIGURE 3.1: PETROLEUM PRODUCT CONSUMPTION RELATED TO GDP, 1969–1980



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Industry, buildings, and institutions used 80% for stationary purposes, 20% for vehicles, whereas the ratio is reversed for government purchases. For agriculture and construction, 50% is for transport and 50% for stationary uses.

3. All retail kerosene is assumed to be for residential use. Some power kerosene is sold and this was allocated according to Shell's market figures.

4. Aviation gasoline is combined with 10% of jet fuel for domestic use.

5. Heavy diesel oil is allocated to marine transport and stationary uses, primarily boiler fuel. Sectoral distribution is according to data from suppliers.

6. Residual fuel oil is allocated similarly to heavy diesel oil, with adjustments for the railway and EAPL.

7. All LPG sold in small cylinders is considered as residential. The remainder is for commercial and institutional use.

The mission considers these assumptions to be reasonable and, the sectoral breakdown of petroleum product consumption for 1979 is shown in Table 3.3.

3.09 The transport sector, excluding international aviation, consumes 42% of all petroleum products used in the country; including international airlines, the proportion is 53%. The next large category is industry, which accounts for 24%. Agriculture consumes 11%, whereas energy transformation (refining, pipeline operation and electricity generation) accounts for 15%. The residential, commercial and construction sectors in total consume about 9% of the petroleum products used annually.

Electricity

3.10 The availability of power to consumers in Kenya is, in general, limited to the central and southwestern sections of the country and along the southeast coast, though there are several isolated diesel installations in the north and east. Of the estimated 16 million inhabitants in Kenya, 90% live in rural areas and only 6% of the total population has access to electricity. Total electricity consumption in 1981 was 1,879 GWh giving an annual per capita consumption of approximately 117 kWh.

TABLE 3.3

Sectoral Distribution of Petroleum Product Consumption, 1979
Percentage

Sector	LPG	Gasoline	Kerosene	Jet-Fuel	Gasoil	Heavy Fuels	Percent of Total
Residential	58.0	-	75.9	-	-	-	5.7
Commercial	26.3	-	2.6	-	0.7	2.3	1.5
Industrial	15.6	-	18.8	-	9.8	60.2	24.0
Energy 1/		-	-	-	1.2	20.0	15.0
Construction		-	0.1	-	4.8	0.2	1.3
Agriculture		3.8	2.0	-	28.8	6.7	10.6
Transportation 2/	-	96.2	0.7	100.0	54.8	10.8	41.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1/ EAPL, the pipeline, and the refinery; the refinery fuel is included in the total but not as a specific product demand.

2/ Excludes international aviation as estimated by Schipper et al.

Source: Schipper et al, Central Bureau of Statistics, and Bank Staff estimates.

TABLE 3.4

East African Power and Light
Operating Statistics

Year	Generated and Purchased 1/ (GWh)	Sales (GWh)	Maximum Demand (at the station) (MW)
1970	747	636	121
1973	1017	850	161
1975	1149	1001	184
1976	1282	1082	207
1977	1405	1203	223
1978	1529	1301	256
1979	1655	1409	269
1980	1735 2/	1468 2/	290
1981	1879	1593	313
Average Annual Growth, %			
1970-1973	10.8	10.2	10.0
1973-1980	7.9	8.1	8.8
1978-1980	6.5	6.2	6.4
1970-1980	8.8	8.7	9.1

1/ From UEB (Uganda Electricity Board).

2/ In 1980 there was load shedding of approximately 40 GWh due to restricted supply. The true demand is therefore estimated to be 1775 GWh.

Source: EAPL Annual Reports.

3.11 Overall statistics for the interconnected system are shown in Table 3.4 for selected years in the past decade. The growth rates show that sales and maximum demand both grew at approximately 9% per annum over the decade, though growth rates have fallen considerably in recent years. The system is characterized by a fairly level demand from 8:00 a.m. to 8:00 p.m. with the minimum overnight demand being about 75 per cent of the average daytime load. There is little seasonal fluctuation in demand.

3.12 EAPL records sales and maximum demand by region for Nairobi, Coast, Western Kenya, Rift Valley, and Mount Kenya. The data show that, while Nairobi and the Coast are the major load centers, accounting for more than 80% of sales, the sales and demand growth in Western Kenya have been the greatest, albeit from a small base. Since 1975, this region has grown from 8.5 per cent of sales to 11.7 per cent, with an average annual growth of 15.1 per cent. This growth has resulted from the Government's intention to industrialize the area and EAPL's response by extending the interconnected system.

3.13 A sectoral analysis of electricity consumption in Kenya is rendered difficult by the method of the tariff classification, which is described more fully in Chapter 5. Before 1979 consumers were classified as domestic, small commercial and industrial (less than 7000 kWh/month), large commercial (over 7000 kWh/month), industrial, off-peak (water heating and irrigation), or street lighting. Separation of consumption by residential, commercial, and industrial sectors could not therefore be done without a detailed analysis of the billing data. In 1979 a new classification further aggregated the consumers into:

(i) all consumers using less than 7000 kWh per month;

(ii) consumers with monthly consumption between 7,000 and 100,000 kWh; and

(iii) those with monthly consumption exceeding 100,000 kWh.

The off-peak and street lighting classifications were retained. Under this new tariff structure almost all residential consumption is combined with small commercial and industrial except for the off-peak water heating which is combined with irrigation uses. In its annual reports, EAPL now reports consumption according to these classifications and data from 1975 to 1980 are available. To reduce the data of prior years to the same basis, it was assumed that one-half of commercial consumption could be classed as "small" and one-half as "large". Table 3.5 shows these data and the growth rates for each group.

TABLE 3.5

Sales of Electricity by Class of Consumer
(GWh and %)

Year	Domestic and Small Commercial	Large Commercial and Industrial	Interruptible Off-Peak	Street Lighting	Total
1969	175 (30.4)	304 (52.9)	87 (15.1)	9 (1.6)	575 (100.0)
1973	239 (28.3)	476 (56.3)	121 (14.3)	10 (1.2)	846 (100.0)
1975	294 (29.4)	562 (56.1)	134 (13.4)	11 (1.1)	1001 (100.0)
1976	302 (27.9)	639 (59.1)	130 (12.0)	11 (1.0)	1082 (100.0)
1977	339 (28.2)	742 (61.7)	111 (9.2)	11 (0.9)	1203 (100.0)
1978	360 (27.7)	814 (62.6)	117 (9.0)	10 (0.8)	1301 (100.0)
1979	385 (27.3)	891 (63.2)	123 (8.7)	10 (0.7)	1409 (100.0)
1980	402 (27.4)	944 (64.3)	111 (7.6)	11 (0.7)	1468 (100.0)
Average Annual Growth Rate, %					
1970-73	8.1	11.9	8.6	2.7	10.1
1973-80	7.7	10.3	-1.2	1.4	8.2
1978-80	5.7	7.7	-2.6	4.9	6.2

Source: EAPL Annual Reports

3.14 The domestic and small commercial group dropped from 30% of sales in 1969 to 27% in 1980, while industrial and large commercial sales grew from 53% to 64% of the total. Sales to interruptible off-peak users have declined since 1975 but it is not clear whether the reduction has been for use for water heating or irrigation pumping. The share of sales in this category dropped from 15% to 8%. (See para. 5.15 for recommendations on tariffs.)

3.15 The sectoral breakdown is very rough because there is no homogeneity of customers in each group. Residential sales are confined mainly to the first group, but a substantial proportion of interruptible off-peak sales is consumed in residential water heating. The commercial sector is likewise confounded by its grouping with residential or industrial sales. Recommendations on changes in the system of consumer classification are included in the discussion of tariffs in Chapter 5.

Coal and Coke

3.16 The demand for coal and coke has arisen primarily from the cement industry. Bamburi Portland Cement Company burns most of the coal consumed in Kenya in some of its kilns. Kenya Railways no longer has coal-fired locomotives, but does consume small amounts of coal and coke in its foundry. Other small foundries use lesser amounts of coal and coke. Table 3.6 presents the imports of coal and coke during the 1970's.

TABLE 3.6

Demand for Coal and Coke
('000 tonnes)

1970	83
1973	72
1975	46
1977	62
1979	60
1980	60

Source: Central Bureau of Statistics.

Some Aspects of Sectoral Energy Consumption

3.17 Time series data on the intersectoral energy consumption patterns in Kenya are lacking. The information that is available does not provide a breakdown of energy consumption by fuel type (except for the 1979 data presented in Table 3.3), the classification of sectors is not uniform, and the recently introduced electricity tariffs make it difficult to disaggregate electricity consumption by sector. One of the priority tasks facing the Government is, indeed, to obtain data for an energy balance sheet for both the commercial and traditional sectors, so that end users can be identified.

3.18 Tables 1.2 and 3.3 indicate that agriculture is the least user of energy of the major commercial sectors, consuming directly only 11% of petroleum fuels in 1979. Future increases in output are not expected to be from energy intensive mechanization or irrigation, nor are there any plans for extensive rural electrification. Consequently, agriculture's share of direct energy consumption could decrease up to the mid-1980's at least.

3.19 However, the application of petroleum-based chemicals such as fertilizer and herbicides to increase yields is likely to increase. In addition, as energy prices rise, the potential competition for land between food, export, and energy crops will be heightened, as agricultural resources may be drawn into energy production. A critical issue, given Kenya's limited amount of arable land and its very fast population growth rate, is, for example, the Government's program to produce fuel alcohol from molasses and cane juice.

3.20 Tables 3.3 and 3.5 show that industry consumes about 24% of petroleum products, about 63%[1/] of the electricity consumed, and essentially all coal and coke. Kenyan industry is characterized by relatively large scale multinational firms, which are capital and energy intensive. This group includes paper, rubber, chemicals, petroleum, basic metals, machinery and transport equipment. A few of these firms consume a disproportionate share of the energy, and, as shown in Chapter 4, the cement plants in particular offer substantial scope for fuel substitution to replace imported oil.

3.21 The Government's Fourth Development Plan, covering 1979-83, calls for the promotion of more "basic and strategic industries", e.g. steel, machinery, chemicals, and fertilizer. An indicative list of industries to be submitted for approval between 1980-86 contains a number which are obviously very energy intensive. These include an iron and steel plant, a sheet glass project, a cement factory in Western Kenya, petrochemical industries such as polyvinyl chloride and low density polyethylene, a caustic soda plant, and a fertilizer plant. However, the mission was not able to ascertain whether all of these projects have been properly evaluated taking into account the economic cost of energy they would consume.

3.22 As in most countries, the transport system in Kenya is energy intensive, and largely dependent on imported oil. A key issue in this

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1/ This is a best estimate based on industrial consumption patterns, since the data do not distinguish between the large commercial and industrial users.

sector is whether freight, both domestic and transit, can be moved off the roads and onto the railways, and proposals to this effect are made in Chapter 4, as are recommendations on urban road traffic.

3.23 Because of the importance of the tourism industry, air transport is of particular significance, with aviation fuel the second largest item of consumption in the tranport sector. Aircraft refueling (which is primarily local purchases of jet fuel by foreign airlines but paid for in foreign exchange) and international bunkering together account for about 42% of total petroleum consumption in the transport sector. These two activities are recorded as domestic consumption, but their inclusion in domestic sales overstates actual domestic petroleum consumption, and they are, of course, no burden on the balance of payments.

3.24 Given Kenya's rapid population growth rate, one of the issues in the residential sector is the likely increase in demand for commercial energy due to increasing urbanization. From 1969 to 1979, rural/urban immigration increased the proportion of the total population living in the major towns from 8.5 to 12.6%. The number of urban dwellers is expected to swell from the 1979 figure of 1.9 million to about 5 million (16% of the total population) by the turn of the century. There should therefore be a continued increase in the demand for urban residential electricity. It still needs to be established whether EAPL's demand forecast takes sufficient account of the projected significant increase in urbanization or whether it reflects only marginal increases in demand due to low growth of real incomes. The growth in urbanization would have important implications for the growth in demand for kerosene and LPG, if they are used as substitute fuels. These issues are, however, expected to begin to acquire major significance only in the latter part of the 1980's and early 1990's and not in the period to 1985 with which this report is largely concerned.

3.25 Meanwhile, wood and charcoal meet most residential cooking and heating needs. There are three estimates of woodfuel consumption: a 1978 rural energy survey (Tuschak), 1980 Forest Department assessment, and a 1981 revision of Tuschak's figures by the Central Bureau of Statistics. The figures are:

1978 Survey	20-25 million tonnes
1980 Forest Department	31.7 million tonnes
1981 CBS Revision	10-12 million tonnes

3.26 With such a wide range of estimated demand it is very difficult to be definitive about the actual level of wood fuel consumption at present in Kenya. What is known, however, is that the annual forest yield amounts to 6 million tonnes. Thus, whatever the correct consumption figure, there is already a very large degree of forest 'mining' in progress unless a massive amount of additional fuel comes from sources outside of the official forests - i.e. crop wastes, twigs, brambles etc.

3.27 The forest 'mining' hypothesis is supported by the fact that some areas of the country are showing signs of deforestation. Nevertheless wood is still available within relatively easy reach. This is highlighted in Table 3.7, in which results of the rural energy survey (1978) show the percentage of household fuels obtained as a function of distance from the source, by province. For example, in all provinces at least 50% of wood and charcoal is obtained within 1 km of the house, hile over 80% of both fuels are available less than 2 km away. In contrast, in all provinces other than Nairobi and the Coast, over 40% of kerosene has to be fetched from distances exceeding 3 km. Table 3.8 shows the percentage use, by province, of the main household fuels (charcoal, wood and kerosene) in the major end-uses. What is significant is that, in spite of the easier access to wood and charcoal, kerosene is important as a cooking fuel in virtually all provinces other than Nyanza and Eastern. Given the conflicting nature of the information available about the demand and supply patterns of wood and charcoal the data must be improved as a matter of high priority.

3.28 The Government recognizes that the demand for fuelwood will grow with the rapid growth of Kenya's population, and has adopted rural afforestation programs to address the energy needs of rural households. A much greater effort is required, however, and, in the meantime, the mission (in Chapter 4) recommends some measures to increase the efficiency of use of woodfuels.

Energy Demand and Supply in the 1980s

3.29 The likely energy balance for 1985, which was given in Chapter 1 (Table 1.5), was built up from a series of assumptions on fuel supply and sectoral demand. These are explained in the following paragraphs.

Petroleum Products

3.30 Because the demand for petroleum products by sector is not well defined in Kenya, it is not possible to forecast future demand on the basis of past sectoral growth. However, the relationship between the past growth in demand for each product and the growth in GDP can be used to project future consumption. The Bank's estimate of GDP growth is 4.0% p.a. for 1981 to 1985 and 5.3% for 1985-90. Future petroleum demand was derived by assuming that the same relationship between the growth rates for petroleum product demand and GDP as existed from 1973 to 1980 would continue to 1985. The projection of fuel oil demand presumes that by 1985 the cement plants are converted to coal, that Kenya Railways retires all steam locomotives, and that EAPL reduces its thermal oil fired generation of electricity.

TABLE 3.7

Percentage of Household Fuel Obtained by Distance, km.

	WOOD					CHARCOAL					KEROSENE				
Province/ Distance	0-1	1-2	2-3	3-7	7+	0-1	1-2	2-3	3-7	7+	0-1	1-2	2-3	3-7	7+
Central	70.8	17.3	5.6	5.5	0.8	59.2	27.8	6.8	5.4	0.9	18.3	23.4	13.7	25.7	18.6
Coast	50.4	26.5	12.4	10.2	0.6	80.7	8.7	1.9	8.7	-	75.0	15.0	4.2	3.9	2.0
Eastern	65.7	18.0	5.7	8.8	1.8	71.6	12.1	5.9	7.6	2.9	18.4	16.7	16.3	25.8	22.8
Nyanza	50.1	23.9	14.3	11.2	0.5	78.4	16.1	2.4	1.0	2.1	16.0	27.5	18.3	24.7	13.5
Rift Valley	49.9	25.5	13.2	11.3	0.1	52.8	26.0	7.8	10.25	3.2	28.0	13.8	16.3	22.0	19.9
Western	64.1	23.0	7.8	5.1	-	79.0	2.7	12.6	4.0	1.9	47.2	4.9	11.7	25.7	10.5
Nairobi	52.6	26.0	5.2	16.2	-	89.6	6.3	4.1	-	-	37.7	22.6	37.1	2.4	0.2
National	58.2	22.0	9.7	9.3	0.8	72.7	15.1	5.5	5.3	1.5	41.8	18.3	18.3	12.8	8.8

TABLE 3.8

Percentage Utilization of Each Household Fuel By Province and End-Use

PROVINCE	WOOD			CHARCOAL			KEROSENE		
	COOKING	HEATING	OTHER	COOKING	HEATING	OTHER	COOKING	LIGHTING	OTHER
Central	84.2	15.8	-	82.9	16.1	1.0	30.0	66.5	3.5
Coast	94.4	5.4	0.2	93.3	2.5	4.2	42.5	57.4	0.1
Eastern	81.8	17.9	0.3	81.8	18.0	0.2	12.4	87.2	0.4
Nyanza	83.5	14.8	1.7	95.7	3.7	0.6	16.6	82.3	1.1
Rift Valley	78.8	20.4	0.8	89.4	10.1	0.5	23.6	74.8	1.6
Western	91.3	8.7	-	83.6	15.5	0.9	25.8	73.7	0.5
Nairobi	94.2	5.8	-	94.9	4.4	0.7	80.4	19.4	0.2
National	83.3	16.1	0.6	90.8	8.1	1.1	42.7	56.6	0.7

Source: Tuschak, T.S., Kenya's Energy Situation and Options for the Future, UNDP Interim Report, August 1979.

3.31 Table 3.09 presents the GDP elasticities for petroleum products which were used in the projection, while Table 3.10 shows the absolute petroleum demand resulting and the market share for each product up to 1985. For comparison, the 1980 demand and market share are included in Table 3.10.

TABLE 3.09

PETROLEUM PRODUCT/GDP ELASTICITIES 1/

Product	1980-85
LPG	1.97
Gasoline 2/	0.84
Kerosene	1.63
Jet Fuel	1.03
Gasoil	1.59
Heavy Diesel 3/	0.00
Aviation Spirit	0.07

1/ Coefficients are the same as 1973-80.

2/ Premium and Regular.

3/ The coefficient for 1973-80 was -0.82 but demand was relatively constant from 1977 to 1980.

Source: Bank staff estimates.

TABLE 3.10

Petroleum Product Demand in Kenya
('000 toe)

Product	1980 Weight	1980 %	1985 Weight	1985 %
LPG	21	1.3	32	1.7
Gasoline 1/	301	18.0	333	17.5
Kerosene	86	5.1	120	6.3
Jet Fuel 2/	348	20.8	429	22.5
Gasoil	408	24.4	567	29.7
Heavy Diesel	39	2.3	39	2.0
Fuel Oil 3/	462	27.6	381	20.0
Aviation Spirit	6	0.4	6	0.3
	1671	100.0	1907	100.0

1/ Gasoline demand reduced by 36 million litres to account for ethanol blending by 1985.

2/ Kenya Airways consumed 13% of the 1980 volume of jet fuel.

3/ See assumptions in text for 1985 forecast demand; bunkering of ships excluded.

Source: EAOR, Bank staff estimates.

3.32 Under this scenario, the average growth rate of total demand for petroleum products would be 2.7% per annum for 1980-85. The structure of the market shows an increasing share for gasoil and a decrease for fuel oil. For automotive gasoil the main hope for reducing the growth rate in transport use in the early 1980s is by moving more freight by rail instead of road, but since 53.6% of gasoil is used in transport 1/ there is also potential for savings in the industrial, agricultural and commercial sectors. The share of gasoline in overall petroleum demand by 1985 is assumed to decline slightly due partly to the substitution of 36 million litres (26,000 toe) of ethanol as gasohol. Despite the unfavourable economics of the ethanol projects it has been explicitly assumed that the KCFC and ACFC projects will not be moth-balled.

1/ USAID study by L. Schipper et al., July 1981.

3.33 Of particular significance is the absolute decline in fuel oil demand in 1985 which is forecast. Indeed this reduction is about 20% of the 1980 level of demand and is expected to be brought about through the substitution of fuel oil by coal in the cement sector, reduced fuel oil fired power generation by EAPL and through increased conservation measures in the industrial sector.

The Refinery Issue

3.34 One of the important trends expected to continue over the next few years is the increasing share of total petroleum demand taken by middle distillates (kerosene, jet-fuel and gasoil) and the decreasing share of fuel oil. This has important implications for the mode of operation and configuration of the EAOR refinery at Mombasa. As noted in Chapter II the refinery has always operated as an export-oriented facility producing more than the Kenyan market requirements and exporting the surplus products. Table 3.11 below shows the refinery yield pattern in 1980 compared with the structure of product demand in Kenya and the land-locked countries (Uganda, Rwanda and Burundi).

TABLE 3.11

Mombasa Refinery Yield Patterns[1/] Versus Market Demand
(% Weight)

Products	1980 Refinery Yield Pattern	1980 Market[2/] Demand Kenya and Inland	Refinery Yield With Secondary Refining, (Thermal-Cracker Option)	1985 Market Demand (Kenya and Inland)
LPG	1	1	1	1
Motor Gasoline	14	20	16	19
Kerosene/Jet Fuel	14	24	20	27
Gas Oil	17	24	27	29
Industrial Diesel	3	3	(	2
Residual Fuel Oil	47	23	(28	17
Losses and Asphalt	4	4	8	5
	100	100	100	100

1/ These yield patterns are for running about 50% Arabian Light and 50% Qatar Marine crudes.

2/ The 1980 market demand structure refers to Kenyan and the land-locked countries demand.

Source: EAOR, Bank staff estimates.

3.35 It can be seen from the first two columns that a significant imbalance exists between the 1980 market demand structure in Kenya and the land-locked countries and the yield pattern of the refinery. For example demand for kerosene (dual purpose) and diesels was 51% of the total products but the refinery could only produce 34% out of each barrel of crude oil processed. This deficit, as well as the deficit for gasolines had to be made up by direct imports of these products. This imbalance is a cause for concern because it is allied with a major surplus of residual fuel oil production over demand (47% of crude oil processed compared with 23% demanded). The surplus fuel oil has to be exported off-shore, primarily to Singapore, at prices, under normal market conditions, of about 85% (on a volume basis for 3% sulphur fuel oil) of the Arabian Light crude price.

3.36 Under these circumstances the refinery owners and operators have a number of marketing and processing options, ranging between the following two extremes.

(a) Processing just enough crude oil to meet the relatively low fuel oil demand - the demand for which is expected to decline over the next few years. This choice would force the import of all other products whose demand could not be met by the refinery.

(b) Processing the amount of crude necessary to meet the relatively high kerosene demand for the Kenyan and land-locked countries market. This alternative causes significant surpluses of all other products to be exported off-shore.

3.37 In practice, the refinery has been operated in a manner close to the second option. This resulted in about 3 million tonnes of crude being processed in 1980, which met Kenyan kerosene demand of some 430,000 tonnes but resulted in the need to export off-shore some 1 million tonnes of residual fuel oil at a loss relative to the crude price.

3.38 This situation is expected to become more severe over the next few years because demand for fuel oil should soften and that for light distillates should grow modestly, while fuel oil has to be exported at a price cheaper than that of crude oil and the deficit products, middle distillates mainly, are more expensive. In order to decrease the cost of supplying petroleum products to the Kenyan market, the refinery's configuration needs to be modified through secondary processing, the objective being to convert surplus fuel oil into needed middle distillates. Several options exist for achieving this. They include, in order of increasing investment cost and processing flexibility, visbreaking (a form of thermal cracking), thermal cracking, fluid catalytic cracking and hydrocracking. The manner in which the refinery yield pattern would change by the introduction of thermal cracking is shown in the third column of Table 3.11. Under this option the yield of middle distillates would increase from 34% at present to 47% whilst that of residual fuel oil would decline from 47% at present to about 28%.

Also shown in this table (fourth column) is the 1985 estimate of the structure of demand for the Kenyan and inland country markets (Burundi, Rwanda and Uganda). This is based on the 1985 forecast of Kenyan demand shown in Table 3.10 and the reasonable assumption that demand in the above land-locked countries remains roughly about the same level, about 20% of the Kenyan market and structure in 1985, as in 1980.

3.39 It can be seen from Table 3.11 that, based on the 1985 estimates of market demand in Kenya and the land-locked countries, a better, though not perfect, balance would exist between refinery production and demand if the thermal cracker were introduced. The investment cost would be about US$84 million for a unit of 4000 tons/day capacity, and the economic rate of return would be about 30% on the basis of 1981 crude oil and product price relationships. The 1985 energy balance assumes that the thermal cracker is introduced.

3.40 However, the optimal configuration for the refinery to minimize the net cost of petroleum products to Kenya is not yet certain, and as a matter of high priority, the Kenya Government should commission a feasibility study to evaluate all secondary refining options for supplying Kenya with petroleum products at least cost taking into account potential exports and comparing all options with importing refined products directly from abroad.

Electricity

3.41 EAPL has forecast the maximum and average demand for electricity for the 1982-2000 period, based on an average system load factor of 70%. Expected growth in energy sales and demand averages 7.0% annually, compared with actual growth in generation (including purchases from UEB) of 8.6% annually from 1975 to 1980. Sales grew at 8.0% p.a. over the same period. Table 3.12 shows the forecast of demand and sales.

TABLE 3.12

Forecast of Sales of and Maximum and Average Demand for Electricity, 1982-1990

Year	Sales GWh	Maximum Demand 2/ MW	Average Demand 2/ MW
1980 1/	1468	290	203
1981 1/	1593	313	219
1982	1704	332	232
1983	1824	355	249
1984	1951	380	266
1985	2088	406	284
1986	2234	435	305
1987	2390	465	326
1988	2558	498	349
1989	2737	533	373
1990	2928	570	399

1/ Actual.

2/ At the station, based on 0.70 system load factor.

Source: EAPL.

Other Energy Sources

3.42 The projected energy balance for 1985 shown in Table 1.5 also assumes that 60 GWh of energy will come from the introduction of solar water heaters and that demand for coal will increase to 180,000 toe. This latter figure implies that only the cement plants will convert to coal; other industry and electric power generation will not.

IV. INTER-FUEL SUBSTITUTION AND DEMAND MANAGEMENT

4.01 This chapter addresses some of the most important actions which can be taken to increase energy efficiency or to reduce consumption of those energy sources which are in short supply by switching to other sources.

Cement Plants

4.02 In 1980 the cement industry accounted for about 23% of domestic residual fuel oil demand or 7% of national petroleum consumption. The Bamburi cement facility in Mombasa uses coal for 35% of the plant's primary energy requirements, the rest being met by residual fuel oil. At the time of the mission, the company paid $43/tonne f.o.b. Maputo for the coal which was subject to a 30% import duty in Kenya. The result was that the price of coal[1/] at the factory is about Ksh 777/tonne (US$97/tonne) compared with a price of fuel oil of KSh1500/tonne (US$188/tonne). Fuel oil is not subject to any import duties or taxes. The net of tax cost of imported coal was about US$2.73/MMBTU compared with that of fuel oil of US$4.45/MMBTU. The import duty was reduced to 20% in July 1981 making the conversion even more attractive.

4.03 Bamburi Cement is proceeding with a project to convert to 90% coal firing at an investment cost of about US$15 million. Up-rating the plant's capacity to 1.4 million tons/year from the present 1.2 million tons/year at a cost of US$10 million is also part of the project. Financing for the project has been arranged and will include a US$5 million (equivalent) loan from IFC as well as loans from EIB, CDC, and Barclays Bank (Kenya). The coal conversion will be completed by November 1982 and the capacity increase by April 1983 [2/].

4.04 The second cement plant in Kenya, East African Portland Cement Co. (EAPC), recently increased its capacity to 450,000 tons/year. This plant is located near Nairobi and serves the domestic market. Its energy source is fuel oil. Unlike the Bamburi plant, which is a dry process plant with an energy input of some 1500 BTU/lb of cement, the Nairobi one is based on the wet process with twice the energy input per pound of cement. The Kenya Government is the largest shareholder (50%) in EAPC and the company is presently preparing a feasibility study for converting its kilns to coal firing -- this cost is estimated at some US$10 million. A second stage program being studied is the conversion of the plant to the dry process, with an option to expand capacity to 1 million tons/year by 1986. The conversion to the dry process, without expansion,

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1/ Calorific value of this coal averages 6,264 Kcals/Kg.

2/ This information is from President's Report No. IFC/P-461 and Appraisal Report No. IFC/T-386.

is estimated to cost some $120 million. The option to expand capacity to 1 million tons/year by 1986 is viewed as an alternative to a government proposal to build a new cement plant further up-country.

4.05 If both coal conversions are undertaken at the existing cement plants in the country, then by 1985 coal imports for this sector could increase to about 300,000 tons/year 1/ from some 60,000 tons in 1980. Fuel oil demand, in this sector, would then correspondingly fall to less than 15,000 tons/year from 108,000 tons in 1980. This represents one of the most important fuel substitution options for petroleum products in Kenya over the medium term.

4.06 The mission considers that:

(a) the conversion of the Bamburi plant to coal firing appears sound and should be pursued as a matter of high priority;

(b) the study of conversion of the EAPC facility to coal firing should be expedited. It can be expected that this conversion will be shown to be economically justified. If so, a decision to proceed with this conversion should be made as soon as possible thereafter, with consideration being given to the implications for Kenya Railways and the Mombasa Port Authority of transporting the required 120,000 tons/year of coal by rail from Mombasa to Nairobi;

(c) the issue of EAPC converting from the wet to dry process needs to be studied urgently. With energy accounting for about 50% of operating costs in the existing wet process plant, EAPC is a high cost producer of cement relative to Bamburi. Energy demand can be reduced by 50% by conversion to the dry process; and

(d) no decision should be taken about construction of a third cement plant in the country until a detailed review has been undertaken of the benefits/costs of this route versus conversion of the EAPC plant to the dry process, followed by expansion to 1 million tons/year.

Solar Water Heating

4.07 Due to the mild climate in Nairobi and the existence in Kenya of a large well-to-do elite, residential electric water heating represents a significant energy load. For households with electricity, electric water heating represented at least 20% of electricity use (about 4% of total electricity sales) in 1979. There are some 19,000 residential electric water heaters in Kenya which are specially metered with an electronic

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1/ The amount of coal required depends on whether the EAPC plant is also converted to the dry process.

signal interrupter to ensure that heating occurs only during off-peak hours 1/. The supply through these meters can be interrupted at will by EAPL and for this facility EAPL offers this supply at a substantial discount to normal charges. There are also an unknown number of residences with electric water heaters which do not have separate off-peak tariff meters. The tariff for off-peak interruptible consumption is currently (March 1982) less than that for residential use: 38 K¢/kWh compared with about 71 K¢/kWh for the normal tariff for consumption in excess of 30 kWh/month (see Table 5.3).

4.08 At the current off-peak tariff, which is discussed in detail in Chapter 5, solar water heaters are not an attractive financial investment in residences. The installed cost for a 40 gallon tank solar water heater (thermo-syphon) with 3 collectors in early 1981 was about Ksh 9,500 ($1188). One reason for this relatively high cost is the fact that import duties ranging from 30% - 100% are levied on all imported components and materials used in fabricating these devices. Another is that there is a 15% sales tax on completed installations. Without the sales taxes and import duties on imported components and materials the installed cost would be about Ksh 6,600 (US$825). Based on the normal residential tariff 2/ and an estimated average level of electricity consumption for water heating of about 350 kWh/month, the payout period for solar water heaters would be about 2 1/2 years when sales taxes and import duties are excluded, and about 3 1/2 years when included. However, based on the off-peak tariff the pay-out periods for this investment with and without sales taxes and import duties are 7 1/2 and 5 1/4 years respectively, much less attractive for consumers.

4.09 A residential solar water heater program could reduce electrical energy requirements for this end-use on the interconnected system by about 80%. It is estimated that such electrical energy savings could amount to at least 64 GWh annually if all heaters were retro-fitted. This is equivalent to about 7 months of expected growth of total electrical energy demand.

4.10 To pursue this issue further government needs to undertake a comprehensive study of the economic benefits and costs of a program to install solar water heaters in homes having electric heaters. The five elements for such a study are:

(a) Review of the economics of solar water heaters compared to meeting residential hot water requirements by electrical water heaters supplied by the inter-connected power system.

1/ Between 10 PM and 8 AM Monday to Friday and all day Saturday and Sunday.

2/ In force in early 1981. Including the fuel adjustment clause, the normal residential tariff was 64 k¢/kWh and the off peak interruptible tariff was 30 k¢/kWh.

(b) Determination of the economic value of electricity for this end-use and review of current tariffs to evaluate whether the correct price signal is being sent to such consumers.

(c) Estimation of the benefits of such a program to reduce electrical energy demand thereby slightly delaying investment in the power sector.

(d) Identification of the benefits/costs to householders; and an assessment of the capability of the private sector manufacturers/installers[1/] of solar water heaters to meet increased production targets.

(e) Review of the import duty and sales tax policies for solar water heaters and components.

4.11 If the study shows this program to be an economically attractive option, there would be two areas where financing would be required: consumers would require credit for purchases of the units and the private sector would require funds for expanding capacity. One suggestion is that consumers could receive loans for installation of the water heaters through EAPL and would continue to be billed by EAPL at their previous billing rate until the credit is paid off. This arrangement is convenient and has worked successfully in other countries.

4.12 It must be stressed that the program for residential solar water heaters would be in addition to the installation of commercial and institutional systems, which already are attractive for owners because of the hire-purchase arrangements which allow write-offs against taxes.

Road and Rail Transport

4.13 The transport sector within Kenya, excluding international aviation and ship's supplies, consumed 40% of all petroleum products in 1979. This was broken down as follows:

Road (private auto, buses, matatus, trucks)	33.3%
Rail	4.3%
Domestic Aviation (Jet Fuel and avgas)	2.8%
Total	40.4%

4.14 Gasoline consumption in road transport was 6,900 bbl/day while gasoil consumption was 3,100 bbl/day or 45% of gasoline consumption. Road transport, consuming one-third of all petroleum products used in the country, offers the greatest opportunity for reduced consumption but the

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1/ Currently that are 3 manufacturers installers of solar water heaters in Kenya - Instrumentation Ltd. (Solar Division); East African Hydraulics Ltd. and Sun Power Products. The first is the largest manufacturer and has the best designed system using imported Australian components.

number of end users creates difficulties in designing and implementing policies, though there are some areas where results can be achieved relatively easily. Import duties have been increased for larger and heavier private cars, and registrations of these vehicles have apparently slowed down as a result. This measure is a step in the right direction although it will take a long time to replace the whole fleet with more efficient vehicles, and thus reduce fuel consumption per mile driven. Another measure, which could reduce gasoline consumption in Nairobi by 10-15 percent is improved traffic management. Implementation and enforcement of no parking zones, exclusive bus lanes, one way streets, and more effective traffic signals would play the major part in this program.

4.15 The Government is currently examining a proposal to introduce gasoil-fueled "matatus" (small buses serving urban and surrounding areas) to replace gasoline-fueled vehicles. Indeed some of the small pickups which are used as "matatus" are now being assembled with diesel engines. This program needs to be assessed carefully because it is by no means clear that this substitution is desirable from either the economic or energy standpoint. An assessment must be made of the costs of supplying a marginal barrel of gasoil compared with a marginal barrel of gasoline. Decisions on modifying the configuration of the Mombasa refinery will be a crucial element in this analysis. Although diesel engines are generally more fuel efficient than gasoline engines, the advantage is somewhat offset by increased weight and is also dependent on the level of maintenance. For these reasons, the Government should exercise caution before encouraging widespread use of small diesel powered vehicles.

4.16 Another issue in the transport sector is freight movement. A recent study financed by the Danish International Development Agency estimated that, in 1979, 1.75 million tonnes of long-haul freight (largely bulk freight) were carried by heavy trucks on roads paralleling the railway. The basic reason for this is that the transit time averages 24 hours by truck from Mombasa to Nairobi compared with 3.5 days by train. The fact that freight rates per tonne-km between Mombasa and Nairobi are K¢27 by rail (excluding additional handling and insurance costs) and K¢62 by truck does not appear to affect the decisions of shippers.

4.17 To encourage rail shipment of freight, Kenya Railways operations must be strengthened so that it competes more effectively with road traffic. The studies included in Loan 1976-KE will address various operational problems. One of the first steps to improve operations would be upgrading the switching systems while the possibility of twinning the line from Mombasa to Nairobi should be considered for the longer term. The study should also include input from the MOE committee studying coal requirements and the results of the consultant's study on bulk freight handling at the Mombasa Port. The railway can currently handle only a small volume of container freight and it is essential that this capability be improved. Another longer term aspect of the railway which needs to be studied is the source of motive power. After 1985 Kenya

Railways will have to replace some of its diesel locomotives; the possibility of electrifying the Mombasa-Nairobi segment needs to be studied before committing the purchase of new diesels.

4.18 In the shorter term, any freight which is diverted from the highway to the rail will directly result in lower consumption of gasoil. If one million tonnes are so diverted, which the mission considers feasible, then based on average haul distances of 400 km, and average gasoil consumption of 0.014 litres per tonne-km for rail and 0.045 litres per tonne-km for truck, the savings would be about 12 million litres per year, or about 2.5% of consumption of gasoil in 1980. This would require no additional investment in physical capacity of the railway.

4.19 The mission makes the following recommendations:

(1) Improvements in traffic flow management in Nairobi should be implemented as soon as possible to relieve congestion.

(2) The introduction of diesel-fueled "matatus" should not be implemented on a large scale unless it is economic to do so.

(3) The matter of diverting long-haul freight traffic to the railway deserves urgent action. A separate study of optimal motive power in the long term (including electrification) should be initiated soon, so that decisions can be taken in an orderly manner.

<u>Other Conservation and Fuel Substitution Potential</u>

4.20 The potential for substituting coal for fuel oil or other petroleum products in industry is not well defined and should be investigated by MOE. One plant which should be studied in detail is the pulp and paper mill which uses about 50,000 tonnes of fuel oil annually.

4.21 In a recent draft report[1/] to USAID/RFF, Schipper et al identified areas where conservation has taken place and where potential lies. Most of the visible effort towards conserving energy has occurred in larger corporations which have access to international affiliates, who provide the technical information and often the expertise to effect savings. The small and medium sized companies without these connections are not able (or willing) to devote resources to such programs, even though financial benefits may be great. Similarly, many of the hotels surveyed had not taken steps to reduce energy consumption in water heating (bathing, laundry, dishwashing) or space conditioning. The potential savings for individual installations were estimated to be as

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1/ Schipper et al, "Measuring Energy Conservation in Kenya - Progress, Potentials, Problems", USAID and Resources for the Future, March 1981.

high as 30% in small- and medium-sized industrial plants and as much as 50% for hotels if solar water-heaters were also used.

4.22 In a separate report[1/], USAID estimated that energy consumption per unit of output in the industrial sector in Kenya could be reduced by 20-30% over the next five years without substantial new capital investment. That project includes provision of the services of an expert in energy conservation who will assist the MOE in organizing a program for improving energy efficiencies. These two reports illustrate the potential that exists in Kenya for conservation and improved energy management in the industrial and commercial sectors.

4.23 The mission recommends that:

(a) The Government, through MOE, should initiate a major program to assist medium and small enterprises in establishing energy management programs. This effort would be aimed at all users of petroleum products above a certain volume, with the objective of, say reducing their energy consumption by 15% in three years.

(b) A detailed data base of energy use by all significant industrial and commercial consumers be established.

Fuelwood and Charcoal

4.24 There are two areas where the efficiency of using woodfuels can be improved: (1) improved stoves for burning wood and charcoal and (2) improved conversion of wood to charcoal.

Improved Cooking Stoves

4.25 In Kenya, it is estimated that 83% of wood and 91% of charcoal are used for cooking[2/]. The overall energy efficiency of cooking is only 5-10% and any improvement will reduce the demand for the diminishing wood resources. There are many types of more efficient cooking stoves which have been developed with the help of international and church organizations, though there are problems of distribution and acceptance by the rural population. The USAID project is addressing these problems and will attempt to overcome the social barriers to controlled-combustion stoves. The mission considers that attention should first be given to improved "jikos" for cooking with charcoal which are largely used in the urban areas, and all agencies involved deserve continued Government support.

1/ Project Paper 615-0205, Kenya Renewable Energy Development Project, USAID, August 1980.

2/ T.S.Tuschak, Rural Energy Survey, 1978.

Charcoal Production

4.26 The most promising option for reducing the demand for wood is to commercialize the production of charcoal, thereby improving conversion efficiency. Charcoal use amounts to about 1.4 million tonnes annually and, with yields varying from 10-14% by weight, this requires from 10-14 million tonnes of wood. Charcoal can be produced in larger, more efficient kilns, with conversion efficiencies ranging as high as 33% for large pyrolysis units. These kilns also produce by-product chemicals which can add to the value of the wood if there is a market, or if local industries can be developed to use them.

4.27 To commercialize the production of charcoal, a corporation, or possibly a series of cooperative, could be set up to introduce this technology into rural areas. The production operations of the estimated 50,000 small rural and semi-rural producers would be replaced and these producers, who also distribute the charcoal, would then receive their charcoal supplies from the corporation. Such a system would maintain the employment and income opportunities for the rural population while reducing the demand for wood. For example, if the average conversion efficiency were raised to 25%, only 5.6 million tonnes of wood would be needed to meet current demand of 1.4 million tonnes of charcoal.

4.28 Three logical areas to introduce large scale charcoal production are the Central Highlands, Nyanza Province, and Coast Province, but the size and cost of such plants cannot be estimated until detailed feasibility studies are performed. An important issue to be addressed is that of transport of charcoal to urban markets from the more efficient but more distant large scale charcoal production plants.

4.29 The mission recommends that the Government review as a priority matter the prospects for establishing a Charcoal Corporation, or several cooperatives, designed to centralize charcoal production. This review should encompass all aspects, and make recommendations on ownership, methods of financing, locations, optimal size, prices for wood and charcoal, transport of charcoal to markets, and timing. Technical assistance will probably be required for this review and the government should ensure the information available from the ongoing Beijer Institute and USAID studies is integrated with the program.

V. ENERGY PRICES AND TAXES

Petroleum and Petroleum Products

Crude Oil Import Prices

5.01 Kenya receives its crude oil from the Middle East and the price varies according to the source and the type of crude. The f.o.b. price for oil imported in September 1980 was US $31.96 per barrel, while the landed cost at the refinery, including insurance, ocean loss and freight, was US $33.83 barrel. In 1980, Kenya's imports of crude oil and petroleum products amounted to KL 277.3 million while re-exports of petroleum products earned KL 160.9 million, resulting in a net oil import cost of KL 116.4 million.

Prices of Petroleum Products

5.03 The Government of Kenya sets prices for all petroleum products. Within Kenya the prices are based on landed cost of crude oil imports, transportation within the country, retailers' and wholesalers' margins, and a refinery processing fee. The Government collects a tax on some of the products. The processing fee at the refinery is based on a return on revalued assets and was set at US$2.10 per barrel in February 1981. The prices for petroleum products at various stages in the chain from refinery to consumer are shown in Table 5.1. The retail price (wholesale where applicable) for all petroleum products sold in Kenya is higher than the equivalent cost of imported products.

5.04 In addition to setting prices in the country, the Government establishes minimum in-bond export prices for products destined for other countries. These prices, as of February 1981, are listed in Table 5.3, and illustrate the profitable margins which Kenya obtains, especially for the surplus production of white products from the refinery which go mainly to neighbouring land-locked countries.

5.05 The main issue in petroleum product pricing is the structure of taxation which causes the premium gasoline price to be 56% higher than the gasoil price at the retail level in Nairobi. This is sending the wrong signal to potential automobile and light pick-up owners and, by encouraging an increased demand for gasoil, is likely to create further problems in matching the refinery yield to market demand. The mission recommends that the Government should narrow the distortion between retail prices for gasoline and gas oil and also consider the possibility of levying higher import duties on diesel automobiles for private use than those for gasoline fueled cars in order to reduce the growth rate for gasoil consumption.

TABLE 5.1

Prices of Petroleum Products[1/]
(US$ per US gallon)

Product	Retail Price Nairobi	Wholesale Price[2/] Nairobi	Wholesale Price[2/] Mombasa	Government Tax	Prorated Processing Fee	Notional Ex- Refinery Price 3/	Estimated Landed Cost of Imported Products[4/]
LPG[5/]	-	0.56	0.54	-	-	0.54	-
Premium gasoline	2.87	2.73	2.63	1.22	0.005	1.405	1.01
Regular gasoline	2.67	2.53	2.43	1.13	0.003	1.297	0.98
Kerosene	1.30	1.21	1.10	0.10	-	1.00	1.11
Jet Fuel	-	1.52	1.36	0.07	0.008[6/]	1.282	1.11
Gasoil	1.84	1.72	1.61	0.48	0.009	1.121	1.03
Industrial Diesel	-	1.09	1.01	-	0.002	1.008	-
Fuel Oil	-	0.79	0.70	-	0.024	0.676	0.67

1/ As of February, 1981; Ksh 8.1 = US$1.0
2/ The difference between Mombasa and Nairobi is the transportation charge.
3/ Wholesalers' margins are included in these figures.
4/ Based on 1980 average spot prices for products in the Persian Gulf plus freight to Mombasa.
5/ US$ per kilogram
6/ Kerosene and Jet fuel are reported together by the refinery.

TABLE 5.2

Minimum In-Bond Export Prices, February 1981
(US$ per US Gallon)

Product	Ex-Mombasa	Ex-Nairobi	Ratio of Ex-Mombasa In-Bond Export Price to Notional Ex-Refinery Price b/
Premium	1.557	1.664	1.108
Regular	1.505	1.613	1.160
Illuminating Kerosene	1.452	1.555	1.452
Gasoil	1.480	1.588	1.320
Industrial Diesel	1.451	1.528	1.439
Fuel Oil	0.748	-	1.107
LPG a/	0.715	-	1.324

a/ US$ per kilogram.

b/ The notional ex-refinery price includes wholesalers' margins.

Source: MOE.

Electricity Tariffs

5.06 EAPL's present tariff schedule is based on a structure that was implemented in January 1979 in accordance with recommendations given in a tariff study performed by the Bank.[1/] There have been two increases in energy charges subsequently by means of a fuel oil surcharge, the second occurring in July 1981. The present tariffs are shown in Table 5.3. The present fuel oil surcharge is 21.2 K ¢/kWh and is applied to all consumer categories. The average revenue per kWh sold has increased from 38.3 K ¢ in 1978 to 40.7 K ¢ in 1979, 47.8 K ¢ in 1980 and 62.0 K ¢ in 1981.

5.07 There are three basic consumer groups in the present tariff schedule:

(a) The first group using less than 7000 kWh/month, which includes all residential consumers and "small commerical" consumers. A lifeline rate of 22 K ¢/kWh is charged for the first 30 kWh of consumption with all additional consumption charged at 50 K ¢/kWh. A fixed charge of

1/ Kenya Electricity Tariff Study, Report No. PUN 38, June 1978.

TABLE 5.3

East African Power and Lighting
Tariffs for Electricity Sales
(February 1982)

Method	Consumption Range Or Delivery Voltage	Fixed Charge Ksh/Month	Energy Charge[3/] Kc/kWh	Demand Charge Ksh/kVA
A	Less than 7000 kWh/month	15.00[1/]	22 (first 30 kWh)	-
			50 (all additional)	-
B1	7000-100,000 kWh/month 240-415 Volts	60.00	27	50.00
B2	7000-100,000 kWh/month 11,000 or 33,000 Volts	360.00	25	45.00
B3	7000-100,000 kWh/month 66,000 or 132,000 Volts	1640.00	23	40.00
C1	Greater than 100,000 kWh/month 415 Volts	60.00	27 16 2/	50.00
C2	Greater than 100,000 kWh/month 11,000-33,000 Volts	360.00	25 15 2/	45.00
C3	Greater than 100,000 kWh/month 66,000 or 132,000 Volts	1640.00	23 14 2/	40.00
D	Interruptible off-peak for domestic water heating and irrigation pumping	32.50[1/]	16[2/]	-
E	Street Lighting	32.50 per terminal	45	-

1/ If meters for tariffs A and D are both used the consumer's total fixed charge is 35 KSh/month.

2/ The lower rate applies for energy consumed between 2200 hours and 0800 hours during weekdays and between 2200 hours on Friday and 0800 hours on Monday.

3/ All sales are currently subject a fuel cost adjustment of 21.2 K¢/kWh.

K Sh 15 per month and the fuel cost adjustment of 21.2 K ¢/kWh are also charged to these consumers.

(b) The second group, using between 7000 and 100,000 kWh/month, is "large commercial and industrial" and the tariff is characterized by a flat rate for consumption and a demand charge (power factor adjusted) dependent on the delivery voltage. The monthly fixed charge also depends on the delivery voltage.

(c) The third group comprises large industrial consumers, using more than 100,000 kWh/month. There is a flat rate for consumption during peak hours (0800 to 2200, Monday to Friday) and a lower rate for off-peak consumption. The fixed monthly charges and demand charges are the same as for the second group.

In addition, there are separate tariffs for interruptible off-peak use for residential water heating and irrigation pumping, and for street lighting. The interruptible off-peak rate is charged to residential consumers who have a separate meter installed for measuring electricity consumption for water heating. The current tariff, including fuel cost adjustment, is 37.2 K ¢/kWh or 52% of the normal residential tariff. The lower off-peak tariff charged for industrial users and residential water heating was part of the tariff structure introduced in September 1976 and was retained when the structure was changed in January 1979.

5.08 At the beginning of 1982, EAPL carried out a new tariff study to take account of planned investments in hydro and geothermal capacity during the 1980s and changes in costs since the previous tariff study. EAPL propose that the structure of the tariff system should be retained apart from some minor modifications (see para. 5.14). The average tariff in 1981 was about equal to the long-run average incremental cost of electric power at mid 1981 prices, according to cost estimates contained in EAPL's report. 1/ This estimate was based on preliminary capital cost estimates for the two major schemes planned for the 1980s, namely Kiambere and Turkwel. A more reliable estimate of long-run economic costs is required as a target for tariff levels, and the mission recommends that further tariff studies should be carried out at frequent intervals, say every two years, as more information becomes available to update the estimates of long-run costs.

5.09 The EAPL tariff study put forward recommendations for raising tariff levels based on the proportion of capital investment requirements for the period 1982-86 that would be supplied from EAPL's internal resources. Three cases were examined, and in all cases it was assumed

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1/ EAPL's cost estimates adjusted by excluding duties and taxes and applying shadow rates to foreign costs and local wages to derive economic costs.

that 60% of the requirements would be financed from foreign sources. The balance would be contributed by Government and EAPL in differing combinations for each case. The revenue and cost projections were computed on the assumption of 12% annual inflation. In all cases, EAPL recommend that fixed charges should be double the present rates, but demand charges should remain unchanged. The recommended increases in energy charges in the three cases are shown below:

	Case A	Case B	Case C
Proportion of planned capital investment funded from (%)			
- foreign sources	60	60	60
- Government	20	16	0
- EAPL	20	24	40
Required increases in energy charges (K ¢/kWh)			
July 1982	9	12	24
January 1984	8	17.3	10

5.10 The amount of tariff increase required for capital investment requirements is directly related to the proportion of the capital investment requirements that have to be financed from EAPL's resources. Government's contribution to the capital investment program is therefore an important aspect of tariff increases. EAPL's Case B, with 16% Government contribution represents the waiving of duties and taxes on imported materials and equipment for major power projects. EAPL recommend that the Case A financing plan and tariff increases should be implemented, but that Case B should be adopted if Government prefers to make a lower contribution and to approve slightly higher tariff increases. Under Case A, the average revenue per kWh sold would increase from 62.0 K ¢ in 1981 to 66.4 K ¢ in 1982 and 79.4 K ¢ in 1984 in current price terms. The tariff increased that would be required if the Government is not in a position to provide any contribution are shown in Case C. EAPL have not recommended this Case because the tariff increases may be unacceptably high for Government.

5.11 The recommended tariff increases for July 1982 and January 1984 together would maintain the average tariff at the 1981 level in constant price terms if inflation in Kenya averages 12%/year for 1982-84. The tariff levels would therefore remain at about the long-run average incremental cost of power at a 12% inflation rate, and would satisfy both revenue and economic requirements.

5.12 EAPL have requested approval to implement increases to tariffs on July 1st, 1982 to provide funds for ongoing preparatory work, such as access roads and site preparation, for the Kiambere project. According to EAPL, delays in implementing tariff increases could result in difficulties for EAPL over payments for contracts already awarded for Kiambere.

5.13 With the completion of the Masinga dam on the Upper Tana River in 1981, the interconnected power system has additional storage to augment river flows during the dry season. Added to this, the strengthening of the transmission system between Nairobi and Mombasa, which will be achieved in 1983 with the completion of the 220 kV line, will permit the transfer of hydro and geothermal generated electricity to the coast. These developments will enable the role of oil-fired power generation in Mombasa to be reduced further, though not eliminated completely since it will continue to be needed primarily for system stability reasons due to certain load characteristics in the Mombasa area (low power factors and concentration of industrial consumers) and to contribute to meeting peak demand. Oil-powered capacity is also needed to provide some back-up in case of interruptions in the lengthy transmission line between Nairobi and Mombasa.

5.14 Since the power system is energy constrained, the marginal cost of energy is constant throughout the year as well as during the daily cycle and is equal to the most expensive energy source which is oil-fired power. However, the present tariff structure provides significant incentives for off-peak power consumption between 10:00 p.m. and 8:00 a.m. EAPL have recognized this anomaly by eliminating the discount for off-peak consumption for Method B and C consumers (Table 5.3) in their proposed new tariff structure (para. 5.08). In the case of residential off-peak rates for interruptible electricity (Method D) the differential of about 47% of the normal residential rate (including the fuel adjustment clause) for consumption in excess of 30 kWh/month is difficult to justify economically, especially since sales in the interruptible off-peak category have actually declined since 1975 (see Table 3.5). The benefit of this category to EAPL is the facility to cut off supplies at short notice with little economic cost. EAPL propose to retain this category, but with a lesser differential of about 30% which is considered to be sufficient to provide the required incentive to use this category without unnecessary loss of revenue. It should also be noted that the present off-peak tariff is below the marginal cost of thermal energy which is about K ç 55/kWh, but that the proposed off-peak tariff in Case A from July 1st, 1982 would be K ç 56/kWh, and therefore would cover marginal costs.

5.15 The mission therefore recommends that:

(a) the Government approves EAPL's application for an increase in tariff charges in time to be implemented by July 1st, 1982;

(b) further tariff studies are carried out as firm capital cost estimates become available for planned power projects;

(c) the Government accepts EAPL's proposal to eliminate the off-peak discount for industrial and commercial users, and to narrow the differential for interruptible supplies to residential users and for irrigation pumping;

(d) the use of an inverted block tariff structure for residential consumption should be considered in place of the present flat rate structure for consumption in excess of 30 kWh/month, with consumption above a certain level charged at a higher rate. Such a change would stimulate residential energy conservation amongst the high income group; and

(e) the present classification system of electricity consumers be reviewed. The current system mixes commercial with residential consumption at the low end, and commercial with industrial at the high end since it is based on the level of monthly energy consumption. A classification system based on consumer type (residential, etc.), rather than as at present would facilitate development of energy balances for all energy sources by consumer type, as well as assist in forecasting electricity demand. The mission understands that EAPL have recently initiated a new classification system which differentiates between consumer classes.

Fuelwood and Charcoal Prices

5.16 The only data on fuelwood and charcoal prices available to the mission were those from a Forest Dept. survey which provides estimates of costs and prices of charcoal and fuelwood marketed through commercial channels. These are summarized in Table 5.4:

TABLE 5.4

Fuelwood and Charcoal Prices

	Wood	Charcoal
	Ksh/M^3	Ksh/bag 1/
Average Production Cost	31.45	9.50
Average Selling Price	52.60	16.60
Gross Margin, %	67	75

1/ Approximately 34 kg per bag.

Of special note is that the charcoal production and selling prices are low by any standards -- US$1.3 and $2.3/MMBTU respectively - which indicates that commercialization of woodfuels is only just starting.

Coal Prices

5.17 At the time of the mission, Bamburi Cement's imports of coal from Swaziland had a price of $43 per tonne f.o.b. Maputo, and the final cost to Bamburi Cement was $97 per tonne, which included ocean freight and a 30% import duty. The import duty has since been reduced to 20%. The coal has a calorific value of 6,264 Kcals/kg and the net of tax cost is US$2.73 per million Btu (US$3.55 with 30% duty) compared with a cost of fuel oil of US$4.45 per million Btu. There are no import duties or taxes on fuel oil.

5.18 The mission recommends that Government review its present policy of levying an import duty on coal since it could act as a deterrent to substitution from fuel oil to coal use by industry. In the case of Bamburi Cement, the conversion appears attractive even with the import duty, although this is not clear for other potential substitution projects.

VI. SECTOR ORGANIZATION AND INSTITUTIONS

6.01 Several organizations have been involved in energy matters in Kenya for many years, particularly in the refining and power sectors, while other organizations, such as the Ministry of Energy and the Kenya Pipeline Company, are relatively new. Moreover, some government departments and agencies whose concerns in the past were outside the energy sector, for example, the Kenya Sugar Authority and the Forest Department, are now responsible for fuel sources. There are gaps in the existing institutional framework which the Government considers would be best filled by creating new organizations or units within existing organizations. Proposals have been forwarded for two such organizations - an Energy Research and Development Institute and an Energy Development Bank. This chapter evaluates these proposals and also examines issues related to some of the existing energy organizations and their functions. In this context, the mission focussed only on proposals to establish new institutions or restructure existing ones.

Ministry of Energy

6.02 The Ministry of Energy (MOE) was established by the Government in December 1979, and is currently functioning according to the structure shown in Annex II. Official responsibilities include: (i) Energy Policy and Development; (ii) Electric Power Development; (iii) Oil and other fossil fuels; and (iv) Exploration and Exploitation of Non-Conventional Energy Sources - Wind, Biogas, Solar, Geothermal, Fuelwood etc.

6.03 As a new, relatively small organization, the MOE is still developing its policies and programs, and its relationship with other ministries. Since energy use is common to almost all economic activities, this interministerial coordination and cooperation is vital. The MOE has started the process by establishing an interministerial committee for energy conservation. It acts as a technical adviser to the other agencies and relies on their operating personnel to achieve energy policy objectives. An additional important function which the MOE performs is coordination of the various energy-related aid programs under way in Kenya. The Ministry provides counterpart and support staff also, and at present these programs require significant MOE input.

6.04 The European Economic Community financed a recent study which reviewed the structure of the MOE and its relationship with other organizations dealing with energy matters. The consultants' study also addressed the long-term national energy strategy, the appropriate structure of and policy guidelines for research and development units within the Ministry, and the establishment of an energy data bank and a library. In their interim report of March 1981, the consultants recommended a revised structure for the MOE as shown in Annex II. The three lines of activity suggested for the ministry are:

(i) planning, with other ministries, to define the needs in the various sectors and to carry out development plans covering various energy sources;

(ii) monitoring that the policy stated by the ministry is implemented;

(iii) promoting the use of new sources of energy as they become economic and feasible.

The recommended duties of the four major units, which are supported by the mission, are described in the following paragraphs.

6.05 The Planning Division would be responsible for forecasting energy requirements and drafting the energy plan, with annual revisions. It would also perform cost analyses and would recommend prices for different energy commodities. New regulations relating to the national energy plan would be drafted by the division, and it would be responsible for managing the data bank and data processing centre. The Planning Division would also coordinate all foreign aid in the energy sector.

6.06 The Administrative Division would handle the routine administration of the ministry including personnel selection, budgeting, and supplies. It would also be responsible for the Energy Development Fund which is described in paras. 6.14 - 6.15.

6.07 Through the Control Division, the Ministry would maintain the data bank by regularly collecting data for different energy uses. This division would also design and implement a mechanism to allow government better to monitor the petroleum product market within the country, and would implement the national energy plan's provisions for conventional electricity and for new technologies. A special inspection unit within this division would ensure that new legislation is implemented.

6.08 The Development Division would promote development of new energy technologies, design and implement large demonstration programs, and help develop a national market for new and renewable energy technologies. This division would also formulate guidelines for research and other activities of the Research and Development Institute.

6.09 The interim report also suggests that the MOE be given sufficient power and authority to harmonize and promote action, in addition to providing guidelines. In view of the interministerial nature of the work and the fact that the MOE is relatively new, the mission considers that this coordination function needs to be strengthened and can only be discharged if MOE has adequate staff resources. While the structure proposed by the consultants assigns coordination functions to the Planning Division, these are not considered among the principal responsibilities listed.

Electric Power Supply Companies

6.10 There are currently four companies involved in power supply in Kenya. These are:

(1) East African Power and Lighting Company, Limited (EAPL) which is the sole distribution company in Kenya. It is a mixed company in which the Government owns 57% (directly or indirectly). EAPL coordinates all sources of power, staffs and manages the generating companies (KPC and TRDC), and is responsible for the Upper Reservoir generating station owned by TRDA.

(2) Kenya Power Company (KPC) is 100% Government owned. It was formed in 1955 to construct and operate the 132 kV interconnection with the Uganda power system and to take over ownership of EAPL's two hydroelectric stations on the Tana River. KPC is in charge of the development of the Olkaria geothermal field.

(3) Tana River Development Company (TRDC), 100% Government-owned, has been responsible for the development of the hydroelectric resources of th Tana River.

(4) Tana River Development Association (TRDA) is primarily concerned with the irrigation potential of the Tana River. It owns the power station at the recently completed Upper Reservoir dam.

EAPL purchases the power generated by KPC and TRDC at ascertained cost while the power from TRDA is purchased at the cost of equivalent thermally generated power (based on the cost in mid-1981).

6.11 EAPL has suggested that the two generating companies, KPC and TRDC, be merged to reduce overhead costs. There appear to be no obstacles to this proposal since both companies are fully owned by the Government and have the same chairman. The mission supports the proposal.

Energy Research and Development Centre

6.12 In February 1980 members of a Steering Committee at the University of Nairobi drafted a proposal for the establishment of a Centre to engage in research and development on energy use and production in Kenya. This proposal identified the major problems for the rural population to be the heavy dependence on wood and the inefficient use of wood and charcoal, the negligible role of electricity in rural energy demand, the small activity in non-conventional renewable energy, and competing claims on scarce land needed for both food and energy production. Immediate action was recommended on large scale afforestation, increased wood productivity and efficiency in its use, and promotion of carefully selected alternative energy sources. The research priorities outlined were:

(1) afforestation techniques focussing on fast-growing species and on conditions affecting land use;

(2) means to improve the efficiency of cooking stoves and charcoal manufacturing techniques;

(3) means to increase rural electrification in certain areas of the country;

(4) the selection and development of alternative energy sources; and

(5) the impact of energy considerations in the planning and design of buildings and settlements.

The need to focus on the rural areas was identified because current efforts are aimed at the urban/industrial sector. To this end the objectives of the proposed centre would be:

(1) research in and development of energy technology;

(2) energy technology extension to the rural and urban population;

(3) monitoring of energy technology; and

(4) forecasting energy demand and performing energy policy research.

6.13 The Committee recommended that research involve scrutiny of available technological solutions, with additional research and development where solutions were inadequate or inappropriate for Kenya. The proposed Centre would be located at the University and would draw on faculty members who are currently involved in research projects related to energy, most of which involve renewable energy such as biogas and windmills. Teaching courses in energy production and use would also be a function of the Centre.

6.14 The Ministry of Energy supports the idea of establishing an Energy Research Centre but its view is broader than that of the University. This view was supported by the mission and by the EEC consultants' interim report. The research organization, in the mission's view, should be involved in interdisciplinary research addressing socio-economic issues related to Kenya's energy problems and should not be viewed as an energy technology institute. An important area for research is in the applied energy economics area which would involve, for example, assessing the energy impact of different industrial development strategies for the remainder of this decade on the country's energy situation.

6.15 Another recommendation of the EEC consultants was that this new organization be strictly linked to the Ministry's Development Division, which would set goals and monitor results. The work would necessarily be coordinated with the University and the National Council for Science and Technology, but would remain under the Ministry's control. The mission concurs with this recommendation.

Energy Development Bank

6.16 Proposals have been put forth that a Fund be established to provide a means for financing demonstration or pilot projects in the energy sector. The Fund's activities would not be limited to new and renewable sources, but could also finance energy conservation schemes if they met the Fund's investment criteria. Such a proposal is contained in USAID's project paper for its renewable energy aid program.

6.17 The USAID project paper (#615-0205, August 1980) contained a detailed proposal indicating that the Fund will be aimed at the development and dissemination of innovative renewable energy technologies and extension approaches. The initial capital from AID and MOE would amount to $859,000 with another $270,000 from MOE for administration. One-half of the initial capital would be allocated to soft loans or grants for broad renewable energy demonstration or extension programs, while the other half would finance specific demonstration projects. Both types of loan will be provided on a cost-sharing basis, with the recipient expected to provide a minimum 25% matching contribution. According to the proposal, MOE would establish specific criteria and would review and approve applications after consideration of comments from other Ministries. MOE would also be responsible for administering the Fund and providing technical and financial monitoring for all grants or loans awarded. It was suggested that administration of the Fund be kept as simple as possible, and that the review process provide for speedy approval. AID assumed that the staff assigned to the Fund would also administer any funds available from other donors.

6.18 In 1979 an Energy Development Bank was proposed which would be capable of designing and executing the financing of the energy projects, as well as assessing their technical feasibility and performance. The three major functions of the Bank would be:

(1) to act as a banker (of last resort) to finance the production and consumption of new forms of energy;

(2) to assess the economic, technical, and financial viability of individual projects; and

(3) to assure that projects are in harmony with overall energy policies.

The Bank would obtain its capital from budgetary allocations, foreign assistance, and by attracting private capital if some tax incentives were offered. The Energy Development Bank was perceived as an organization to assist in energy policy implementation. This recommendation led to the inclusion of the Energy Development Fund in the Ministry of Energy organization structure.

6.19 The Mission considers that neither a special fund nor a separate organization is necessary for funding energy projects. There are already several agencies which can provide financing including the Industrial Development Bank, Industrial and Commercial Development Corporation, Agricultural Finance Corporation, Development Finance Company of Kenya, and the Co-operative Bank. However, to facilitate financing of energy-related projects, the Ministry of Energy should develop the guidelines for selection and assist these agencies in analyzing proposals and appraising projects. Funds from external donors should be lodged in one of the existing agencies until the projects to be financed have been properly appraised.

Other Government and Non-Government Organizations

6.20 There are various other organizations within Kenya which have programs related to energy use, particularly in rural areas. Their programs range from information dissemination to development of fuelwood plantations and introduction of more efficient wood and charcoal stoves. Some of these groups are organized by Churches, others are related to Government Ministries such as Agriculture and Culture and Social Services. These groups can be helpful in introducing energy saving devices or in assisting with other programs aimed at the rural sector, and the MOE should make increasing use of these agencies wherever possible, and act as a clearing house for information and advice about their activities.

VII. ENERGY INVESTMENTS AND TECHNICAL ASSISTANCE

7.01 The major investments in the energy sector in Kenya in the past have been in the electric power sub-sector, mainly for the development of the Tana River's hydro-potential. They have included contributions from the Government and the three power companies in Kenya (EAPL, KPC, TRDC).

7.02 In the petroleum sector, both public and private sector investments have been made in petroleum exploration, in the refinery at Mombasa and in a pipeline between Mombasa and Nairobi for the transport of the white oil products. Petroleum exploration, initiated in the early 1950's has been disappointing so far. The exploration has been done mainly by private oil companies, and past campaigns have been limited with only 12 wells drilled (over a total sedimentary area of 260,000 km^2).

7.03 Besides the above, the Government has also undertaken a limited number of rural electrification programs, the funds being provided by EAP&L (which apportions about 1% of its gross sales revenue, about US$1,000,000 in 1980, towards this). Funds are also provided from the interest differential between the soft terms of a Swedish International Agency (SIDA) credit to the Government for the Kamburu Hydroelectric Power Project, and the Government's harder on-lending terms to TRDC (who implemented the project). It is envisaged that when the Swedish grant ends, the rural electrification program will continue with funds from the Canadian International Development Agency.

Sectoral Energy Investments

7.04 Table 7.1 lists the available data on past investments in the energy sector. The power sub-sector investments include the commissioning of the Kamburu (1974) and Gitaru (1977) hydroelectric power projects. These investments would be increased by KL25 million if the costs of the energy investments in the Upper Reservoir were included. As the project is being currently constructed as a multipurpose one, only a part of the total costs can be allocated to energy investments. The investments in the fuel alcohol sub-sector represent the initial investments in the Kisumu plant. The bulk of the investments in this sub-sector are expected in the early 1980s.

7.05 Investments between 1957-78 in exploration in the petroleum sub-sector have been estimated at about KL 12 million. While the search for oil has been disappointing, further exploration is expected in the future. Other investments in this sub-sector include the construction of the East African Oil Refinery (EAOR), at a cost of KL25.4 million, and the construction of the Mombasa-Nairobi oil products pipeline for the transport of the refinery's output.

7.06 The data in Table 7.1 indicate the very low rate of capital formation in the energy sector, relative to both total fixed investment and GDP. Energy investments as a percentage of total investments have been less than 10% over the period 1972-79, and energy investments as a percentage of GDP have not risen over 2.6% for the same period. Even if the investments in the Upper Reservoir, the refinery, and petroleum exploration were included in the totals for each year, they would not increase the percentages substantially. The very low rate of capital formation in this sector arose primarily because in Kenya, as in all other oil importing developing countries, petroleum importation was clearly the least cost route. In addition, until oil prices were substantially increased, Kenya's limited indigenous energy sources (hydro and geothermal) were not worth developing at a more rapid rate. The Fourth Development Plan recognized the need to formulate a comprehensive national energy development plan, and to develop indigenous resources. However, the proposed energy investments in the plan period were only marginally increased over those in the previous plan period, and also constitute only a very small percentage of total sectoral investments for the period 1979-83. This was due largely to the long lead time in identifying and completing pre-investment work. Thus the proposed energy investments in the Third Plan, mainly for power investment, amounted to KL 36.3 million, or 2.3% of the total investments, while the proposed investments in the Fourth Plan come to KL114 million [1/], or 3.2% of the total investments. The bulk of this planned development will be, as in the Third Plan, for the development of hydro-electric power, transmission and distribution systems. However, an important development is the increasing importance attached to the exploitation and development of geothermal resources, where investments have increased from about 0.3% (KL0.12 million) to about 21% (KL21.7 million) of the total power sector investments.

1/ 1979/80 prices. Most of the sectoral investments were subsequently revised downwards in Sessional Paper No. 4 of 1980. However, the relative priorities were not subsequently altered.

TABLE 7.1

Investments in the Energy Sector 1971-79
(KL million - current prices)

	1972	1973	1974	1975	1976	1977	1978	1979
1) Power Sector Investment	5.4	8.7	7.9	11.2	16.5	14.4	21.8	6.7
2) Mombasa-Nairobi Oil Products Pipeline	-	-	0.4	1.2	16.5	16.1	4.7	0.2
3) Fuel Alcohol	-	-	-	-	-	-	10.0	10.0
4) Total Fixed Investment	163.8	179.6	202.8	241.9	290.4	390.0	514.0	530.6
5) GDP	675.4	783.3	939.8	1057.2	1278.1	1640.7	1788.4	1974.9
6) (1)+(2)+(3) as % of 4	3.3	4.8	4.1	5.1	11.4	7.8	7.1	3.2
(1)+(2)+(3) as % of 5	0.8	1.1	0.9	1.2	2.6	1.9	2.0	0.9

Source: (1) Power Sector Investments - EAP&L

(2) Information on Mombasa-Nairobi Oil Products Pipeline from IBRD project completion report dated June 20, 1980.

(3) Fuel Alcohol - "The Agro-Chemical Energy and Food Complex at Kisumu", report dated April 1981, prepared by Eximcorp SA for Kenya Chemical and Food Corporation Ltd., Capital Expenditure Summary - pg. 14. The table indicates that expenditures up to 3.11.1980 were KL30.3 million. The allocations have been divided equally over the period 1978-80 in the absence of data on annual expenditures.

Energy Investments 1981-90

7.07 Since the publication of the Fourth Development Plan, modifications have been made in the energy investment program. The Government has already invested in the fuel alcohol program (see Chapter II). Alcohol plants are being constructed at Kisumu (estimated cost US$122 million 1/), and Muhoroni (estimated cost US$33 million 2/). The Government is also contemplating investing in a third plant in Riana, in the Nyanza Province (estimated cost US$76 million 3/, excluding agricultural development costs). (None of these investments have been included in the energy sector allocations of the Fourth Development Plan.) Further allocations, although minor - (US$1.8 million) have been made for the development of non-conventional energy sources such as wind power, solar energy, and biomass. An initial investment from the public sector of about US$6 million in a petroleum exploration and promotion project is expected in the early 1980's. Additional investments are expected once the project is under way, as foreign oil companies bid for exploration permits.

7.08 Table 7.2 lists the proposed energy investments through the 1980s. It includes the Government plan's proposed investments, plus investments which have now been identified as priority items in the energy sector, such as for secondary refining facilities at Mombasa, at an estimated cost of US$84 million. It also includes energy substitution measures such as the investments in the cement industry to convert from fuel oil to coal which is about $30 million for the two cement plants.

7.09 Most of the investments in the power sector in the past have not been a direct drain on the Government's resources, since these investments have been financed partly from the power companies' internal cash generation, and also from local borrowings. Significant amounts of external borrowings, however, have been used in the construction of the projects. Government participation has generally been in the form of equity contributions, and in guarantees for the foreign loans which has reduced the availability of loans for other public investments. This policy is expected to continue in the proposed power investments in the 1980s and the ability of EAPL to finance local costs from internal resources has been considered in EAPL's tariff study (para. 5.09-5.12).

7.10 In the petroleum sub-sector, the Government's investment strategy includes the participation of foreign oil companies in domestic exploration activity. However, it is difficult to estimate with any degree of accuracy the expected private investment in this sector, since this can only be ascertained during the implementation of the proposed petroleum exploration program. Private sector involvement, however, is expected in the fuel alcohol program, the economic justification of which is dubious.

1/ 1980 prices.

2/ 1980 prices.

3/ 1980 prices.

TABLE 7.2 Estimated Major Energy Sector Investments in Kenya 1980-90
(K£ Million - 1980 prices)

Energy Sub-Sector/Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1. Power Sector											
a) Hydro-electricity											
Kiambere 1/	-	4.0	26.1	20.1	19.2	11.2	2.4	-	-	-	-
Turkwel 1/	-	-	-	2.9	8.6	14.3	14.3	11.4	5.7	-	-
Grand-Falls	-	-	-	-	-	-	6.8	13.3	20.0	33.3	33.3
b) Thermal											
45 MW set	-	-	-	-	-	-	-	1.7	3.4	9.3	1.7
60 MW set	-	-	-	-	-	-	-	-	-	-	2.2
c) Geothermal											
Olkaria (30 MW)	-	3.8	5.2	7.3	0.8	-	-	-	-	-	-
2nd 30 MW	-	-	-	1.7	1.7	3.6	7.0	10.0	2.0	-	-
3rd 30 MW	-	-	-	-	-	-	-	-	1.7	1.7	3.6
d) Transmission	-	30.0	11.6	8.5	3.3	2.1	1.6	1.4	5.4	11.7	6.2
Total		37.8	42.9	40.5	33.6	28.2	32.1	37.8	38.2	56.0	47.0
2. Refinery Modification 2/	-	-	3.3	9.9	9.9	9.9	-	-	-	-	-
3. Fuel Alcohol	28.9	39.4	8.9	3.0	-	-	-	-	-	-	-
4. Industry Conversion	-	-	4.0	4.0	4.0	-	-	-	-	-	-
5. Oil and Gas Exploration	-	0.2	0.9	0.6	0.3	0.2	-	-	-	-	-
Total Energy Investment	28.9	77.4	60.0	58.0	47.8	38.3	32.1	37.8	38.2	56.0	47.0

1/ Estimates for Kiambere and Turkwel shown in the above table may now be grossly underestimated. In addition, the implementation of the Kiambere project is expected to be delayed. The latest Interim Report on Kiambere shows a total project cost, excluding price contingencies, interest during construction, and other financing charges, as K£119 million. If these other costs are also included, the estimated cost is about K£172 million (1981) prices). A recent Norconsult study on Turkwel now estimates the project cost to be about K£180 million.

2/ Preliminary estimate.

Source: Power Sub-sector - EAP&L
Alcohol - IPD draft report on the Fuel Alcohol Sub-sector
Petroleum - Petroleum Exploration Promotion Project - preliminary estimates
Renewables - Ministry of Energy

7.11 In Chapter I, the investment necessary for some of these projects in the energy sector was compared with the potential savings in oil imports and foreign exchange. The analysis showed that the hydropower and geothermal projects and the cement plant conversions are attractive options while the ethanol projects are not.

Inventory of Existing and Planned Technical Assistance from Bilateral and Multilateral Donors.

7.12 Kenya has been fortunate in attracting aid from many donors in both conventional and non-conventional energy areas. There are several projects which have been receiving external financing for some time, for example, the Upper Reservoir hydropower project, and others which have been identified and are being prepared for financing, such as the Kiambere hydropower project. In this section a partial list of the aid programs which are either more general or are in the renewable field, some of them on a small scale, are presented. This list is shown in Table 7.3.

7.13 Not all of the details of these programs were available to the mission. It is apparent that many of these projects overlap, particularly in the renewable energy field and most obviously in the fuelwood area. These programs are being implemented through different agencies and in several cases their objectives overlap or duplicate each other; there appears to be insufficient coordination between the Ministries in question. What is clearly needed is an energy policy framework and coordination through the Ministry of Energy to ensure that aid is directed at the highest priority areas. Having defined the policy objectives and plan what is also needed is an implementation and investment program to give substance to such policies. It also follows that the energy strategies and investment programs have to be not only launched, but continuously monitored and even policed. The newly formed Ministry of Energy should be placed in a position to design such energy policies and programs and analyze their interaction with the rest of the economy.

7.14 Other projects not listed here include the Bank's loan (with CDC) to Kenya Power Company for the 30MW geothermal power plant at Olkaria, the CIDA loan for 220 kV transmission line from Kamburu to Mombasa, and the various loans for the Upper Reservoir (Masinga Dam) hydro and irrigation project. New Zealand is also assisting in geothermal development and exploration. Additionally, EAPL is actively seeking financing for the 140MW Kiambere hydro project.

Proposed Program of Technical Assistance

7.15 The major role which the Bank and other donors can play is to provide for technical assistance to the MOE, to strengthen its policy making and coordinating role. The UNDP advisers now with the Ministry are in a position to help establish priorities for energy sector investment or studies but the Bank can help by reviewing the terms of reference for consultants.

TABLE 7.3

AGENCY	PROJECT DESCRIPTION
1. Finland	Ongoing rural electrification, US$ 2.7 million.
2. Japan International Co-operation Agency	Geothermal exploration in the Eburu area US$269,000.
3. UNDP/TCD	Energy Planning, Policy and Programming. High-level senior energy advisor plus consultants. US$206,000.
4. UNDP/UNCTAD/TCD	Advisory Services in Petroleum. Specialist to serve as an adviser to the Government. US$99,000.
5. USAID	Renewable Energy Project to (i) establish tree nurseries, (ii) establish links with voluntary agencies, (iii) provide technical assistance, and (iv) provide energy policy assistance, particularly in energy conservation. US$4.8 million over four years.
6. Canadian International Development Agency	Development of photovoltaics
7. Swedish International Development Agency	Soil conservation and tree nurseries
8. Norwegian Agency for Development	Afforestation and solar pumps.
9. Danish International Development Agency	Village Forestry
10. Swiss Aid	Forestry
11. West Germany	Stove design, windmills, biogas.
12. Netherlands	Participant in Beijer/MOE study of fuelwood/ charcoal cycle.
13. Finland	Forestry
14. China	Biogas
15. Australia	Solar communication systems, windmills, and geothermal
16. Brazil	Ethanol development
17. Great Britain	Pyrolysis, forestry projects
18. E.E.C.	Forestry projects, advice on structure and functions of MOE.
19. U.N.S.O.	Forestry
20. Belgium	Experiments with euphorbia for fast-growing fuelwood.
21. World Bank	Forestry III. Mainly concerned with industrial plantations, but includes a fuelwood component.
22. Beijer Institute (Sweden)	Analysis of fuelwood cycle;analysis of commercial energy demand.
23. British Department of Transport	Providing an adviser for two years to study energy consumption in the Transport Sector.

7.16 The specific areas identified in this report where assistance is urgently needed are:

(i) Refinery Modification - a study of the optimal configuration based on projected demand should be performed immediately. It was learned recently that USAID is considering financing the study of refinery configuration.

(ii) Solar Water Heating - the study recommended for development, testing, standardization and other facets could be financed by donor agencies after detailed terms of reference have been developed.

(iii) Cement Plant Conversion - the feasibility study for both phases of conversion at East African Portland Cement (EAPC) needs to be completed. External financing may not be necessary for the study due to EAPC's association with international cement companies, but the project itself may require financing.

(iv) Ethanol Production - External assistance here should be limited to technical assistance to Government to assist in reviewing the entire alcohol program.

(v) Electricity Tariffs - carry out an economic evaluation of a solar water heating program.

(vi) Conservation - though some assistance is to be provided by USAID in this area, other agencies could provide technical and financial support for undertaking an industrial and commercial sector energy audit program to identify viable projects to conserve energy in these sectors.

(vii) Fuelwood and Charcoal - MOE is receiving assistance from USAID and a study of the fuelwood cycle is being performed by the Beijer Institute of Sweden. Additional assistance will be required if more efficient charcoal production methods are to be implemented on a large scale.

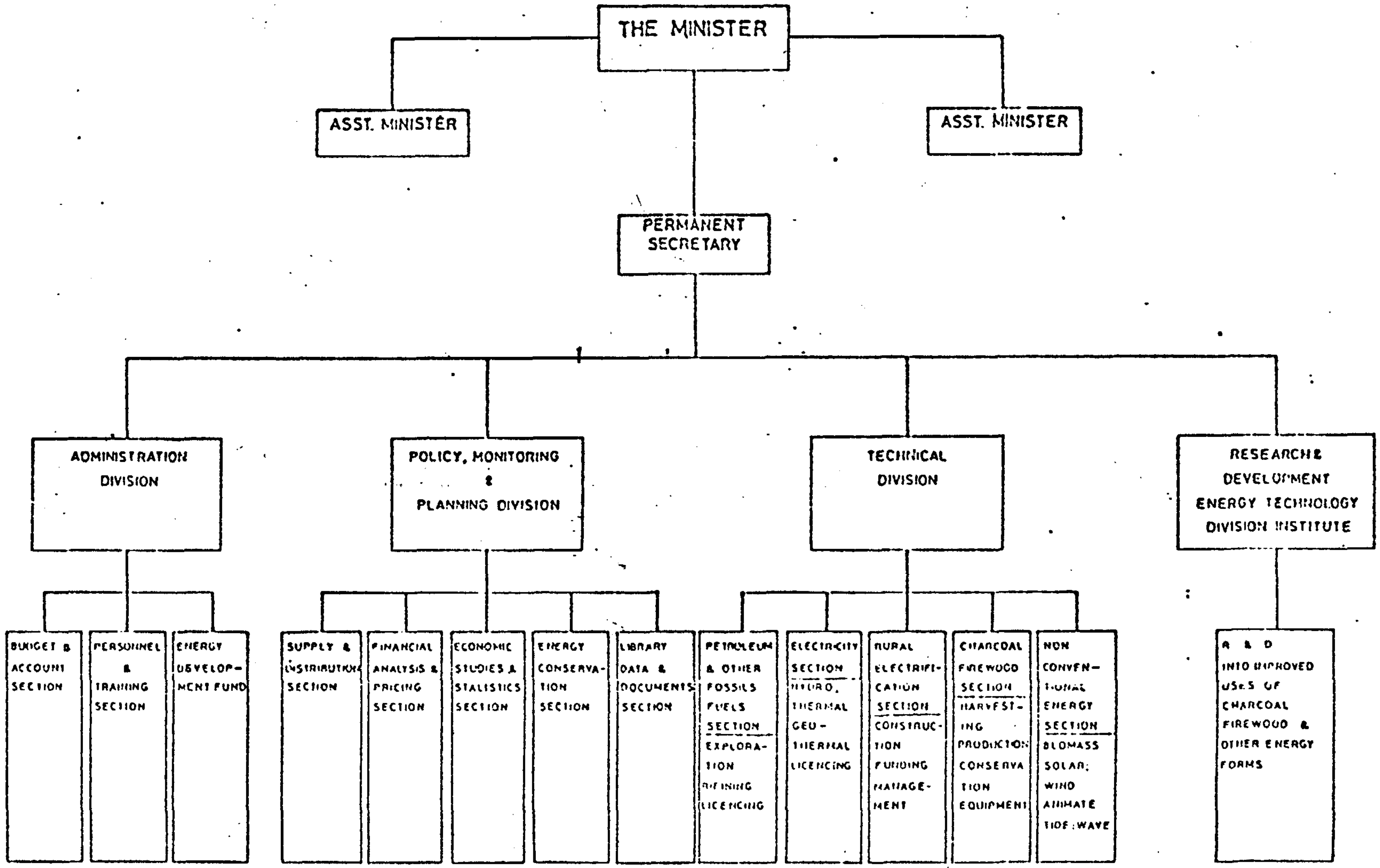
ANNEX I

CONVERSION FACTORS

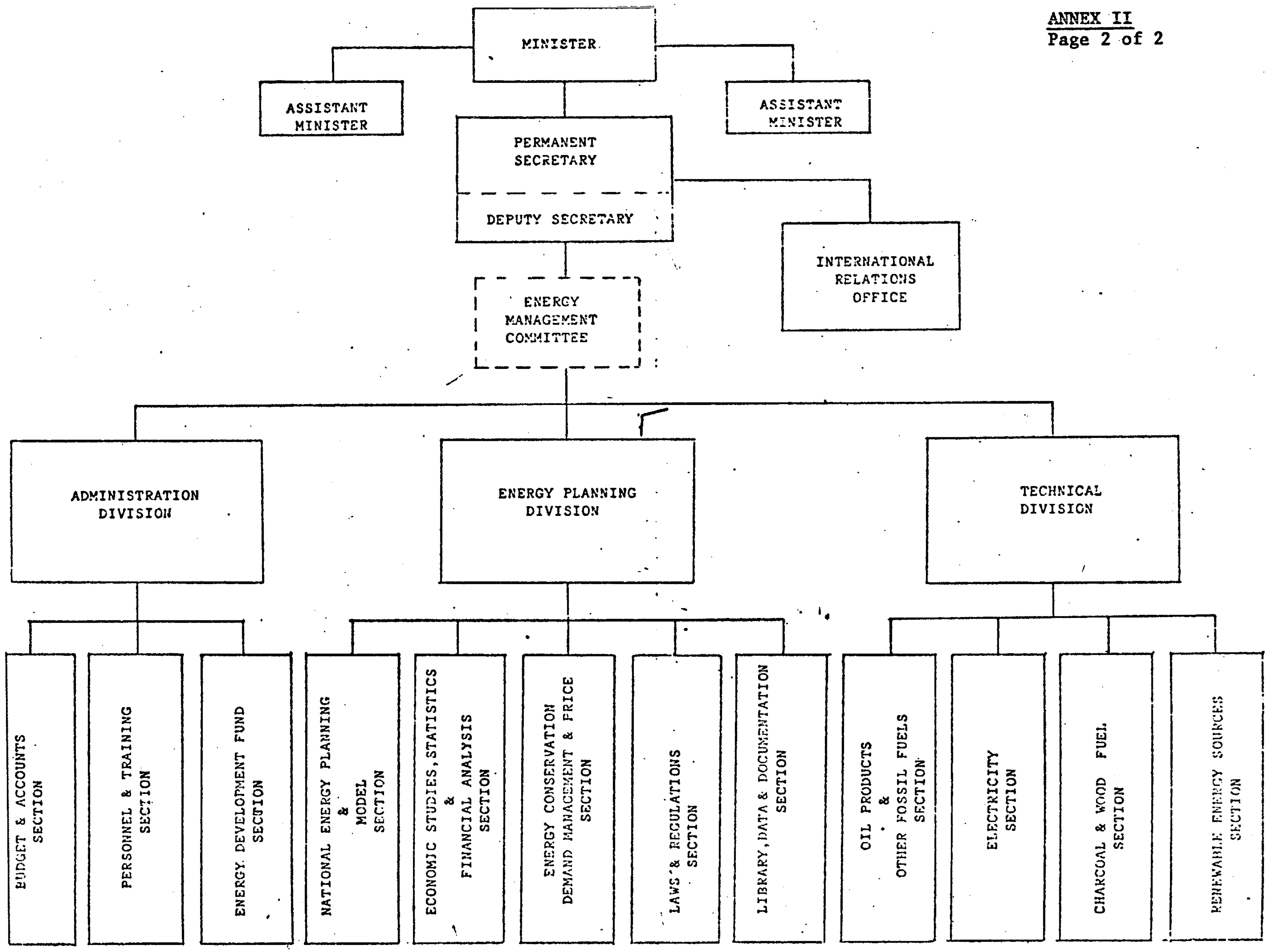
Petroleum Products	Litres per Metric Tonne
LPG	1,852
Aviation Spirit	1,400
Jet Fuel	1,335
Premium Gasoline	1,364
Regular Gasoline	1,403
Kerosene, Illuminating	1,274
Kerosene, Power	1,235
Gasoil	1,191
Industrial Diesel Oil	1,177
Fuel Oil, Average	1,060

4000 kWh equal one tonne of oil equivalent = 41 million Btu. (In other words 10,250 Btu are required to generate 1 kWh)

At consumer end use, 12000 kWh = 1 toe (i.e., 1 kWh = 3412 Btu).
1 tonne of coal = 0.6 toe



PROPOSED STRUCTURE OF THE
MINISTRY OF ENERGY
MARCH 1980



PROPOSED STRUCTURE OF THE MINISTRY

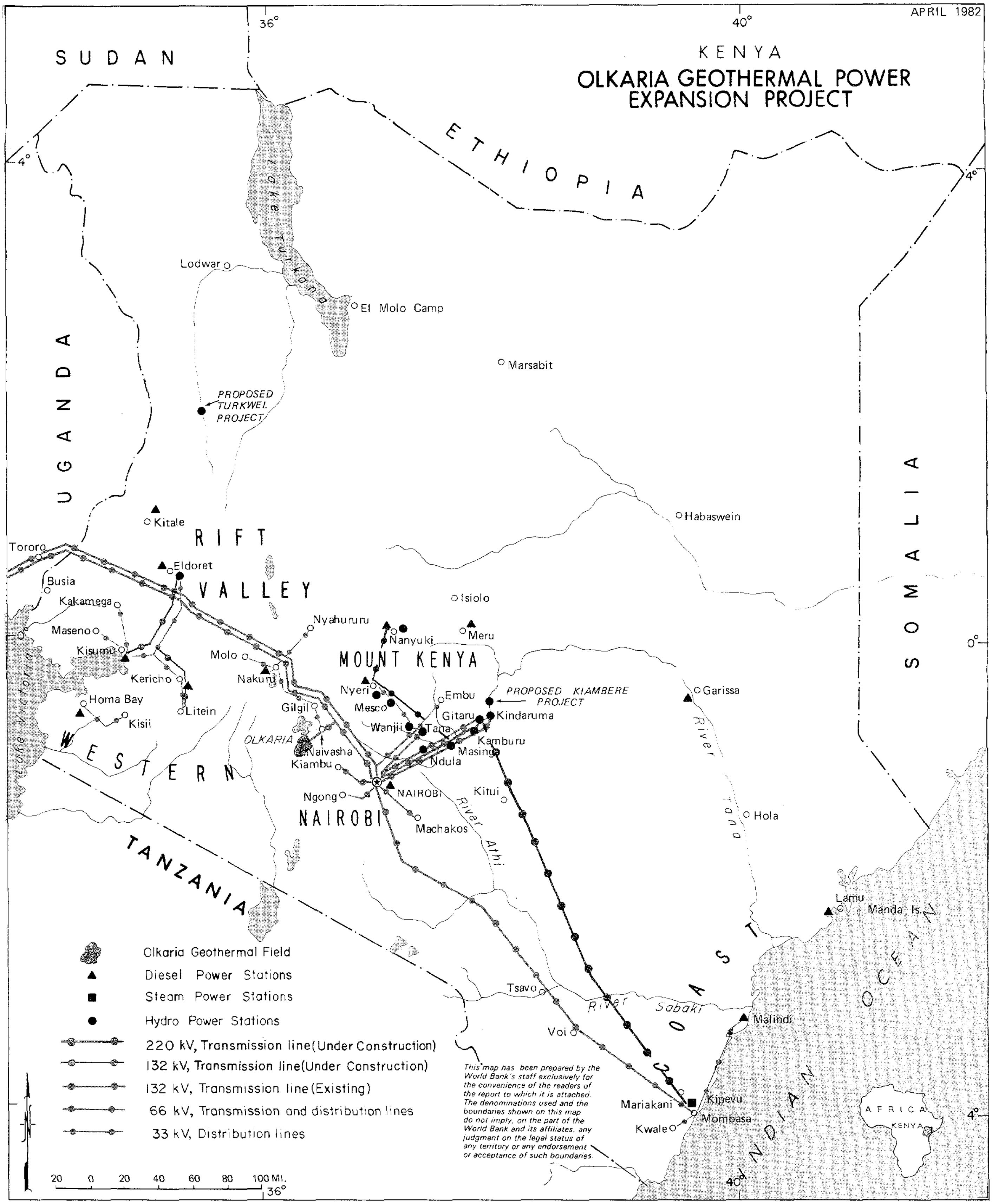
KENYA

LIST OF EXPLORATORY WELLS 1/

	Well	Total Depth (in ft)	Bottom Hole	Operator	Year
1.	Ras Kalug - 1	5,043	Permo-Carb	Mehta	1959
2.	Kipini - 1	12,014	U. Cretaceous	BP/Shell	1971
3.	Pate - 1	13,736	Eocene	BP/Shell	
4.	Dodori - 1	14,140	U. Cretaceous	BP/Shell	
5.	Walu - 1	5,800	U. Cretaceous	BP/Shell	
6.	Walu - 2	12,230	L. Cretaceous	BP/Shell	
7.	Garissa - 1	4,067		BP/Shell	
8.	Wal Merer - 1	12,000		BP/Shell	
9.	Hargaso - 1	10,141	L. Albian	Texas Pacific	Sept/Dec. 1975
10.	Anza - 1	12,015	Cretaceous	Chevron/Esso	Jan./Apr. 1978
11.	Bahati - 1	11,220	Tertiary	Chevron/Esso	May/Jul. 1978
12.	Simba - 1	11,824	n.a.	Total/SNEA	November 1977/78

1/ BP/Shell also drilled 15 statigraphic holes.

IBRD 16389


APRIL 1982
KENYA
OLKARIA GEOTHERMAL POWER EXPANSION PROJECT
36°
40°
4°
0°
SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
Lake Turkana
Lake Victoria
Lodwar
El Molo Camp
Marsabit
PROPOSED TURKWEL PROJECT
Habaswein
Kitale
RIFT VALLEY
Tororo
Eldoret
Busia
Kakamega
Maseno
Kisumu
Kericho
Litein
Homa Bay
Kisii
WESTERN
Molo
Nakuru
Nyahururu
Nanyuki
Meru
Isiolo
MOUNT KENYA
Nyeri
Mesco
Wanjii
Tana
Embu
Gitaru
Kindaruma
PROPOSED KIAMBERE PROJECT
Kamburu
Masinga
Ndula
Gilgil
OLKARIA
Naivasha
Kiambu
Ngong
NAIROBI
Kitui
Machakos
River Athi
Garissa
River Tana
Hola
Lamu
Manda Is.
COAST
INDIAN OCEAN
Tsavo
Voi
River Sabaki
Malindi
Mariakani
Kipevu
Mombasa
Kwale
AFRICA
KENYA
Olkaria Geothermal Field
Diesel Power Stations
Steam Power Stations
Hydro Power Stations
220 kV, Transmission line (Under Construction)
132 kV, Transmission line (Under Construction)
132 kV, Transmission line (Existing)
66 kV, Transmission and distribution lines
33 kV, Distribution lines
20 0 20 40 60 80 100 MI.
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