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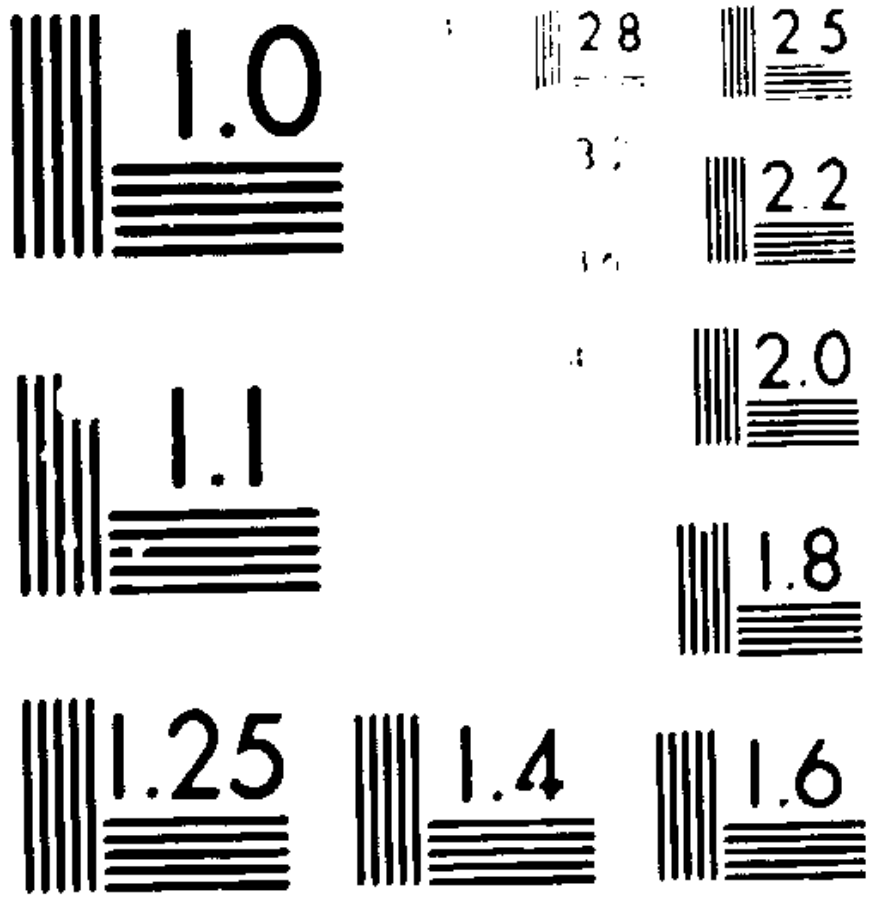
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Experiences and Technology Transfer
on Mini Hydro Electric Generation Units

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LOW HEAD POWER GENERATION FOR RURAL ECONOMIC DEVELOPMENT IN KENYA*

by

Industrial Survey and Promotion Centre
Ministry of Commerce and Industry
Nairobi
Kenya

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BACKGROUND

THE KENYAN ECONOMY

The Republic of Kenya is situated on the Equator that divides it into two almost equal halves. It extends over 582,647 square kilometers and is surrounded by the Republics of Somalia, Ethiopia, Sudan, Uganda, Tanzania and the Indian Ocean. About 13,000 square kilometres is covered by water (Lakes and rivers).

Kenya has a population of about 15 million people. The official census has just been completed (August,1979), although the actual figures have not been released yet. The GDP is K£1761 millions (1977) which gives a per capita GDP K£120. Agriculture continues to be the mainstay of the bulk of the population both in generation of GDP and employment. The manufacturing sector contributes 14.3% of GDP whereas Agriculture's contribution is over 30%.

CLIMATIC AND RELIEF FEATURES

With a total of over 500,000 kilometres and altitudes of upto 3000 metres and more, Kenya is a country of tremendous climate diversity. Twenty per cent of the land, or almost 12 million hectares receive more than 760 mm of rainfall per annum mostly in hilly terrains at a height of 1500 m. or more. Most of

these areas have rainfall spread throughout the year. Temperatures vary from region to region and are influenced by relief and season. The long rains come between March and July and the short-rains between September and December.

HYDROLOGY

The surface drainage is through several small and medium rivers and inland lakes. Some of these rivers like the Tana River and Athi River flow into the Indian Ocean, while other rivers like Nzoia Sondu, Yala, Gacha etc. flow from great heights into Lake Victoria: For instance rivers Yala, Sondu and Gucha flow from a height of 2500 metres and above, untapped and discharge over 2 million CUSEC into Lake Victoria year after year. There are several lakes namely Magadi, Nakuru,Naivasha and Elimentaita that also provide the necessary drainage. It is estimated that the rivers flowing into Lake Victoria alone have an economically exploitable power generation potential of 250-300 MW.

PATTERN OF ENERGY CONSUMPTION AND PRODUCTION

The present pattern of Kenya's energy consumption as shown below in table I is mainly dependent on imported petroleum based sources and exceeds 85% of total energy consumption. The import bill for these petroleum and petroleum products exceed 30% of total national imports.

TABLE I

Units: 1000 tons of oil equivalent

	1972	1973	1974	1975	1976	1977
Coal & Coke	28.3	50.0	46.6	32.1	44.9	43.8
%	(1.9)	(3.2)	(2.9)	(1.9)	(2.5)	(2.3)
Oil	1288.2	1359.9	1352.7	1392.8	1563.5	1605.9
%	(87.0)	(86.0)	(84.5)	(84.7)	(86.5)	(85.3)
Hydro-Power	164.1	170.4	202.3	218.4	198.1	232.6
%	(11.1)	(10.8)	(12.6)	(13.3)	(11.0)	(12.4)
Total Energy	1480.6	1580.3	1601.6	1643.3	1806.5	1882.3
%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: Central Bureau of Statistics: Statistics of Energy and Power, September, 1978 P. 17.

Because of complete absence of petroleum and coal from indigenous sources (till to-day) the main emphasis for local energy production is based on utilization of hydro, geothermal and wood-charcoal from the forest.

As regards hydro power generation, the total power generated is 496 MW mainly from Tana River that flows into the Indian Ocean (Table II). With the exception of few micro power generation stations installed by large coffee and tea estates, the power generating potential of the rest of the rivers and streams has not been exploited so far.

REGIONAL IMBALANCES

Although Kenya has made impressive strides in economic development, a large segment of the rural population is still engaged in subsistence type of activities that offer limited opportunities in the elevation of incomes. With the rapid economic development of the country in the past decade and half, specifically around the urban and semi-urban areas, some regional imbalances have been created with very little links in terms of economic benefits. This dichotomy of a fairly 'modern' urban class and economically undeveloped rural sector has created a 'rural poor' which looks to the urban centres as the growthpoles and is reflected in the rural-urban migration. As revealed in the Integrated Rural Survey of 1977, 41% of families which represents about 80% of Kenya's population, are engaged in smallhold agriculture with an income of less than Shs.2000 per family. It is, therefore, difficult to expect that this mass of the rural poor will be carried on the back of the urban centres, without creating serious socio-economic problems, especially with the expectation that the fruits of urban growth will trickle to the rural areas.

FUTURE STRATEGY

In recognition of such a state, Kenya Government plans to tackle the problem (1979-83, Development Plan) through measures that will contribute towards creating income earning opportunities, in order to diversify and increase rural economic activities. Some of the measures will include

dispersion of industries to the rural areas and provision of infrastructural facilities like roads, water, power housing etc. Lack of infrastructural facilities in rural areas often tends to inhibit industralization.

In our fourth National Development Plan (1978-83) a lot of emphasis has been laid on economic development of rural areas through rural electrification and extensive road building which are looked at as a forerunner of rural industrialization. Rural industrialization is considered to be the most conducive to rural economic development by creating employment opportunities at site, and generation of additional economic activities. One way of increasing activities is through processing of agricultural produce and also manufacturing consumer items and inputs by adopting low cost technologies to suit the local demand patterns.

Rural electrification is important in many ways. Firstly, it creates a capacity to locate industries in the rural areas. Modern production techniques in industry require energy as an essential input in one way or the other and it is difficult to imagine of a case where industry will do without any form of energy particularly electricity. Secondly, electrification can also be a source of domestic lighting thereof replacing charcoal burning and cooking methods which have the consequence of depleting the forest resources leaving the land exposed to soil erosion.

THE PRESENT POWER GENERATION AND ELECTRIFICATION FACILITIES

One way of taking power to the rural areas is by extending the current national grid to the needy places. But considering that at present hardly 15% of the country is served from the grid, alternative means of accelerating the programme must be sought. Total installed capacity at the moment is

only 496 MW with maximum concentration of power consumption in few selected areas as shown in table II. Keeping Kenya's population size in view, the per capita consumption is extremely low and less than 5% of consumption in U.S.A.

By process of elimination (taking into account various sources of power) hydro based generation of power, seems to be the only feasible means of implementing rural electrification programme in Kenya. In order to make it economically viable rural industrialization programme needs to be implemented simultaneously with the electrification schemes.

THE PROBLEMS

In spite of the great potential for Low-head power generation from innumerable rivulets and streams in Rift Valley and Western Province of Kenya, the LHPG Scheme has not taken off the ground up to now, except as indicated above by large coffee or tea estates, due to a number of problems faced for its planning. Consumers in the rural areas are widely scattered with very little energy requirement, mainly limited to domestic heating and lighting purposes. The high cost of the minimal load on long transmission lines required from national grid could'nt justify the need for it, inspite of the proportionate social benefits gained. It is therefore considered imperative to create additional power demand by generating some industrial activity in the rural areas or adjacent to the potential sites.

THE RECENT TRENDS

The recent price hikes in the international fuel prices, with possibilities for still further increases, have compelled the

non-oil producing countries, the world over, to adopt all possible measures to conserve the available energy supplies and explore possible alternative sources of energy. The situation in Kenya is all the more serious because of absence of any indigenous sources of fossil fuels or petroleum products. The potential for major hydel power generation is also limited. Considering the huge demand for power for industrial development as per our National Plan and implementing other programmes, it is imperative to explore all untapped sources of energy in the country.

THE CONCEPT OF LOW-HEAD POWER GENERATION

The idea of low-head power generation is nothing new, and in fact, has been practised since centuries in a number of countries devoid of any other natural source of energy. Initially, such hydel power potentials were utilized for operating grinding mills, pulp mills or small forge shops with the help of water turbines in the rural areas. With the development of modern technology, the same was utilized for generation of electric power with the help of electric generator. This practice was given up couple of decades ago, because of abundant supply of oil available at extremely low prices, and other cheaper alternative sources of energy.

The oil crisis has now completely changed the picture, and has accentuated the need for exploitation of all feasible sites by use of preferably standard capacity plants, specifically in non-oil producing countries. A number of international organizations have now specialized in providing turn-key services from the conception stage to power-on-line stage, including

general survey, site and power studies, engineering, economic feasibility and the project implementation. As regards the selection of the power generating equipment, it is more economical to select a standard power generating plant, rather than go in for a specially designed plant.

Hydro-electric power generation was traditionally not considered to be feasible for the regions of head 3-30 metric and discharges 1-6m^3/sec. of water unless there existed exceptional circumstances. Today, because of the energy crises, and the urgent need for rural development in the country the exceptional circumstances do exist. This seminar could not be held in a better place than Nepal to illustrate this fact.

The main objective of this scheme therefore in the Kenyan context, is to reduce reliance on imported energy supplies, achieve rural economic development and thus alleviate poverty and regional economic imbalances in the country. Rural electrification of remote areas, inaccessible from the existing power lines, by low-head power generation from nearby sources, leading ultimately to growth of small scale rural industries in the area thus creating employment opportunities at site, is the first step towards achievement of this goal.

ADVANTAGES

The main advantages of such low-head power stations, with capacities from 25 kw to 1000 kw or upwards are:

- Low investments
- Short gestation period
- Low transmission and distribution cost
- Modest water resource requirements
- Insignificant environmental changes
- Minimal service requirement
- Low running costs
- Compact unit size
- Well suited for rural development, housing and small industries

THE ECONOMIC VIABILITY

Its economic viability has to be judged, by considering both the commercial and social benefits that accrues to the rural population.

In order to achieve this laudable objective, Kenya has already initiated the necessary steps to survey all the drainage areas covered by rivulets and streams, presently untapped for its hydel power or irrigation potential in order to identify the feasibility sites for low-head power generation. We have tried to contact practically all known parties capable of implementing the Low-head-power generating schemes in Kenya, including general survey of the area, intensive studies of the potential sites, engineering designs and installation of the plants. It is encouraging to note that 13 parties of international repute, have responded, and some of them with full backing of their governments. We are now planning to survey the entire area having Low-head power generation

potential, before the end of this year.

The major areas with such potential should have a minimum rainfall, suitable gradients and adequate water discharge for minimum number of days in the year. Simultaneously the demand for power consumption nearest to the point of generation has also to be determined. In case of lack of adequate demand in the surrounding area for a given power station, studies shall have to be undertaken well in advance for exploring the possibility of initiating new industrial or agricultural activities for optimum consumption of power to be generated.

ORGANIZATION

It is visualized that ultimately at least 20 small and medium sized low-head power generating stations may be installed in different parts of Kenya within the next five years, involving an investment of K.sh.100,000,000 or over. In order to have a unified policy and centralized system of administration at the national level, for selection of sites, purchase of equipment and its commissioning and efficient operation for maximum benefit of the rural population, an institution within the Ministry of Power and Communication has been created and entrusted with the full responsibility of implementing the rural electrification programme, mainly based on Low-head-power generation.

CONCLUSION

With the energy crisis looming large all over the world and threatening to hit at the very roots of non-oil producing countries, this seminar on 'The Exchange of Experiences and Technology Transfer on Mini-Hydro Electric Generation Units', has not come a day too early. This important alternative source of energy once given up and forgotten as wasteful and too small to be bothered about, is most likely to prove as a great boon to some of the developing countries like Kenya in this period of economic crisis.

To us in Kenya, it carries a special importance, as we have just managed to take the first step towards this direction though very cautiously. The sharing of information and experiences with others regarding its potentiality, selection of appropriate sites, sources of supply of expertise and equipment, and its economic analysis vis-a-vis large hydro generation plants, will make us lot wiser and help us to avoid grave financial and technical pitfalls in future.

We are extremely thankful to UNIDO to have given us this opportunity of sharing this knowledge with, others at the most appropriate time and look forward to continuous guidance and assistance from it in future for implementation of this massive programme.

We would be too pleased to share our experiences and expertise gained with passage of time, with other less privileged countries with the African region and elsewhere.

E. A. P. & L. SYSTEM OPERATION STATISTICS FOR 5 YEARS

TABLE II

GENERATION, IMPORTS & CONSUMPTION OF ELECTRICITY FOR INTERCONNECTED SYSTEM

Location	*Installed capacity as on 31.12.78 (MW)*	*Effective capacity (MW)*	*ENERGY IN GWHr.*					*Average % increase in 5 years*
			1974	*1975*	*1976*	*1977*	*1978*	
HYDRO								
Tana (KPC)	14.4	14.4	108	98	100	105	101	
Wanjii „	7.4	7.4	51	55	57	54	44	
Kamburu (TRDC)	91.5	84.0	156	308	261	401	456	
Gitaru (TRDC)	145.0	145.0	—	—	—	—	241	
Kindaruma (TRDC)	44.0	44.0	192	156	128	205	193	
EAP & L (Hydro)	4.2	4.2	19	17	17	20	18	
TOTAL HYDRO	306.5	299.0	526	634	563	785	1053	
THERMAL								
Kipevu	98.0	90.5	229	242	376	317	252	
GAS TURBINE								
Nairobi South	17.9	13.8	13	2	40	10	2	
Kipevu	12.2	8.0	1	—	—	1	—	
DIESEL								
All diesel Stations	31.5	13.7	21	10	63	20	5	
IMPORTS								
U.E.B.	30.0	30.0	296	261	240	272	217	
TOTAL SYSTEM INCLUDING IMPORTS	496.1	460.0	1086	1149	1282	1405	1529	8.9
UNITS USED ON WORKS AND LOSSES			161	148	200	202	228	
UNITS SOLD			925	1001	1082	1203	1301	8.9

TABLE II(a)

SALE OF ELECTRICITY IN GWHr
(Split into different Categories of Consumers)

Category	*1974*	*1975*	*1976*	*1977*	*1978*	*Average % Increase in 5 years*
Domestic	139	151	156	175	194	8.7
Off Peak	121	134	130	111	117	—
Industrial	403	427	498	588	641	12.3
Commercial	239	263	273	301	321	7.7
Street Lights	10	11	11	11	10	—
Small Consumers	13	15	14	17	18	8.5
TOTAL	925	1001	1082	1203	1301	8.9
Percentage Increase from Previous year	7.5	8.2	8.1	11.2	8.1	

TABLE II(b)

AREA-WISE TOTAL MAXIMUM DEMAND (MW)

Area	*1974*	*1975*	1976	1977	1978	*Average % Increase in 5 years (%)*
Nairobi	97	102	108	124	147	11
Coast	38	42	48	50	58	11.2
Western Kenya	14	18	20	23	27	17.8
Rift Valley	9	10	12	13	17	17.2
Mt. Kenya	5	6	6	9	9	15.8
Total System (simultaneous)	170	184	207	223	256	10.8
% Increase from previous year	5.6	8.2	12.5	7.9	14.8	

TABLE II(c)

AREA-WISE AND TOTAL UNIT SALES (GWHr)

Area	*1974*	*1975*	*1976*	*1977*	*1978*	*Average % increase in 5 years*
Nairobi	565	602	637	684	732	6.7
Coast	224	238	268	301	331	10.3
Western Kenya	69	85	89	116	134	18.0
Rift Valley	44	51	59	63	70	12.3
Mt. Kenya	23	25	29	39	34	10.3
Total Sales	925	1001	1082	1203	1301	8.9

TABLE II(d)

CATEGORY—WISE REVENUE (KSH'000)

	1974	*1975*	*1976*	*1977*	*1978*	*Average % increase in 5 years*
Domestic	34,734	39,551	51,038	63,794	69,174	18.8
Off peak	15,136	20,082	24,276	23,459	24,751	13 0
Industrial	67,877	86,445	126,457	180,251	201,714	31.3
Commercial	77,404	93,096	120,760	159,111	170,157	21.8
Street Lighting	2,824	3,350	4,066	5,055	4,875	14.6
Small consumers	13,603	16,368	18,498	23,110	24,951	16.4
TOTAL	211,578	158,892	345,095	454,780	495,622	23.7
% increase from previous year	7.5	22.4	33.3	31.8	9.0	

NOTE: Total revenue does not include Sundry items such as fuel oil surcharge, Reddy Board meter rent etc.

TABLE II(e)

TRANSMISSION & DISTRIBUTION LINES

Voltage	*TOTAL CIRCUIT LENGTH (KM)*	
	As on 13.12.1977	*As on 31.12.1978*
275 kV	102	210
132 kV	1410	1429
66 kV	366	366
40 kV	108	108
33 kV	1439	1502
11 kV	4954	5104

TABLE II(f)

TRANSFORMERS

	As on 31.12.1977		As on 31.12.1978	
	Number	*Capacity (MVA)*	*Number*	*Capacity (MVA)*
Generating Substations				
11/132 kV	5	161	7	331
11/66 kV	6	30	6	30
11/33 kV	8	137	8	137
11/40 kV	4	5	4	5
3.3/11/40 kV	2	8	2	8
3.3/40 kV	2	4	2	4
Distribution Substations				
132/66 kV	6	195	6	195
132/33 kV	10	165	10	165
66/11 kV	25	284	25	284
66/40 kV	2	15	2	15
40/11 kV	4	5.5	4	5.5
33/11 kV	74	203	74	203
Distribution Transformers				
33/.415, 11/.415 kV	4650	528	4726	588

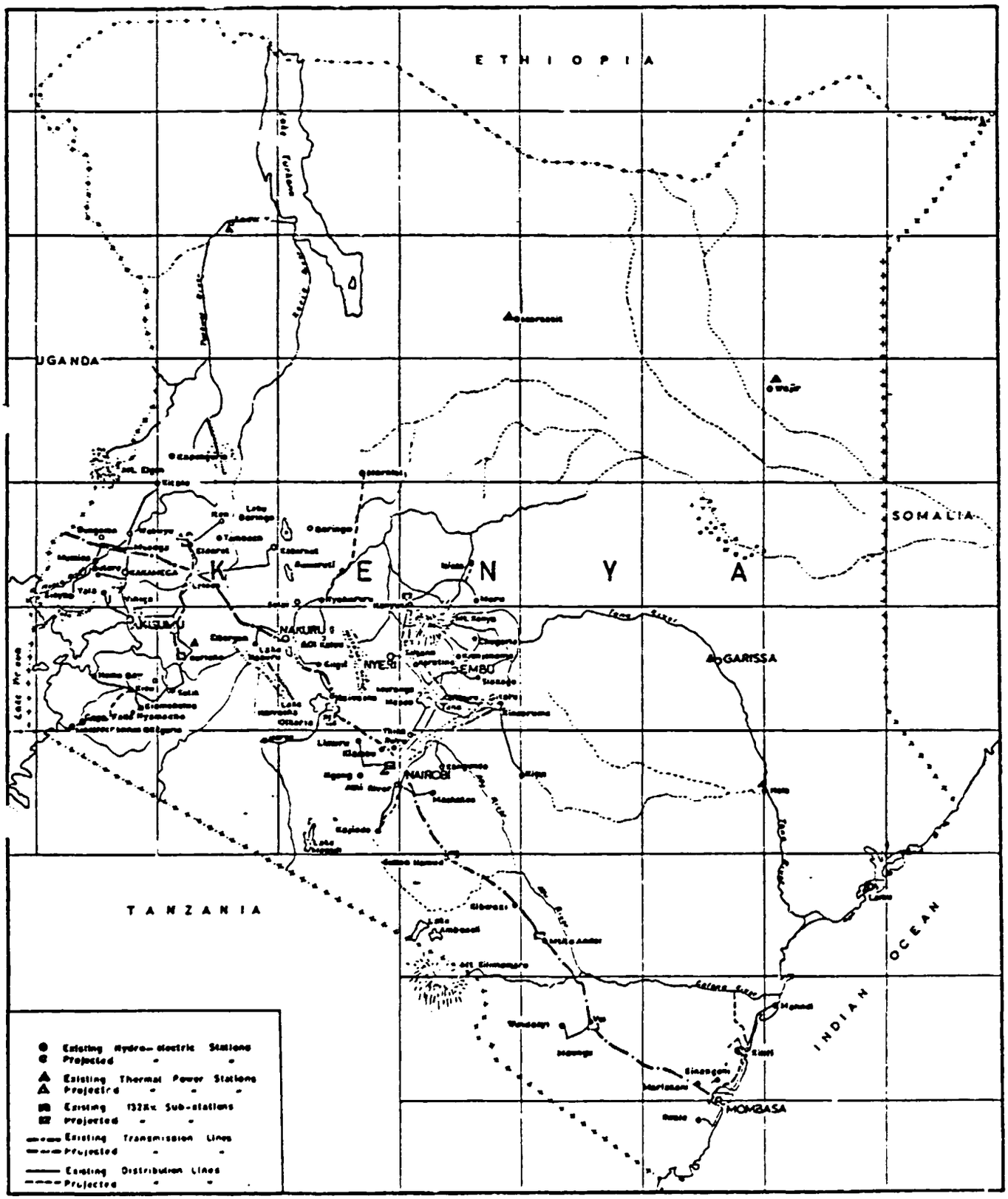
TABLE II(g)

Principal Areas of Supply

ATHI RIVER
BUNGOMA
BUTERE
CHOGORIA
ELBURGON
ELDORET
EMBU
GARISSA
GILGIL
HOMA BAY
ITEN
KABARNET
KAJIADO
KAKAMEGA
KANGUNDO—TALA
KAPSABET
KERICHO
KERUGOYA
KIAMBU
KILIFI
KISII
KISUMU
KITALE
KITUI
KWALE
LAMU
LIMURU
LODWAR
MACHAKOS
MALINDI
MARIAKANI
MARSABIT
MASENO
MAZERAS
MERU
MOLO
MOMBASA
MUMIAS
MURANG'A
NAIROBI
NAIVASHA
NAKURU
NAROK
NANDI HILLS
NANYUKI
NGONG
NJORO
NYAHURURU
NYERI
OL'KALOU
RONGAI
RUIRU
SAGANA
SIAKAGO
SIAYA
SOTIK
THIKA
VOI
WEBUYE
WUNDANYI
YALA

System: AC 415/240 volts 3 phase 4 wire

TABLE II(h)


ETHIOPIA
UGANDA
SOMALIA
K E N Y A
TANZANIA
INDIAN OCEAN
KISUMU
NAKURU
NYERI
EMBU
GARISSA
NAIROBI
MOMBASA
Existing Hydro-electric Stations
Projected
Existing Thermal Power Stations
Projected
Existing 132Kv. Sub-stations
Projected
Existing Transmission Lines
Projected
Existing Distribution Lines
Projected