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ENERGY DEVELOPMENT IN THE COUNTRIES OF THE EAST AFRICAN SUB-REGION

M65-261

Contents

I. INTRODUCTION

The present Energy Paper for the countries of the East African sub-region is based on the draft country papers on energy prepared in May this year and sent to the respective governments for checking and completion of data.

In the final version of the Energy Paper, the answers received by the governments (seven out of thirteen) and other additional information have been taken into consideration.

This Paper deals with primary energy resources and their production, trade and consumption for the period 1959-1963. In the part dealing with electric energy, the existing power installations (capacity, production, trade and consumption), and generation costs and tariffs are discussed in so far as particulars were available. Only a few official data are known on the future development in electric energy.

In the summary for the total of the sub-region, the future consumption of primary and electric energy up to 1975 is estimated mainly on basis of the foreseen industrial development, taking into consideration also the past trends in energy consumption.

The question of covering the future estimated energy demands has not been dealt with in this paper to the extent that would be desirable. With the exception of some new hydropower projects which are mentioned in the country papers, there are no data on new projects for production primary energy.

For the same reason it was not possible to deal with the financial questions of investments necessary for the new primary and electric energy projects.

At the end of the paper, recommendations are given for future work in the energy field so that energy as a constituent factor in the economy would be able to contribute its share to the harmonization of industrial development in the East African sub-region.

Two maps are attached to the paper, one on the primary energy resources and the other on the existing electric energy installations and the known hydropower projects under construction or in plan.

II. ENERGY SURVEY ON A COUNTRY-BY-COUNTRY BASIS

1. ETHIOPIA

I. Primary Energy Resources (1, 3)

(1) Hydropower

Ethiopia is extremely rich in hydropower resources, the full potential of which is not yet known. The Blue Nile between Lake Tana and the Sudanese border has an exploitable hydropower potential of 25 TWh per annum. This is reported to be about half the total hydropower potential of Ethiopia excluding Eritrea which is estimated at 45 TWh per annum. Present installed capacity is concentrated in a few plants, most of which are located on the Awash River and its tributaries in the region of Addis Ababa.

(2) Hydrocarbons

Two regions of the country are regarded on geological grounds as having prospects of containing economically exploitable accumulations of petroleum, these being the zone of shallow water off the Eritrean coast, including the Dahlak archipelago, and the Ogaden province in the eastern part of the country. The latter has been more extensively explored than the former and several exploratory wells have been drilled, so far without success.

(3) Coal (3,4)

No coal deposits of economic significance are known in Ethiopia. Low-grade lignites occur in the southern part of the country, but the beds are thin, of the order of 1 metre thick, and laterally discontinuous. The calorific value is low, of the order of 2,000-3,000 calories/gramme, and the reserves of individual deposits are small, of the order of 10,000 metric tons. In view of the small amount of systematic geological survey work which has been done in Ethiopia it is possible that larger undiscovered reserves may exist.

In the doc. (4), the following information is given:

Coalfield	Type of coal	Calorific value cal/g	Ash content %	Reserve million tons
Nejo	Non-coking	-	-	10
Debre Berhan ...	Lignite	4,000	35	1
Chelga	Lignite	4,500	6	2

(4) Non-conventional sources of energy

(a) Radio-active minerals: No deposits of uranium minerals are known in Ethiopia at the present time, but these might exist, given the geological constitution of Ethiopia.

(b) Geothermal: On geological grounds it seems likely that Ethiopia possesses considerable geothermal potential. Numerous hot springs and fumeroles occur in the basin of the Awash River, notably near Mounts Fantalo and Dojan, and near Lake Abbe.

II. Production, Trade and Consumption of Primary energy (2, 4, 5, 5a, 6)

(1) Production

Hydroelectric energy is the only kind of primary energy produced in the country.

	Hydroenergy	
	in GWh	in 1,000 tce (rounded)
1959	27.8	13.9
1960	46.7	23.3
1961	68.1	34.0
1962	92.1	46.0
1963	108.8	54.4

Conversion ratio: 1 GWh = 500 tce

(2) Import

Imports of primary energy in the form of liquid and solid fuels are given below in 1,000 tce (rounded):

	Import	Bunkers	Net import		
			Solid fuels	Liquid fuels	Total
1959	190	10	10	170	180
1960	180	30	-	150	150
1961	190	30	10	150	160
1962	220	30	10	180	190
1963	230	30	10	190	200

Remark: Quantities mentioned under "Bunkers" are those supplied to foreign-bound ships and aircraft, irrespective of the flag of the vessel or plane. "Bunkers" are not considered as "Export".

(3) Consumption in 1,000 tce:

	Hydroenergy	Net import	Total
1959	13.9	180	193.9
1960	23.3	150	173.3
1961	34.0	160	194.0
1962	46.0	190	236.0
1963	54.4	200	254.4

Consumption per capita :

1959 ..... 9.7 kg coal equivalent
1960 ..... 7.7 " " "
1961 ..... 8.7 " " "
1962 ..... 10.6 " " "
1962 ..... 11.5 " " "

III. Electric energy (2, 4-10)

(1) Existing power systems

In Ethiopia, electric power is provided by:

- The Ethiopian Electric Light and Power Authority (EELPA), which has electric power installations throughout the country and whose present production is more than 75 per cent of the country's total.

- The Società Elettrica dell'Africa Orientale (SEDAO), which is a private enterprise and is responsible for supply of electric energy in Eritrea.

- Also some industrial enterprises have their own power installations.

(a) Installed capacities (10) : In doc. (10), capacity is quoted in kVA (and not in kW). To get capacity in kW, we suppose an average generator power factor of 0.8. In addition to the stations mentioned in (10), the hydropower station of Tis Abbay went on stream in 1964 with two units and a total capacity of 7,700 kW. In this way we get the present capacity:

- Hydro	72.862 MVA	60.0 MW
- Thermal	32.489 MVA	26.0 MW
Total :	105.351 MVA	86.0 MW

The above figures include not only the capacities of EELPA and SEDAO, but also of the private industrial enterprises. EELPA has an inter-connected system, with the Koka hydro-power plant as nucleus, and 11 self-contained systems. The existing power plants in these areas have the following characteristics:

Inter-connected system

	Capacity			Producibility in GWh		
	Installed		Firm	Year's hydrolicity		
	kVA	kW *	kW	Rich	Average	Poor
HE Koka	54,000	45,000	23,000	120	110	80
Aba Samuel ...	8,250	6,600	4,750	27	23	18
Oursc	525	400	250	2	.2	2
HE Sub-total :	62,775	52,000	28,000	149	135	100
SE Addis Ababa ..	6,250	5,000	5,000	30	30	30
DE Alemaya	2,910	2,000	2,000	10	10	10
TE Sub-total :	9,160	7,000	7,000	40	40	40
HE & TE Total ...	71,935	59,000	35,000	189	175	140

* - Estimated.

Self-contained systems

Location	Installed capacity in kVA		Firm capacity	Producibility in GWh	
	Diesel	Hydro	kW	Diesel	Hydro
Jimma	1,125	170	600	2.4	0.3
Dessie	1,125	-	600	2.4	-
Hagere Hiwot	-	210	100	-	0.35
Ghicn	40	30	50	0.1	0.5
Debre Berhan	-	125	100	-	0.3
Gondar	200	-	100	0.4	-
Yrgalem	110	-	80	0.3	-
Debre Markos	60	-	40	0.15	-
Jigjiga	40	-	30	0.1	-
Neghelli	150	-	50	0.15	-
Tis Abbay	-	9,600	2,400	-	25.0
Total ..	2,850	10,135	4,150	6.0	26.45
Grand total	12,985			32.45	

As at December 1964, the following Diesel power plants have to be added:

Location	Installed capacity kVA
Assab	2030
Bahar Dar	865
Shashamane	500
Debre Markos (additional)	190
Lekempte	250
Assella	250
Total :	4080 kVA
	= 3260 kW

For the EELPA's self-contained systems, at the end of 1964, the total installed capacities are estimated as follows:

Hydro	about	8,000 kW
Diesel	about	5,600 kw
Total	about	13,600 kW

SEDAO has a total capacity of 16,525 kVA or, estimated 13,500 kW. The main SEADO's power plants are the following:

- Diesel power plant at Gherar ..... 6,000 kW
- Diesel power plant at Asmara ..... 550 kW
- Hydropower plant at Dorfu ..... 1,100 kW
- Steam power plant at Belesa ..... 5,000 kW

In the final stage, this power station is planned to have 30,000 kW capacity. The second set of 10,000 kW capacity was foreseen to start operation in 1965. The power house is completed to accommodate the 30 MW capacity referred to above.

In Eritrea, the private company CONIEL is also active in the electric utility field, but no detailed information on its activity is available. Industrial diesel power stations have a capacity of 3,954 kVA or 3,200 kW (estimated).

A summary of installed capacities with regard to the ownership and type of power plants gives the following picture (in MW) :

	Hydro	Thermal	Total
EELPA	60.0	12.6	72.6
SEDAO	-	13.5	13.5
Industry	-	3.2	3.2
	60.0	29.3	89.3

With the exception of the steam power plant in Addis Ababa, all the thermal power plants are diesel plants.

(b) Production in GWh :

Ownership	1959	1960	1961	1962	1963	1964
EELPA	47.1	55.4	71.4	96.5	117.0	145.5
SEDAO	24.1	27.3	31.5	36.1	37.8	?
Industry	17.3	19.0	19.0	20.0	?	?
Total :	88.5	101.7	121.9	152.6	?	?

The relative importance of the EELPA in supplying the country with electric energy is steadily growing.

EELPA's share in the total production :

1959	53.5%
1960	54.4%
1961	58.6%
1962	63.1%

With regard to the type of energy, we have the following picture:

	1959	1960	1961	1962	1963	1964
Hydro	27.8	46.7	68.1	92.1	108.8	137
Thermal	60.7	55.0	59.8	60.5	?	?
Total :	88.5	101.7	127.9	152.6	?	?
Hydro in % of total	31	46	53	60.5	?	?

(c) Sales and losses in GWh :

For the two utilities EELPA and SEDAO, the following tables show how much of the produced energy was sold and lost:

	1960	1961	1962	1963
EELPA				
Production	55.4	74.4	96.5	117.0
Sales	42.9	59.5	83.5	98.0
Power-plants consumption and losses	12.5	14.9	13.0	19.0
In % of production	22.6	20.0	13.4	16.2

	1962	1963
SEDAO		
Production	36.1	37.8
Sales	29.2	30.6
Power-plants consumption and losses GWh	6.9	7.2
In % of production	19.0	19.0

There follows a rough breakdown of electric power consumption expressed in percentages of the total production, for 1962:

- Economy	42.5%
- Public consumption and illumination of towns	40.0%
- Power plant consumption and losses	17.5%
	100.0%

The average rate of growth of production for the period 1959-1962 was:

- for the country as a whole ..... about 20%
- for EELPA ..... about 26.6%

(d) Transmission and distribution

Only information for EELPA is available :

	Transmission lines in km		Distribution		Number of consumers
			Feeders in km	Transformers' capacity kVA	
	132 kV	35 kV	15 kV		
1960	418	129	370	28,100	32,435
1961	418	159	408	40,463	37,930
1962	418	159	468	47,998	44,184
1963	418	159	595	62,798	52,391
1964	418	159	662	71,463	60,190

The low-voltage distribution networks employ a 380/220 V three-phase system with a neutral wire. The lengths of these networks are not known.

(e) Tariffs

1. General tariff

First 100 kWh per month	Eth. cents	15 per kWh
Exceeding 100 kWh per month	Eth. cents	10 per kWh
Service charge, single-phase ...	Eth. doll.	1 per month
three-phase ...	Eth. doll.	5 per month

2. Commercial and industrial tariff

First 1000 kWh per month	Eth. cents	10 per kWh
Exceeding 1000 kWh per month	Eth. cents	5 per kWh
Reactive consumption, below cos phi = 0.89	Eth. cent	1 per kVArh
Maximum demand charge, per month ...	Eth. doll.	5 per kWh
Service charge, three-phase	Eth. doll.	5 per month

Rebate on total charges :

Exceeding 100,000 kWh per month :	5%
" 400,000 kWh " "	10%
" 700,000 " " "	15%
" 1,000,000 " " "	20%

3. Off-peak tariff

All consumption	Eth. cents	5 per kWh
Reactive consumption, below cos phi = 0.89	Eth. cent	1 per kVArh
Service charge, three-phase	Eth. doll.	5 per month

Rebate on total charges :

Exceeding 100,000 kWh per month:	10%
" 400,000 " " "	20%
" 700,000 " " "	30%
" 1,000,000 " " "	40%

The supply of this tariff is subject to special negotiations and to conditions of discontinuance of supply for certain periods.

(f) Prices of fuel for power generation:

- Fuel oil for the steam power plant at Addis Ababa .. 120 E$/ton
- Diesel oil in the coastal zone ..... 103 "
- Diesel oil far away from the coast ..... 350 "

On this basis it can be estimated that energy from the diesel power plants in the self-contained areas costs about Eth. cents 18-30 per kWh, depending, of course, on the amount of energy produced. In these figures, all expenses are included, e.g. fuel, operation, depreciation and interest for the power plant as well as the distribution system.

(2) Future development

(a) Production targets for the period 1963-1967 are given in doc. (8) as follows: (in GWh)

	1963	1964	1965	1966	1967
EELPA	134	143	175	225	260
SEDAO	35	55	60	65	70
Industry	21	22	22	25	25
Total :	190	220	257	315	355

The average rates of increase forecast for this 4-year period are:

for EELPA 18.0%
for SEDAO ..... 18.8% } Total : 17.0%
for Industry 7.05%

SEDAO's production in GWh, taken from its own documents, seems to be rather different:

1964 38
1965 41
1966 49
1967 51

(b) Investments in electric power for the period 1963-1967 have been as follows:

Group of investment	In 1,000 E$	In %
Interconnected system	32,000	38.5
Self-contained systems	19,900	23.8
Tis Abbay system	5,900	7.1
Industrial firms	450	0.5
Transmission lines, substations and distribution	25,200	30.1
Total	83,450	100.0

Technical particulars about the investments

- The Tis Abbay hydropower plant went on stream in 1964, with the following producibility:

  1967 ..... 25 GWh
  final ..... 56 GWh

- In the interconnected system, one more hydropower plant, Awash II, is now under construction. Its installed capacity will be 32 MW and its producibility as follows:

  1967 ..... 75 GWh
  final ..... 182 GWh

- The Awash III project is also included in the expansion programme for the immediate future, and will have outputs identical to Awash II.

- In the self-contained systems (besides Tis Abbay), new power plants will be built in Dilla, Makalle, Axum, Asba Teferi, Bonga, Debre Tabor, Adua and Dembidollo.

  Expansion of the existing power plants is planned in : Jimma, Dessie, Hagere Hiwot, Debre Berhan, Gondar, Debre Markos, Yirgalem, Negellie Borana, Assab, Jigjiga, Wolamo Soddo, Assella, Lekempte and Shashamane.

  Production in the self-contained systems will increase from 9 GWh in 1963 to 25 GWh in 1967.

- During the same period, the following new power capacities will be installed:

  9,200 kW diesel electric power,
  200 km distribution feeders 15 kV
  18 MVA distribution transformer capacity.

- SEDAO will expand its existing generating power by 5,000 kW by construction of the first stage of the thermal power plant at Bellesa.

- Industrial enterprises will build power plants only in those cases when the factory sites render it impossible for them to be supplied by electric power from the public network.

- By 1967, the following 132-kV transmission lines will be constructed:

From Awash II to Koka double circuit ...	25 km
From Koka to Akaki	75 km
From Akaki to Sabata and Gafarsa	25 km
Total :	125 km

- There will be installed in the interconnected system also:

45 kV transmission lines, ...	about 80 km
15 kV distribution feeder	about 400 km
Distribution transformer capacity .	about 56 MVA

- US AID financed the feasibility survey for a hydropower station on the Fingiar River, the Blue Nile, tributary. The 94 MW project requires an investment of E$70 million or US$28 million. Specific investment is US$296 per kW.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963 E/CN.14/EP/3 Part I.
2. Ditto, Part II.
3. Ditto, Add. 1.
4. "Industries et travaux d'outre-mer", January 1964, No. 122.
5. World Energy Supplies, 1960-1963, UN, New York 1964, No.8.
5a. " " " 1959-1962 " " 1963, No.7.
6. Ethiopian Electric Light and Power Authority: Report - Past activities and future programme, Addis Ababa 1962.
7. Report of the Preliminary Assistance Mission to Ethiopia, IAEA, Vienna, 1962.
8. Imperial Ethiopian Government: Second Five-Year Development Plan 1963-1967, Addis Ababa 1962.
9. Electricity in Ethiopia, Ethiopian Electric Light and Power Authority, Addis Ababa 1963.
10. Imperial Ethiopian Government: Statistical Abstract, Addis Ababa 1964.
11. Development of the Steel industry in East and Central Africa, W.S. Atkins and Partners, Preprint, 1965.

Abbreviations and symbols used

MW	Megawatt = 1,000 kW
MVA	Megavoltampere = 1,000 kVA
GWh	Gigawatthour = 1,000,000 kWh
TWh	Terawatthour = 1,000 GWh
tce	tons (metric) of coal equivalent
HE	Hydroelectric power plant
DE	Diesel electric power plant
SE	Steam electric power plant
TE	Thermal electric power plant

2. SOMALI REPUBLIC

I. Primary Energy Resources (3,6)

(1) Hydropower

Somalia has only two perennial rivers, the Uebi Shibeli and the Juba. Neither has very great potential within Somalian territory. The total hydro-potential is estimated at 200 - 1,000 GWh, but it seems that the specific investments would be considerable. According to Associated Consulting Engineers, the Northern Region has a hydro-electric potential of over 300 MW firm or over 500 MW peak load capacity. For the Shebeli river, no figures are given.

(2) Hydrocarbons

Much of the territory of Somalia is underlain by sedimentary rocks, principally calcareous and evaporitic in nature, and oil seepages occur at Daga Shabel in the Berbera district. There has been a considerable amount of exploratory activity and a number of deep wells have been drilled, mainly in the coastal regions. Shows of oil and gas have been observed in a number of wells but so far no economically exploitable accumulations have been discovered.

Exploration continues and may ultimately be successful.

(3) Coal

Low grade coal is reported to occur at Durbo, in the northern mountains near the Gulf of Aden. The bed is reported to be about 2 metres thick, but to be lenticular. The coal has the following characteristics: moisture 16 per cent, volatile matter 39.4 per cent, ash content 6.4 per cent, calorific value 5,719 calories per gramme. No estimate of reserves is available. This deposit is reported to have been worked prior to 1939.

(4) Lignite

Lignite is reported to occur in the territory of former British Somaliland, but it is stated that it is uneconomic to develop these deposits.

(5) Non-conventional sources of energy

(a) Geothermal: Hot springs with a temperature of around 40°C are known to occur in the north-eastern part of Somalia. Given the occurrence in this area of major faulting along the southern side of the Gulf of Aden, it is possible that geothermal fields might exist in this area.

(b) Solar: Much of Somalia is suitable for the utilization of solar energy if this could be developed on an economic basis.

(c) Wind: The northern mountains provide many sites which would be suitable for the development of wind power, were it not for the fact that the winds in this area are seasonal. Power could undoubtedly be developed during the season of the north-east monsoon, but the potential during the remainder of the year is dubious.

II. Production, Trade and Consumption of Primary Energy (5, 5a)

With exception of wood and wood charcoal, largely for domestic consumption, there is no production of primary energy in the country and only imported energy in form of liquid fuels is used.

In the period 1959-1963, the following quantities of liquid fuels were imported and consumed:

- 1959	50,000 tce (rounded)	
- 1960	40,000 tce	"
- 1961	50,000 tce	"
- 1962	50,000 tce	"
- 1963	50,000 tce	"

Specific consumption per capita was about 23 kg coal equivalent.

III. Electric Energy (2, 4, 5, 6)

(1) Existing power plants

(a) There are only diesel power plants in the country, the total installed capacity being 7,900 kW in 1962. Self-producers are not included in that figure and their capacity is not known.

(b) Production of electric energy amounted to somewhat more than 10 GWh per annum in the period 1959-1963. In 1961, it was 12 GWh. For other years, exact figures are not known.

(c) Consumption: In 1961, the total amount of units sold to consumers was 11 GWh. Power-station consumption and distribution losses were about 1 GWh or some 8.3 per cent of the total generation.

Only 3 GWh or 27 per cent of the total consumption were used by industry. In the period 1956-1961, the average rate of growth of consumption was about 6.2 per cent, which is rather low.

In the period 1959-1963, specific consumption of electric energy was about 6 kWh per capita.

(d) Transmission: No lines existing.

(e) Distribution networks: In 1961, fifteen twons were electrified. No details are known about the distribution system in the country.

(f) Generation costs: No data available.

(g) Tariffs: No data available. For industrial purposes, the average prices of electric energy amount to:

- In the Southern Region: So.Sh. 0.60/kWh = 8.5 US¢ 1 kWh
- In the Northern Region: So.Sh. 0.45/kWh = 6.3 US¢ 1 kWh

(h) Fuel costs: At Mogadiscio, for gas oil :

. Import cost c.i.f. Mogadiscio	17.4	Somali cents	per	litre
. Government taxes	39.0	"	"	"
. Distribution costs	23.6	"	"	"
. Sale price	80.0	"	"	"

(2) Future development (6)

The existing and potential demand for electricity in the near future is of rather modest dimensions. Besides, the existing centres of consumption are very far from the possible sites for the generation of hydroelectric power. Thus the very large investments in the generation of hydroelectric power and its transmission over long distances cannot be justified on the basis of the foreseeable demand for electricity. The country will therefore have to depend on thermal stations for quite some time to come. However, the hydroelectric potentialities need thorough investigation, for demand for the utilization of this hydroelectric power may arise as a result of certain future developments, particularly in respect of mineral resources, which it is not possible to foresee at present.

The establishment of a national grid system is not feasible, due to the long distances separating the various centres of consumption and to the relatively small demand at each centre. Capital investment in the transmission system will have to be very high, resulting in high transmission costs. This would tend to raise the unit cost of electricity to the consumer. The country will therefore have to rely on separate thermal power stations for each main centre of consumption.

There is no standardization in the electric supplies of the country. It is proposed that, unless otherwise necessitated by the requirements of the existing sets, new generating sets should be standardized and should be designed to supply 3-phase 230 volts 50 cycle per second alternating current.

In the First Five-year Plan, the following development of electric power is foreseen:

Locality	Existing power kW	New power kW	Investments 1,000 So.Sh.
Hargeisa	800	750	600
Berbera	360	1,420	1,800
Mogadiscio	2,744	1,920	
a) Purchase of existing installation			5,000
b) Development			5,800
Campo Bottego and Afgoi	?	Supply from Mogadiscio	500
Kisimayo	310	1,200	1,800
25 other small towns	?	?	9,500
Total	4,214	5,290	25,000

Remarks :

Hargeisa ..... : The demand for electricity is expected to increase in future at the rate of 20 per cent per annum. The distribution system will be expanded and improved.

Berbera ..... : The distribution system will be improved and expanded to take care of the demand of the new port and of the growing demand of the town.

Mogadiscio ..... : The existing power installations owned by Elettro-Industriale Italo-Somala (SEIS), will be purchased by the Government.

Campo Bottego and Afgoi ..... : The local generation will be discontinued. A high voltage supply feeder will bring power from Mogadiscio and the local distribution system will be improved.

Kisimayo ..... : As a result of the building of the port, the demand for electric power will increase substantially. The old two 30 kWh units will be removed and two 600 kW units will be added.

Other towns ..... : Improvement and/or installation of new capacity and distribution system in twenty five towns is foreseen.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963
E/CN.14/EP/3 Part I.

2. Ditto, Part II.

3. Ditto, Add. 1.

4. Industries et travaux d'outre-mer, January 1964, No. 122.

5. World Energy Supplies, 1959-1962, UN, New York 1964, No. 7.

5a " " " 1960-1963, " " 1965, No. 8.

6. Somali Republic : First Five-Year Plan, 1963-1967, Mogadiscio 1963.

Abbreviations and symbols used :

MW - Megawatt = 1,000 kW

GWh - Gigawatthour = 1,000,000 kWh

tce - tons (metric) of coal equivalent

3. FRENCH SOMALILAND

I. Primary Energy Resources (1)

There are no known energy resources, except Lake Assal for hydro-electric power.

There are no data available about the hydro-potential of the country.

II. Production, Trade and Consumption of Primary Energy (5)

There is no local production of primary energy in the country. Primary energy is imported in relatively large quantities in the form of liquid fuels. Only a small portion of that energy is consumed in the country, whereas the largest part of it goes to "Bunkers", meaning that it is supplied to foreign-bound ships and aircraft, irrespective of the flag of the vessel or plane. "Bunkers" are not considered as "Export".

In the period 1959-1962, trade and consumption of primary energy, expressed in 1,000 tce (rounded) were :

	Net import	Bunkers	Consumption
1959	1,460	1,440	20
1960	1,460	1,440	20
1961	1,860	1,840	20
1962	1,910	1,890	20

Consumption per capita was:

1959 ..... 278 kg coal equivalent
1960 ..... 278 " "
1961 ..... 278 " "
1962 ..... 342 " "

III. Electric Energy (4)

(1) Existing power plants

There are only two diesel plants:

- DE Djibouti with an installed capacity of 8,800 kVA (about 7,000 kW)*;
- DE Arta, in a cattle-breeding centre, some 40 km from Djibouti. The capacity is 400 kVA.

(a) The installed capacity of the DE Djibouti has increased gradually since 1953:

	New Capacity in kVA	Total Capacity in kVA	Total Capacity in kW
1953	3,600	3,600	2,900*
1961	2,750	6,350	5,100*
1963	2,450	8,800	7,000*

(b) Production

DE Djibouti

1953 ..... 2.8 GWh
1962 ..... 12.6 GWh
1963 ..... 15.0 GWh (estimation)
1964 ..... 19.6 GWh

In the 11-year period 1953-1963, the rate of increase of production averaged 18.5 per cent.

(2) Transmission and distribution

As the DE Djibouti supplies only the town of Djibouti and its suburbs, there are no transmission lines in the country. The generation voltage of the DE Djibouti is 5,500 V and at that voltage electric energy is fed to about 40 5.5/0.4 kV transformer stations.

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* - Estimated.

The installed capacities of these stations range from 13 to 750 kVA. The lengths of the 5.5 kV feeders are:

- 30 km underground cables in the town.
- 10 km overhead lines in the suburbs.

The 220/380V low-voltage distribution system is led mainly as overhead lines.

(3) Consumption

The consumption of the DE Djibouti itself and the distribution losses amount to about 10 per cent of the total production. Therefore, net consumption is 90 per cent of gross production. About one-third of net consumption falls to the 5.5-kV network and two-thirds to the low-voltage network.

In recent years, consumption in the Djibouti area has been as follows:

1963	14.4 GWh
1964	17.5 GWh

(4) Tariffs

(rate of exchange: fr. CFS 1,000 = Ffr 23 = US$4.6)

It is very significant that the electricity tariffs have been dropping constantly and quite noticeably. So, for instance, the domestic tariff per kWh (low-voltage, 1st rate) developed as follows:

1955	about US¢ 12.4
1963	about US¢ 8.3

that is to say, a reduction of 33 per cent.

In 1963, the tariff structure in fr CFS/kWh was as follows:

(A) Low voltage

(a) General tariff : fr 22/kWh

(b) Industry:

1st rate (150 h)	fr 22/kWh
2nd rate (next 175 h)	fr 20/kWh
3rd rate (next 200 h)	fr 17/kWh
4th rate (rest)	fr 13/kWh

The charge is based on the maximum power demand and the corresponding hours per month.

(c) Domestic use:

The tariffs decrease according to the number of rooms. For a three-roomed apartment, the tariffs are:

1st rate (110 kWh/month) ...	18	fr CFS/kWh
2nd rate (next 140 kWh/month)	17	"
3rd rate (next 160 kWh/month)	15	"
4th rate (rest)	13	"

(d) Power : fr CFS 18/kWh .....

(e) Public lighting : .....

1st rate (till midnight)	18 fr CFS/kWh
2nd rate (from midnight to dawn)	14.5 fr CFS/kWh

(B) Medium voltage (5.5kV) :

(a) Peak tariff (from 6 p.m. to midnight) : 19.5 fr CFS/kWh.

(b) Off-peak tariffs (from midnight to 6 p.m.)

For a two-month consumption:

from 0 to 20 MWh	13.0	fr CFS/kWh
from 20 to 60 MWh	12.0	"
from 60 to 140 MWh	11.0	"
from 140 to 300 MWh	9.5	"
over 300 MWh	7.5	"

(c) Fixed charges for power : fr CFS 5,000 per kW and year, the first 10 kW being free.

(5) Fuel prices

Fuel : FD 6,000 per ton; consumption in 1964: 3,320 tons.
Gas oil : FD 11,320 per ton; consumption in 1964 : 2,460 tons.

(6) Future development

In the present five-year plan, the following constructions and investments have been foreseen:

(a) In 1965, a new diesel set was installed in the power plant of Djibouti. Another diesel set with a capacity of 4,200 kW will be installed in 1967-1968. At the same time, the electric installations of the power plant will be modified.

(b) Distribution network : The medium-voltage feeders will be changed from 5.5 kV to 20 kV. The transformer stations will be modified accordingly.

(c) Investments: The following sums have been earmarked:
- FD 150 million for the 4,200 kW diesel set;
- FD 30 million for the modification of the power station of Djibouti;
- FD 320 million for the modification and extension of the distribution network.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP 3, Part I.

2. Ibid., Part II.

3. Ibid., Add.1.

4. Industries et travaux d'outremer, January 1964, No. 122.

5. United Nations, World Energy, 1959-1962, New York 1964, No. 7.

Abbreviations and symbols used:

MW - Megawatt = 1,000 kW
GW - Gigawatt = 1,000,000 kW
MWh - Megawatthour = 1,000 kWh
GWh - Gigawatthour = 1,000,000 kWh
TWh - Terawatthour = 1,000,000,000 kWh
tce - tons (metric) of coal equivalent
DE - Diesel electric power plant
FD - Djibouti francs

4. UGANDA

I. Primary energy resources (3)

(1) Hydropower (2, 3, 4)

There are several estimates for the total hydro-potential of Uganda. They range from 15 to 45 TWh p.a. Most of this potential is concentrated along the Nile below Lake Victoria. At Owen Falls there is already a 120-MW installation, later to be extended to 150 MW. A further 180-MW project has been proposed for future development at Bujagali Falls, 7 miles down-stream from Owen Falls, and there are seven more sites capable of development on the Nile below Bujagali. In south-west Uganda there is a small hydro-electric installation (1.2 MW) at Kikagati and another small plant is to be erected near Kabale. At present the total hydroelectric energy production is about 450 GWh p.a., or 2.1/2 - 3 per cent only of the total lowest estimated potential of the country. About one-half of this production is being exported to Kenya.

(2) Hydrocarbons

The greater part of Uganda is underlain by rocks totally unsuitable for the formation and accumulation of petroleum. Only in the Rift Valley system of the western part of the country is there any thickness of undisturbed sedimentary rocks, and these appear to be entirely non-marine in character. Oil and gas seepages occur at several localities in the Lake Albert area and some exploration work has been done in the area, including drilling a well. The beds penetrated by the well appear to have originated from very young Plio-Pleistocene lacustrine sediments, and include oil shales. Oil-saturated sands were found at shallow depths and the oil may have resulted from distillation of the oil shales by igneous intrusions associated with the Rift Valley fault system.

(3) Coal

Small areas of Uganda are known to be underlain by rocks equivalent to the coal-bearing series of south-eastern Africa, but drilling has not disclosed any workable coals, only coaly streaks having been found.

(4) Non-conventional sources of energy

(a) Radio-active minerals

Several deposits of radio-active minerals are known in Uganda and some small low-grade deposits were worked for uranium during the war, although none are at present in production. Prospecting continues and the prospects of finding economically workable deposits are considered to be good.

Uranium minerals, although so far rare in Uganda, have been found mainly as euxenite in pegmatites in various localities in Buganda, Toro, Ankole and Karamoga, and as microlite in eastern Uganda. Radio-activity is also found in certain spring waters along the boundary of the western Rift Valley.

Thorium minerals are common compared to uranium minerals and occur as monazite from the weathering of granites and as thorite. At Kalapata in northern Karamoja monazite is found in quartz-ilmenite-rutile nodules in biotite gneiss, and other monazite occurrences are at Kalere River, Mpuywi, Buhweju and Bugarama. Although some have a ThO_2 as commercially exploitable. The same is true of thorite which is found at Lunyo (Eastern Province) and Apeykale in northern Karamoja.

No sustained search for uranium has been carried out in Uganda, although, considering its geology, tectonic activity and igneous activity, the country must be regarded as offering many favourable aspects for the occurrence of radio-active minerals; this is confirmed to some extent by the early results of the aerial geophysical survey being carried out under a United Nations Special Fund project. Thorium-bearing ores are known but the possibility of their commercial exploitation is doubtful at the present stage of knowledge of these occurrences.

(b) Geothermal

It is highly probable that geothermal fields exist in Uganda, in connexion with the Rift Valley faulting and its associated volcanic activity. At Buranga, in Toro province, there is an extensive area of hot springs and swamps and a definite attempt was made to locate an accumulation of geothermal steam. Ten wells were drilled, most of which gave hot water at 96° - 98° C, and two of which made considerable quantities of steam before dying into geysers. The area is located in the Albert Rift Valley and the springs are immediately adjacent to the main Rift fault.

II. Production, trade and consumption of primary energy (5,5a,7,9,10)

(1) Production

Hydropower stations are the only source of primary energy in the country.

	Hydro-energy in GWh			Total in 1,000 tce (rounded)
	Total	Public	Private	
1959	345.6	345.6	-	173
1960	396.2	396.2	-	198
1961	450	434.8	about 15	225
1962	470	453.0	" 17	235
1963	570	500	" 10	255

Conversion ratio : 1 KWh = 0.5 kg coal equivalent.

(2) Trade

In docs (5 and 5a), there is a want of clearness about the real amounts of imported and consumed quantities of liquid fuels. The figures quoted are as follows (in 1,000 tce rounded):

	Net Imports	Bunkers	Consumption
1959	170	below the level of rounding	180
1960	170	below the level of rounding	190
1961	160	10	180
1962	180	10	190
1963	180	10	200

Quantities given under "Bunkers" were supplied to foreign-bound ships and aircraft, irrespective of the flag of the vessel or plane. "Bunkers" are not considered as "Export", nor as "consumption" of the country under consideration

In the figures given above, the equation :

Net Imports - Bunkers = Consumption

is not complied with.

(3) Consumption

Part of the hydro-energy produced is exported to Kenya according to a 50-year agreement between Uganda and Kenya.

	Hydro-energy				Consumption	
	Produced	Export	Consumed in country GWh	1,000 tce	Liquid fuels 1,000 tce	Total 1,000 tce
1959	345.6	129.4	216.2	108	180	288
1960	396.2	160.1	236.1	118	190	308
1961	450	191.3	258.7	129	180	309
1962	470	188.9	281.1	140	190	330
1963	570	190	320	160	200	360

Consumption per capita :

	Population (in 1000)	Kg of coal equivalent
1959	6513	44
1960	6677	46
1961	6845	45
1962	7016	47
1963	7190	50

III. Electric energy (2,4,5, 5a, 7, 8, 9, 10)

(1) Existing power plants

(a) Installed capacities

The bulk of electric energy is produced in the HE Owen Falls, north-west of Jinja. This hydropower plant is constructed on the Victoria Nile, with a head of about 20 m.

HE Owen Falls is designed for 10 turbo-generator sets, each 15 MW, with a final installed capacity of 150 MW. At present, only 8 sets are installed with a capacity of 120 MW. The last two sets will not be installed until about 1968. The total producibility of the plant will amount to some 700 GWh.

Besides HE Owen Falls, UEB (Uganda, Electricity Board) has a small hydropower plant at Kikagati (1,200 kW) and another small hydropower plant will be erected near Kabale (installed capacity not known).

The UEB has had an installed diesel capacity of abcut 15 MW since 1950, but since 1954, when HE Owen Falls was commissioned with the first two sets (30 MW), the diesel power plant has served for stand-by purposes only.

Besides the UEB, there are some industrial enterprises (mines of Kilembe, plantations of tea and coffee, and cotton-spinning mills) with their own hydro and thermal plants. Their installed capacities are not known.

Summary of installed capacities (in MW):

	UEB	Private	Total
HE	121.2	Not known	Not known
TE	15.0		
Total	136.2		

(b) Production, export and consumption

Exact figures are available only for UEB's production (in MWh):

	HE	DE	Total
1959	345,570	316	345,886
1960	396,166	292	396,458
1961	434,774	69	434,843
1962	452,328	818	453,146
1963	?	?	495,000

The 4 year average rate of increase is 9.4 per cent.

For the electric energy production of the private enterprises, there are available only very rough figures in GWh (docs. 5, 5a):

	HE	TE	Total
1959	-	20	20
1960	-	20	20
1961	20	20	40
1962	20	20	40
1963	10	20	30

In the same way, therefore only rough figures for the country's total production, export and consumption in GWh:

	Total production	Export	Consumption	
1959	370	130	240	The 4-year average rate of growth is 9.25 per cent
1960	420	160	260	
1961	470	190	280	
1962	490	190	300	
1963	530	190	340	

"Consumption" includes power-station internal consumption and transmission and distribution losses. In the UEB-system, the station consumption and losses amounted to:

1959	31.04	GWh	= 8.9 % of total UEB-production
1960	33.94	"	= 8.6 % of total UEB-production
1961	34.38	"	= 7.9 % of total UEB-production
1962	35.34	"	= 7.8 % of total UEB-production

(c) Transmission and distribution

In 1961, the route-lengths of the existing transmission lines were:

132 kV and 66 kV ----- 265 km, overhead
33 kV and 11 kV -----3400 km, overhead
33 kV and 11 kV ----- 50 km, underground

The system-lengths of the transmission lines are not known. In the same way, there is no information about transmission lines constructed after 1961.

The distribution system of the UEB is standardized at 240/415V 50 cycles, 3 phase with neutral wire. In 1961, the low voltage distribution system consisted of:

Overhead lines about 730 km route-length
Underground lines " 68 " " "

(d) UEB generation costs in cents per KWh sold

	1959	1960	1961
Cost of fuel	0.01	0.01	-
Operation and maintenance	2.83	2.73	2.70
Depreciation and interests	7.69	7.66	9.76
Total costs	10.53	10.40	12.46

(e) Tariffs

The tariffs of UEB are as follows (US$ 1 = LAS 7 = LA cents 700)

Domestic: For domestic purposes in premises used exclusively as a private residence:

First 6 units per month, per room 100 cents per unit
Next 18 units per month, per room 30 cents per unit
All units in excess ..... 14 cents per unit

Premises with less than three rooms shall be taken as having three rooms.

Power: For industrial premises and others where electricity issued mainly for motive power purposes, a limited amount of lighting of the premises being permitted.

Low voltage supply

First 50 KVA of maximum demand	Shs 31.00	per KVA per month
Next 250 kVA of maximum demand	Shs 29.50	per kVA per month
All kVA of maximum demand in excess	" 28.00	per kVA per month

and

First 200 units per month per kVA of maximum demand
13.25 cents per unit
Next 160 " " " " " 11.75 " " "
All units in excess ..... 10.25 " " "

- For premises requiring a supply not exceeding 50 kVA for power and/or heating. Lighting is not included.

First 500 units per month..... 47.5 cents per unit
All units in excess ..... 42.5 " " "

Floor area block: For hotels, residential clubs, hospitals, cinemas, theatres, boarding schools, missions and other similar premises:

First 25 units per month, per 1,000 sq.ft. of floor area,
100 cents per unit
Next 75 " " " " " " 45 " " "
All units in excess..... 14 " " "

The floor area shall be taken as the superficial floor area of the premises and part of 1,000 square feet shall be regarded as 1,000 sq.ft. This tariff also applies to restaurants with the proviso that the number of units allocated to the 100 and 45 cents rates shall be not less than 175 and 525 per month respectively.

General: For all purposes in premises requiring a supply of electricity exceeding 50 kVA, except premises to which the domestic or maximum demand power tariffs apply.

For all kVA of maximum demand.....Shs 33.00 per kVA per month and
For all units ..... 14.00 cents per unit

- For all purposes except for street lighting and premises to which the domestic tariff applies.

For all units.....100 cents per unit.

Electrode boiler and approved industrial heating installations:

- For supplies of electricity to appliances each with a capacity of 30 kV and over where the installation is separately wired and metered. The right is reserved to restrict the supply during periods of peak demand.

For all units.....9.5 cents per unit

Meter rentals:

Single-phase meters over 40 A maximum rating and three-phase meters.....Shs 3.00 per month
Time switches ..... " 1.75 " "

Security lighting tariff: The consumer must be taking a supply of electricity on one of the Board's other tariffs.
Separate metering has to be provided.

For all units.....75 cents per unit

Institutional cooking tariff: The consumer must be taking a supply of electricity on one of the Board's other tariffs.
Separate metering has to be provided.

For all units.....15 cents per unit

Consumer unit tariff: For supplies of electricity for lighting, radio and small appliances to premises where the installation is comprised solely of a consumer unit of the Board's standard pattern and controlled by a current limiter.

With 1 A current limiter.....Shs 8.50 per month
With 5 " " " ..... " 20.00 " "

2. Future development

For the time being, there is no need of additional hydropower plant besides HE Owen Falls, which is far from being fully exploited:

Power plant parameters	Present (8 sets)	Final (10 sets)	Actual utilization in 1962
Installed capacity, MW	120	150	Maximum demand 73.4 MW
Producibility, GWh	560 1/	700	Annual production 452.3 GWh

In order to utilize the HE Owen Falls, completely, transmission lines have been constructed, under the first five-year development plan, from Owen Falls Power Station to Kasese, Fort Portal, Lira, Gulu, Masindi and Hoima. These installations were to have been completed in 1964, but there is no confirmation existing in that respect. Also some other information is missing, as e.g. voltage, length etc.

By 1965, a new switching station is to be built at Kabulosoke near Masaka and the lines from Kampala to Masaka and Fort Portal are to be up-rated from 66 kV to 132 kV.

For expanding transmission and distribution networks, a yearly investment of £ 500,000 has been planned.

1/ Estimate

Documents used

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.

2. Ibid., Part II

3. Ibid., Add. 1

4. Industries et travaux d'outre-mer, January 1964, Nr. 122

5. United Nations World Energy Supplies, 1959-1962, New York, 1964, No.7

5a. United Nations World Energy Supplies, 1960-1963, New York, 1965, No.8

6. Power in Uganda, 1957-1970. The Economist Intelligence Unit Ltd., London 1957.

7. IAEA, Report of the Preliminary Assistance Mission to Uganda, Vienna, 1962.

8. Uganda Government, The First Five-Year Development Plan, 1961/62 to 1965/66, Entebbe 1961.

9. Uganda Government Statistical Abstract 1963, Entebbe 1964.

10. Uganda Electricity Board, Annual Report and Accounts, 1961

11. World Power Engineering, November 1962, p. 57

12. United Nations, Monthly Bulletin of Statistics, March 1965

Abbreviations and symbols used

MW	- Megawatt	= 1,000 kW
MWh	- Megawatthour	= 1,000 kWh
GWh	- Gigawatthour	= 1 million kWh
TWh	- Terawatthour	= 1,000 GWh
tce	- tons (Metric)	of coal equivalent
HE	- Hydroelectric	power plant
DE	- Diesel	" "
TE	- Thermal	" "

5. KENYA

I. Primary Energy Resources (1, 3)

(1) Hydro power

Estimations of the exploitable hydro potential of Kenya range between 1.5 and 50 TWh p.a.. The present hydroelectric production is only about 205 GWh p.a.. There are eight existing hydro stations having a total installed capacity of about 26 MW. All of them are run-of-river plants, and most of them are on the Tana River system. A 250 MW project known as the Seven Forks scheme has been planned on the Tana River system. This could produce about 1,246 TWh p.a. and would be a scheme for combined power, irrigation and flood control. Further exploitation would be possible to the extent of about 150 MW on the Tana River downstream from Seven Forks, 10 MW at Lugards Falls on the River Athi and about 20 MW in multipurpose plants east of Lake Victoria.

(2) Hydrocarbons

The coastal area of Kenya, bordering on the Indian Ocean, is underlain by sedimentary rocks of marine origin and the sedimentary section appears to be favourable for the generation and retention of petroleum in economically exploitable quantities. Some exploration work has been carried out and is still in progress. No deep exploratory wells have yet been drilled on the mainland but wells drilled on Pemba and Zanzibar Islands, off the cost of Tanganyika, were unsuccessful.

Exploration work has not yet progressed to the point where it is possible to give a definite opinion about the possibility of finding oil or gas in quantity.

(3) Non-conventional sources of energy

(a) Geothermal: There are good possibilities of finding geothermal steam in association with the Rift Valley system, where deep-seated faulting is asscciated with extensive Pleistocene volcanic activity. Such volcanic rocks are found in several parts of the highlands to the south-east of Nairobi, in the Northern

Province and north-east of Mount Kenya where they form the Nyambeni Range.

Carbon dioxide gas occurs under pressure at Esegeri on the west flank of the Rift Valley and at lower pressure on the east flank. It is exploited for making "dry ice", some 700 tons per year being produced. The energy content of these deposits is probably small, but they are an indication that suitable reservoir conditions exist for geothermal steam. Some wells were drilled for steam in the Naivasha area, but no details are available. There is no exploitation of geothermal energy in Kenya at the present time.

(b) Radio-active minerals: No workable deposits of uranium minerals have been found yet in Kenya, but there are indications that other radio-active minerals occur. Geological conditions over much of the country are favourable for the occurrence of such minerals, and economically workable deposits may eventually be found.

II. Production, Trade and Consumption of Primary Energy (5,6)

(1) Production Only hydro power

	in GWh	in 1,000 tce (rounded)
1959	140	70
1960	150	75
1961	130	65
1962	160	80
1963	170	85
1964	205	102

Conversion ratio: 1 KWh = 0.5 kgs coal equivalent

(2) Trade (in 1,000 tce, rounded)

	IMPORTS				Bunkers	Net imports
	Solid fuels	Liquid fuels	Hydropower			
			GWh	1,000 tce		
1959	40	1,170	150	75	190	1,095
1960	40	1,230	182	91	180	1,181
1961	40	1,180	211	106	250	1,076
1962	40	1,290	210	105	240	1,195
1963	40	1,360	205	102	230	1,195
1964	-	-	183	91	-	-

Quantities given under "Bunkers" were supplied to foreign-bound ships and aircraft, irrespective of the flag of the vessel or plans. "Bunkers" are not considered as "export", neither as "consumption" of the country under consideration.

(3) Consumption in 1,000 tce:

	Production	Net import	Total
1959	70	1095	1165
1960	75	1181	1256
1961	65	1076	1141
1962	80	1195	1275
1963	85	1272	1357

Consumption per capita:

1959 ..... 167 Kgs Coal equivalent
1960 ..... 170 " " "
1961 ..... 163 " " "
1962 ..... 171 " " "
1963 ..... 182 " " "

III. Electric Energy (2,4, 5,6)

(1) Existing power plants

(a) Installed capacities in 1964 and production in 1960 and 1964

A. Hydropower stations (HE)

Area	Name	River	Installed capacity in 1964	Production in MWh. 1960	1964
			KW		
Nairobi	Tana	Maragua	6,400)	72,917	119,013
Nairobi	Low Tana	Tana	8,000)		
Nairobi	Wanjii	Mathieya	7,400	52,741	58,064
Nairobi	Ndula	Thika	2,250	12,210	18,743
Nairobi	Mesco	Maragua	400	1,404	1,360
Eldoret	Selby Falls	Sosiani	360	2,129	2,805
Manykki	Liki	Liki	100	677	797
Nyeri	Sagana Falls	Nyeri	1,500	4,422	4,402
	TOTAL HE		26,410	146,500	205,184

B. Thermal power stations (TE)

Area	Name	Installed capacity in 1964 (KW)	Production in MWh 1960	Production in MWh 1964
(i) Steam power plants (SE)				
Coast	Kipevu	27,500	53,500	112,345
	Total SE ...	27,500	53,500	112,345
(ii) Diesel power plants (DE)				
Nairobi	Ruiru	3,000	6,522	14
"	Nairobi South I	20,700		136
Coast	Mbaraki	6,000	5,000	463
"	Malindi	240		
Rift Valley	Mereron	4,400	9,660	10
Eldoret	Eldoret	1,600	2,808	1,169
Nyanza	Kisumu	1,965	2,237	119
"	Kericho	1,200		
Kitale	Kitale	1,230	2,337	2,434
Nanyuki	Nanyuki	1,445	680	1,295
Nyeri	Sagana	450	17	2
	Total DE	42,230	29,261	5,642
(iii) Gas turbines (GE)				
Nairobi	Nairobi South II	4,400	1,000	Nil
	Total GE	4,400	1,000	Nil

(b) Production, import and consumption in the period 1959-1964 in GWh (rounded)

Year	Production		Import from			Consumption
	Total	Hydro	Uganda	Tanganyika	Total	
1959 ...	210	140	129	22	151	361
1960 ...	230	150	160	21	181	411
1961 ...	210	130	191	20	211	421
1962 ...	240	160	189	19	208	448
1963 ...	263	171	190	15	205	468
1964 ...	323	205	177	6	183	506

The average rate of increase of consumption was about 7 per cent.

(c) Transmission and distribution: Kenya has interconnexion lines with Uganda: 132 kV double circuit line Nairobi-Tororo, total length about 400 km.

Route lengths of transmission and distribution mains are as follows:

66 kV 3 wire	40/33 kV 3 wire & U.G.	11 kV 6/3/2 wire O.H. & U.G.	L.T. O.H. & U.G.
194	706	2,160	1,060 km

The distribution system is standardized on 240/415 Volts, 50 cycles, 3 phase with neutral wire.

There are no data available about the number of distribution transformers.

SUMMARY

	KW	MWh	
		1960	1964
(i) SE	27,500	53,500	112,345
(ii) DE	42,230	29,261	5,642
(iii) GE	4,400	1,000	-
Total TE	74,130	83,761	117,987
Total HE	26,410	146,500	205,184
Power stations in total	100,540	230,261	323,171

Consumption and the maximum power demand in the various areas of Kenya were as follows in 1960 and 1964:

Area	Sent out to system GWh	Consumption (sales) GWh (rounded)		Maximum demand KW	
	1964	1960	1964	1960	1964
Nairobi	300.1	227.0	270.6	49,360	54,940
Coast	112.5	71.2	107.0	14,646	19,400
Rift Valley.	25.7	15.1	23.2	4,220	4,400
Eldoret	6.5	4.4	6.0	1,080	1,160
Nyanza	12.6	8.9	11.1	2,250	1,400
Kitale	2.4	2.0	2.1	500	504
Nanyuki	2.0	1.7	1.8	480	546
Nyeri	4.3	3.9	3.9	950	934
Total for Kenya ...	466.1	334.1[a]	425.7[a]	73,486[b]	83,284[b]

a/ This figure is for about 19 per cent lower than the figure given in the next table. The difference might represent losses in transmission lines and distribution networks plus consumption of power stations' auxiliary drives, but in spite of that, the figures should be checked for correctness.

b/ The actual total maximum demand of Kenya is somewhat lower than the sum of all partial maximum demands, as they did not occur at the same time.

(d) Cost of electric power: In 1962, the price for diesel oil F.O.R. Mombasa was EAS 250.29 per ton, and furnace oil cost EAS 112.17 per ton. In both cases the cost of transport should be added for supplies elsewhere. Therefore, the fuel cost per kWh generated is about 6 cents at Mombasa, but inland the cost is up to 9 or 10 cents. Taking into account all other expenses for generation and distribution, including interest and depreciation, the total costs per kWh sold may be approximately 22 cents near the coast and 37 cents or more in the Highlands.

Hydropower in Kenya is cheaper. It is estimated, that the selling cost per unit is about 19 cents, including interest and depreciation.

(e) Tariffs: The tariffs of EAPL (East African Power and Light Co.) in the Nairobi area for the public supply are calculated as follows: (1/- (one shilling) = 100 cents (East African)).

Method A. Lighting and Power for Domestic Purposes:

- 1/- per unit for the first 20 units per month, subject to a minimum charge of 18/- per month,
- 17 1/2 cents per unit for the next 125 units per month,
- 10 1/2 cents per unit for the next 1,100 units per month,
- 15 cents per unit for all consumption in excess of 1,245 units per month.

All units supplied under this method of charge in excess of 145 units per month are subject to a Fuel Oil Price Surcharge.

Method B.[1] Lighting for all purposes and for the supply to domestic radio sets:

- 1/- per unit subject to a minimum charge of 6/- per month.

Method B.[2] Restricted supplies for all lighting purposes and for the supply to domestic radio sets:

either:

(i) . 11/- per month payable in advance, including the hire of a composite supply unit and a load limiting device;

or

(ii) . 10/- per month payable in advance including the hire of a load limiting device only.

The load limiting device will be so adjusted that the supply will be disconnected when the load exceeds 120 watts.

Method C. Lighting and Power for Hotels, Clubs, Hospitals, Prisons, Restaurants, Cafés, Boarding Houses, Schools and Flats (not separately metred) for both lighting and power purposes:

. 75 cents per unit for the first 125 units per months subject to a minimum charge of 70/- per month,

. 30 cents per unit for the next 400 units per month.

. 17.5 cents per unit for all consumption in excess of 525 units per month.

Method D. Power for Off-Peak Water Heating:

. 9 cents per unit plus a Fuel Oil Price Surcharge, subject to a minimum charge of 6/- per month.

Method E. Lighting only for Churches, Chapels, Cinemas, Theatres, Offices, Shops and Commercial Premises:

. 72.5 cents for the first 200 units per month subject to a minimum charge of 100/- per month,

. 55 cents per unit for the next 240 units per month,

. 35 cents per unit for the next 500 units per month,

. 27.5 cents per unit for all consumption in excess of 940 units per month.

Method F^2. Small Power Supplies:

. 42 cents per unit for the first 375 units per month, subject to a minimum charge of 17/50 per month,

. 36 cents per unit for the next 600 units per month,

. 27.5 cents per unit for all consumption in excess of 975 units per month.

There is also a charge of 2/50 per KVA continuous rating of all electric welding plant.

Method F^2. Restricted Power Supplies for Water Pumping:

. 11 cents per unit plus a Fuel Oil Price Surcharge, subject to a minimum charge of 120/- per month,

Method G. Large Power Supplies - including limited supplies for lighting purposes:

(i) A maximum demand charge according to the following table

Maximum demand as recorded :	Fixed charge per kVA per annum
0 to 50 kVA	305/-
51 to 200 kVA	260/-
Over 200 kVA	225/-

(ii) A unit charge of 7.5 cents per unit subject to a minimum annual guarantee of consumption of 40,000 units.

The unit charge will be subject to a Fuel Oil Price Surcharge, but such Surcharge will not be imposed on units which have not been consumed but are deemed to have been supplied in order to make up the guaranteed annual consumption. There is also a charge of 2/50 per kVA of nameplate kVA continuous rating of all electric welding plant.

Method H. Restricted Power Supplies for the Production of Sisal Fibre only:

. 17 cents per unit, subject to a minimum charge of 60/- per month.

Method K. Lighting and Power for Military Camps, Hospitals, Institutions, Hotels, Clubs, Prisons, Restaurants, Cafés, Boarding Houses, Schools, Flats (not separately metred) and large buildings with a mixed load for combined purposes of lighting and power (including water heating)

(i) A fixed charge of 32/50 per kVA per metre reading period, based upon the actual recorded maximum demand, and

(ii) 11 cents per unit plus a Fuel Oil Surcharge.

The above charges are subject to a minimum charge of 812/50 per month.

Method M. Lighting and Power combined for Cinemas and Theatres only:

- 85 cents per unit for the first 200 units per month subject to a minimum charge of 150/- per month,
- 32 cents per unit for the next 1,000 units per month,
- 18 cents per unit for the next 2,000 units per month,
- 16 cents per unit for all consumption in excess of 3,200 units per month.

Method N.[1] Lighting and Power combined for Commercial Premises:

- 72.5 cents per unit subject to a minimum charge of 6/- per month.

Method N.[2] Bulk Supplies for Lighting and Power Purposes to Farms:

- 30 cents per unit subject to a minimum charge of 400/- per month.

(2) Future development (2,6,7,8)

There are available three estimates of the future consumption growth of electric energy:

Doc. (2)	Doc. (6)	Doc. (7)	Doc. (9)
1964/1965 : 10 %	1962/1970 : 9.5%	1964/1970 : 13 %	1963/1967 : 12.1 %
1966/1968 : 15 %			1967/1971 : 13 %
			1971/1975 : 11.4 %

However, there is no official estimate existing

Future power plant development is based mainly on the hydroelectric potential of the Tana River. Long-range plans have been made for a three-stage development at Seven Forks with a total capacity of about 250/270 MW. The producibility of the individual stages has not been given. The total investments will amount to £ 37 million. The Seven Forks scheme will be completed in 10 to 12 years, but construction works will be phased to anticipate expansion in the demands for electricity and other water storage requirements.

(a) Kindaruma power station, installed capacity 40 MW:
Construction started in March 1965. There will be two generating units, each with a Kaplan turbine of 28,000 HP (gross) or 20 MW nett and a generator of 23.5 MVA. The main transformers of 25 MVA will each step up the voltage from 11 KV to 132 KV for transport to Nairobi. Later, a third unit should be added and in this way the total installed capacity would be increased to 60 MW.

The total investments of the 40 MW phase, including transmission line 132 KV to Nairobi amount to £ 6 million.

(b) The Gtaru scheme power station with a total installed capacity of 170 MV will have four power units, each of 42.5 MW. This power station, with a head of about 203 m, will be situated underground and will be supplied by water from the large water reservoir upstream.

(c) A reservoir scheme power station (40 MW) will be located immediately downstream of the dam of the large reservoir. The useful storage of this reservoir will be about one million acre-feet of 1,200 million m3.

(d) At Kipevu on the coast, an additional oil-fired steam plant is to be installed in 1965; it is a 12.5 MW unit, the boiler of which is already in service.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.

2. Ditto, Part II.

3. Ditto, Add.1.

4. Industries et Travaux d'outre-mer, January 1964, Nr. 122.

5. World Energy Supplies, 1959-1962, UN, New York 1964, No. 7.

6. Report of the Preliminary Assistance Mission to Kenya, Vienna 1962.

7. Development Plan 1964-1970, Government of Kenya, 1964.

8. "Electric Power for Kenya", East African Standard, March 5, 1965.

9. Merz & Mc Lellan Report on Market for Electricity, February 1964.

Abbreviations and symbols used:

MW : Megawatt = 1,000 KW
GWh : Gigawatthour = 1,000,000 kWh
TWh : Terawatthour = 1,000 GWh
tce : tons (metric) of coal equivalent
HE : Hydroelectric power plant
DE : Diesel electric power plant
SE : Steam power plant
GE : Gas turbines power plant
TE : Thermal power plant

L.T. - Length of transmission and distribution mains
O.H. - Overhead lines
U.G. - Underground lines

6. TANZANIA

A. TANGANYIKA

I. Primary Energy Resources (3)

(1) Hydropower (from page 7)

Exploitable sites for hydropower are situated on the rivers flowing into the Indian Ocean. Other rivers, feeding the great lakes, are dry during part of each year and are not regarded as suitable for developing hydropower owing to the over-riding demands of irrigation. In general, hydropower and irrigation projects are inter-related in Tanganyika, and must be planned as a co-ordinated whole. No complete survey has been taken yet, but it would seem that not less than 2,500 million kWh p.a.[1/] could probably be generated ultimately, even though some of this production would be very costly owing to the need for large storage dams to even out the wide seasonal variations of flow. At present about 40 MW of plant is installed or under construction at five sites, and the total production of hydraulic energy is about 100 million kWh p.a. though this should be about doubled when the Hale 21 MW plant is in full operation. The largest of the possible hydro schemes is in the Rufiji Basin, where a total of about 500 MW of plant could be installed.

(2) Hydrocarbons

The coastal zone of Tanganyika, bordering on the Indian Ocean, is to a large extent underlain by sedimentary rocks of marine origin. A considerable amount of exploration for petroleum has been carried out in this area during the last 10 years, including the drilling of a deep well at Mandawa in the Southern Province. So far no economically exploitable accumulations of oil or gas have been found, but exploration continues.

1/ According to doc. (1), hydro potential is estimated at 75,000 million kWH (=75 TWh). The figure in the text above seems to be very much underestimated.

(3) Coal

Tanganyika has large reserves of bituminous coal, which have not so far been developed on a large scale, reportedly owing to the remoteness and inaccessibility of their location. The largest part of this reserve is in the Ruhuhu river area, on the east side of Lake Nyasa near its northern end. Numerous coal seams are known to occur in this area, varying in thickness from a few centimetres up to 5 metres. Reserves of good quality non-coking bituminous steam coal in this area are stated to be of the order of 300 million metric tons; if lower grades are included, the reserves exceed 400 million metric tons. The seams are generally undisturbed except for some block faulting, but only a small proportion of the coal could be mined by open-cast methods.

Analyses of some of the coals are given below:

Area	Moisture %	Volatiles %	Fixed Carbon %	Ash %	Sulphur %	Calorific Value Calories/ gramme
Ngaka	2.7	26.0	63.8	7.5	0.9	6,800
Ketewaka	1.2	23.4	50.2	25.2	0.53	5,800
South Manda	1.5	19.7	63.2	15.6	0.57	6,500
Njembe	3.5	19.9	40.6	36.0	0.24	4,100

All the above analyses were made on coal samples taken from outcrop, and the coals are non-coking.

Smaller coal-bearing areas are known to occur in the general area of L. Rukwa, between L. Nyasa and L. Tanganyika. These areas are of limited extent, bounded by faults, the coal is in general of poorer quality than that in the Ruhuhu valley, and the reserves are much smaller.

(4) Radio-active minerals

No economically exploitable deposits of such minerals have been found yet although significant indications are known to exist. Exploration continues and may be successful.

(5) Geothermal

It is undoubtedly possible that geothermal anomalies may exist in connexion with the Rift Valley system and the extensive recent volcanic activity associated with it, but no specific details are available.

II. Production, trade and consumption of primary energy (1, 5, 5a)

(1) Production

(a) In natural units (rounded):

	Hydroenergy	Coal
	GWh	tons
1959	90	2,000
1960	90	2,000
1961	90	2,000
1962	100	2,000
1963	100	2,000 1/

(b) In equivalent units, 1,000 tce (rounded):

	Hydroenergy	Coal	Total
1959	45	2	47
1960	45	2	47
1961	45	2	47
1962	50	2	52
1963	50	2	52

Ratio of 1 kWh = 0.5 kgs coal equivalent has been taken as the basis for calculation

(2) Net import of liquid fuels, in 1,000 tce (rounded):

1959	370
1960	430
1961	400
1962	430
1963	450

1/ Estimated

(3) Consumption in 1,000 tce:

	Hydroenergy	Coal	Liquid fuels	Total
1959	45	2	370	417
1960	45	2	430	477
1961	45	2	400	447
1962	50	2	430	482
1963	50	2	450	502

Consumption per capita:

1959	45	kg coal	equivalent
1960	51	"	"
1961	47	"	"
1962	51	"	"
1963	51	"	"

III. Electric energy (2, 4, 5, 5a, 6, 7, 8)

(1) Existing power plants

(a) Installed capacity (in 1961):

Hydropower plants	20.2 MW
Diesel power plants	26.3 "
	46.5 "

Hydropower plants:

	Capacity in kW	Producibility in GWh
HE Pangani Falls	17,500	80.0
HE Kikuletwa	1,160	6.0
HE Little Ruaha River	1,220	2.6
HE Mbalizi (near Mbeya)	340	1.6
	20,220	90.2

Diesel power plants

DE Kurasini (near Dar-es-Salaam)	17,200 kW
Small DE (Arusha, Moshi, Mwanza and others) about	9,100 "
	26,300 "

(b) Production, trade and consumption, in GWh (rounded)

	Production			Export	
	Hydro	Diesel	Total	to Kenya	Consumption
1959	90	60	150	20	130
1960	90	60	150	20	130
1961	90	70	160	20	140
1962	100	80	180	20	160
1963	100	90	190	20	170

In the period 1959-1963, the average rate of growth of consumption was 6.8 per cent.

In 1962 the distribution of unit sales was as follows:

	Per cent
Household power and lighting	27
Sisal supplies	28
Power supplies	22.6
Commercial power and lighting	15
Street and lighting supplies	3
All other	4.4
	100.0

(c) Transmission and distribution

In 1961 there were no internal transmission lines between the existing power centres. There is only one 33-kV cross-frontier inter-connexion line with a total length of 70 km (estimated to the border of Kenya).

No information is available about the existing distribution systems.

(d) Tariffs (US$ 1 = EAS 7 = E.A. cents 700)

In Dar-es-Salaam, Arusha and Moshi, the tariffs are:

Ordinary lighting E.A. cents 120/kWh

" power E.A. cents 60

Lighting and power for hotels, hospitals, clubs, cinemas:

standing charge per month and the first rate 25 E.A. cents/kWh

exceeding 12.5 "

Domestic, private consumption: standing charge per month and 25 E.A. cents/kWh

Off-peak domestic water-heating and air-conditioning: 8 E.A. cents/kWh

The tariffs in the Tanga area are lower on average than the above cited ones, except the price for lighting, which is also 120 E.A. cents/kWh. In other distribution areas the tariffs are similar to those of Dar-es-Salaam.

(e) Fuel costs

The price of diesel oil at various places in Tanganyika depends very much on transport costs:

Dar-es-Salaam	247.60 EAS/ton
Arusha	316.95 "
Moshi	317.24 "
Mwanza	387.92 "

(f) Production costs

Hydropower costs: About 18 E.A. cents/kWh. This covers all expenditure including interests and depreciation, and a high voltage line from the hydropower plant to the consumption centre.

Diesel power plants

Fuel costs	6.7 - 10.2 E.A. cents/kWh
Operating costs	11.0 - 16.0 "
Interest and depreciation	not known

(2) H.E. Hale and 132-kV transmission line Hale - Dar-es-Salaam

In 1964, the HE Hale on the Pangani River was to have come into operation, according to previous construction plans. At the same time the Dar-es-Salaam distribution system was to have been linked to the Tanga system by a 132-kV line with a length of approximately 280 km.

H.E. Hale is to have an installed power of 21,000 kW with a yearly producibility of 95 GWh.

There is no information available which would confirm that the above-mentioned objects went into operation according to schedule.

(3) Future development (8)

For the five-year period 1964-1969, it is supposed that the average rate of increase of consumption will be 12 per cent. The provisional breakdown of 1970 sales of electricity is as follows:

Dar-es-Salaam	201.0 GWh
Tanga	80.5 "
Arusha/Moshi	24.8 "
Central line	23.2 "
Up country	25.9 "
	355.4 GWh

The new investment that is required up to 1970 to achieve this increase in electricity supplies is estimated at £10.6 million, of which £8.1 million will pay for the installation of new generating capacity and transmission lines.

The preliminary phasing of investment is estimated to be (in £1,000):

	1965	1966	1967	1968	1969	1970	Six-year total
General extension to existing plant	350	400	400	400	500	500	2,550
New power station	-	-	-	1,300	2,300	3,000	6,600
New transmission lines	1,500	-	-	-	-	-	1,500
Total	1,850	400	400	1,700	2,800	3,500	10,650

The total investment programmes of the Tanganyika Electricity Supply Company (TANESCO) for the five-year period 1964-1965 to 1968-1969 amount to £ 6.71 million.

(a) Additional power station of about 30 MW to supply Dar-es-Salaam

It was not yet decided if this power station will be erected on the Pangani River or on the Wami River.

Breakdown of the total project investment:	
- Power station for Dar-es-Salaam supply	£ 3,500,000
- Duplicate Hale/Dar-es-Salaam 132-kV Transmission line	520,000
- Additional interconnectors Pangani/Hale	30,000
- Additions to Hale Sub-station switchgear and transformers	100,000
- Additions to Ilala Sub-station	80,000
- New feeders out of Ilala	100,000
Total	£ 4,330,000

(b) Kilimanjaro and Arusha power supplies

Items	Amount
- HE Nyumba ya Mungu (5 or 6 MW)	£ 710,000
- Transmission line HE Nyumba ya Mungu to Moshi	140,000
- Sub-station Moshi	140,000
- Moshi/Arushi duplicate transmission line	120,000
- New 32 kV-feeders	160,000
Total	£ 1,230,000

(c) Miscellaneous small scale projects

Total amount of £1,150,000

B. ZANZIBAR AND PEMBA

Very little is known about the energy situation in the island-part of Tanzania, on Zanzibar and Pemba.

I. Primary energy resources

No data

II. Production, trade and consumption of primary energy

There is no domestic production of primary energy. Only the imported liquid fuels are consumed in the country:

Import and consumption of liquid fuels

1959	20,000 tce (rounded)
1960	20,000 " (")
1961	20,000 " (")
1962	20,000 " (")
1963	20,000 " (")

Consumption per capita

1959	55 kg coal equivalent
1960	53 " " "
1961	51 " " "
1962	60 " " "
1963	56 " " "

III. Electric energy

The total installed power of thermal plants was 3,600 kW, with a yearly production of 11.9 GWh in 1961. The number and the kind of power plants is not known, but according to some indications they are diesel power plants. There are no hydropower plants.

According to docs. (5) and (5a), production and consumption of electric energy was:

1959	10	GWh.(rounded)
1960	10	" "
1961	10	" "
1962	10	" "
1963	10	" "

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.

2. Ibid., Part II

3. Ibid., Add.1

4. Industries et travaux d'outre-mer, January 1964, Nr. 122

5. United Nations, World Energy Supplies, 1959-1962, New York 1964, No.7

5a. " " " " " 1960-1963, " " 1965, No.8.

6. Report of an IAEA Mission to Tanganyika & Vienna, 1962

7. Development Plan for Tanganyika 1961/62 - 1963/64.

8. Tanganyika Five-Year Plan for Economic and Social Development, 1 July 1964-30 June 1969.
   (a) Volume I: General analysis
   (b) Volume II: The programmes

9. Development of the Steel Industry in East and Central Africa, W.S. Atkins and Partners, Preprint, 1965.

Abbreviations and symbols used

MW - Megawatt = 1,000 kW
GWh - Gigawatthour = 1,000,000 kWh
TWh - Terawatthour = 1,000 GWh
tce - tons (metric) of coal equivalent
HE - Hydroelectric power plant
DE - Diesel electric power plant.

7. MALAWI

I. Primary Energy Resources (3)

(1) Hydro-power

Malawi has a considerable hydro-power potential, located principally on the Shire River between Matope and Chikwawa. Details of the various schemes and quantitative estimates of their potential output are given in a report prepared for the Government in 1954 by Sir William Halcrow and Partners. In this report, the following figures are given on the Shire River potential sites and the necessary investments:

Site	Capacity in MW			Investments £ million
	Firm	Peak	Installed	
Matopi	16	30	40	2.740
Nkula	67	135	180	9.496
Mpatamanga	96	120	150	10.985
Hamilton Falls	61	75	100	7.229
Various improvements	-	-	-	2.441
Total	240	360	470	32.891

Expressed in US $, specific investments of the whole scheme would amount to $ 196 per kW installed and the energy costs to 3.2 mills/kWh. It should however, be pointed out that these estimates were made in 1954 and that since then, the level of prices has risen considerably.

(2) Hydrocarbons

Malawi has no known hydrocarbon resources but small amounts of dissolved methane are present in the deep waters (300 m plus) of Lake Malawi and it is possible that further prospecting might show produceable quantities.

(3) Coal

Coal is known to occur at five different localities: two of these are in the Shire Valley and three in the Northern Region not far from Lake Malawi. In general, the coal seams are thin, with a high ash content and, locally, badly broken up by faulting. In the Sumbu area of the Shire Valley they have been intruded and partly decarbonised by igneous rocks. The most promising occurrences appear to be in the Livingstonia and Nkana areas, located on the west side of Lake Malawi near its northern end. At Livingstonia, coal is found in an area of 90 km^2: it varies laterally in thickness from 30 cm to 3 m and is often split into more than one seam. The area is block-faulted and the coal seams are overlain by sand-stones locally containing artesian water. The coal has an average ash content (including outcrop samples) of 31.9 per cent but there are some thick workable seams with an average ash content of 14 per cent. The calorific value ranges from 5,400 to 7,050 cal/g. (mean 6,230). However, the coal would be difficult and expensive to mine. At Nkana, just south of the Tanzania border, there is a smaller amount of coal that would probably be easier to mine and that is of similar quality: individual seams are up to 2 m in thickness. The average ash content is 21.2 per cent and average calorific value 4813 cal/g.

(4) Non-conventional sources of energy

a) Radio-active minerals: A number of occurrences of refractory U-minerals are known in Malawi, the largest of which are at Tambani, Blantyre District, and to the north-west of Chitipa (Fort Hill). If extraction problems can be solved, the deposits may be economically exploitable.

b) Geothermal: Geothermal energy derived from hot springs is a possibility as such springs are fairly commonly associated with the Rift Valley faults bordering Lake Malawi.

II. Production, Trade and Consumption of Primary Energy

(1) Production

Only small amounts of hydroelectric energy are produced in the country. In 1961/1962, this production amounted to 4,6 GWh.

(2) Trade

No data available.

(3) Consumption

No data available.

III. Electric Energy (1,2,4,5,6)

(1) Existing power plants

(a) Installed capacity at 30 June 1963

Station	Type of the Station in kW	Total capacity in kW	Peak Load kW	System Load Factor %
Blantyre	ST 2 x 2500 + 2 x 1000 DE 1 x 1340 2 x 1100	10,540	8,025	55.5
Zomba	DE 1 x 1100 HE 2 x 300	2,800		
Lilongwe	DE 1 x 700 + 2 x 240 + 1 x 235 + 1 x 140 + 3 x 85	1,810	700	43.9
Fort Johnston	DE 3 x 20	60	-	-
Mzuzu	DE 1 x 105 + 1 x 80 + 1 x 50 + 2 x 20	275	-	-
	Total	15,425	8,725	56.5

Breakdown of the total capacity according to the type of power station:

SE	7,000 kW
DE	7,825 kW
HE	600 kW
Total	15,425 kW

(b) Production in 1961/1962 and 1962/1963, according to the type of the stations and the province of the country (in MWh):

	DE		SE		HE		Total generation	
	1961/62	1962/63	1961/62	1962/63	1961/62	1962/63	1961/62	1962/63
Southern Province	2,890.8	4,276.0	28,383.9	30,488.3	4,553.4	4,276.1	35,828.1	39,040.0
Lilongwe	2,538.9	2,691.7	-		-		2,538.9	2,691.7
Fort Johnston	46.2	48.2	-		-		46.2	48.2
Mzuzu	143.0	200.2	-		-		143.0	200.2
Total	5,618.9	7,216.1	28,383.9	30,488.3	4,553.4	4,276.1	38,556.2	41,980.5

(c) Breakdown of consumption in 1961/1962 and 1962/1963, by various groups of consumers (in MWh):

Groups of consumers	Southern Province		Lilongwe		Districts Mzuzu and Fort Johnston	
	1961/62	1962/63	1961/62	1962/63	1961/62	1962/63
Street lighting	241	312	36	51	-	-
Industrial	17,346	18,651	566	855	14	52
Domestic	8,565	9,088	683	669	88	107
Commercial	4,339	5,272	868	769	62	57
General purposes	167	147	27	26	-	-
High-density areas	104	108	21	18	1	2
Sales total	30,761	33,577	2,201	2,388	165	218

TOTAL:

Groups of consumers	1961 / 1962		1962/ 1963	
	MWh	%	MWh	%
Street lighting	277	0.8	363	1.0
Industrial	17,926	54.2	19,558	54.1
Domestic	9,336	28.2	9,864	27.2
Commercial	5,269	15.8	6,098	16.8
General purposes	194	0.6	173	0.5
High-density areas	126	0.4	128	0.4
Total	33,127	100.0	36,183	100.0

	1961/1962	1962/1963
Total generation	38,556	41,980.5
Power-station consumption and losses	5,429 or 14 %	5,797 or 13.8 %

(d) Transmission and distribution networks as at 30 June 1963

Overhead lines and underground cables, in km:

	Southern Province	Lilongwe	Districts	Total
OVERHEAD LINES				
66 kV	44	-	-	44
33 kV	210	-	-	210
11 kV and 3.3 kV	343	55	12	410
Low voltage 400/230 V ..	189	38	9	236
Overhead lines Total	786	93	21	900
UNDERGROUND CABLES				
11 kV and 3.3 kV	13.8	-	-	13.8
Low voltage 400/230 V ..	3.3	0.4	0.06	3.76
Underground cables Total	17.1	0.4	0.06	17.56

The total length of power lines was at that time:

Transmission lines:	254 km	(rounded)
Distribution - Medium voltage feeders	424 km	"
- Low voltage network	240 km	"

Transformer capacity, in kVA:

	Southern Province	Lilongwe	Districts	Total
STEP-UP				
11/33 kV	6,000	-	-	6,000
LV/3.3 and 11 kV	300	1,100	210	1,610
Sub-total	6,300	1,100	210	7,610
STEP-DOWN				
33/11 kV	4,500	-	-	4,500
33/0.4 kV	2,315	-	-	2,315
11 and 3.3/0.4 kV	20,075	2,665	170	22,910
Sub-total	26,890	2,665	170	29,725
TOTAL	33,190	3,765	380	37,335

(e) Prices of electric energy in pence/kWh by consumer groups and provinces, including fixed charges for power, for the periods 1961/1962 and 1962/1963:

Consumer groups	Southern Province		Lilongwe		Districts	
	61/62	62/63	61/62	62/63	61/62	62/63
Street lighting	3.47	3.37	4.58	4.50	-	-
Industrial	3.06	3.15	4.78	4.78	7.35	8.74
Domestic	3.57	3.51	5.66	5.68	12.16	11.80
Commercial	5.24	4.99	5.52	5.65	12.20	12.51
General purposes	16.02	16.07	16.32	16.62	15.61	17.23
High-density areas	8.50	8.56	13.55	13.97	17.14	14.61
Provincial averages	3.60	3.61	5.57	5.51	11.81	11.29

The average for the country amounted to 3.77 pence/kWh in 1961/1962 and 3.78 pence/kWh in 1962/1963

(f) Tariffs:

Since 1961, the tariff system in power has had five scales:

- Scale I - Domestic tariff

For the supply of electricity to premises used solely for residential purposes and to all apparatus normally used for such premises, including motors up to 2 H.P....

	Southern Province Interconnected System	Lilongwe	Fort Johnston Mzuzu
First 20 units per month	1/3d. per unit	1/3d. per unit	1/6d per unit
Next 120 units " "	4d. per unit	6d. per unit	9d. per unit
Balance	2d. per unit	3d. per unit	9d. per unit
Minimum charge per month or part thereof	10/-	10/-	10/-

- Scale II - General Purpose Tariff

For the supply of electricity to premises or installations for which, in the opinion of the Commission, no other tariff is appropriate.

	Southern Province Interconnected System	Lilongwe	Fort Johnston Mzuzu
All units per month	1/3d. per unit	1/3d. per unit	1/6d. per unit
Minimum charge per month or part thereof	10/-	10/-	10/-

- Scale III - Commercial Tariff

For the supply of electricity to premises used for the following purposes: hotels, theatres, restaurants, clubs, public houses, cinemas, institutions, hospitals, offices, nursing homes, garages, shops, small workshops, public halls, schools, hostels, airfields, communications centres, railway stations and similar establishments, providing the demand does not exceed 50 kW of which not more than 15 h.p. of connected motor load will be allowed.

	Southern Province Interconnected System	Lilongwe	Fort Johnston Mzuzu
First 100 units per month	1/- per unit	1/- per unit	1/6d per unit
Next 4,000 units " "	4.5d. per unit	4.5d. per unit	9d. per unit
Balance	2d. per unit	3d. per unit	9d. per unit
Minimum charge per month, or part thereof	£ 3	£ 3	10/-

- Scale IV - Industrial Tariff

For the supply of electricity for manufacturing and processing purposes, commercial water heating, cooking and refrigeration, water pumping, farming and workshops:

	Southern Province Interconnected System	Lilongwe	Fort Johnston Mzuzu
First 200 kW of maximum demand per month	£ 1 12 0d. per kW	£ 1 12 0d. per kW	£1 12 0d. per kW
Next 200 kW per month	£1 6 0d. per kW	£1 6 0d. per kW	£1 6 0d. per kW
Balance	£1 0 0d. per kW	£1 0 0d. per kW	£1 0 0d. per kW
First 10,000 units per month	2d. per unit	3d. per unit	6d. per unit
Next 40,000 units per month	1.6d. per unit	3d. per unit	6d. per unit
Balance.....	1.4d. per unit	3d. per unit	6d. per unit

In addition to that, the industrial tariff has also the following clauses:

(a) Minimum Charge at all Undertakings,

(b) Power Factor clause at all Undertakings,

(c) Coal Price Variation clause at Southern Province Interconnected System,

(d) Fuel Oil Price Variation clause at Lilongwe,

(e) Fuel Oil Price Variation clause at Fort Johnston and Mzuzu.

- Scale V - High Density Residential Area Tariff

For the supply of electricity used solely for residentail purposes in premises of a type approved by the Commission and situated in areas declared by the Commission as High Density Residential Areas for the purposes of electricity supply. .....

	Southern Province Interconnected System	Lilongwe	Fort Johnston Mzuzu
First 12 units	7/6d.	7/6d.	First 8 units for 7/6
Balance at	4d. per unit	6d. per unit	9d. per unit

Minimum Charge (including Meter Rent) is in each case 8/6d. per month or part thereof.

(g) Production costs of electric energy in pence/kWh in 1963/1962 are given in document (4) for the provinces; these costs represent an average of the production costs for steam, diesel and hydropower plants. .....

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Generation costs	Southern Province		Lilongwe		Districts	
	61/62	62/63	61/62	62/63	61/62	62/63
Fuel	0.87	0.86	2.28	2.15	7.24	6.32
Oil, water, etc.	0.05	0.06	0.11	0.11	0.61	0.36
Operation	0.20	0.27	0.37	0.39	3.15	2.62
Maintenance	0.19	0.23	0.39	0.33	2.82	1.91
Interest	0.36	0.34	0.34	0.44	1.94	1.23
Depreciation	0.37	0.35	0.34	0.45	1.59	1.33
Overhead charges	0.13	0.12	0.30	0.29	0.74	0.60
Total generation	2.17	2.23	4.13	4.16	18.09	14.37

Distribution costs	Southern Province		Lilongwe		Districts	
	61/62	62/63	61/62	62/63	61/62	62/63
Operation and maintenance	0.22	0.24	0.22	0.22	0.34	0.85
Interest	0.22	0.24	0.31	0.28	0.62	0.59
Depreciation	0.24	0.24	0.29	0.28	0.49	0.64
Overhead charges	0.13	0.12	0.30	0.29	0.74	0.60
Total distribution	0.81	0.84	1.12	1.07	2.19	2.68
Total costs per kWh sent out	2.98	3.07	5.25	5.23	20.28	17.05
Total costs per kWh sold	3.28	3.36	5.84	5.72	21.29	18.66
Average revenue per kWh sold	3.60	3.61	5.57	5.51	11.81	11.29
Difference	+ 0.32	+ 0.25	- 0.27	- 0.21	- 9.48	- 8.37

(2) Future development (5)

Very little information is available about the future development plans of the country. The investments of the Electricity Corporation for the five-year period 1965-1969 have been revised as follows:

		£ 1000
(a)	completion of the Nkula Falls Hydroelectric Scheme (2nd stage)	350
(b)	Maintenance of general development	100
(c)	Construction of a second transmission line from the Nkula site to Blantyre	148
(d)	Installation of a transmission line to Lilongwe	600
(e)	Erection of special transmission lines for large private power producers (Sugar Project line)	130
	TOTAL	1,328

The Electric Supply Commission is already looking ahead to its second hydropower station on the Shire River.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.

2. Ditto, Part II.

3. Ditto, Add.1.

4. Nyasaland Electricity Supply Commission: the sixth annual report and statement of accounts for the year 1961/1962.

5. Malawi Government: Development plan 1965-1969. Zomba, 1964.

6. Nyasaland Electricity Supply Commission: The Seventh annual report and statement of accounts for the year 1962/1963.

Abbreviations and symbols used

MWh - Megawatthour = 1,000 kWh

GWh - Gigawatthour = 1,000,000 kWh

HE - Hydroelectric power plant

DE - Diesel electric power plant

SE - Steam electric power plant

8. ZAMBIA

(1) **HYdropower:**

The hydro potential of Zambia is mainly concentrated on the Zambezi River, which is shared with Rhodesia. The Kariba scheme, already partly developed, is planned to have an ultimate plant installation of 1200 MW and an annual production of 7.5 TWh. A further 40-50 MW could later be generated at Victoria Falls, raising the total Zambezi production to about 7.8 TWh p.a. For the Kafue scheme a further 450 MW installation has been planned. The total hydro resources of the country (less whatever contribution must go to (Rhodesia) are at least 12 TWh p.a. which is divided into :

.1000 MW firm capacity, load factor	100%	=	8.8 TWh, and
.1000 MW seasonal " "	40%	=	3.4 TWh
			12.2 TWh

(2) Hydrocarbons

Zambia has no resources of hydrocarbons, nor are any likely to be found.

(3) Coal:

Coal is reported to occur in Gwembe district of the middle Zambezi, in the valleys of the Launo and Shangani Rivers, and in the lower Kafue valley (Kafue Flats), but the seams are stated to be thin, with a high ash content and to be badly broken up by faulting, so that they are not considered to be capable of economic exploitation. The most promising occurrence is in the Kandabwe area of Gwembe district, where a seam of 2 to 3 metres in thickness occurs, having an ash content of 22%. Reserves of this down to a depth of 300 metres are reported to be 20 million metric tons of coal with a calorific value of 5500 kcal/kg. In doc. (7), the reserves are reported to be 50 million metric tons.

(4) Non-conventional sources of energy:

a) Radio-active minerals: The "Copper Belt" of Northern Rhodesia is considered a most favourable area for the occurrence of uranium, but little has been found so far due to thick over-burden present over much of the country. Uranium occurs in low concentrations in most of the large copper mines.

b) Geothermal: Hot springs are reported to occur in the Zambezi River trough, near the junction of the Gwai and Sanyati rivers. It is possible that these might indicate the presence of geothermal steam.

II. Production, Trade and Consumption of Primary Energy (4)

Doc. (5) gives data only about the former Federation of Rhodesia and Nyasaland and not about its constituent parts. All information is taken therefore from docs. (2) and (4).

(1) Production:

The only primary energy produced in the country is hydroelectric energy:

	Hydro-energy		
	GWh	1000 tce	Remark: Kariba I Hydro-
1961	272	136	power station is treated for
1962	290	145	statistical purposes as a
1963	305	152.5	
1964	295	147.5	Rhodesian producer.

Conversion ratio : 1 kWh = 0.5 kgs. coal equivalent,

(2) Trade (Import)

The bulk of primary energy is imported in form of coal, refined petroleum products and hydroelectric energy from neighbour countries. Information about imports is available for 1962 and 1964 (in natural units):

	1962	1964
Coal	1,600,000 tons	977,842 tons
Coke and semi-coke	?	65,749 tons
Refined petroleum products	130,000 tons	147,576 tons
Electric energy	1,766 GWh	1,959 GWh

Conversion factors : 1 ton coal = 1 tce
1 ton refined products = 1.5 tce

Details of imports (in 1000 tce):

	1962	1964
Coal (from Wankie in Rhodesia)	1,600	978
Coke (from Rhodesia)	?	66
Refined petroleum products (via Lourenco Marques and Rhodesia)	195	220
Electric energy	883	980
TOTAL ..	2,678	2,244
Of these totals, the following percentages came from or via Rhodesia	91%	95%

(3) Consumption:

	1962		1964	
	1000 tce	%	1000 tce	%
Production	145	5.1	147.5	6.1
Import	2,678	94.9	2,244.0	93.8
Consumption	2,823	100.0	2,391.5	100.0

Consumption per capita : 1962 .. 830 kgs coal equivalent
1964 .. 700 kgs coal equivalent

III. Electric Energy (2,4)

(I) Existing power plants:

(a) Installed capacities (in MW) at end December 1964:

Territory and undertakings	Thermal	Hydro	Load factor % 1962	Load factor % 1964
Copperbelt mines	193.1	-	82	84
Broken Hill mine	-	42.7	76	89
Lusaka	15.0	-	54	55.6
Victoria Falls	-	8.0	55	65
Others	0.3	4.8	30	34
TOTAL	208.4	55.5		
Total TE + HE	263.9			

Doc. (6) indicates some more diesel power plants (state at end of December 1960):

Mongu	300 kW
Choma	600 "
Monze	228 "
Mazabuka	558 "
Kafne	480 "
Fort Jameson	495 "
Fort Rosebery	2,000 "
Abercorn	500 "
Kasama	495 "
TOTAL:	5,656 kW

It is not known which of these power plants are still operating.

(b) Production in GWh

	1959	1960	1961	1962	1963	1964
Broken Hill						
Mine	228.0	233.6	242.6	255.2	275.5	263.5
Victoria Falls	17.9	21.8	22.9	27.3	30.4	32.3
Others	4.4	5.5	7.3	7.8	8.4	9.7
HE Total :	250.3	260.9	272.8	290.3	314.3	305.5
Copperbelt						
Mines	827.0	455.1	344.3	310.2	400.5	372.4
Lusaka	37.8	46.8	21.5	15.3	4.9	15.3
Ndola	52.3	44.5	15.3	-	?	-
Chilanga	20.3	15.5	14.9	4.7	?	-
TE Total :	937.4	561.9	396.0	330.2		387.7
HE + TE Total	1,187.7	822.8	668.8	620.5	730.0	693.2

(c) Import in GWh

	1959	1960	1961	1962	1963	1964
From:						
Congo	744.7	521.3	463.2	470.3	275.0	201.4
Rhodesia (Kariba).	0.5	800.1	1,124.4	1,296.0	1,570.0	1,757.7
TOTAL	745.2	1,321.4	1,587.6	1,766.3	1,845.0	1,959.1

(d) Consumption, including power-station consumption & losses, in GWh:

	1959	1960	1961	1962	1963	1964
Production	1,187.7	822.8	668.8	620.5	730.0	693.2
Import	745.2	1,321.4	1,587.6	1,766.3	1,845.0	1,959.1
TOTAL	1,932.9	2,144.2	2,256.4	2,386.8	2,575.0	2,652.3

In the period 1959/64, the average rate of increase of consumption was 6.5 per cent.

(e) Breakdown of consumption, in GWh:

	1959	1960	1961	1962	1963	1964
Farms	0.1	0.4	0.7	0.8	1.2	1.5
Mines	1,625.3	1,773.7	1,828.7	1,907.8	2,031.5	2,176.4
Industry	46.2	45.4	61.1	71.8	80.5	98.8
Domestic	135.7	128.6	137.5	147.7	154.7	157.1
Others	36.5	65.4	75.7	91.1	97.5	105.3
Sales Total	1,843.8	2,013.5	2,103.7	2,219.2	2,365.4	2,539.1
Consumption	1,932.9	2,144.2	2,256.4	2,386.8	2,575.0	2,652.3
Power-station consumption and losses	89.1	130.7	152.7	167.6	209.6	113.2
In % of consumption	4.6%	6.1%	6.7%	7.0%	8.1%	4.2% a/

a/ Internal consumption of power stations and losses seem to be abnormally low. Most likely some of the figures given are faulty.

(f) Transmission and distribution

Interconnexion between Zambia and the Congo (DR) exists in the form of a 220 kV transmission line from Jadotville (Congo) to the Kitwe sub-station where two step-up transformers effect liaison with Zambia's 330 kV system, namely with the transmission lines Kitwe-Lusaka and Lusaka-Kariba (Rhodesia). The capacity of the line-Kariba-Lusaka-Kitwe, with a total length of 600 km, is about 250 MW.

At Lusaka, there are 330/88 kV step-down transformers, but no data are available about the medium-voltage transmission lines in Zambia.

Distribution of electric power is carried out by fifteen different undertakings, most of which have considerable unused capacity. The largest undertaking is the Rhodesia Congo Border Power Corporation (RCBPC) which distributes about 86 per cent of the total energy, mainly to the mines. It also wholesales power to the municipalities of the region (Ndola, Kitwe, etc.) and to the Northern Electricity Supply Corporation. There are three other major undertakings: the Central Electricity Corporation (Lusaka), the Victoria Falls Electricity Board and the Livingstone municipal undertaking.

There is no information available about the technical and economic details of Zambia's distribution systems.

The dissolution of the Federation of Rhodesia and Nyasaland resulted in the transfer of responsibility for Kariba power development from the former Federal Power Board to the Central African Power Corporation, which has now the responsibility of operating and developing the system on behalf of the Governments of Zambia and Rhodesia.

(g) Tariffs:

In doc. (7), the following information is given: "The normal tariffs are approximately 0.70 pence per kWh but a large consumer taking power with a 80-90 per cent load factor would purchase at 0.40 pence per kWh."

(2) Future development (4)

There are no fixed development plans existing but in doc.(4) some projections and recommendations are made.

(a) Electric energy consumption in 1970 (in GWh)

	1962	1970
Mines: supplied by RCPBPC	1,900	2,800
Broken Hill	220	260
Industry : Fertilizers	0	120
Others	70	190
Domestic	150	460
Commercial	90	280
Agriculture	1	5
Railways	0	150
Total	2,431 a/	4,265

The average rate of growth in the eight-year period is 7.3 per cent.

There is no information about maximum demand in MW.

(b) New generating capacity:

The Kariba hydropower plant was planned to be developed in two stages. The first of these, Kariba I, consists of the dam and the erection of a generating plant on the south bank of the Zambezi River (in

a/ - This figure is not consistent with the figure for consumption in the foregoing table, but the difference is not large.

Rhodesia). Stage two, Kariba II, will consist of a corresponding installation on the north bank in Zambia.

	Installed capacity MW	Specif. investment £/kW	Total Investment 10 £
Kariba I	700	110	78
Kariba II	900	47	42
TOTAL	1,600	75	120

As Kariba I is not fully operational (in 1962, the maximum demand was only about 345 MW or less than 50 per cent), there is no need for the time being to construct new capacities.

Kariba II should go on stream not earlier than 1973.

. After 1970, construction of the hydro power station in the fifth gorge of the Victoria Falls (184 MW) and its connexion with the Kariba system should be considered.

. The Kafue River development should start early enough to meet the needs after 1980.

(c) New transmission lines:

By 1970, the RCBPC's maximum power demand will be about 384 MW and a second 330-kW line (Kariba-Kitwe) will be necessary. The cost of this secondline is estimated at £5.5 million.

Documents used:

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.
2. Ditto, Part II.
3. Ditto, Add. 1.
4. Report of the UN/ECA/FAO Economic Survey Mission on the Economic Development of Zambia, Ndola, 1964.
5. World Energy Supplies, 1959-1962, UN, New York 1964, No.7.
6. Federation Rhodesia and Nyasaland : Fourth Report of the Under-Secretary for Power, covering the period 1 July 1959 to 31 December 1960, Salisbury 1961.
7. Development of the steel industry in East and Central Africa, W.S. Atkins & Partners, Preprint 1965.

Abbreviations and symbols used:

MW -Megawatt = 1,000 kW
GWh - Gigawatthour = 1,000,000 kWh
TWh - Terawatthour = 1,000 GWh
tce - tons (metric) of coal equivalent
HE - Hydroelectric power plant
DE - Diesel electric power plant
TE - Thermal power plant

9. RHODESIA

I. Primary Energy Resources (3)

(1) Hydropower

The hydro-potential of Rhodesia is considerable, particularly on that section of the Zambezi river which forms the border between Zambia and Rhodesia. There are no data available about estimates of Rhodesia's hydro-potential. For the total of the former Federation of Rhodesia and Nyasaland the hydro-potential was estimated at 36 TWh.

(2) Hydrocarbons

Rhodesia has no known hydrocarbon resources nor are any likely to be discovered.

(3) Coal

Rhodesia is relatively rich in coal of good quality, which is exploited on a large scale at Wankie.

In the Wankie field there are three seams of coal, of which only the lowest is mined. This yields a bituminous coal of excellent quality, much of it with coking properties. In thickness it ranges from 4 to 12m, and reserves are reported to be of the order of 5,000 million metric tons.

Coal occurs elsewhere in Rhodesia, principally along the Zambezi river, but its quality is inferior to that of Wankie and it is not mined on a large scale. Total reserves of coal in Rhodesia are reported to be in excess of 10,000 million metric tons.

The following information on coal deposits is taken from doc. (9). It is somewhat different from the data given above.

Coalfield	Type of coal	Ash content in %	Calorific value cal/g	Reserves in million tons	
				Proved	Probable
Wankie	Coking	11.0	7,400	824	300
Wankie	Non-coking	25.0		266	112
Entuba	Coking	12.8		68	
Entuba	Non-coking	30.0		72	
Lulimbi	Coking	12.8		20	
Lulimbi	Non-coking	18.6		54	
Bubye	Coking	12.0		20	
Gengwe	Non-coking	32.0		45	
Lubu-Sebwngu	Non-coking	23.2		90	
Makushwe	Non-coking	34.8		4,733	
Malilongwe	Non-coking	34.3		264	
				6,456	412
				6,868	

(4) Non-conventional sources of energy

Radio-active minerals: These are known to occur in several areas but no economically exploitable deposits have yet been found. Geological conditions are favourable for their occurrence.

II. Production, Trade and Consumption of Primary Energy (4, 6, 6a)

(1) Production: Coal and hydropower

(a) In natural units:

	Coal (1,000 tons)	Hydroelectric power (GWh)
1959	4,143	0.5
1960	3,923	1,046.5
1961	3,387	2,205.7
1962	3,115	2,736.3
1963	3,021	3,142.0

(b) In 1,000 tce:

Conversion factors: 1 ton of coal = 1 tce
1 GWh = 500 tce

	Coal	Hydroelectric power (rounded)	Total
1959	4,143	-	4,143
1960	3,923	523	4,446
1961	3,387	1,103	4,490
1962	3,115	1,368	4,483
1963	3,021	1,571	4,592

(2) Trade:

(a) Coal: A large part of production is exported to Zambia and very small quantities outside of the former Federation (6):

1959	170,000 tce	Export outside Federation
1960	190,000 tce	
1961	280,000 tce	
1962	180,000 tce	
1963	230,000 tce	

Data about exports to Zambia are lacking. In 1962, they are reported to have been 1,600,000 tons.

In 1962, the total exports were estimated at 1,780,000 tce.

(b) Hydroenergy:

	Exports to Zambia in GWh	Imports from Mozambique in GWh	Net exports	
			GWh	1,000 tce (rounded)
1959	0.5	61.5	61.0	30
1960	801.6	71.2	730.4	365
1961	1,124.4	71.1	1,053.3	527
1962	1,296.0	80.7	1,215.3	608
1963	1,565.9	87.6	1,478.3	739

(c) Liquid fuels: No data available.

(3) Consumption:

Because of data for trade are lacking, a summary for consumption cannot be set up.

III. Electric Energy (4, 8)

(1) Existing power plants:

(a) Installed capacity of all producers (in MW)

	Kariba HE	Other producers TE	Total
December 1959	100.0	509.4	609.4
" 1960	300.0	501.4	801.4
" 1961	562.5	501.4	1,063.9
" 1962	675.0	473.9	1,148.9
" 1963	705.0	483.4	1,188.4

Thermal power plants consist mainly of steam power plants and of only two small diesel power plants (position in 1960):

Steam power plants			Diesel power plants	
1.	Salisbury	153.0 MW	1. Komativi	2.01 MW
2.	Bulawayo	148.5 MW	2. Chipinga	0.37 MW
3.	Umniati	120.0 MW	DE total :	2.38 MW
4.	Shabani	30.0 MW		
5.	Wankie	18.5 MW	In 1960 was:	
6.	Umtali	16.5 MW		
7.	Gwanda	12.5 MW		
	SE Total:	499.0 MW	SE + DE Total =	501.38 MW

(b) Production, net export and consumption (in GWh):

	Production				Net Export	Consumption
	Centr. African Power Corp.		Other producers	Total		
	Interconnected TE	HE	TE			
1959	-	0.5	1,530.2	1,530.7	-61.0	1,591.7
1960	448.1	1,046.5	893.1	2,387.7	730.4	1,657.3
1961	297.4	2,205.7	278.4	2,781.5	1,053.3	1,728.2
1962	131.8	2,736.3	121.6	2,989.7	1,215.3	1,774.4
1963	105.4	3,142.0	121.8	3,369.2	1,478.3	1,890.9

The average rate of growth of consumption in the period 1959-1963 was 4.4 per cent.

(c) Breakdown of consumption (in GWh)

	1959	1960	1961	1962	1963
Agriculture, forestry	61.5	69.1	69.4	76.8	81.5
Mining, Quarrying	377.0	390.6	398.7	383.9	389.2
Manufacturing industries	432.0	435.6	442.7	455.8	528.2
Domestic consumers	388.8	406.9	427.9	430.1	436.7
Others	193.4	211.5	223.3	254.3	273.4
Sales total	1,452.7	1,513.7	1,562.0	1,600.9	1,709.0
Consumption	1,591.7	1,657.3	1,728.2	1,774.4	1,890.9
Power-station consumption and losses — GWh	139.0	143.6	166.2	173.5	181.9
Power-station consumption and losses — % of consumption	8.85	8.65	9.6	9.75	9.65

(d) Transmission and distribution

The circuit lengths of the high-voltage overhead transmission lines are, according to information of different years:

-330 KV	1,030 km	(information of the year 1964 - Doc. 7)
-110 kV	5 km	" " " " 1961 - " 8
- 88 kV	925 km	" " " " 1961 - " 8
- 66 kV	190 km	" " " " 1961 - " 8
- 33 kV	1,580 km	" " " " 1961 - " 8
	3,730 km	

Medium-voltage distribution feeders, in 1960 (8):

11 kV	1,194 km	Total: 1,433 km
3.3 kV	23 km	
others	216 km	

In 1960, the length of the low-voltage distribution networks was about 4,800 km (8).

(e) Tariffs (5): In 1962, the Federal Power Board's tariffs to the Southern Rhodesia Electricity Supply Commission were as follows:

Region	Basic tariff: Demand MW	Basic tariff: Consumption GWh	Basic tariff: Price Pence per kWh	Growth tariff: Effective on any growth of either demand or consumption over basic
Central	99.4	533	0.71	£ 7. 0s. 0d. per kW and 0.1 d. per kWh
Western	13	83	0.77	

In 1962, the average prices in pence per kWh for different classes of consumers were:

Mining	1,220 d. per kWh
Industry	0.985 "
Municipalities	1,188 "
Farming	2,152 "
Domestic	2,168 "
" Commercial " " "	2,671 "
" Hotels, Institutions and public lighting	1,779 "
" Total - All classes "	1,290 "

The price quoted above include the fixed charges for power.

(f) Power production costs : No data available.

(2) Future development:

No information available.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3/ Part I.

2. Ibid., Part II.

3. Ibid., Add.1.

4. Monthly Digest of Statistics, Salisbury, December 1964.

5. Electricity Supply Commission, Annual Report and Accounts for 1962, Southern Rhodesia.

6. United Nations, World Energy Supplies, 1959-1962, New York, 1964, No.7.

6a. " " " 1960-1963, " " 1965, No.8.

7. Report of the UN/ECA/FAO Economic Survey Mission on the Economic Development of Zambia, Ndola 1964.

8. Federation Rhodesia and Nyasaland: Fourth report of the Under-Secretary for Power covering the period 1959-1960, Salisbury 1961.

9. Development of the Steel Industry in East and Central Africa. W.S. Atkins & Partners, Preprint, 1965.

Abbreviations and symbols used:

MW - Megawatt = 1,000 kW
GWh - Gigawatthour = 1,000,000 kWh
TWh - Terawatthour = 1,000 GWh
tce - tons (metric) of coal equivalent
HE - Hydroelectric power plant
DE - Diesel electric power plant
SE - Steam power plant
TE - Thermal power plant.

10. MALAGASY REPUBLIC (MADAGASCAR)

1. Primary Energy Resources

(1) Hydropower

According to Parker (World Power Conference Survey of Energy Resources, 1962), the hydroelectric potential of Madagascar is very large: a theoretical potential of over 100 TWh p.a. could be inferred. At present a total installation of some 28 MW is producing about 74 GWh p.a. from nine stations. Further projects have been investigated at twenty-four sites involving a possible ultimate installation of more than 2,500 MW with an annual production of about 17 TWh.

The total exploitable potential is estimated at 114 TWh. Gross theoretical capacity is calculated as follows:

- For arithmetical mean flow	80,000 MW
- For 50 % probability flow (Q 50)	49,000 MW
- For 95 % probability flow (Q 95)	14,300 MW

(2) Hydrocarbons

(a) Petroleum and gas: The western part of Madagascar is underlain by two sedimentary basins separated by a basement ridge in the neighbourhood of Bemolanga. The northern basin, which is smaller, is known as the Majunga, and the southern one as the Morondava basin.

Petroleum exploration in Madagascar commenced in the early years of this century with an investigation of the extensive tar sands which outcrop in the neighbourhood of Bemolanga and Morafenobe.

In 1945, exploration for petroleum, using modern geological and geophysical techniques, commenced in the Morondava basin, followed by the drilling of a number of deep exploration wells. It was found that geological conditions in the subsurface were complex, and although a thick sedimentary section

was present ranging in age from Permian to recent, much of it of marine origin, it was decided that the possibility of finding economically exploitable deposits of oil or gas was slight.

Following this decision, exploration was commenced in the Majunga basin, which had heretofore been considered less promising because of the presence in the sedimentary section of intercalations of volcanic rocks.

The SPN carried out:

- detailed geological surveys directed at a study of variation in the properties of rocks and the thickness of strata;
- several large-scale terrestrial and fluvio-marine seismic reflection operations;
- finally two test drillings to study two marginal problems, the results of which were important for the continuation of exploration.

Finally, after three years of exploration, the SPM defined a zone of interest in the central part of the Majunga basin. During subsequent operations, work will be concentrated on this area to find the areas of subsidence and sedimentation fringing the continent.

Despite the lack of success attending the considerable effort and money so far expended on petroleum exploration in Madagascar, the presence of enormous quantities of hydrocarbons in the tar-sands of Bemolanga-Morafenobe indicates that petroleum has been formed and accumulated on a very large scale at some period during the geological history of the island. This being so, there always remains a possibility that further exploration may discover petroleum in economically exploitable quantities.

(b) Tar-sands: These outcrop irregularly at the surface over an area of some 3,500 km2 between latitude 19°50' and 21°30' in the general region of Bemolanga-Monafenobe in the west-central part of Madagascar. The degree of impregnation of the sands with tar varies locally but averages about 3-4 per cent over the area as a whole. The sands themselves form the basal unit of the Isalo series and are some 200m. thick, resting directly on crystalline basement. The tar itself is black, very viscous, and apparently homogeneous throughout its thickness. The richest impregnation is only of the order of 8 per cent by weight, as compared with 14.7 per cent in the case of the Athabasca tar sands in western Canada; this latter is the only occurrence of this type which it is proposed to exploit for its petroleum content, on an economic basis, at the present time. The tar yields the following constituents upon distillation:

Naphta	7.2 per cent
Kerosene	25.1 per cent
Light fuel oil	24.3 per cent
Heavy fuel oil	21.1 per cent
Coke	7.8 per cent
Gas and losses	4.5 per cent

The sulphur content of the crude tar is 0.65 per cent, which is relatively low for this type of material. The distillation analysis of the tar indicates that it would be an economically desirable product if it could be extracted from the sands at a low enough cost: so far no method of doing this has been discovered.

Total reserves of tar in place in the sands appear to be of the order of 1,000 million metric tons or more, of which 25 million metric tons have been proved by localized drilling. It is estimated that about 100 million metric tons could be exploited from the surface by open-cut mining.

(c) Oil shales: Oil shales occur in two or three localities in the central part of Madagascar, where they were deposited in ancient lakes resulting from volcanic action. The beds are more of less horizontal but are generally rather thin and reserves are comparatively limited.

Near Sambaina, located about 100 km south-west of Antananarivo on the Antananarivo-Antsirabe railway, are two deposits of oil shales : one at Mandroschasina contains about 500,000 tons of shale; the other, at Antanifotsy contains about 26 million tons. The yield of oil from the first deposit was relatively low, most of the hydrocarbons being semi-solid; the Antanifotsy deposit gave a better oil yield with about 35 per cent of volatile matter, of which 40 per cent was liquid hydrocarbons.

Distillation of the bituminous schists gave the following composition (in percentages) of the run-of-the-mine product:

Stratum No.	Water	Oil	Gas	Semi-coke
III	60.96	4.3	4.6	30.1
IV	42.7	5.2	7.2	45.8

(3) Solid fuels

(a) Coal: Only one occurrence of coal is known in Madagascar, at Sakoa near Tulear in the extreme south of the island. The coal is of Gonswana age and type, similar to that of southern Africa but of a lower grade. Total reserves are reported to be of the order of 1,000 million metric tons. Measured reserves are 100 million tons.

In the area that has been investigated in detail, there are five beds of coal, three of them of workable thickness:

Bed No.	Thickness	Ash content	Volatile matter
III	1.2 - 1.8 m	32 %	24 %
IV	3.5 - 7.0 m	17 %	26 %
V	5.0 - 9.0 m	22 %	31 %

The coal is composed of an intimate mixture of vegetable and mineral matter, with calcareous granules and calcite veins; washing does little improve its calorific value. The calorific value of run-of-mine coal from the No. IV seam is 6,500 calories/gramme, and after screening and washing 6,900 calories/grammes.

Proven exploitable reserves of coal in this area, down to a depth of 400 m., are of the order of 50-60 million tons of bituminous hard coal, having 25 per cent volatile matter, 17 per cent ash, 0.5-1 per cent sulphur, and a calorific value of 6,500-6,900 calories per gramme. It is stated to be good for industrial furnaces and boilers, and for thermal electricity generating plants, but unsuitable for ships and locomotives. It is not reported to have coking properties.

The location of this coal is remote from the main centres of population, and although a number of plans have been drawn up for its exploitation, no large-scale development has yet taken place. It appears that the minimum level of economic production would be of the order of 1 million metric tons per year, which would require the export of a considerable portion of the output to markets outside Madagascar; the quality of the coal, however, precludes its ready sale in foreign markets.

(b) Lignite: A small deposit of lignite occurs at Antanifotsy in association with the oil shales. Reserves are stated to be of the order of 32 million tons.

There are five strata, whose total average thickness is 1.50m. Run-of-the-mine crude lignites of stratum III have the following composition (in percentages):

Humidity	47.9	Fixed carbon	23.6
Combined water	5.1	Tar	0.6
Ash	15.8	Gas	5.06

The mean calorific value of the dry lignite is 3,500 cal./gramme. The lignite consists of combustible matter closely mixed with mineral particles and cannot be enriched.

(4) Non-conventional sources of energy

(a) Radio-active minerals: Madagascar has numerous deposits of radio-active minerals of various kinds and appears to have abundant resources of most of the minerals necessary for the production of metals needed for obtaining atomic energy. At present, uranothorianite is mined at a rate of 440-550 tons p.a. for export to France. Estimates of the known reserves are:

Uranium oxide	about 1,000 tons
Thorium oxide	about 2,000 tons

In the period 1959-1964, production was as follows:

1959	536,679 tons
1960	510,203 tons
1961	416,588 tons
1962	534,579 tons
1963	480,651 tons
1964	560,125 tons.

At that yearly production, the known reserves of the uranthorianite will be exhausted by 1968.

(b) Geothermal: Numerous hot springs are known in Madagascar; volcanic rocks of the Neogene and Quaternary ages are common, and there is considerable deep-seated faulting. Given these conditions, it is probable that a definite programme of exploration for geothermal deposits would succeed in finding them.

(c) Wind: The mountainous south-eastern coastline of Madagascar lies in the zone of the south-east trade-winds, and runs approximately at right angles to them. These winds are of moderate strength and blow from the same direction throughout the year. The combination of topography and wind conditions should be favourable for the development of wind-power on a large-scale, if this should ever be necessary or desirable.

II. Production, Trade and Consumption of Primary Energy (1, 2, 5, 8)

(1) Production:

Only hydroenergy and small amounts of coal are produced

	Hydropower		Coal	Total
	GWH	1,000 tce (rounded)		
1959	53	26	-	26
1960	61	31	-	31
1961	60	33	2	35
1962	70	35	2 *	37 *
1963	74	37	2	39

* Estimation.

The conversion coefficient taken is 1 kWh = 0.5 kg coal equivalent.

(2) Trade of solid and liquid fuel in 1,000 tce (rounded)

	Import	Bunkers	Net import
1959	190	10	180
1960	200	10	190
1961	180	10	170
1962	200	10	190
1963	210	10	200

(3) Consumption in 1,000 tce (rounded)

	Production	Net import	Total
1959	26	180	206
1960	31	190	221
1961	35	170	205
1962	37 *	190	227 *
1963	39	200	239

* Estimation.

Breakdown of energy consumption according to the various kinds of energy (in 1,000 tce, rounded) :

	Solid fuels	Liquid fuels	Hydropower	Total
1959	10	170	26	206
1960	20	170	31	221
1961	2	170	33	205
1962	12 *	180	35	227 *
1963	12	190	37	239

* Estimation.

Consumption per capita:

1959	38	kg	coal	equivalent
1960	40	"	"	"
1961	37	"	"	"
1962	39	"	"	"
1963	40	"	"	"

III. Electric Energy (2, 4, 5, 6, 7)

(1) Existing power plants:

(a) Installed capacities:

Power stations	Installed power in 1963		Production in GWh	
	kVA	kW	1962	1963
Hydro	34,712	27,769	75.5	74
Diesel, public	23,182	18,560	13.5	18
Diesel, private	30,760	24,608*	32.0	33
Total	88,654	70,937*	121.0	125

* Estimated.

Hydropower plants:

Location	River	Near the town	Installed power kW	Yearly producibility in GWh
Mandraka	Mandraka	Antananasivo	11,000	68.0
Antelomita I	Ikopa	Antananasivo	5,000	33.0
Antelomita II	Ikopa	Antananasivo	5,000	27.0
Volobe	Ivondro	Tamatave	4,500	35.0
Ambohimanga	Manandona	Antsirabe	1,620	11.0
Manandray	Manandray	Fianarantsoa	460	1.5
Ifahidaky	?	Ambohimahasoa	160	?
Ambodiriana	Iefitra	Vatamandry	80	?
Fitososona	Andranobe	Ankazobe	50	?
Beantsy	Fiheranana	Tulear	500	3

There are also some small private HE with a total installed power of about 300 kW.

Diesel power plants (public), in 1963

Location	Number of units	Installed power (total)	
		kVA	kW *
Antananarivo, Mandroseza	4	5,000	4,000
Tamatave	6	3,020	2,400
Majunga	5	3,435	2,750
Antsirabe	3	2,840	2,280
Fianarantsoa	4	1,630	1,300
Diego-Suarez	3	1,490	1,200
Nossi-Bé	5	575	460
Morondava	4	395	320
Fort Dauphin	4	420	340
Manandjary	3	300	240
Antalaha	3	405	330
Ambatolampy	?	212	170
Tulear	?	1,500	1,200
Ambositra	4	530	420
Farafangana	3	205	160
Manakara	3	415	330
Ambatondrazaka	3	310	220
Others	?	500	440
Total		23,182	18,560

* Estimated.

Details of the private (industrial, municipal) diesel power plants are not known.

(b) Production and consumption in GWh:

Year	Hydro	Diesel public	Diesel private	Total rounded
1959	53.2	17.6	not known	100.0
1960	61.2	15.9	30.2	107.3
1961	66.3	15.5	31.3	113.1
1962	75.5	13.5	32.0	121.0
1963	74.0	18.0	33.0	125.0

Production figures in documents (7) and (8) differ slightly from each other.

(c) Transmission and distribution:

- 63 kV transmission line from HE Mandraka to Moramanga (40 km) and to Tananarive (50 km);
- 35 kV two-system transmission line from HE Antelonita to Tananarive, 2 x 25 = to circuit km;
- 35 kV as medium voltage for the feeders to the substations in the suburbs of Tananariva. The total 35 kV-feeder length is about 34 km.

The total length of the 35 kV and 63 kV lines is 174 km. In the city of Antananarivo and in other localities, the distribution feeders have a voltage of 5 kV.

The low-voltage distribution systems are changing over from 127/220 V to 220/380 V.

(d) Tariffs in CFA or FMG per kWh [1]

At Antananarivo, the tariffs are as follows:

1/ Since July 1963 the Fr. CFA has been replaced by the FMC (Franc Malagache) with the rate 1 Fr. CFA = 1 FMG.

	1962	1963
- Domestic lighting, up to 10 kWh/month :	24,527	25,423
- Domestic lighting, over 10 kWh/month :	27,294	29,167
- Other domestic use	13,647	14,583
- Other domestic use, off-peak	10,918	11,667

- Power low-voltage:

	Yearly fixed charge		Per kWh	
	1962	1963	1962	1963
Up to 1 kW	1290.80	1379.56	17,031	18,200
1 to 5 kW	1267.75	1354.92	16,840	17,996
5 to 10 kW	1244.70	1330.29	16,677	17,821
10 to 15 kW	1221.65	1,305.65	16,513	17,646

Fixed charges for metres (in Fr. CFA/month):

	1962	1963
- One-phase 5 amp.	72.47	73.41
" " 10 amp.	87.00	88.13
- Three-phase 10 amp.	101.43	102.76
" " 15 amp.	112.43	113.84
" " 20 amp.	123.35	124.84
" " 30 amp.	130.48	132.18

(e) Fuel costs:

The prices of diesel oil depend very much on transport costs. They were in 1963:

Antsirabe	20.750 Fr	FMG/litre
Tamatave	14.246 Fr	"
Nossi-Bé	14.470 Fr	"
Antananarivo	18.850 Fr	"
Morondava	20.150 Fr	"
Fianarantsoa	23.100 Fr	"
Majunga	16.113 Fr	"
Tuléar	21.430 Fr	"
Ambatondrazaka	20.950 Fr	"

(2) Future development (7)

(a) The total production of electricity should be increased, according to the five-year plan 1964/1968, as follows:

	Total production in GWh	Rate of increase %	Production of hydroenergy in GWh	Production of hydroenergy % of total
1962	121	-	75.5	62
1968	195	7.2	138	67
1973	385	14.5	295	76

(b) Breakdown of consumption in percentages:

	1960	1968	1973
Industry	35.0	41.0	57.0
Water pumping	6.9	6.1	4.7
High voltage consumers	7.7	8.2	6.5
Low voltage consumers	37.0	30.8	22.2
Losses	13.4	13.9	9.6
	100.0	100.0	100.0

(c) Investments in two five-year periods (in million FMG):

		1964 - 1968	1969 - 1973
A.	Studies	200	250
B.	Production	1200	3700
	1. Large power stations High Plateau	560	2850
	2. Equipment for regional centres	190	200
	3. Small DE and HE	450	650
C.	Transmission and distribution	2100	3500
	1. 90 kV-line Antsirabe-Antananarivo	500	-
	2. 150 kV line Fianarantsoa "	-	1500
	3. Distribution	1600	2000
	Total	3500	7450

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963 E/CN.14/EP/3 Part I.

2. Ditto, Part II.

3. Ditto, Add.1.

4. Industries et travaux d'outremer, January 1964, No. 122.

5. United Nations, World Energy Supplies, 1959-62, New York 1964, No.7.

6. Rapport d'une mission de l'AIEA à Madagascar, Vienna 1962.

7. Plan quinquennal 1964-1968, Tananarive 1964.

8. République Malagache, Situation Economique au début de 1963.

Abbreviations and symbols used

MW - Megawatt = 1,000 kW

GWh - Gigawatthour = 1,000,000 kWh

TWh - Terawatthour = 1,000 GWh

tce - tons (metric) of coal equivalent

HE - Hydroelectric power plant

DE - Diesel electric power plant

SPM - Société Pétrolière Malagache

11. MAURITIUS

I. Primary Energy Resources

No data available

II Production, Trade and Consumption of Primary Energy (1,2)

(1) - Production:

There are only small amounts of hydro-energy produced on the island:

	in GWh (rounded)	in 100 tce (rounded)
1959	30	15
1960	30	15
1961	20	10
1962	50	25
1963	60	30

Conversion ratio: 1 kWh = 0.5 kg coal equivalent

(2) - Trade :

in 1000 tce (rounded):

	Import	Bunkers	Net import
1959	110	10	100
1960	90	20	70
1961	90	20	70
1962	130	20	110
1963	110	20	90

Quantities given under "Bunkers" were supplied to foreign-bound ships and aircraft, irrespective of the flag of the vessel or plane. "Bunkers" are not considered as "Export", nor as "Consumption" of the country under consideration.

(3) - Consumption : in 1000 tce (rounded)

	Production	Net Import	Total
1959	15	100	115
1960	15	70	85
1961	10	70	80
1962	25	110	135
1963	30	90	120

Breakdown of consumption according to various forms of energy, in 1000 tce (rounded) :

	Solid fuels	Liquid fuels	Hydroenergy	Total
1959 ..	15 x/	85 x/	15	115
1960 ..	-	70	15	85
1961 ..	-	70	10	80
1962 ..	10 x/	100	25	135
1963 ..	-	90	30	120

x/ - Estimated as the rounded figures in the doc. (1) and (2) are not always consistent.

Conversion ratio for: solid fuels : 1.0
liquid fuels: 1.3
that is to say: 1 ton liquid fuel = 1.3 tce.

- Consumption per capita:

1959 ..	185 kg coal equivalent
1960 ..	127 " " "
1961 ..	129 " " "
1962 ..	192 " " "
1963 ..	171 " " "

III. Electric Energy (1, 2, 3, 4)

(1) - Installed capacity

The only available information is taken from doc. (4), issued in 1963 when the International Bank made a loan of $ 7 million to expand electric power facilities in Mauritius.

The beneficiary of the loan was the Central Electricity Board (C.E.B.), a semi-autonomous government corporation established in 1952 to consolidate the various electricity undertakings on the island. Since 1956, CEB has been the sole public supplier of electricity on the island and now serves about half the population.

CEB obtains most of its energy requirements from its own plants, which have a combined capacity of about 30,000 kW, of which about half is in hydro plants. It supplements this capacity, in the dry season, by purchases of power from private plants on sugar estates.

The loan helped to finance the construction of a 12,000 kW diesel power station at Port Louis, the capital city, and an expansion and improvements of the transmission and distribution systems.

The project increased the island's public supply by nearly a third, improving the efficiency of service in towns connected to the power network, and extending service to some additional communities. It is expected that the project will meet the CEB power requirements until mid-1968.

The new station is equipped with two diesel generating sets of 6,000 kW each. The plant site is large enough to permit eventual expansion of the station to 40,000 kW.

The total cost of the project was estimated at the equivalent of $ 8.6 million, which gives a specific investment of $ 715 per installed kilowatt.

The loan was given for a term of 20 years at an annual interest rate of 5.5 per cent, including the one per cent commission allocated to the Bank's special reserve.

(2) - Production :

There are only a few data available:

in GWh (rounded)

	Production				Consumption
	Public & industrial		Public only		
	Total	Hydro	Total	Hydro	
1959 ..	150	30	55.8	30	150
1960 ..	150	30	54.6	30	150
1961 ..	160	20	63.2	20	160
1962 ..	170	50	77.2	50	170
1963 ..	180	60	87.4	60	180

DOCUMENTS USED

1. World energy supplies, 1959 - 1962, UN, New York, 1964
2. World energy supplies, 1960 - 1963, UN, New York, 1965.
3. Colony of Mauritius: Quarterly digest of statistics, 1964.
4. UN Press Services, Office of Public Information, UN, New York: Press Release IB/1386, 23 September 1963.

Abreviations and symbols used

GWh - Gigawatt hour = 1,000,000 kWh.

tce - tons (metric) coal equivalent.

12. RWANDA

I. Primary Energy Resources (3)

(1) Hydro-power

Rwanda has considerable hydro-power resources in relation to its needs for electricity. Hydroelectric stations have already been constructed at several locations, but it is reported that there still remains a considerable unexploited potential, especially on the River Ruzizi between Lake Kivu and Lake Tanganyika.

The largest part of the total difference in elevation between the two lakes (689m) over a distance of some 30 km downstream from Lake Kivu, lies on Rwandese territory. The hydro-power potential of this part of the Ruzizi is estimated to be some 2.6 tWh, but one half of this potential belongs to Rwanda as the Ruzizi forms the frontier with the Congo.

(2) Other primary energy resources

(a) Hydrocarbons (3,8,9): Rwanda has no known petroleum resources, and in general the geology of the country is not favourable for their occurrence. The waters at the bottom of Lake Kivu lying between Rwanda and the Congo, which covers an area of approximately 2,300 square kilometres and is very deep, contain a considerable quantity of dissolved gases, including methane. Tests have been made to investigate the possibility of using this gas as a source of energy. Reserves of methane are reported to be 57,000 million m3 which is equivalent to 36 million tons of coal. A pilot extraction station of methane from water has been set up at Gisenyi and the gas is employed as fuel for one of the boilers in the Bralirwa brewery.

(b) Coal : No coal is known to occur in Rwanda.

(c) Peat : Thick layers of peat occur in many of the river valleys and exploitation has commenced near Shangugu to provide fuel for a cement plant.

(d) Radio-active minerals: These are known to occur in Rwanda and may ultimately be found in economically exploitable quantities.

(e) Geothermal : It is possible that geothermal anomalies may o occur in connexion with the Rift Valley in which Lake Kivu lies.

II. Production, Trade and Consumption of Primary Energy (5, 5a)

(1) Production:

Only small amounts of hydro-energy are produced in the country, but it is not clear what are the real amounts. The available documents give the following information:

Doc.(4) : Hydro energy produced in 1961 in Rwanda-Urundi was 5.6 GWh.

Doc.(5a): For the period 1961-1963, production of hydro-energy was 10 GWh

Doc.(6a): Table I,p.7:Present hydro-energy production amounts to 37.5 GWh (This should read "producibility" and not "production").

(2) Net import of liquid fuels (in 1,000 tce, rounded)

1959	30
1960	30
1961	40
1962	40
1963	40

(3) Consumption (in 1,000 tce, rounded):

1959	30	)
1960	30	)
1961	40	) + not known amounts
1962	40	) of hydro-energy
1963	40	)

(4) Consumption per capita (in kg coal equivalent) :

1959	11
1960	11
1961	14
1962	15
1963	15

III. Electric Energy (5, 5a, 6, 7):

(1) Existing power plants:

The available information is in some respect not clear:

(a) Doc. (6)

Hydropower plants

Locality	Installed capacity in kW		Present max.load kW	Production in GWh (= producibility)	
	Present	Possible		Present	Max Possible
Ntaruka	7,500	11,250	1,510	9.0	20
Kisenyi	1,100	1,100	550	2.5	5
Total	8,600	12,350	2,060	11.5	25

The maximum load is only 36 per cent of the present installed capacity.

Thermal power plants (=DE)

Locality	Installed capacity kW	Present Max. load kW	Yearly Production kWh
Butare	555	120	476,000
Nyanza	70	20	72,000
Gisenyi	690	Stand-by	
Kigali	250	"	
Total	1,565	140	548,000

(b) Doc.(7) :

In 1958, the Power and Water Company REGIDESO had the following power plants in Rwanda:

Locality	Installed capacity in kW		
	Thermal	Hydro	Total
Astrida ..	265	-	265
Kisenyi	690	550	1,240
Niawza	40	-	40
Kigali	250	70	320
Total	1,245	620	1,865

(c) Doc. (5) and (5a) : Production and consumption, in GWh (rounded)

	Production		Consumption
	Total	Hydro	
1959	10	below	10
1960	10	the	10
1961	10	level	10
1962	10	of	10
1963	10	round-ing	10

(2) Transmission and distribution (6)

(a) 70-kV transmission lines exist between the HE Ntaruka and and the following substations:

- Substation Kagera for the region of Kigali and for the mines of Somuki at Rutongo;
- Substation Musha for the mines of Minetain.
- Substation Rwinkwaon for the mines of Georwanda (about 115 km long).

(b) The medium distribution voltages are given as 15 kV and 6.6kV. The length of the respective lines is not given, nor the number of distribution substations.

(c) The low-voltage distribution systems use 220/380 V, mainly with underground cables. The length of the lines is not known. The number of the substations is not known.

(3) Power plants, transmission lines and distribution networks under construction or in project :

Only recommendations given in (6) are known :

(a) Hydropower plants :

- It is possible to raise the installed capacities in the HE Ntaruka and Mururu by 19,350 kW.
- The hydropotential of the River Ruzizi south of Lake Kivu amounts to some 2,600 GWh/year. Half of this potential belongs to Rwanda.

(b) Transmission lines:

- 130-kV transmission lines are to inter-connect the HE Mururu with Gikongoro-Butare, ending in the power station "Forces" to the north of Kigali. Neither technical nor economic explanations have been given for this recommendation. The possible installed capacity of the HE Mururu is quoted at 28.2 MW but no justification for such a high voltage as 130 kV is given.
- 30-kV lines are in the same way recommended for the gross distribution network without any technical or economic justification.

(4) Tariffs:

No data available.

(5) Fuel prices in retail :

No data available.

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963, E/CN.14/EP/3 Part I.

2. Ibid, Part II.

3. Ibid, Add.1.

4. Industries et travaux d'outremer, January 1964 No.122

5. United Nations, World Energy Supplies, 1959-1962, New York 1964, No.7

5a. " " " " " 1960-1963 " " 1965, No.8

6. Les problèmes énergètiques au Rwanda, Paul Meystre, UN Expert, with the Government of Rwanda.

   a) Rapport périodique No.I, February 1964

   b) " " No.II, April 1964

   c) Rapport final, June 1964

7. Rapport 1958, by the public enterprise REGIDESO (Régie de distribution d'eau et d'électricité du Congo Belge et du Rwanda-Urundi).

8. Mise en valeur du gaz methane du lac Kivu, J. de Lavallée, UN Technical Assistance, Butare, Rwanda (1965)

9. Development of the Steel Industry in East and Central Africa, W.S. Atkins & Partners, Preprint, 1965

Abbreviations and symbols used:

MW - Megawatt = 1,000 kW

GWh- Gigawatt hour = 1 million de kWh

tce- tons (metric) of coal equivalent

DE - Diesel power plant

HE - Hydro power plant

13. BURUNDI

I. Primary Energy Resources (3)

No data are available.

II. Production, Trade and Consumption of Primary Energy (5, 5a)

(1) Production:

Only small amounts of hydro-energy are produced, but they are "below the level of rounding", which means under 10 GWh/year.

(2) Net import of liquid fuels (rounded) :

1959	..	20,000 tce
1960	..	20,000 "
1961	..	30,000 "
1962	..	30,000 "
1963	..	40,000 "

(3) Consumption (rounded) :

1959	..	20,000 tce)	
1960	..	20,000 ")	+ small amounts of hydroenergy which are "below the level of rounding"
1961	..	30,000 ")	
1962	..	30,000 ")	
1963	..	40,000 ")	

Consumption per capita :

1959	..	10 kg coal equivalent
1960	...	11 " " "
1961	..	12 " " "
1962	..	13 " " "
1963	..	14 " " "

III. Electric Energy (5, 5a, 6)

The only data available are:

(1) Existing power plants of REGIDESO in 1958 - (6)

	Installed capacity (in kW)	Production in 1958 (kWh)
DE Usumbura ..	3,040	9,276,774
DE Kitega ..	95	141,948
	3,135	9,418,722

(2) Production and consumption in the period 1959/63 (5,5a)

1959	under 10 GWh	+ small amounts of hydroenergy, which are "below the level of rounding".
1960	more than 10 GWh	
1961	" " 10 GWh	
1962	" " 10 GWh	
1963	" " 10 GWh	

DOCUMENTS USED

1. African Electric Power Meeting, Addis Ababa, October 1963 E/CN.14.EP/3 Part I
2. Ibid, Part II
3. Ibid, Add 1
4. Industries et travaux d'outremer, January 1964 No.122
5. United Nations, World Energy Supplies, 1959-1962, New York 1964,No.7
5a. " " " " " 1960-1963, New York,1965,No.8
6. Rapport 1958, REGIDESO (Régie de Distribution d'eau et d'électricité du Congo Belge et du Rwanda-Urúndi).

Abbreviations and symbols used:

tce tons (metric) of coal equivalent

DE Diesel electric power plant

III. SUMMARY

The following six tables give a survey on the energy situation in thirteen countries of the East African sub-region:

Table 1: Summary of the conventional fuel deposits (proved and estimated).

Table 2: Summary of the estimated hydroelectric potential

Table 3: Primary energy in the period 1959-1963, in 1,000 tce

Table 4: Projections of primary energy consumption for the period 1963-1975

Table 5: Electric energy in the period 1959-1963

Table 6: Projections of electric energy consumption for the period 1963-1975.

TABLE I

Summary

of the conventional fuel deposits

(proved and estimated)

No.	Country	Hydrocarbons		Solid fuels	
		Quality	Quantity	Quality	Quantity
1.	Ethiopia	-	-	Non-coking Lignite	10 m.tons 3 m.tons
2.	Somali Republic	-	-	Coal 5,700 kcal/kg	not known
3.	French Somaliland	-	-	-	-
4.	Uganda	-	-	-	-
5.	Kenya	-	-	-	-
6.	Tanzania	-	-	Bituminus coal 4,000-7,000 kcal/kg low grade	300 m.tons 100 m.tons
7.	Malawi	-	-	low grade coal	50 m.tons
8.	Zambia	-	-	coal	20 m.tons
9.	Rhodesia	-	-	coal	10,000 m.tons
10.	Malagasy Republic	tar (in sands). oil shales	25 m.tons proved 1,000 m.tons estimated 17.5 m.tons	6,500 kcal/kg lignite 3,500 kcal/kg	100 m. tons measured 1,000 m.tons estimated 32 m.tons
11.	Mauritius	-	-	-	-
12.	Rwanda	methane	equivalent of	peat	large
13.	Burundi	Lake Kivu	76 m.tons coal	-	-

Expressed in tons of coal equivalent, the total deposits in all countries of the East African sub-region amount to:

Hydrocarbons	1,435
Solid fuels	11,615
In total	13,050

TABLE 2

Summary

of the estimated

hydroelectric potential

		In GWH	
1.	Ethiopia	45,000	
2.	Somali Republic	1,000	
3.	French Somaliland	———	not known
4.	Uganda	5,000	
5.	Kenya	50,000	
6.	Tanzania	75,000	
7.	Malawi		
8.	Zambia	36,000	
9.	Rhodesia		
10.	Madagascar	114,000	
11.	Mauritius	———	not known
12.	Rwanda	1,300	
13.	Burundi	———	not known
East African sub-region		367,300	

The **continental part** of the sub-region (without Madagascar and Mauritius) has an estimated **hydropower** potential of 253,300 Gwh per annum.

TABLE 3

Primary Energy in the period 1959/1963 in 1000 tce

Country	Production						Trade								Consumption			
	Hydro electric energy		Coal lignite		Total		Electric energy		Coal lignite		liquid fuels		Total		Total		Per capita kg of coal equiv.	
	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963
1. Ethiopia	14	54	-	-	14	54	-	-	10	10	170	190	180	200	194	254	9.7	11.5
2. Somali Republic	5	6 x/	-	-	5	6	-	-	-	-	50	50	50	50	55	56	23	23
3. French Somaliland	-	-	-	-	-	-	-	-	-	-	20	30	20	30	20	30	278	367
4. Uganda	173	255	-	-	173	255	-65	-95	-	-	180	200	115	105	288	360	44	50
5. Kenya	70	85	-	-	70	85	75	102	40	40	980	1130	1095	1,272	1,165	1,357	167	182
6. Tanzania	50	55	2	2	52	57	-10	-7	-	-	370	450	370	450	422	507	45	51
7. Malawi	-	2	-	-	-	2)	403)	182)	-127	-259)	710)	810)	986)	733)	5,129)	5,480)	512)	476)
8. Zambia	-	153	-	-	-	153)	)	)		)	)	)	)	)	)	)	)	)
9. Rhodesia	-	1,571	4,143	3,021	4,143	4,592)	)	)		)	)	)	)	)	)	)	)	)
10. Madagascar	26	37	-	2	26	39	-	-	10	10	170	190	180	200	206	239	38	40
11. Mauritius	15	30	-	-	15	30	-	-	15 x/	-	85 x/	90	100	90	115	120	185	171
12. Rwanda	5	5	-	-	5	5	-	-	-	-	30	40	30	40	35	45	11	15
13. Burundi	-	-	-	-	-	-	-	-	-	-	20	40	20	40	20	40	8.2	14
East African sub-region	358	2,253	4,145	3,025	4,503	5,278	403	182	-52	-199	2,785	3,220	3,136	4,203	7,639	8,484	113	128
Total for Africa	3,180	4,820	42,080	46,590	48,800 d/	90,780 d/	-	-	200	-1033	11,370	21,400	11,570	22,430	60,370	68,350	225	233

Remarks:

(a) The Conversion ratio selected for electric energy is: 1 GWh. = 500 tce.

(b) Under "Trade", the figures with a negative sign indicate exports. The figures without any sign indicate "Net Imports" that is "Imports" minus "Bunkers".

(c) In the East African sub-region, there has been no production of hydrocarbons yet.

(d) The whole of Africa including all countries of the continent had the following production of crude petroleum and natural gas, which is included in the "Total" of production:

	1959	1963
crude petroleum	3510	38810
natural gas	30	560
hydrocarbons	3,540	39370

x/ Estimated

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TABLE 4

Projections of primary energy consumption for the period 1963-1975

	Rate of growth, %		Consumption in 1,000 tce			
		Estimate		Estimated		
	1959-1963	1963-1975	1963	1965	1970	1975
1. Ethiopia	5.6	5.0	254	280	460	750
2. Somali Republic	0.4	5.0	56	62	100	163
3. French Somaliland	8.5	5.0	30	33	54	88
4. Uganda	4.5	4.2	360	392	480	590
5. Kenya	3.0	3.0	1,357	1,440	1,670	1,950
6. Tanzania	3.7	5.0	507	560	920	1,500
7. Malawi	1.5	2.5	5,480	5,780	6,520	+ 200
8. Zambia						7,380
9. Rhodesia						
10. Madagascar	3.0	5.0	239	263	430	700
11. Mauritius	0.8	3.0	120	127	148	172
12. Rwanda	5.0	5.0	45	50	82	134
13. Burundi	15.0	5.0	40	44	72	118
East African sub-region	3.0	4.0	8,484	9,031	10,936	13,745

TABLE 5

Electric energy in the period 1959-1963

Country	Existing installations						Production in GWh						Trade		Consumption			
	Power stations, in MW			Transmission lines km	Distrib. feeders km	Low-voltage km	HE		TE		Total		in GWh		Total		Per capita	
	HE	TE	Total				1959	1963	1959	1963	1959	1963	1959	1963	1959	1963	1959	1963
1. Ethiopia	60.0	29.3	89.3	577	662	?	28	109	61	66 x/	89	175 x/	-	-	89	175	4.4	8.0
2. Somali Republic	-	7.9	7.9	-	?	?	-	-	10	13 x/	10	13	-	-	10	13	5.0	5.7
3. French Somaliland	-	7.0	7.0	-	40	?	-	-	10 x/	15	10 x/	15	-	-	10	15	13.8	20.2
4. Uganda	121.2	15.0	136.2	265	3,450	798	350	510	20	20	370	530	-130	-190	240	340	36.5	47.0
5. Kenya	26.4	74.1	100.5	900	2,160	1,060	140	170	70	92	210	263	150	205	360	468	46.2	52.6
6. Tanzania	20.2	29.9	50.1	70	?	?	90	100	70	100	160	200	-20	-20	140	180	14.8	18.2
7. Malawi	9.6	14.8	15.4	254	424	240	4 x/	4	28 x/	38	32 x/	42	-	-	32	42	9.3	11.2
8. Zambia	55.5	208.4	263.9	600	?	?	250	314	937	416	1,187	730	745	1,845	1,933	2,575	620	736
9. Rhodesia	705.0	483.4	1,188.4	3,730	1,433	4,800	1	3,142	1,530	227	1,531	3,369	61	-1,478	1,592	1,891	452	475
10. Madagascar	27.8	33.2	61.0	174	?	?	53	74	47	51	100	125	-	-	100	125	19.0	21.0
11. Mauritius	15.0 x/	27.0 x/	42.0 x/	?	?	?	30	60	120	120	150	180	-	-	150	180	240	256
12. Rwanda	8.6	1.6	10.2	?	?	?	2	11	?	?	10	11	-	-	10	11	3.8	4.1
13. Burundi	-	3.1	3.1	?	?	?	?	?	10	10	10	10	-	-	10	10	4.1	3.8
East African sub-region	1,040.3	1,144.7	2,185.0	6,550	8,169	6,898	948	4,494	2,913	1,168	3,869	5,662	806	362	4,675	6,024	69.0	81.5
Total for Africa	2,747 a/	7,604 a/	10,351 a/		33,585 a/	?	6,350	9,640	28,290	34,280	34,640	43,920	-	-	34,640	43,920	130	150

Remarks:

(a) At the end of 1961

(b) Under "Trade", the figures with a negative sign indicate exports. The figures without any sign indicate "Imports".

(c) Dashes (-) in the table mean "zero".

(d) Question marks in the table mean that the relative data are not available.

(e) The "Total for Africa" includes all countries of the continent

x/ Estimated

TABLE 6

Projections of electric energy consumption

in the period 1963-1975.

Country	Rate of growth, in %				Total Consumption, in GWh				Industrial consumption in GWh and % of the total				Estimated rate of growth for the remaining consumption (= without industry) for the period 1963-1975
	Past 1959-1963	Future official		Estimate for 1963/1975 in average	Past	Future Estimated			Past		Future estimate for 1975		
		Period	%	%	1963	1965	1970	1975	Year	%	GWh	%	%
1. Ethiopia	20.0	1963/1967	17.0	13.1	175	257 o/	477	890	1961	46.0	578	65.0 b/	12.0
2. Somali Republic	6.8	-	-	17.6	13	15	34	77	1961	27.0	46	60.0	12.0
3. French Somaliland	10.7	-	-	12.0	15	18	32	57	1963	30.0 x/	17 x/	30.0	12.0
4. Uganda	9.2	-	-	10.0	340	410	660	1,060	1961	67.0	708	67.0	10.0
5. Kenya	6.7	-	-	12.0	468	530	935	1,650	1961	31.0	856	51.5	12.0
6. Tanzania	6.5	1964/1970	12.0	15.1	180	204	355 o/	978	1962	65.6 a/	785	80.0	10.0
7. Malawi	7.0	-	-	40.0	42	48	85	2,250	1963	54.0	2,100	93.1	12.0
8. Zambia	7.2	1962/1970	7.3	7.3	2,575	2,950	4,265 o/	5,900	1962	90.0	4,660	79.0	7.3
9. Rhodesia	4.4	-	-	4.4	1,891	2,070	2,570	3,200	1963	54.0	1,710	54.0	4.4
10. Madagasoar	5.7	1962/1967	7.2	13.5	125	152 o/	240 o/	680	1960	35.0	441	65.0 c/	10.0
11. Mauritius	6.2	1968/1973	14.5	6.2	180	204	276	374	1963	25.0 x/	95	25.4	6.2
12. Rwanda	2.5	-	-	25.0	11	12	38	121	1963	30 x/	94	78.0	12.0
13. Burundi	-	-	-	19.5	10	12	29	73	1963	30 x/	46	63.0	12.0
East African sub-region	5.2	-	-	9.1	6,024	6,882	9,996	17,310	1963	67.0 x/	12,136	70.0	8.2

Remarks: (o) Official estimate or based on its extra- or inter polation.

(a) Including supplies for the sisal industry plus commercial power and lighting.

(x) Estimated, as nearer data are lacking.

(b) For 1967, the official estimate is 58.5 %

(c) For 1973, the official estimate is 57.0 %

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As a result of all these surveys the following conclusions may be pointed out:

1. Hydrocarbons: Crude petroleum and natural gas have not yet been found in the sub-region in economically exploitable quantities.

The methane gas in Lake Kivu seems to be the best known source of hydrocarbons in the sub-region.

Crude petroleum for the refineries and large quantities of liquid fuels have to be imported for the time being.

2. Coal, lignite:

There are relatively large deposits of high grade coal and other kinds of solid fuels in the sub-region.

Taking into account the estimate that by 1975 about one-third of the total requirements for primary energy will be covered by solid fuels, the known and the probable deposits of coal and lignite in the sub-region would be sufficient for some 2,400 years.

Five countries in the sub-region are without any known solid fuel deposits.

3. Hydropower:

The East African sub-region has a very large hydropower potential with Madagascar being relatively the strongest in this respect.

The per capita hydropower potential amounts to:

Madagascar about	19,000KWh p.a.
Continental part of the sub-region about	3,700 KWh p.a.

These figures have to be compared with about 5,500 KWh per capita and per annum for the whole of Africa.

4. Electric energy

In 1963, the ratio of hydropower production to thermal power production was 80:20. This ratio will steadily increase in favour of hydropower and by 1975 it might be 90:10 or thereabouts. To cover the future

requirements for electric energy by 1975, about 6 per cent of the total hydropower potential of the continental part of the sub-region will have to be developed.

By that time, new power projects with a total power of about 2000 MW will have to be constructed and the total investments, including transmission and distribution installations are likely to amount to some US$ 700 or 800 million.

IV. RECOMMENDATIONS

1. Taking into consideration the fact that all kinds of primary energy and especially the secondary form-electric energy - are among the basic prime movers of economic development, appropriate attention should be given to a proportionate development of various forms of energy in the sub-region.

2. In the light of the necessity to co-ordinate the general economic development of the countries on a sub-regional basis, the same basic principle of co-ordination should be applied in the energy field as well.

3. As the aim of co-ordination in the energy field is to provide various forms of energy for the countries in the sub-region on the most economic conditions, all possible efforts should be made to get a really complete and up-to-date picture of the economic side of the production and distribution costs of various forms of energy in all countries of the sub-region.

These energy price analyses on a country-by-country basis should be later co-ordinated in such a way that similar or equal financial conditions be taken as starting points in order to get a realistic comparison between various countries of the sub-region.

4. The dynamics of the economy and energy development require that the necessary, reasonable amount of statistical data from the energy field be collected on a routine basis.

5. Being one of the most promising primary energy resources in the sub-region, hydropower potential should be intensively studied in all countries in order to find out the most economic hydropower sites.

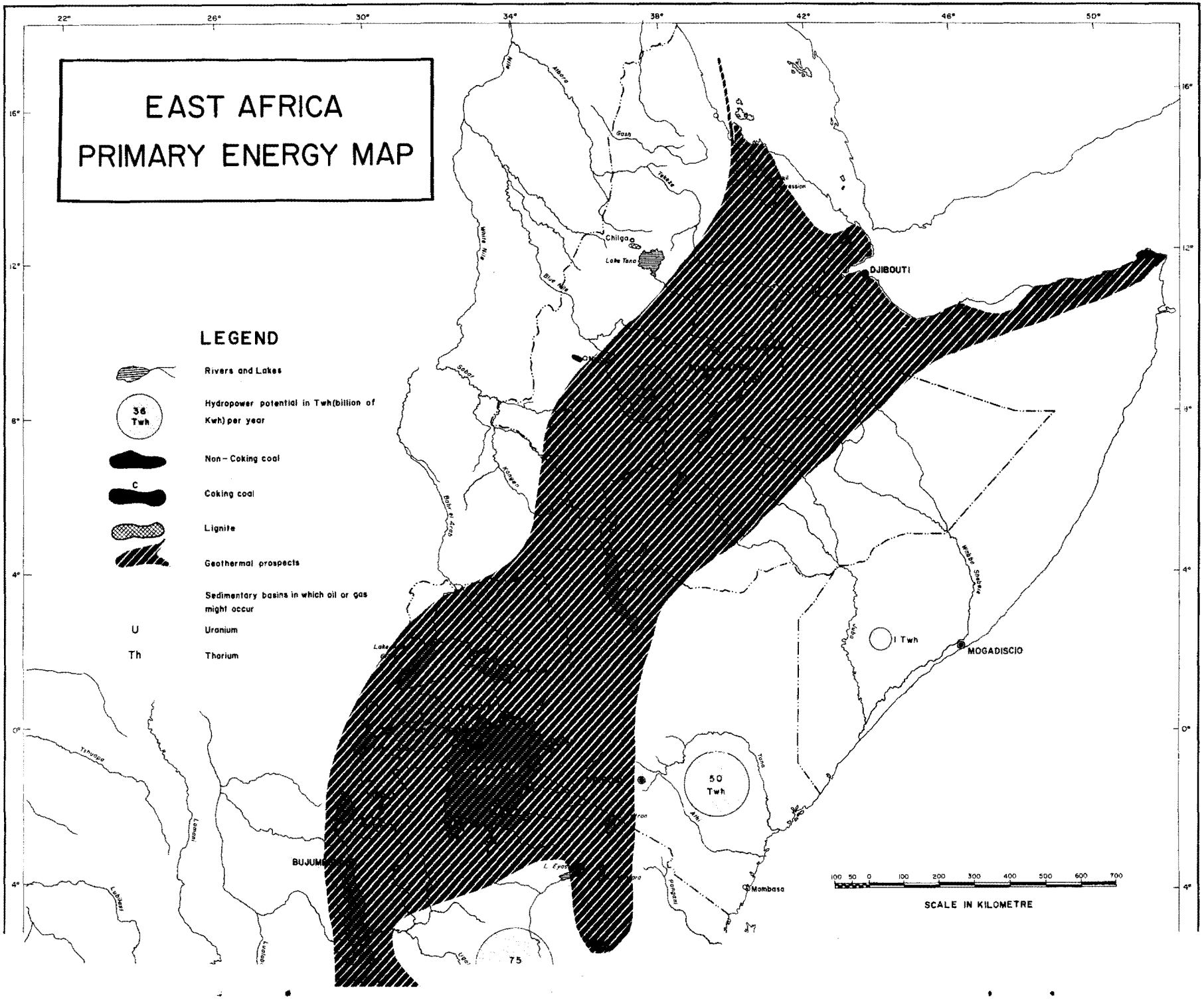
6. It seems that the methane gas in Lake Kivu has been sufficiently explored from the theoretical as well as the practical points of view with pilot plant in operation and that a feasibility study of its large scale exploitation should take place.

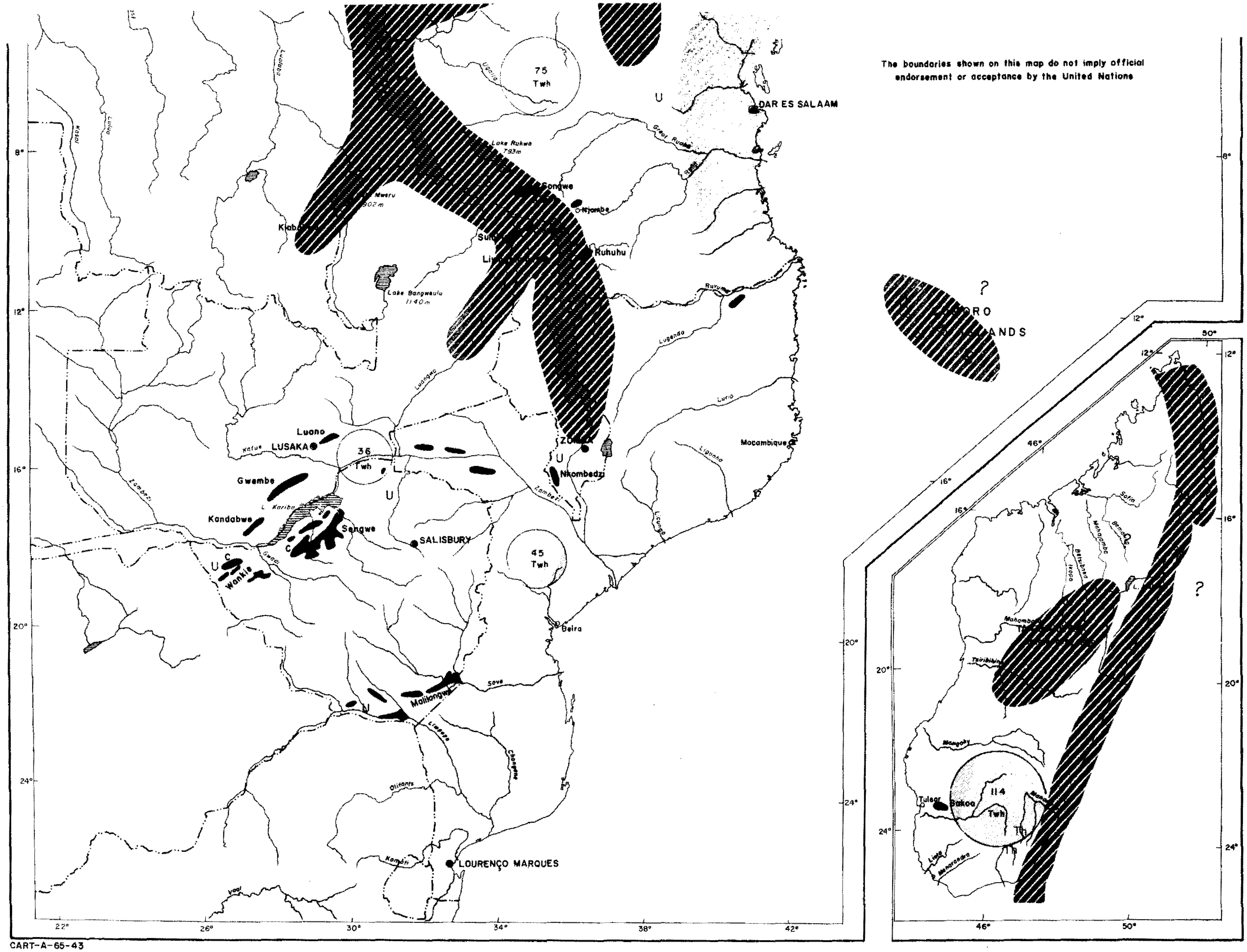
7. The prospects of exploiting geothermal energy in the East African sub-region in an economic way are supposed to be large and it would be advisable to propose a few sites for which feasibility studies should be prepared.

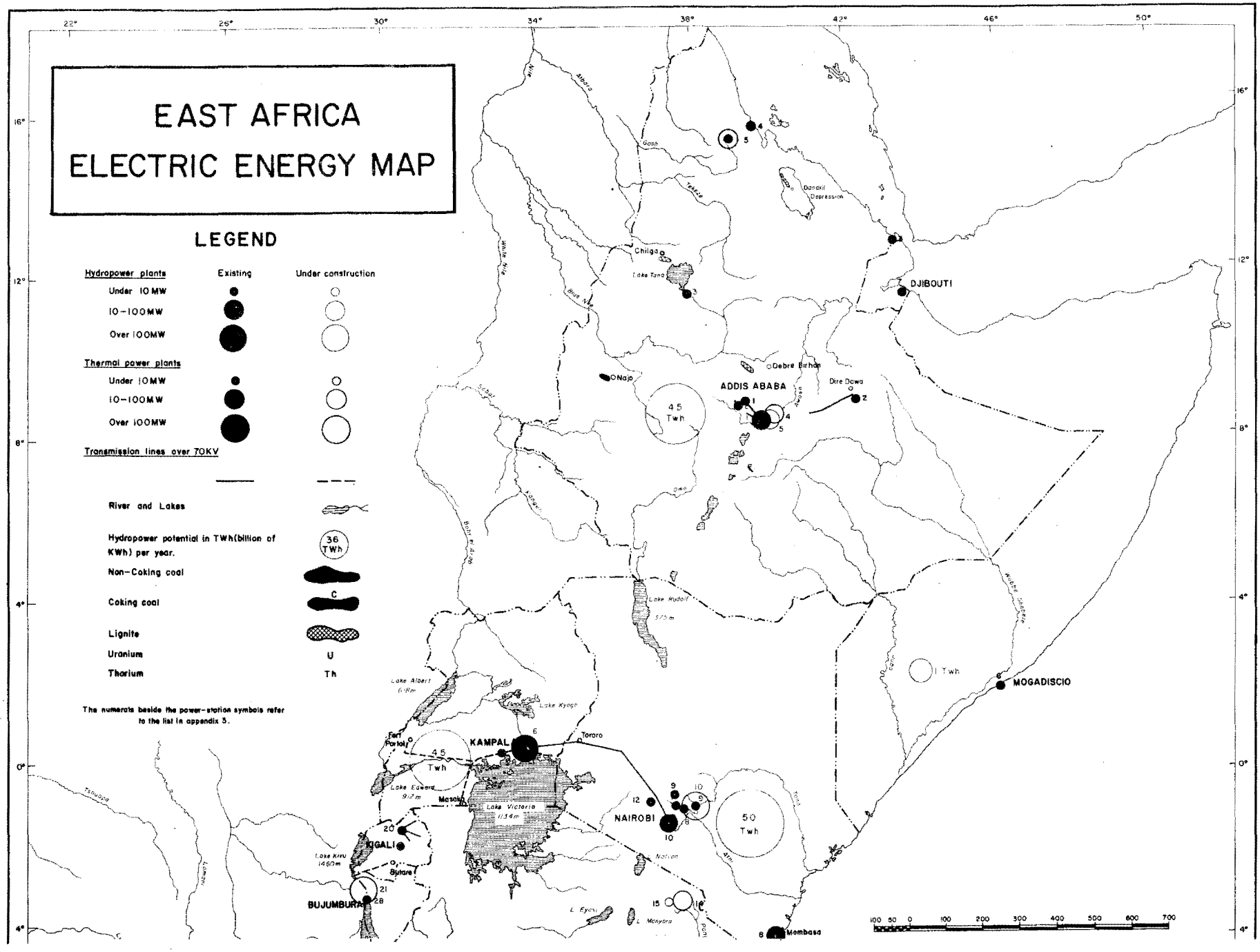
8. In parallel with the technical and economic side of energy development, the manpower problem in this field of activity should be given the necessary attention by the governments in the sub-region.

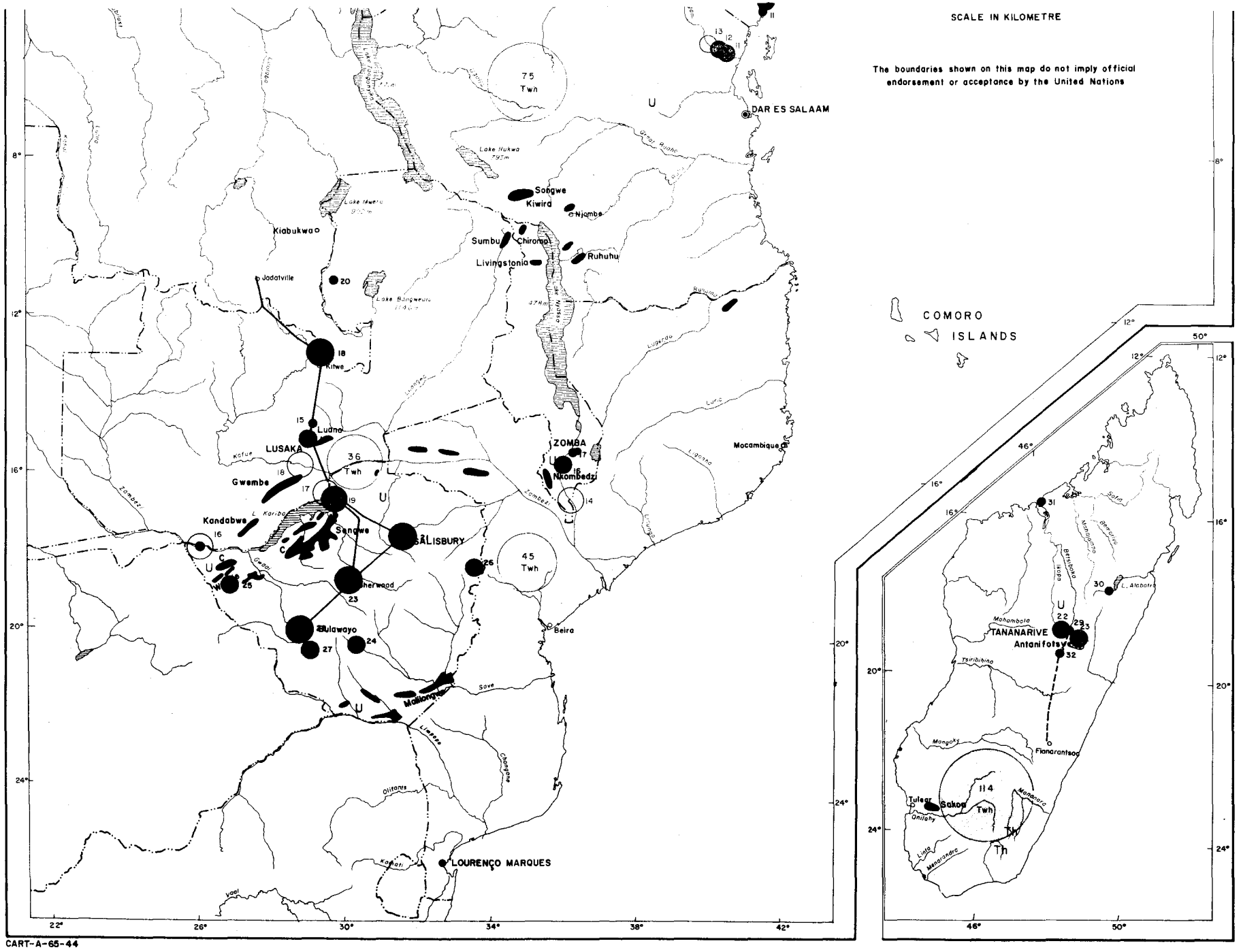
UNESCO and ILO should be requested to render assistance to the governments in organizing various training programmes to provide the necessary professional and skilled personnel at all levels.

9. Efforts in the energy field should be co-ordinated to such extent that more important power projects may be financed and administered on a sub-regional basis.


EAST AFRICA
PRIMARY ENERGY MAP
LEGEND
Rivers and Lakes
36 Twh
Hydropower potential in Twh(billion of Kwh) per year
Non-Coking coal
C
Coking coal
Lignite
Geothermal prospects
Sedimentary basins in which oil or gas might occur
U
Uranium
Th
Thorium
DJIBOUTI
MOGADISCIO
Mombasa
BUJUMBURA
Chilga
Lake Tana
1 Twh
50 Twh
75
SCALE IN KILOMETRE
100 50 0 100 200 300 400 500 600 700


The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations
75 Twh
36 Twh
45 Twh
114 Twh
DAR ES SALAAM
LUSAKA
SALISBURY
LOURENÇO MARQUES
Beira
Mocambique
Luano
Gwembe
Kandabwe
Sengwe
Wankie
Nkombedzi
Ruhuhu
Songwe
Njombe
Malilongwe
Lake Rukwa 793m
Lake Bangweulu 1140m
Tulear
Sakoa
Zambezi
Kafue
Luangwa
Great Ruaha
Lugenda
Lurio
Ligonha
Save
Limpopo
Olifants
Changane
Komati
Vaal
Mangoky
Sofia
Linta
Menarandra
Tsiribihina
Mahombo
CART-A-65-43


EAST AFRICA
ELECTRIC ENERGY MAP
LEGEND
Hydropower plants
Existing
Under construction
Under 10 MW
10–100MW
Over 100MW
Thermal power plants
Under 10MW
10–100MW
Over 100MW
Transmission lines over 70KV
River and Lakes
Hydropower potential in TWh(billion of KWh) per year.
36 TWh
Non-Coking coal
Coking coal
C
Lignite
Uranium
U
Thorium
Th
The numerals beside the power-station symbols refer to the list in appendix 5.
22°
26°
30°
34°
38°
42°
46°
50°
16°
12°
8°
4°
0°
DJIBOUTI
ADDIS ABABA
Debre Birhan
Dire Dowa
Najo
Chiliga
Lake Tana
Danakil Depression
4.5 Twh
1 Twh
MOGADISCIO
KAMPALA
Fort Portal
Tororo
Lake Albert 619m
Lake Kyoga
Lake Edward 912m
Masaka
Lake Victoria 1134m
4.5 Twh
NAIROBI
50 Twh
KIGALI
Lake Kivu 1460m
Butare
BUJUMBURA
Lake Rudolf 375m
L. Eyasi
L. Manyara
Mombasa
100 50 0 100 200 300 400 500 600 700


SCALE IN KILOMETRE
The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations
COMORO ISLANDS
DAR ES SALAAM
Songwe
Kiwird
Njombe
Kiabukwao
Sumbu
Chirombo
Livingstonia
Ruhuhu
Jadotville
Kitwe
Ndola
LUSAKA
Gwembe
Kandabwe
Sengwe
SALISBURY
Sherwood
Bulawayo
ZOMBA
Nkombedzi
Mocambique
Beira
Mafilongo
LOURENÇO MARQUES
TANANARIVE
Antanifotsy
Fianarantsoa
Tuléar
Sakoa
Twh
Th
75 Twh
36 Twh
45 Twh
114
Lake Hukwa
Lake Mweru
Lake Bangweulu
Lake Nyasa
Zambezi
Kafue
Luangwa
Lugenda
Lurio
Ligonha
Save
Limpopo
Olifants
Komati
Vaal
Changane
Mahajamba
Betsiboka
Ikopa
Sofia
Mangoky
Onilahy
Linta
Menarandra
Tsiribihina
Mahambole
CART-A-65-44

APPENDIX III

Larger electric power stations in the East African sub-region

A. Hydropower Stations (over 5 MW installed capacity

Country	No.	Name	Installed Capacity in MW Existing	under construction or proposed
Ethiopia	1	Koka	45.0	
	2	Aba Samuel	6.6	
	3	Tis Abbay	9.6	
	4	Awash II	-	32.0
	5	Awash III	-	32.0
Uganda	6	Owen Falls	120.0	+30.0
Kenya	7	Tana	6.4	
	8	Low Tana	8.0	
	9	Wonjii	7.4	
	10	Seven Forks	-	250.0
Tanzania	11	Pangani Falls	17.5	
	12	Hale	21.0	
	13	Pangani River or Wami River	-	30.0
Malawi	14	Shire River	-	470.0
Zambia	15	Broken Hill	42.7	
	16	Victoria Falls	8.0	184.0
	17	Kariba II	-	900.0
	18	Kafue River	-	257.0
Rhodesia	19	Kariba I	705.0	
Rwanda	20	Ntaruka	7.5	+ 4.2
	21	River Ruzizi	-	2600GWh/year
Madagascar	22	Manoviaka	11.0	
	23	Anklomita-I + II	10.0	

B. Thermal power stations (Over 2 MW installed capacity).

Country	No.	Name	Installed Capacity in MW: Existing	under construction or proposed
Ethiopia	1.	Addis Ababa	5.0	
	2.	Alemaya	2.0	
	3.	Assab	2.0	
	4.	Massawa	6.0	
	5.	Asmara	5.0	30.0
Somali Republic	6.	Mogadiscio	2.7	+ 1.9
Fr.Somaliland	7.	Djibouti	7.0	
Kenya	8.	Kipevu	27.5	
	9.	Ruizu	3.0	
	10.	Nairobi South I + II	25.1	
	11.	Mbiraki	6.0	
	12.	Mereron	4.4	
Tanzania	13.	Kurasini (Dar-es-Salaam)	17.2	
	14.	Moshi	?	13.5
	15.	Arusha	?	8.0
Malawi	16.	Blantyre	10.5	
	17.	Zomba	2.8	
Zambia	18.	Copper belt mines	193.1	
	19.	Lusaka	15.0	
	20.	Fort Rosebery	2.0	
	21.	Salisbury	153.0	
	22.	Bulawayo	148.5	
	23.	Umniatk	120.0	
	24.	Shabani	30.0	
	25.	Wankie	18.5	
	26.	Umtali	16.5	
	27.	Gwomda	12.5	
Burundi	28.	Bujumbura	3.0	
Madagascar	29.	Antananarivo	5.0	
	30.	Tmatave	3.0	
	31.	Majunga	3.4	
	32.	Antsizabe	2.8	

The main electric Transmission Lines in the East African Sub-region

A. Exi ting (over 70 kt)

Country	No.	End points	KV	Circuit length Km
Ethiopia	1.	Koka-Addis Ababa	132	418
	2.	Koka-Dire Dawa	132	
Uganda	3.	Kampala-Owen Falls -Tororo - Kenya	132	200[x]
Kenya	4.	Nairobi-Tororo	132	400
Tanzania	5.	Hale-Dar-es-Salaam	132	280
Zambia	6.	Kitwe-Jadotville(Congo)	220	290
	7.	Kitwe-Lusaka	330	600
	8.	Lusaka-Kariba(Rhodesia)	330	
	9.	88kv - System	88	115[a/]
Rhodesia	10.	Kariba-Salisbury	330	1,030
	11.	Salisbury-Sherwood	330	
	12.	Sherwood-Bulawayo	330	
	13.	Kariba-Sherwood	330	
	14.	88 kv - system	88	925
Rwanda	15.	Ntvmka - Kagera	70	?
	16.	Ntvmka - Musha	70	?
	17.	Ntvmka - Rwinkwaon	70	115

B. Under construction or proposed

Country	No.	End points	KV	Circuit length km
Ethiopia	1.	Koka-Awash II	132	50
	2.	Koka-Akaki	132	75
	3.	Akaki-Sabata, Gafarsa	132	25
Uganda	4.	Kampala - Kabulasoke	132	100[x/]
	5.	Kampala - Masaka	132	130[x]
	6.	Kabulasoke - Fort Portal	132	260[x]
Tanzania	7.	Hale-Dar-es-Salaam duplication	132	250

B. Under construction or proposed (continued)

Country	No.	End points	KV	Circuit length km
Zambia	8.	Kariba-Kitwe, duplication	330	600
	9.	Antananarivo-Antsirabe	90	150 [x]
	10.	Antananarivo-Fianarantsoa	150	300 [x]
Rwanda	11.	Mururu-Gikongoro-Butare	130	120 [x]