in 2005. This implies that the per capita consumption of woodfuel will decrease from the present level of 1.2 tons to 1.0 tons per annum.

Supply

Table 9.22 gives the data on standing stocks and sustainable yields of forest resources in the country. As seen from the table, the sustainable yield of about 25 million m^3/year or about 18 million tons/year has been surpassed by the current woodfuel consumption of 23.4 million tons.

Of the 9.5 million tons of woodfuel consumed in the Region in 1985, only less than 3 million tons were supplied from the yield and the rest from stocks. To what extent the increased future demand for woodfuel can be supplied from the sustainable yield would depend on the success of afforestation activities on all the different levels from the Central Government to individual farmers and households. This will be examined and recommendations will be made in the following section.

(5) Other forms of energy

Power alcohol

Potential demand for power alcohol is quite large and growing as long as its price remains competitive for blending with gasoline. The Kenyan Government embarked in 1977 on the implementation of a national power alcohol programme, aiming at reducing Kenya's dependance on petroleum products. Its venture started off with the commissioning of the Agro-Chemical and Food Company (ACFC) in Muhoroni, Kisumu district in May 1983. Its alcohol has since been blended with both regular and premium gasoline in Nairobi.

Supply potential of power alcohol depends on the availability of molasses as raw materials. ACFC is collecting molasses from four sugar factories to produce about 50,000 litres per day of power alcohol at present, although the production capacity is 60,000 litres per day.

Another project on power alcohol has been proposed in Mumias, Kakamega district and waiting for the Government approval. This project of Mumias Sugar Company (MSC) has a planned capacity of 60,000 litres per day. The cost of producing alcohol is said to be about half the petrol price,and the production cost is around KShs.5 per litre (interview with MSC).

Power alcohol projects, however, have at least two disadvantages. One is high capital costs, and the other is foreign exchange required for the facilities. The total costs of planned MSC alcohol plant will be KShs.200 million, of which KShs.77 million is for the equipment to be imported from Brasil in a completed form.

Biomass

Manufacturing briquettes from sawdust and other waste materials is considered one of measures to conserve wood resources. The main objective of supplying briquettes from sawdust and other materials is to substitute for charcoal in urban areas. In Kakamega district, for instance, 166 thousand tons of charcoal are presently used annually, of which one-tenth can be substituted by briquettes to be produced by 10 plants having the capacity of 3,000 tons per annum each. About 100,000 tons of sawdust and other forest wastes are available as raw materials, mainly, in Kakamega, Kaimosi, Mt. Elgon and Nandi forests.

Utilization of bagasse from sugar factories presents another possibility. Utilization of molasses was already discussed above.

Biogas

Biogas is an alternative to woodfuel and petroleum in rural areas, used for cooking, lighting or even fueling internal combustion engines. It is produced from anaerobic decomposition of organic materials in a digester. Raw organic materials abound in the Region, but the problem is how to collect them. SEP has been extending its biogas programme in zero-grazing farms in the Region, including Kisii and Kakamega.

According to SEP report, the cost of energy for cooking and lighting by rural households would be KShs.1,700 per year with the biogas produced by the Sasse type promoted by SEP, while it is in the range of KShs.2,000 - 3,000 by using fuelwood, charcoal or kerosene.

Solar heating

Solar thermal energy can be used for water heating, drying crops and other purposes. Due to its geographic location, solar radiation in the country and the Region is high and evenly distributed throughout a year. Technologies for utilizing solar thermal energy have been well established for heating and drying purposes. Widespread use would be constrained only by potential uses.

Photovoltaics

Solar photovoltaic energy can be used for water pumping, rural electrification, electric fencing, telecommunication and micro-electric devises. Their application seems to be constrained only by the fact that photovoltaic cells are currently manufactured in developed countries and their costs are still comparatively high. The costs, however, have been decreasing steadily and will reach around US$2-3 by 1990 in Japan to become competitive with diesel for power generation.

If the costs of associated facilities such as inverter, batteries and supporting structure are added, the total cost of photovoltaic power generation system would be about US$12 per Wp in 1985. Assuming a village with the population of 100, the system of 10 kW would cost about US$120,000 or Kshs.1.8 million.

Wind

Wind energy can be used directly to pump water and indirectly to generate power for various uses. The potential for its utilization is promising, and the Government is already involved in programmes to promote its application. In the Region, there are several windmills installed recently, and some more are planned to be installed in the current five year plan period.

The lack of adequate wind energy data, however, is pointed out by NEP as one of constraints. Technology development is also necessary to obtain a higher operation ratio.

Wind mills appear to compare favourably with diesel pumps at 4,000 gallons of water per day, although less favourable at 2,000 gallons per day (UNDP/World Bank, 1983). Power generation by wind mill would be superior to photovoltaic generation for the daily demand larger than 1 kWh according to SEP.

9.2.2 Demand structure

The demand for energy in Kenya is bound to grow significantly for years to come, as a result of population growth and socio-economic development. Demand structure for energy or emphasis on different sources of energy will change, as the economy develops. Such changes will also be affected by Government policies and interventions.

The Ministry of Energy and Regional Development has provided alternative projections of demand for different sources of energy as indicated in the previous subsection. Its "Policy Case" projection is based on the following assumptions as to interventions by the Government.

1) Higher rate of penetration of more efficient (improved) charcoal and woodfuel jikos.

2) Expansion of the energy conservation programme as well as gradual introduction of more energy efficient boilers, kilns and other energy firing systems in both industrial and commercial sectors.

3) Reduction in electric power system losses throughout the national grid.

4) Formation of Stoves Producers Association for the exchange of information on technology and marketing.

The "Policy Case" projection is summarized for 2005 in Table 9.23, and compared with the energy demand in 1985. As seen from the table, the total energy demand is projected to grow from 5.66 million TOE in 1985 to 12.1 million TOE in 2005 at the average annual growth rate of 3.9%. The demand for woodfuel will increase from 4.11 million TOE in 1985 to 9.2 million TOE in 2005, slightly increasing its share to 77% of the total energy demand. The share of petroleum will decline significantly from 23.0% in 1985 to 18.2% in 2005. The demand for electricity will increase its share from 3.4% in 1985 to 5.0% in 2005 to reach about 600 thousand TOE, equivalent to 6,500 GWh (see also Table 9.13).

The energy demand structure in the Region is difficult to analyze due to the lack of quantitative data for different energy sources. The analysis on the previous subsection indicates that the demand structure in the Region may change roughly as follows, under the same set of policy assumptions. The share of woodfuel may slightly decrease to about

80%, while petroleum may increase its share slightly. Electricity will also increase its share as a result of economic development and commissioning of major hydropower plants in the Region.

Although the share in total energy demand will slightly decrease, the quantity of woodfuel demanded will increase by more than 70% by 2005. Only about 20% of this demand can be met by the yield unless aggressive efforts are made to increase the sustainable supply of woodfuel.

9.3 Energy Development Plan

(1) Objective and basic strategy

Given the prospects outlined above, the objective of energy development in the Region should be to reduce the dependence on woodfuel as much as possible by promoting the development of alternative sources of energy, while intensifying the efforts of afforestation to increase the timber stock and sustainable yield. However, options available for developing alternative energy sources are quite limited; chief among them are hydropower, biomass and to a much lesser degree other new types of energy.

Thus the basic strategy for energy development in the Region are set as follows. First and foremost, aggressive measures should be taken to increase sustainable yield of woodfuel. Second, every effort should be made to accelerate the development of hydropower. Third, of the new types of energy, those that can be developed with readily available technologies should be put to implementation. Fourth, demonstration schemes should be initiated at an early time for other new types of energy to prepare for a longer term future.

Under the basic strategy presented above, more specific measures are sought below to develop alternative forms of energy.

(2) Woodfuel programmes

Promotion of agro-forestry and on-farm tree planting

Agro-forestry is described in SP1 as an important measures to increase sustainable woodfuel supply without reducing areas for food and cash crop production. In the Region, agro-forestry and on-farm tree planting are already quite popular in some areas. According to the work of KWDP, farms in high potential areas have much larger woodlot and windrow areas and the area of woodlots and the extent of on-farm tree planting tend to increase following land adjudication. In fact, 15.9% of all land in Kakamega (excluding the Kakamega forest) is occupied by trees around houses and along paths, in hedges, woodlots or windrow, and in bush and riparian woodland. The corresponding figure for Kisii is 15.6% (ESMAP,1985).

It may be assumed from the observation above that the area corresponding to 15% of the agricultural land can be developed for agro-forestry and on-farm tree planting. This will make some 300 thousand ha available to produce a total of 5 million tons of wood on sustainable basis.

For this to be possible, the following measures would be indispensable:

1) to provide farmers with seeds and seedlings of selected species, and

2) to extend advice to farmers on nursery practices, and other technical advice on woodlot management.

The measures can be taken basically by extending the efforts of KWDP, but coordination of activities by Forestry Department (e.g. RAES, see below), the Ministry of Agriculture (e.g. agro-forestry programme) and other agencies would be necessary.

Aggressive re-afforestation

As stated before, significant mining of forest resources is already taking place in the Region, especially in Nyanza and Western Provinces. If this trend continued, over 50% and 40% of wood resources in respective provinces would have been lost by the end of the century. In order to counteract such a trend, an aggressive programme has to be implemented to expand the sustainable forest resources.

The Forestry Department has planted within gazetted forests some 165,000 ha with either fast growing softwoods (150,000 ha) or hardwoods. The Department's planting target is 6,400 ha of softwood per year, although the average attained so far is 5,500 ha. If this target is attained for the next 20 year period, 128,000 ha can be newly afforested. Of this total, at least 50,000 ha should be in the Region, if the present distribution of gazetted forests in the country is considered.

The forest area in the Region is as shown in Table 9.24. Excluding those portions of districts only partly falling in the Region, the remaining part of LBDA region has over 320 thousand ha of gazetted forest area. Of this total area, softwood plantation occupies about 52 thousand ha and fuel wood/pole plantation 5 thousand ha. The remaining 266 thousand ha are covered by production forest, protection forest, bush, bamboo or grassland. The afforestation area of 50,000 ha may be selected from the last category of gazetted forest areas. The areas identified by KWDP for industrial plantations are shown in Figure 9.5.

The Rural Afforestation Extension Service (RAES) was created in 1971 by the Forestry Department to deal with community forests outside gazetted forest areas as already mentioned. Much of the work of RAES is presently directed toward the production of tree seedlings for distribution and sale to farmers. The Department has been aiming at 200 million seedlings per year, sufficient to cover the entire area to be re-afforested.

In addition to the formal tree planting outlined above, tree-planting activities in the private sector should be encouraged. Activities of farmers in rural areas are already mentioned above. They obtain the major portion of their seedlings from on-farm nurseries and only small portions from institutional nurseries. Thus their increased activities would not much inflict on the public afforestation programmes. Commercial establishment of plantations would also be induced, if proper pricing systems are established reflecting the real costs of establishing and operating such plantations. The total area of commercial plantations is assumed to be 50,000 ha in 2005.

With all these measures for aggressive afforestation, some 1.5 million tons of wood may be newly made available by 2005 on sustainable basis.

Establishment of peri-urban charcoal plantations

In order to meet the growing demand for charcoal by urban households, charcoal plantations should be established within reasonable proximity of major urban areas. The first few establishments should be made by the public sector, but the majority should eventually be established by the private sector by the price and other incentive measures.

Since there are hardly any gazetted forests near those towns such as Kisumu, Siaya, Homa Bay and Busia which will soon face serious charcoal shortage, private land should be made available for charcoal plantations. Potential areas include Kisian Hills around Kisumu, Adiado Hills near Busia and others. These are not high potential areas and can economically be turned into commercial forestry without serious conflicts with crop cultivation.

Overall assessment

By successfully implementing the general measures described above, about 6.5 million tons of wood will become newly available by 2005 on sustainable basis. Thus the rate of timber depletion in 2005 will be about 7 million tons per year, while the present rate is about 6 million tons per year. This will contribute greatly to delaying the timber depletion and gaining time for developing alternative sources of energy. Without these measures, the timber depletion rate would be as much as 13.5 million tons per year in 2005.

As the first step of implementing the general measures presented above, a few pilot projects should be implemented by the public sector in Phase 1. First, a plantation should be established by the Forestry Department in one of the areas within gazetted forests already identified in the Region for this purpose. Second, a model woodlot should be established with the participation of farmers in high potential agricultural area such as Kisii and Kakamega. The possibility should be sought to let it serve KTDA tea factories in Kericho. Third, a pilot charcoal plantation should be established close to the major municipalities, Kisumu and Eldoret.

In addition, a proper pricing policy should be taken as recommended by the UNDP/World Bank study. It includes the following:

- to lift the price controls on kerosene and LPG so that the real economic costs of supply will be reflected, and

- to ensure that charcoal prices reflect the real economic costs of production.

Since the woodfuel is the major concern in the energy development and the household energy use especially for cooking is the major consumer category, comparative costs of using alternative cooking fuels may be most relevant in determining proper pricing. Table 9.25 summarizes the results of the UNDP/World Bank study on this aspect. As seen from the table, the charcoal is by far the most economical fuel in larger cities where fuelwood cannot be easily collected by users themselves. If the charcoal prices are raised, most likely kerosene will substitute for it, as electricity is more expensive in most urban areas except larger cities. This is not a desirable effect. Thus favourable effects of such pricing should be found first in the conversion to more efficient charcoal stoves and second in the encouragement of commercial establishment of charcoal plantations. To see the multiplicity of socio-economic impact, a further study should be conducted in the nearest future.

(3) Measures for other forms of energy

Petroleum products and coal

As discussed in the previous subsection, to what extent the supply of petroleum products and coal can or should be expanded is first of all a policy issue. The national policy is to suppress their demand by pricing and other measures. Secondly it is a question of transport capacity, especially for the Region. To answer this question, a comprehensive comparative study would be required to examine alternative modes of transport including the extension of oil pipeline, the improvement of roads and the reinforcement of railway system, particularly in view of the export demand from neighbouring countries, the internationalization of Kisumu airport and more generally future relationships with neighbouring countries.

Electricity

For power development, measures should be taken especially for hydropower development and rural electrification. Of prospective hydropower projects, those of which the feasibility has been verified should immediately be proceeded to implementation. These are the Sondu/Miriu, the first stage of the Sondu River multipurpose development project, Teremi and Webuye. Other hydropower projects need to be studied in detail in the nearest future aiming at implementation by 2000. They are Magwagwa, the second stage of the Sondu project, and Nandi Forest. Other multipurpose schemes such as Namba Kodera and Hemsteds Bridge would be subject to the viability of respective irrigation components, which need to be examined in detail.

The national Rural Electrification Programme was recently intensified by merging the KPLC Amenity Programme. The KPLC now contributes 2% of its gross annual revenue to the Rural Electrification Fund. Under the predecessor of this programme, the following towns were electrified in the Region: Butere, Vihiga, Kimilili and Busia in Western Province, Irianyi and Migori in Nyanza Province, Iten and Londiani in Rift Valley Province. With the electrification of Kapenguria in 1987, all the district capitals in the Region will have been electrified. Therefore, the target of the programme is now shifted to other smaller secondary towns. Those towns associated with the eight area development schemes formulated by this Master Plan should be given the highest priorities (Master Plan Report).

Biomas

Of all the possibilities for utilizing biomas or agricultural/forestry residues, the briquetting of sawdust and other biomas materials should be examined for earlier implementation, since both raw materials and technologies are readily available. A demonstration plant should be established and start its operation in Phase 1 with the capacity of several hundred tons of briquetts per year (Section 4.5, Sector Report).

Commercial plants should follow with the capacity ranging from several hundred to one thousand tons per year. Potential locations include Uasin Gishu and Nakuru districts. Products will be delivered to urban areas in the Region.

Some government interventions may be necessary for dissemination of briquett utilization. Pricing of sawdust (which at present is not priced), tax credits or subsidies for manufacturers and other measures suggested in NEP for charcoal should be examined. It is worth considering the possibility that rural cooperatives would be supported to grow into suppliers of briquetts. This may be a step for them to play a wider role in "an integrated energy industry" in rural areas, combining other forms of energy to meet the demand specific to the respective areas.

Solar heating

Demonstration projects for solar water heating should be commenced in the nearest future first in governmental buildings and other public facilities. The planned new headquarters of LBDA may provide one of the first such opportunities. As the hotel accommodations are expanded in Phase 1 such as the extension of Sunset Hotel in Kisumu and Homa Bay Hotel in South Nyanza (Chapter 6, Sector Report), the installation of solar water heater should be considered.

Photovoltaics

A few pilot projects for solar photovoltaic generation should be considered also in Phase 1. Some sites along the Lake shores, where fishery centers are planned (Chapter 3, of Sector Report), are good candidates for such a demonstration project. The electricity produced by photovoltaic cells may be used for lighting of market and other community facilities or even for ice-making and refrigeration. Another site should be selected in agricultural areas, where the electricity will be used for milling grains, pumping water for irrigation and other community services.

Biogas

The current efforts made under both SEP and KRDP for improving biogass digesters and disseminating them should be intensified. Areas in Kisii and Kakamega districts are already covered by these programmes, but they should be expanded to other areas. Increased production of pigs envisioned by this Master Plan would present new opportunities, as pig manure is an excellent raw material for biogas production (Chapter 2, Report on Preparatory Study). This possibility should be incorporated into the programmes when they are expanded.

Power alcohol

As the production of sugarcane increases following the Master Plan, the production of molasses will also increase to provide raw materials for industrial alcohol production. By the year 2005, about 160 thousand tons of molasses can be additionally produced, sufficient for the production of 40 thousand kiloliters of alcohol per day. However a gasohol plant planned in Kisumu has been suspended since 1982 in the middle of construction. Thus, the possibility to re-vitalize this plant should be investigated first (more details of power alcohol project in Chapter 4 , Sector Report).

Wind

More windmills should be installed in different types of areas in the Region such as Lake shores, highland, hillsides etc. and the performance should be monitored and recorded to obtain data useful for further dissemination in the future. A research should be undertaken to investigate into not only improved efficiency but also manufacturing with local materials.

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Table 9.1 Energy Consumption at End-Use by Sector in Kenya, 1985

Sector	1000 TOE*	%
Household	3,304	58.4
Agriculture	571	10.1
Industry	864	15.3
Commerce	274	4.8
Transportation	648	11.4
Total	5,661	100.0

Note: * Tons of oil equivalent; 1 ton of oil = 10 x 10^6 kcal = 42 x 10^6 Joule
Source: MOERD, National Energy Policy

Table 9.2 Energy Supply by Source in Kenya, 1985

(Unit: 1000 TOE)

Energy Source	Production	Import	Total Primary Supply	Supply after Conversion
Woodfuel[1/]	5,160		5,160	
Fuelwood				3,486
Charcoal				624
Coal		60	60	60
Crude oil		1,980	1,980	
LPG				25
Gasoline		17	17	352
DPK		11	11	373
Gas oil		54	54	530
IDO				32
Aviation gas[2/]		7	7	7
Residual fuel				638
Ethanol	4		4	4
Electricity				214
Hydro	403		403	
Geothermal	80		80	
YEB imports		52	52	
Total	5,647	2,181	7,828	6,345

Notes: 1. Exact data not available, projections based on 1980 figures using annual growth rates of 5% for fuelwood and 10% for charcoal.
2. Excludes international aviation

Source: Same as Table 9.1

Table 9.3 Net Domestic Sale of Petroleum Fuels by Consumer Category, 1981-1985

(Unit: 1000 tons)

User	1981	1982	1983	1984	1985[1/]
Agriculture	71.9	45.8	45.5	44.0	48.9
Retail Pump Outlets and Road Transport	515.7	507.4	520.5	568.7	616.6
Rail Transport	45.2	41.9	40.9	42.5	35.0
Tourism	-	8.5	8.0	9.3	9.4
Marine (excluding Naval forces)	182.0	144.1	201.7	158.9	147.1
Aviation[2/] (excluding Government)	349.6	283.2	250.6	258.8	260.4
Power Generation	109.9	95.6	43.6	54.5	27.4
Industrial, Commercial and Other	464.0	445.2	416.0	452.6	452.7
Government	95.3	51.2	47.7	51.8	46.7
Balancing Item	-249.1	-133.6	-201.5	-158.7	-146.9
Total	1,584.5	1,489.3	1,373.1	1,482.4	1,497.3

Notes:
1. Provisional
2. Includes about 87 per cent of its total sale to foreign airlines at airports in Kenya

Source: Central Bureau of Statistics, Ministry of Finance and Planning, "Economic Survey 1986", 1986

Table 9.4 Electricity Generation in Kenya by Mode, 1981-85

(Unit: Gwh)

Year	Hydro	Thermal	Geothermal	Total
1981	1,381	334	39	1,754
1982	1,397	311	96	1,804
1983	1,478	164	262	1,904
1984	1,491	225	233	1,949
1985	1,680	139	336	2,155

Source: Economic Survey, 1986

Table 9.5 Electricity Enrgy Supply and Demand Balance, 1981-85

(Unit: Million KWh)

	1981	1982	1983	1984	1985
DEMAND					
Domestic and Small Commercial	438	455	484	514	545
Large Commercial and Industrial	1,096	1,121	1,144	1,206	1,354
Off-peak	118	114	109	116	106
Street Lighting	11	11	10	9	9
Total	1,663	1,701	1,747	1,845	2,014
Transmission losses and unallocated demand	256	284	294	276	310
TOTAL DEMAND - TOTAL SUPPLY	1,919	1,985	2,041	2,121	2,324
Of which imports from Uganda	194	212	179	215	215
Net Generation	1,725	1,773	1,862	1,906	2,109

Source: Same as Table 9.3

Table 9.6 Installed Power Generating Capacity and Energy Generation, 1985

Company or Development Agency	Installed Capacity (MW)	Energy Generation Million KWh	% Contri-bution
Kenya Power and Lighting Co.			
Hydro:-			
(Ndula	2.00)		
(Sagana	1.50)		
(Gogo	2.00)		
(Selby	0.40)		
(Mesco	0.38)		
	6.28	17	1
Oil Fired:-			
Thermal - Kipevu	98.0	83	4
Gas Turbine	30.1	4	-
Diesel	20.1	2	-
Sub-totals	154.48	106	5
Kenya Power Co. (KPC)			
UEB imports	30.0	215	9
Tana River - Hydro	14.4	67	3
Wanjii River - Hydro	7.4	39	2
Olkaria - Geothermal	45.0	336	14
Sub-totals	96.8	657	28
Tana River Development Co. (TRDC)			
Kamburu - Hydro	91.5	398	17
Gitaru - Hydro	145.0	776	34
Kindaruma - Hydro	44.0	202	9
Sub-totals	280.5	1376	60
Tana and Athi River Development Authority (TARDA)			
Masinga - Hydro	40.0	161	7
Sub-totals	40.0	161	7
TOTAL	571.78	2300	100

Source: MOERD, National Energy Policy

Table 9.7 Provincial and National Wood Supply and Demand

(Unit: million tons)

	Central Nairobi	Coast	Eastern	North Eastern	Nyanza	Rift Valley	Western	Total
Source of Demand								
Local Woofuel Demand	2.46	1.94	3.11	.48	2.51	3.94	1.98	-
Woodfuel Demand Other Regions	-	-	.94	.06	-	1.91	.30	-
Sub-total Wood-fuel Demand	2.46	1.94	4.06	.54	2.51	5.85	2.28	19.64
Feedstock Demand	.18	.01	.03	-	-	.51	.04	.77
Total Demand	2.64	1.95	4.09	.54	2.51	6.36	2.32	20.41
Source of Supply								
Sustainable Supply	.99	1.62	3.06	.54	.38	4.17	.31	11.07
Supply from Stocks	1.63	.33	1.02	-	2.13	2.14	2.00	9.26
Total Supply	2.62	1.95	4.08	.54	2.51	6.31	2.31	20.33
Shortfall	.02	-	-	-	-	.05	-	.08

Notes: 1) Woodfuel demand from other regions stands for wood demand for charcoal from other regions, i.e. exports of charcoal to other regions.

2) Rural Pole demand is omitted from this table.

Source: Same as Table 9.1

Table 9.8 Estimate of Charcoal Consumption in Kakamega District

Consumption per capita per annum*	(A)	128.2 kg
Population in 1985**	(B)	1,306 thousand
A x B		166,400 tonnes

Notes: * Barnes, C., Ensminger, J., and O'keefe, P., ed. "Wood, Energy and Households, Perspectives in rural Kenya", 1984

** Our estimate

Table 9.9 Percentage Utilization of Each Household Fuel by Province and End-Use

(Unit: %)

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

Table 9.10 Estimation of Household Electrification Ratio

	Power Supply Region					Whole
	W.Kenya	R.Valley	Coast	Mt.Kenya	Nairobi	Country
Population 1979 census[1]	6,118,423	733,015	1,342,794	3,257,534	4,362,194	
Assumed growth rate % p.a. '79-'83	3.5	5.0	4.0	4.0	5.0	
1983 Population	7,021,000	891,000	1,571,000	3,811,000	5,302,000	
1979 No. of household	1,120,707	152,371	269,199	662,431	880,661	
1979 Avg. houeholds size	5.46	4.81	4.99	4.92	4.95	
1983 No. of h.h estimated	1,285,900	185,200	314,800	774,600	1,071,100	3,631,600
1983 No. of domestic consumers[2]	18,878	11,040	35,460	10,188	72,467	148,042
Household electrification ratio (%)	1.5	6.0	11.3	1.3	6.8	4.1

Notes: 1. Power supply regions do not coincide with administrative jurisdictions; therefore, the population of any power supply region was estimated by using the census data by district. That is, the population of districts having larger demand centers registered under each power supply region constitutes the population in this power supply region.

2. The number of consumers in the domestic and small commercial category; off-peak domestic consumers not included to avoid double-counting.

Source: Japan International Cooperation Agency, "Sondu River Multipurpose Development Project", December 1985.

Table 9.11 Comparison of Demand Structure (1983)

(Unit: %)

	Power Supply Region					Whole
	W.Kenya	R.Valley	Coast	Mt.Kenya	Nairobi	Country
Domestic & small commercial (+off-peak domestic)	19.2 (21.1)	36.5 (38.8)	20.7 (21.8)	40.1 (43.6)	32.7 (43.1)	28.6
Industrial & large commercial	78.2	59.8	77.5	55.5	56.1	64.1
Public & other	2.6	3.6	1.8	4.6	11.3	7.3

Source: KPLC

Table 9.12 Domestic Petroleum Products Demand Projections

(Unit: 1000 tons)

Product	1980	1984	1985	1986	1990	1995	2000
LPG	21	22	24	26	36	38	40
Gasoline	300	275	279	288	340	351	372
Kerosene IK	90	95	97	105	153	160	372
Jet Kerosene	367	343	354	362	396	437	461
Gas oil	407	413	432	464	601	643	671
Industrial/ Marine Diesel	70	65	65	62	58	56	54
Fuel oil	533	551	520	473	260	240	233
Bitumen	33	38	42	47	50	51	53
Total	1,821	1,802	1,813	1,827	1,893	1,976	2,053

Source: NEP

Table 9.13 Electric Power Demand Forecast in Kenya

Year	JICA Load[1/] (MW)	JICA Generation (GWh/yr)	Acres[2/] Load[1/] (MW)	Acres[2/] Generation (GWh/yr)
1985	355	2,148	394	2,318
1886	371	2,240	423	2,477
1987	387	2,340	447	2,617
1988	406	2,457	472	2,761
1989	429	2,592	500	2,912
1990	454	2,747	529	3,077
1991	482	2,912	559	3,248
1992	511	3,087	589	3,418
1993	541	3,272	620	3,598
1994	574	3,489	650	3,787
1995	608	3,677	689	3,985
1996	645	3,898	726	4,194
1997	683	4,131	765	4,414
1998	724	4,379	804	4,644
1999	768	4,642	847	4,885
2000	814	4,920	892	5,138
2001			939	5,404
2002	915	5,528	989	5,681
2003			1,039	5,974
2004			1,093	6,280
2005			1,150	6,601

Notes:
1. A load factor applied is 0.69 for JICA and 0.67 to 0.65 for Acres
2. Acres' forecast for net converted to the sent-out basis, taking into account the station use, which is assumed 1.7% and 2.0% of the total load and generation, respectively (see below).

Station use

1) Power (load)

Assumed station use:

Thermal: 6% of effective power

Hydro: 0.8%

Weighted average of station use:

$$\frac{0.003 \times (\text{Total effective power of hydro}) + 0.06 \times (\text{Total effective power of thermal})}{(\text{Total effective power of hydro}) + (\text{Total effective power of thermal})}$$

$$= \frac{0.003 \times 589 + 0.06 \times 184}{(589 + 184)} = \frac{12.807}{773} = 0.017$$

2) Energy (generation)

Assumed station use: Same as above for thermal and hydro

Weighted average of station use:

$$\frac{0.003 \times (\text{Total generated energy of hydro}) + 0.06 \times (\text{Total generated energy of thermal})}{(\text{Total generated energy of hydro}) + (\text{Total generated energy of thermal})}$$

$$= \frac{0.003 \times 2{,}332.9 + 0.06 \times 967.1}{2{,}332.9 + 967.1} = \frac{65.0}{3{,}300} = 0.02$$

* Generated energy of thermal plants has been estimated assuming the operating rate of 0.6.

Table 9.14 Construction and O&M Cost of Thermal Candidates for Planting-up of Kenya Power Supply System

Type	Installed Capacity MW	Annual Max. Operation Rate (%)	Lead Time Year	Construction Time Period Year	Construction Disbursement	Life Time Year	Construction US$/KW	O&M Cost (%)	Fuel Price US$/t	Calorific Value Kcal/kg	Fuel Cost US¢/kwh
Oil-fired	60 1)	70	2	5	0.05/0.25/0.40/0.20/0.10	30	1230	2	170	10300	5.25
	120	70	2	5	"	30	1230	2	170	10300	5.25
Coal-fired	60 1)	70	2	5	"	30	2115	2	50	6200	2.57
	120	70	2	5	"	30	2115	2	50	6200	2.57
	180	70	2	5	"	30	2115	2	50	6200	2.57
Gas-turbine	20	50	0	2	0.40/0.60	25	660	2.5	270	10800	8.95
	40	50	0	2	"	25	535	2.5	270	10800	8.95
Diesel	2	60	0	1	1	20	1515	3	270	10800	6.32
	5	60	0	1	1	20	1155	3	270	10800	6.32
	10 2)	60	0	1	1	20	930	3	270	10800	6.32
	20	60	0	1	1	20	930	3	270	10800	6.32
	30	60	0	1	1	20	930	3	270	10800	6.32

Notes:

1) Maximum unit capacity is set at 60 MW considering the system reliability as recommended by WLPU (Consulting Engineers in England), and it is confirmed by the PCR (Consulting Engineers in England) reconaissance that plant construction sites are available including coal handling facilities at Port Reitz, Mombasa.

2) Maximum unit capacity is set at 10 MW.

3) Construction costs include those of related infrastructure such as coal handling facilities in the case of coal-fired thermal.

Sources: JICA, Feasibility Study at Sandn River Multipurpose Development Project, December 1985.

Table 9.15 Construction and O&M Cost of Hydro Candidates for Planning-up of Kenya Power Supply System

Project	Installed Capacity MW	Firm Energy GWh/year	Lead 1) Time Year	Construction Time Period Year	Construction Disbursement	Life Time Year	Construc- 2) tion Cost Million US$	O&M 3) Cost (%)
Hydro								
Sondu	48.6	32	3	4	0.20/0.30/0.30/0.20	50	71.6	1
Magwagwa	94.6	481 4)	5	5	0.15/0.25/0.30/0.20/0.10	50	175.7	1
Mutonga	70	153	5	5	"	50	202.5	1
Grand Falls	120	321	5	5	"	50	524.7	1
Adamson's Falls	50	200	5	6	0.15/0.20/0.25/0.20/0.15/0.05	50	606.3	1
Munyu	38	133	5	5	0.15/0.25/0.30/0.20/0.10	50	261.1	1
Nandi Forest	44.5	195	5	4	0.20/0.30/0.30/0.20	50	82.5	

Notes:
1. Presumable lead time before construction is set forth as follows: 2 years for feasibility study, 1 year for finance and tendering, and 2 years for detailed design, Lead time is reduced based on the project maturity.
2. Price level is set at December 1986.
3. Annual O&M costs are expressed with percentage for construction cost.
4. Incremental firm energy from Sondu by the installation of Magwagwa is counted in Magwagwa.

Sources: JICA, Feasibility Report on Sondu Hydropower Development Project, December 1986
PCR, Generation and Economic Study for Turkwell Gerge Project, 1985.

Table 9.16 Existing and Committed Hydro Plants in Kenya Power Supply System

Plant	Installed Capacity MW	Effective Capacity MW	Average/ Firm Energy GWh/year	Installation Year	Remarks
Existing					
Tana	14.4	12.4	69.8	1935/50/53	Average energy
Wanjii	7.4	7.4	43.6	1952	"
Masinga	40.0	40.0	59.7	1981	"
Kamburu	91.5	84.0	324.2	1974/76	"
Gitaru	145.0	145.0	638.8	1978	"
Kindaruma	44.0	44.0	170.4	1968	"
Others	6.2	6.2	22.4		Ndula, Mesco, Sagana, Selby Falls
Unde-construction					
Kiambere	144.0	144.0	683	1988	Firm energy
Turkwell	106.0	106.0	321	1991	"
Electricity imported from the UEB					
	-	30.0			

Source: Same as Table 9.15

Table 9.17 Existing and Committed Thermal Plants in Kenya Power Supply System

Plant	Type	Plate Capacity MW	Effective Capacity MW	Installation Year	Remarks
<u>Existing</u>					
Kipevu-2	Oil-fired	5.0	4.0	1958	**
Kipevu-3	"	5.0	4.0	1958	**
Kipevu-4	"	12.5	10.0*	1961	
Kipevu-5	"	12.5	10.0	1962	
Kipevu-6	"	30.0	27.0	1973	
Kipevu-7	"	33.0	30.0	1976	
Nairobi	Gas-turbine	17.9	12.0	1973	
Nairobi	Diesel	-	8.0	-	***
Ruiru	"	-	2.0	-	***
Mbaraki	"	-	2.0	-	***
Olkaria 1	Geothermal	15.0	15.0	1981	
Olkaria 2	"	15.0	15.0	1982	
Olkaria 3	"	15.0	15.0	1985	
<u>Committed</u>					
Kipevu	Gas-turbine	30.0	30.0	1987	

Notes:
* Based on the proposed rehabilitation works.
** Two 5 MW units will be retired in 1992.
*** These plants will be retired in 1988.

Source: Same as Table 9.15

Table 9.18 Assumptions and Input Data for Power Development Planning (Optimal Planting-up Sequence)

1) Operating characteristics of different types of plants

	Hydro	Coal-fired Steam	Oil-fired Steam	Diesel	Gas Turbine
Economic life, years	50	30	30	20	25
Maximum annual operation rate, %	-	70	70	60	50
Forced cutage rate, %	0.5	8.0	7.0	6.0	7.0
Station use, % of generation	0.3	6.0	6.0	6.0	6.0
Operation and maintenance cost, % of construction cost	1.0	2.0	2.0	2.5	3.0
Adjustment factor	-	1.030	1.028	1.007	1.007

* Adjustment factor is to reflect in the construction costs the difference in operating characteristics of thermal plants from those of hydro plants, and calculated from the rate of station use, transmission loss rate, forced and scheduled outage rates.

2) Other assumptions and data

- Reserve capacity is taken to be 17% of the total capacity.
- Discount rate of 10% p.a. is used to calculate the present worths.
- Replacement cost is 90% of initial investment cost.

Source: JICA Study Team

Table 9.19 Optimal Planting-up Sequence in KPLC (1986 to 2005)
(Based on JICA Demand Projection Prepared for Sondu)

Plang	Type	Plant Capacity MW	Installation Year	Notes
Kipevu	Gas turbine	30	1987	Committed
Kiambere	Hydro	144	1988	Under construction
Turkwell	Hydro	106	1991	Under construction
Sondu	Hydro	48.6	1992	F/S completed
Diesel-1	Diesel	10	1993	
Diesel-2	Diesel	20	1994	
Diesel-3	Diesel	20	1995	
Magwagwa	Hydro	94.6	1996	
Coal-1	Coal	60	1997	
Nandi Forest	Hydro	44.5	1998	
Coal-2	Coal	60	1999	
Coal-3	Coal	60	2000	
Diesel-4	Diesel	30	2001	
Coal-4	Coal	60	2002	
Coal-5	Coal	120	2003	
Coal-6	Coal	60	2004	

Note: * Total discounted present cost is US$920.2 million, not including costs of projects under construction (i.e. Kiambere and Turkwell).

Source: JICA Study Team

Table 9.20 Optimal Planting-up Sequence of KPLC System (Based on Acres Demand Projection)

Plant	Type	Capacity MW	Installation Year	Notes
Kipevu	Gas turbine	30	1987	Committed
Kiambere	Hydro	144	1988	Under construction
Diesel-1	Diesel	20	1990	
Turkwell	Hydro	106	1992	Under construction
Sondu	Hydro	48.6	1992	F/S completed
Coal-1	Coal	60	1992	
Coal-2	Coal	60	1994	
Diesel-2	Diesel	20	1995	
Magwagwa	Hydro	94.6	1996	
Diesel-3	Diesel	10	1997	
Nandi Foest	Hydro	44.5	1998	
Coal-3	Coal	60	1999	
Diesel-4	Diesel	30	2000	
Coal-4	Coal	60	2001	
Coal-5	Coal	60	2002	
Coal-6	Coal	120	2003	
Gas turbine-1	Gas turbine	40	2004	

Note: * Total discounted present cost is US$1,062.7 million, not including costs of projects under construction (i.e. Kiambere and Turkwell).

Source: JICA Study Team

Table 9.21 Demand for Woodfuels by Consumer Category, Kenya (1985)

Consumer category	Roundwood equivalent 10^6 m^3
Urban households	
Fuelwood	0.3
Charcoal	5.2
Rural households	
Fuelwood	14.9
Charcoal	3.6
Industrial	
Urban informal	
Fuelwood	0.1
Charcoal	1.0
Rural informal	
Fuelwood	3.2
Charcoal	0.9
Formal	
Fuelwood	1.7
Commercial/Institutional	
Fuelwood	0.1
Charcoal	0.1
Total Fuelwood	20.1
Charcoal	10.9
	31.0

Source: UNDP/World Bank Energy Sector Management Assistance Programme (ESMAS), Urban Woodfuel Development Programme: Feasibility Report, February, 1987.

Table 9.22 Standing Stocks and Sustainable Yields of Wood, Kenya

Land Category	Standing Stocks (10^6 m^3)	Yields (10^3 m^3/year)
Large farms		
Food crops	3.1	362
Temporary crops	2.0	176
Permanent crops	2.8	250
Uncultivated	32.2	2,650
Small farms		
Food crops	26.9	3,050
Temporary crops	0.9	137
Permanent crops	4.6	262
Uncultivated	34.2	3,087
Urban area, settled	0.1	-
Rural area, settled	1.0	162
Parks/reserves	82.2	475
Natural forests	137.4	2,025
Woodlots	10.0	2,000
Plantations	27.4	850
Savannah bush	635.5	8,475
Savannah grassland	122.8	1,487
Rangeland	50.4	1,412
Total	1,168.5	25,350

Source: Same as Table 9.21

Table 9.23 Change in Energy Demand Structure between 1985 and 2005, Kenya

Energy Source	1985		2005	
	10^6 TOE	(%)	10^6 TOE	(%)
Fuelwood	3.49	(61.7)	7.2	(59.5)
Charcoal	0.62	(11.0)	2.0	(16.5)
Petroleum	1.30	(23.0)	2.2	(18.2)
Electricity	0.19	(3.4)	0.6	(5.0)
Coal, ethanol etc.	0.06	(1.0)	0.1	(0.8)
Total	5.66	(100.0)	12.1	(100.0)

Source: Same as Table 9.1.

Table 9.24 Forest Area by Type and by District

(Unit: ha)

District	Total gazetted forst	Softwood plantations	Fuelwood/pole plantations	Total unplanted area
South Nyanza	nil	735	256	-
Kisii	nil	-	nil	-
Kisumu	nil	443	107	-
Siaya	nil	-	nil	-
Kakamega	37,945	8,770	1,338	27,837
Bungoma	49,383	1,248	179	47,956
Busia	1,500	nil	3	-
Nandi	38,637	3,507	266	34,864
Kericho	109,298	11,709	1,040	96,549
Trans Nzoia	29,057	5,956	385	22,716
Uasin Gishu	56,719	20,070	926	35,723
Total	32,539	52,438	4,500	265,645
Kenya total	1,711,367	150,025	14,790	1,546,552

Note: The total unplanted forest area is made up of the following major cover types.

High Forest:	Productive	395,781 ha
	Protective	460,782
Bushland		308,940
Bamboo		146,481
Grassland		189,500
Mangrove		45,068
Total		1,546,552

Source: ESMAS, "Forest Resources", Working Paper IV, November, 1985.

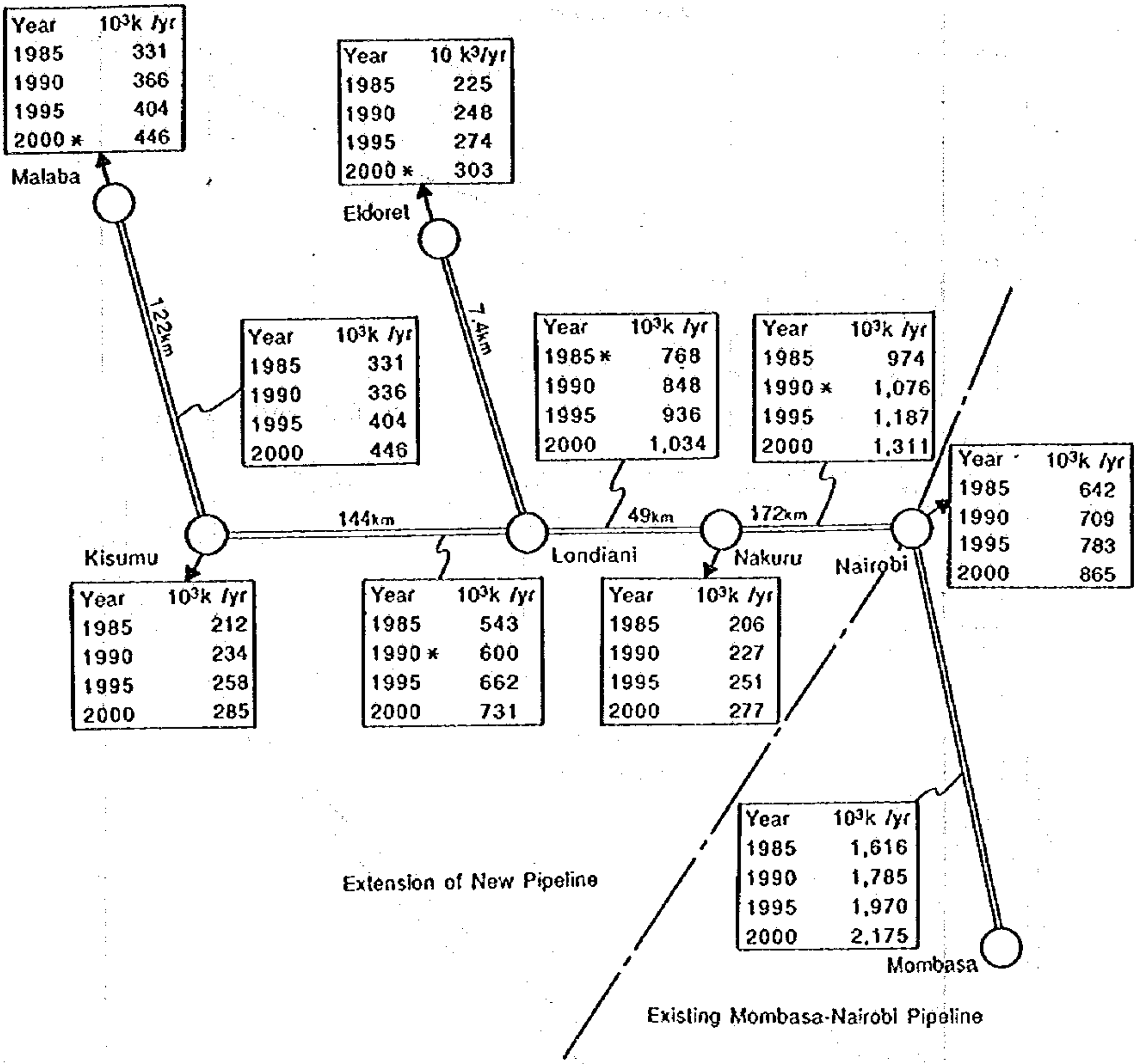
Table 9.25 Delivered Household Energy Costs, Nairobi

Fuel	Unit	Energy Content (MJ/unit)	Energy Price (KSh/unit)	Conversion Efficiency (percent)	Delivered Price (KSh/MJ)	Annual Household Energy Cost (KSh/yr)	Cost of Conversion Device (KSh/yr)	Energy Cost w/ Cooking Device (KSh/yr)
Fuelwood	m3	8990	180.0 a/	13	0.15	676	20	696
	m3	8990	319.0 b/	13	0.27	1196	20	1216
Charcoal	kg	32.5	1.5	20	0.23	1011	24	1035
Paraffin (Kerosene)	lit.	35	6.5	50	0.37	1627	110	1737
LP Gas	kg	45.2	9.2	60	0.34	1486	333	1819
Electricity	kWh	3.6	0.75	75	0.21	1217	200	1417

a/ Fuelwood collected for permit fee of KSh 4 per month.
Collection of 10 kg of wood per hour. Wood density of 0.7 tons/m3.
Labor shadow-priced at KSh 20/day. Wood collected for 330 days per year.

b/ Fuelwood purchased in the market. Quartered and split.

Source: same as Table 9.21



Notes: The annual growth rate is assumed at 2.0%
The year when the extention may be justified is indicated by the asterisk(*).

Source: JICA, National Transportation Master Plan for Kenya, 1984

Figure 9.1 Projected Demand for Petroleum and Extension Timing of Pipeline

REPUBLIC OF KENYA LAKE BASIN DEVELOPMENT AUTHORITY
THE STUDY OF INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE LAKE BASIN DEVELOPMENT AREA
JAPAN INTERNATIONAL COOPERATION AGENCY

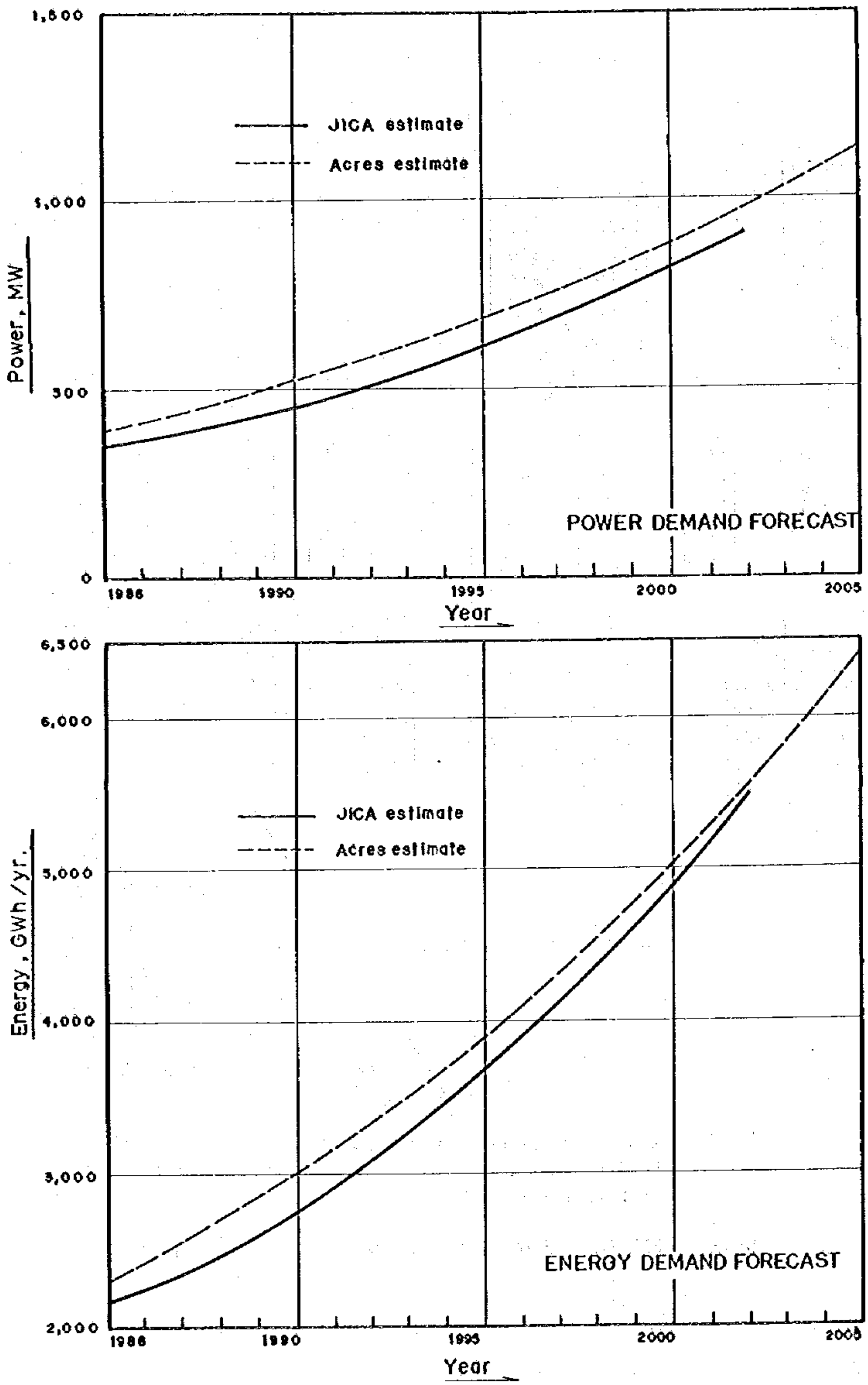
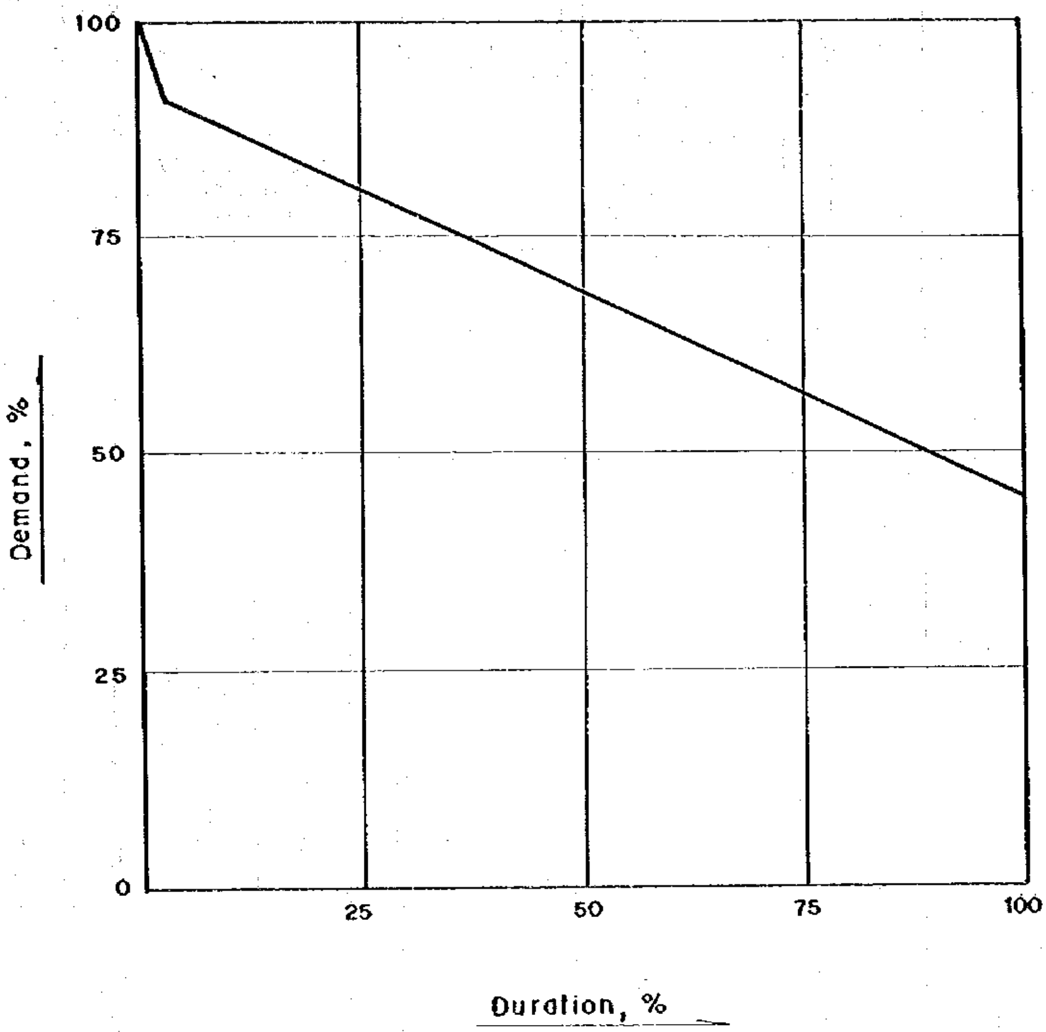


Figure 9.2 Power and Energy Demand Forecast

REPUBLIC OF KENYA LAKE BASIN DEVELOPMENT AUTHORITY

THE STUDY OF INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE LAKE BASIN DEVELOPMENT AREA

JAPAN INTERNATIONAL COOPERATION AGENCY



Load Factor : 0.69 (JICA)
0.65 ~ 0.67 (Acres)

Figure 9.3 Presumed Load Duration Curve

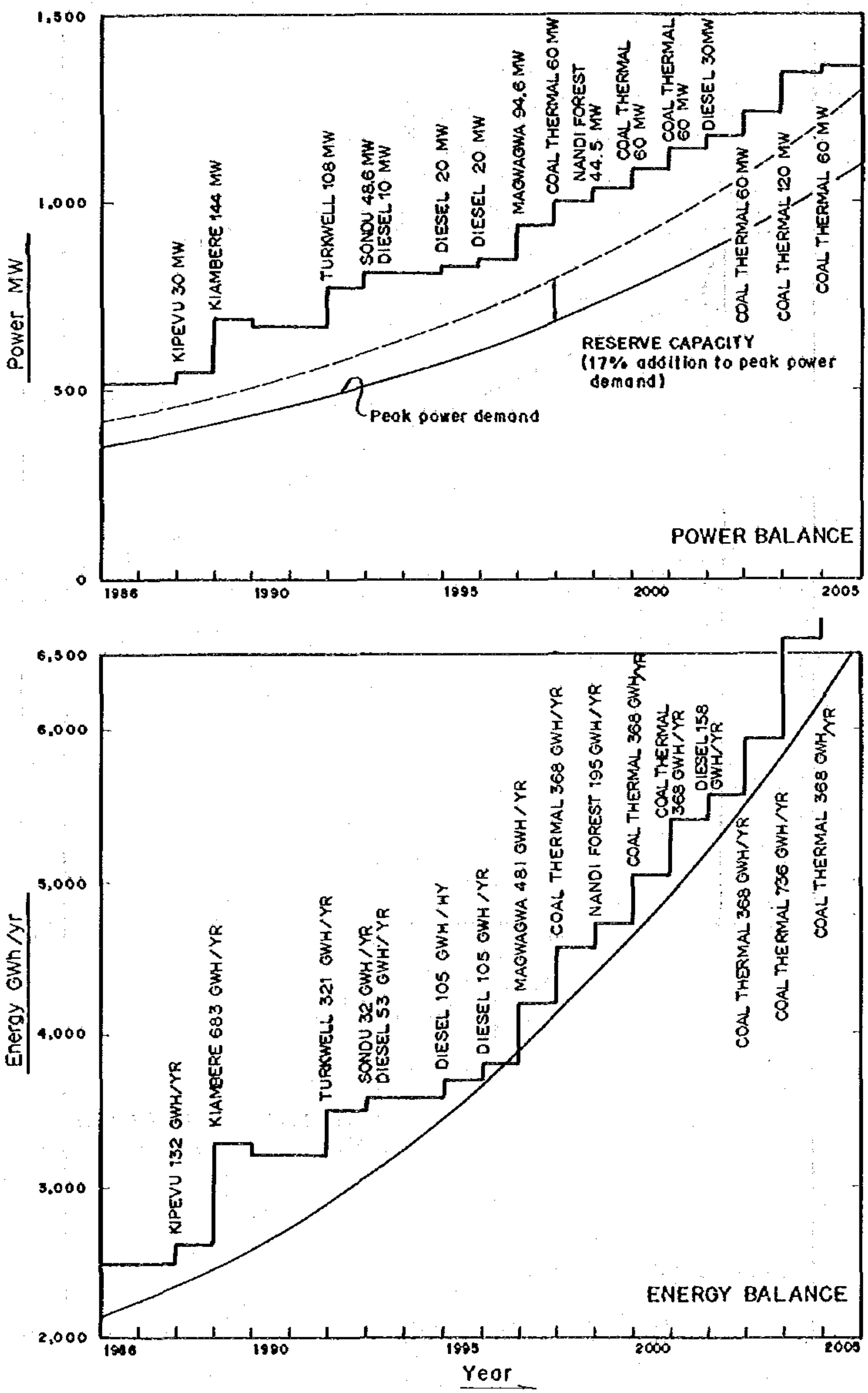


Figure 9.4 Peak Power and Energy Balances in KP & L Power Supply System

REPUBLIC OF KENYA LAKE BASIN DEVELOPMENT AUTHORITY
THE STUDY OF INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE LAKE BASIN DEVELOPMENT AREA
JAPAN INTERNATIONAL COOPERATION AGENCY

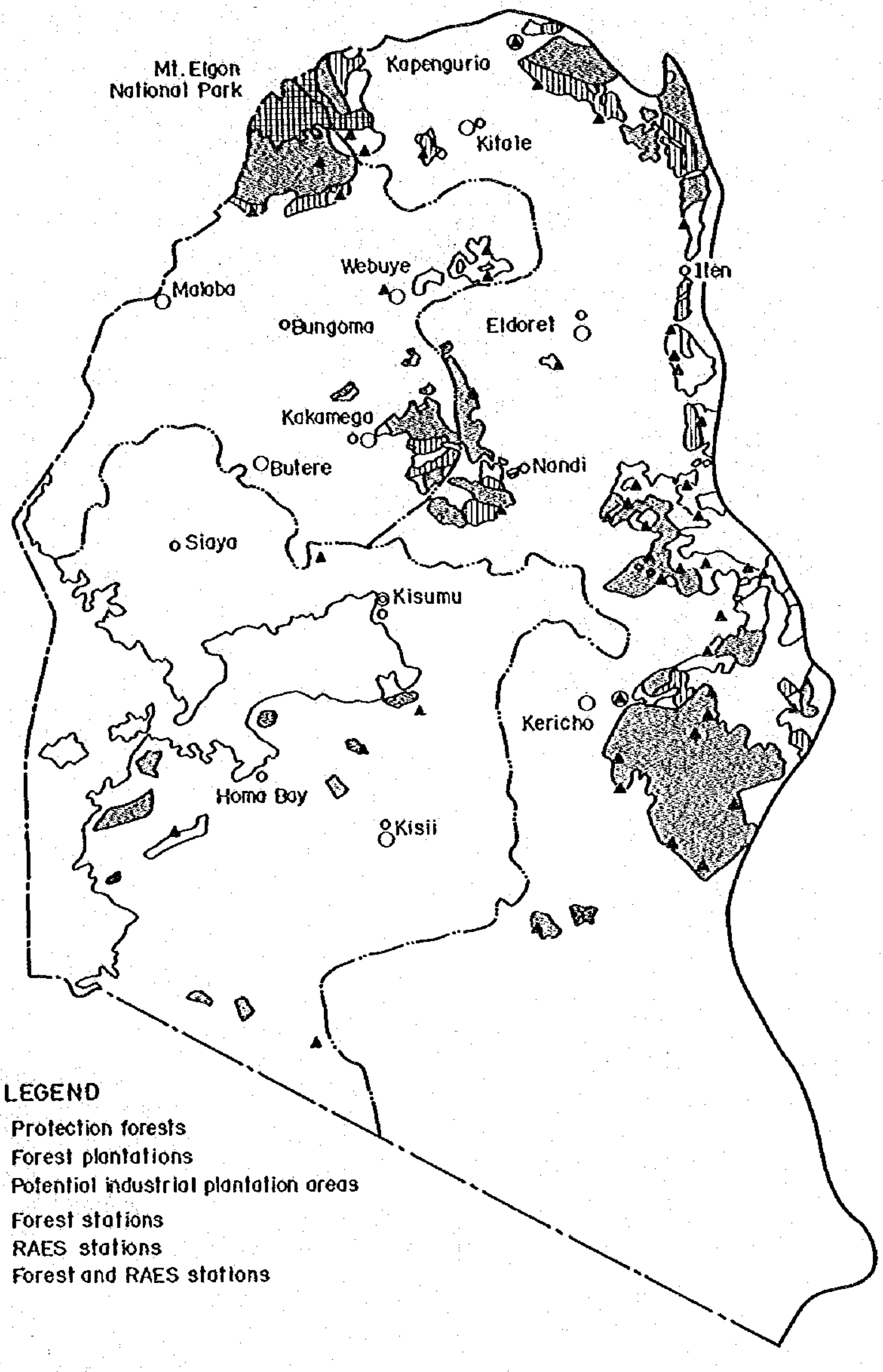


Figure 9.5 Distribution of Forest Areas and Potential Plantation Areas Identified in the Region

REPUBLIC OF KENYA LAKE BASIN DEVELOPMENT AUTHORITY
THE STUDY OF INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE LAKE BASIN DEVELOPMENT AREA
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