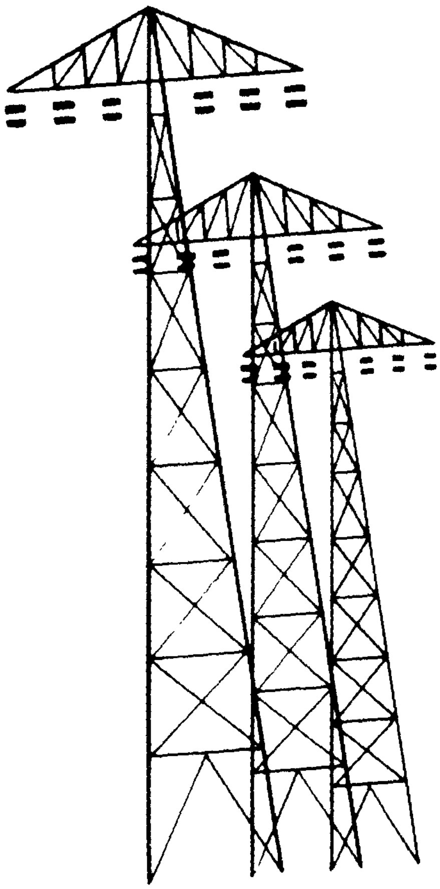

# SITUATION, TRENDS AND PROSPECTS OF ELECTRIC POWER SUPPLY IN AFRICA

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# PREFATORY NOTE BY THE SECRETARIAT

The report which follows contains the first comprehensive survey and analysis of the production and use of electric energy in Africa. Above all, an attempt has been made to bring out some main tendencies and prospects and to point to salient problems which may require further attention.

In preparing the study, at the request of the Economic Commission for Africa, the Energy Division of the Economic Commission for Europe has made use of the 1 replies received to a questionnaire circulated to African territories in November 1962 and of other data in the possession of the ECA, as well as information supplied 2 by the Resources and Transport Branch of the Department of Economic and Social Affairs at UN Headquarters. 3 In addition, many other national and international sources of information have been consulted. The analysis has equally been based on information supplied on the spot during visits to various countries by members of the Secretariat. To the maximum extent possible all available sources have been taken into account.

The study represents a first attempt to evaluate the many-sided problems of electric power development throughout a continent comprising 50 distinct territories. Because the analysis is based in various respects on incomplete data, certain of the details and statistical information contained in it must necessarily remain highly provisional. Moreover, since no information was available on the energy situation in some of the smaller territories in particular, some omissions were unavoidable.

A first version of the study was prepared as a basis for discussion during the African Electric Power Meeting held at Addis Ababa from 21-31 October 1963, under the auspices of the Economic Commission for Africa. As decided during the Meeting the report has been revised for general distribution in the light of the discussion and of additional information or amendments received up to 31 January 1964. It is issued on the responsibility of the Secretariat.

## Explanatory Notes

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of the frontiers of any country or territory.

For clarity of presentation the names of territories are omitted from certain of the Maps included in this document, and for identification purposes reference should therefore be made to Map 1.

Since many of the Tables in the report contain information for various years prior to 1962, the grouping of territories employed in the Tables often depends on the availability of statistical data. It should also be noted that in a number of cases designations of territories are those which applied at the date in question rather than those which have subsequently come into use. For a number of the Tables some of the more recent data for certain territories remain provisional.

The following meanings and abbreviations have been employed in the study:

| | | | |
|---|---|---|---|
| UAR | United Arab Republic | Gwh | million kilowatt hours (or $10^6$ kWh) |
| milliard | one thousand million or $10^9$) | kV | kilovolt |
| hl | hectolitre | kcal | kilocalorie |
| t (or tons) | normally refers to metric tons | AC | alternating current |
| MW | megawatt or 1000 kW | DC | direct current |
| kWh | kilowatt-hour | OH | overhead |

The following symbols have been used throughout the study:

- .. figures not available
- — nil or negligible quantity (less than half the appropriate unit)
- * Secretariat estimate
- P Provisional figure

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# THE POLITICAL DIVISIONS OF AFRICA
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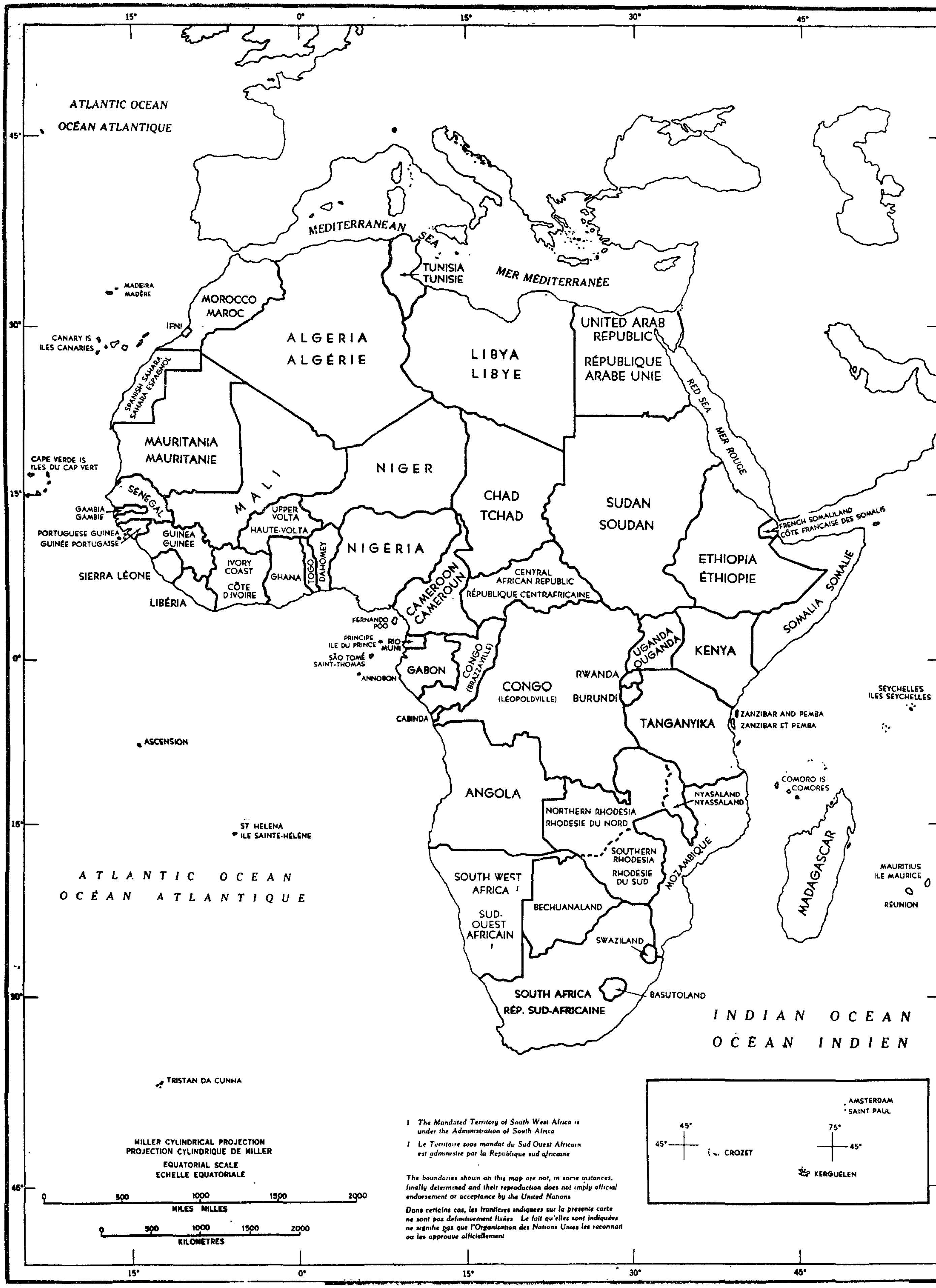



1 The Mandated Territory of South West Africa is under the Administration of South Africa

1 Le Territoire sous mandat du Sud Ouest Africain est administré par la République sud africaine

The boundaries shown on this map are not, in some instances, finally determined and their reproduction does not imply official endorsement or acceptance by the United Nations

Dans certains cas, les frontières indiquées sur la présente carte ne sont pas définitivement fixées. Le fait qu'elles sont indiquées ne signifie pas que l'Organisation des Nations Unies les reconnait ou les approuve officiellement

# Part I

# FACTORS OF DEVELOPMENT AND THE ENERGY SITUATION AS A WHOLE

## Chapter I

## THE ECONOMIC SETTING OF ELECTRIC POWER SUPPLY

### A. INTRODUCTION

The problems involved in developing the output and use of electric energy in Africa are complex and many-sided. In this field the different African territories show on the one hand much variety and many contrasts in their basic characteristics - in respect of natural environment; situation relative to means of transport and communication; endowment in natural resources; and structure of economic development. On the other hand they also possess many common features and share much undeveloped natural wealth. They also share many common problems in developing power supply systems and can thus benefit from a pooling of experience and from mutually advantageous co-operation.

It is the purpose of this initial chapter to analyse certain of those basic conditions in Africa which underlie the growth of electric power demand and supply in the special circumstances prevailing in the different countries.

### B. ECONOMIC FACTORS INFLUENCING POWER DEVELOPMENT

a) Population

Africa comprises over one fifth (22.4 per cent) of the world's land area but contains only 8.5 per cent (261 millions in 1961) of the world's population. All but about 3 per cent of that population is of African origin.

The consequences of these facts for electricity supply are far-reaching. Throughout the continent, in northern, central and southern Africa alike, the overall density of population is very low - about 9 persons per km$^2$ as against 23 for the world as a whole and around 100 in Europe (excluding the USSR). Since large areas of desert, barren land or dense forest are included in some territories, average densities are sometimes far higher when productive areas are the basis of comparison. To take an extreme case, while the population of the UAR (Egypt) (nearly 27 million) gives an average density of only 27 persons per km$^2$, the figure rises to some 600 when productive land only is taken into account. Taking mean density per km$^2$ of **agricultural** land as a basis of comparison, the regional average rises from 9 to about 56 persons per km$^2$ in north Africa; from 9 to about 27 in west Africa; and from 9 to 21 in southern and east Africa, with an average density of 30 inhabitants per km$^2$ over the continent as a whole.

Some main facts of the distribution of population in African countries are set out in tables 1 and 2. It can be seen that 15 territories have very low densities of between 1 and 5 persons per km$^2$, the most sparsely settled being Bechuanaland, the Central African Republic, Chad, Gabon, Mauritania, Niger and South West Africa. By contrast, though still **on the average** thinly populated, are Nigeria, Ghana, Sierra Leone, Tunisia and Uganda, with from 30-40 persons per km$^2$. When concentrations of urban population are taken into account, it can be seen from map 4 that in fact the comparatively dense areas around clusters of cities (with population densities of from 40 to 100 per km$^2$ on the average) are confined mainly to some coastal regions of Nigeria, Ghana, Algeria, Morocco, South Africa and the Nile delta strip. The only other inland areas are around Johannesburg, Pretoria, Kano and Nairobi, together with further regions in Uganda and Rwanda and Burundi. The Delta area of northern Egypt as far south as Aswan has a density in excess of the highest figure mentioned above. When urban centres themselves are considered it is noteworthy that there are at present only about 55 in the whole of Africa with populations above 100,000, eight of these possessing more than half a million inhabitants. These facts are of basic importance in considering the economics of electric power supply and plant interconnexion and also of surface transport electrification in Africa.

It is, however, the very rapid rate of population growth throughout the continent that is a cardinal fact nearly everywhere for the development of power demand. Between 1951 and 1961 over 50 millions have been added to the over-all population of Africa which, by the latter year, amounted to some 261 million. The average rate of increase (2.1 per cent per year) is the world's highest after Central and South America and south-west and south-east Asia. In twelve African territories, however, - three in north Africa, four in central Africa, four in southern Africa and one in west Africa - annual growth-rates between 1958 and 1961 can be seen from table 1 to reach between 2.5 and 3.1 per cent and rank among the world's highest rates for large regions.

Under such conditions it is almost an axiom that there is a net movement from rural to urban areas. This has certainly been occurring in those countries for which data are available, the concentrations of both African and non-African population in urban areas growing more rapidly than those in the inhabitated country areas.[1] Nevertheless, in most countries the rural areas still contain around 80-90 per cent of the population of African origin - a preliminary statement which still over-simplifies the complex problem of assessing the growth of a potential market for the use of electric power, both in the home and in terms of the total requirements to be met.[2]

### b) Natural non-energy resources

The natural mineral and other raw materials available throughout Africa are adequate to support a high level of economic development. Moreover, their distribution is complemented by that of the natural inanimate energy resources (considered in chapter II) in such a way as to foreshadow a high level of electric power consumption in a number of countries throughout the continent where consumption is at present low, once the average levels of national product per head have risen to the minimum necessary to allow demand-promoting factors to come fully into play.

Space does not allow a full analysis here of the economic geography of Africa's natural resources. These are well diversified and include many basic materials which underlie types of industrial output requiring, in their processing and manufacture, large quantities of electric energy per unit of product. In addition to many agricultural products, timber, vegetable oils, rubber and various fabrics and textiles - including cotton lint and thread, sisal, etc. - the continent is an actual or potential source of supply for the following among many ferrous and non-ferrous ores and other minerals:

Diamonds
Platinum
Gold
Silver
Copper (chalcopyrite, etc.)
Lead (galena, etc.)
Zinc (sphalerite, etc.)
Tin (cassiterite)
Aluminium (bauxite)
Mica
Asbestos
Phosphate rock
Iron ore (magnetite, hematite, limonite etc.)
Chrome ore (chromite)
Manganese (pyrolusite etc.)
Cobalt (cobalt etc.)
Tungsten (wolfram)
Vanadium (patronite, etc.)
Magnesium (magnesite etc.)
Columbium (columbite)
Beryllium (beryl)
Titanium (ilmenite, rutile)

The output of a selection of eighteen metallic and non-metallic mineral ores in the different African countries where production existed in 1961 is summarized in table 3. From this table it can be seen that for ten of these products Africa accounts for between 22 and 95 per cent of total world production. In fact, however, when the changing world position of the output of African countries is considered over the period since 1950 it can be seen that for a number of the products - bauxite, copper ore, gold, chrome ore, vanadium and asbestos in particular - the role of Africa is expanding; while for various other minerals it remains constant or has of late been, relatively, in decline. It is noteworthy in the present context that it is among certain minerals of importance in determining future demand for electric power - largely (though not entirely) because of the high specific kilowatt-hour consumption involved in ore reduction or later processing - that the role of African countries is growing in the world economy. The African production of bauxite has already risen rapidly over the post-war years. The same applies to many other minerals, including cobalt, phosphate rock and asbestos.

This however is to some extent a sign of future potential rather than of existing demand. When the world role of Africa in primary output of some selected metals and non-metallic mineral-based products (see table 4) is compared with that of the mining of the corresponding ores it is seen that in some cases other than copper there is a big difference between ore mining and ore reduction or processing. Nevertheless, is can be seen from table 4 that the output of some of Africa's processed energy-consuming products is proving increasingly competitive on the world scale.

[1] The considerable migratory and seasonal movements of workers — as in recent years from Ruanda-Urundi to the Congo (Leopoldville), Tanganyika and Uganda (c. 40,000 per year); from Upper Volta to Ghana and the Ivory Coast (150,000 per year); from Nyasaland to Southern Rhodesia and also from Basutoland to South Africa — further complicate the situation.

[2] Rates of enrolment of the appropriate population age-groups in primary, secondary and higher education are also relevant in considering electric power development. This question is referred to in Part II of the study.

It is of interest in this connexion to set out some average specific consumption figures in kWh per unit of product required to process alloys or prepare some of the raw materials available in African countries:

**Selected metal products**

| Product | kWh required per ton |
|---|---|
| Aluminium | 16 - 18,000 |
| Electrolytic copper | 2,500 |
| Ferro-chromium | 7,700 |
| Ferro-manganese | 5,000 |
| Ferro-tungsten | 8,000 |
| Electrolytic manganese | 11,000 |
| Pig-iron (electric furnace) | 3,000 |
| Titanium metal | 40,000 |
| Electrolytic zinc | 4,000 |

**Other selected products**

| Product | kWh required per ton |
|---|---|
| Paper and board | 500 |
| Leather and skins | 730 |
| Natural rubber | 500 — 1,000 |
| Sugar refining | 240 |
| Cement | 120 |

In the light of the possibilities for expanding some special forms of industrial electricity consumption where suitable low-cost power sites exist, it is of interest to judge how far the reserves of some important minerals (other than energy products) may justify such considerations for the future (see also map 2). Reserves of gold-bearing ore in some of the richest areas of exploitation are considered sufficient for perhaps a further half-century of operation, although in some areas the position is less certain. For certain minerals, including gold and diamonds, the economic possibilities, prospects for productive mechanization, etc., vary widely according to the method of extraction - i. e. whether the sources are from easily accessible and highly productive ores or whether they are in thin veins, in alluvial workings or in scattered eluvial sources etc. Thus the rich diamond resources of the Congo (Leopoldville) are in contrast in this respect with the alluvial sources (often rich) in Liberia, Sierra Leone and some other regions.

Reserves in the richest concentration of sources of copper - that of the Copper Belt of Northern Rhodesia - are also considered sufficient to ensure a further 50 years of output, and are evaluated at around 25 million tons (metal content) out of some 45 million tons for Africa as a whole - over a quarter of world reserves. Together with the smaller known reserves of the Congo (Leopoldville) this source accounts for the bulk of present African production.

Bauxite reserves, and their proximity to abundant low-cost power sources, are particularly important from the viewpoint of this study. It is currently estimated that about a third of the known world reserves, evaluated at one milliard tons, is located in Guinea in the localities of Fria, Boké, Dabola and Kindia. From the first-named locality there is an annual mined output of bauxite of about 1.2 million tons, giving a possible annual output of 440,000 tons of aluminium. It is envisaged that initially about half this capacity will be possible in addition at the installations planned at Boké.

Bauxite is, however, fairly widely distributed in Africa. This is not particularly surprising, since deposits of bauxite are formed near the surface under moist tropical conditions, by the decomposition of rocks high in aluminous silicates (various clays, clayey limestones and some igneous rocks). Reserves are known in various territories, including the Cameroun Republic, Ghana, the Ivory Coast, the Inga region of the Congo (Leopoldville), the Malagasy Republic and at Mount Mlanje in Nyasaland, near the hydro source of the Shire river. In each of these occurrences in fact available hydro resources promise future development of aluminium reduction and in some cases, as will be discussed in a later chapter, large-scale projects already exist. Processing plants are in fact planned in connexion with available hydro power on the Volta River (Ghana), with a capacity of 100-150,000 tons per year; the Kouilou (Gabon) giving 250,000 tons; on the Cuanza at Cambambe and other possible sites in Angola (6-7,000 tons); on the Konkouré in Guinea (150,000 tons); in Egypt at Aswan (10,000 tons); and in Algeria at Arzew (50-100,000 tons from natural gas).

Iron ore production is mainly concentrated in Algeria, Liberia, Morocco, Tunisia, Sierra Leone and the Union of South Africa, although large reserves exist also in Mauritania and elsewhere. Iron and steel industries are planned near some large deposits. Thus some 500 million tons of reserves are known in Algeria and a further 500-600 million tons in the Bome and Nimba regions and elsewhere in Liberia. This country may thus become one of the major producers of Africa. South Africa's reserves, located near other minerals used for alloys and processing, are also very high (around 2 milliard tons of varying quality) and are thus the centre of an existing iron and steel complex. A further 2.5 milliard tons (of lateritic iron ore) is located in Guinea (Kaloum) and other large reserves (around 200 million tons of high-grade ore) exist in Gabon (Mekambo etc.) where transport difficulties are aggravated by the inland situation.

Tin ore is mined more particularly in Nigeria, Congo (Leopoldville) - with some refining, Rwanda and South Africa. Output has fluctuated in these and some other producing areas, but reserves are considered sufficient for many years' operation.

Another mineral requiring power consumption for its processing in various forms is phosphate rock.

Most of the output is from substantial reserves, often of comparatively low quality, in north Africa (Algeria, Morocco, Tunisia and Egypt). One of the largest known apatite sources giving phosphate is, however, located at Tororo, in Uganda, where a major development of output could be envisaged.

This brief resumé covers a few only of the many important mineral reserves from which major energy-consuming development could emerge or expand. The economic factors involved are, however, complex in some fields. Potential requirements might in principle arise from three possibilities — mining for export of the ore to processing centres abroad; mining for mineral reduction in Africa based on available supplies of energy, with subsequent export of the metal to manufacturing centres; or processing of the metal at manufacturing centres to meet internal African needs as well as exports. In most cases this last alternative must await the emergence of a suitable economic and technical climate and other favourable conditions. These questions are considered further in part III of this study.

Other circumstances which complicate the evaluation of prospects in particular cases include the possibility of over-equipment due to the outcome of partial competition and substitution between certain metals - for example, copper, steel and aluminium - which in certain sectors of demand can provide possible alternatives for each other. Here the possibilities of cost-reducing technical progress, including further mechanization involving an added use of energy where this is easily available, can weigh the balance in some cases. In several African countries, however, it is the difficulty of reducing specific transport costs and constructing viable transport facilities that may offer a bottleneck to mineral transfer at present, in cases where the use of such facilities has been insufficiently diversified so far to encourage immediate capital investment.

### c) **Transport facilities**

In view of the importance of transport both in the development of Africa's economy and in its power supply, it is worth while to set out some main facts concerning land transport. This is done in table 5.

It can be seen from the table that total ton-km of rail-freight is increasing steadily in most areas in line with general economic growth. The actual levels achieved are, however, held back in many cases by the low density of population and of economic activity and by the considerable distances of a number of inland States from ports and industrial centres. Only when the traffic densities reach a certain minimum level does electrification become a practical proposition. The projects in this field are in fact considered in part II of the study. While possibilities of water transport are also available in principle in many areas, the problems of this form of transport need careful consideration at an international level where important contiguous or successive[3] rivers which may entail large multi-purpose hydro schemes are in question.

### d) **Economic structure**

In line with the foregoing analysis, and although agriculture and other non-industrial activities make up the major part of African output, the composition of the total domestic product of different countries at the present time varies very widely. Despite the importance of mineral reserves, mining so far accounts for under five per cent of total output in all except a few countries. The respective roles of manufacturing and of transport and communications in the total product are often approximately equal except in some less-industrialized territories where means of transport are geographically of major importance. Table 6 shows the distribution of economic activity for some selected countries.

It is of interest to study at the same time the corresponding breakdown of capital expenditure under the economic plans currently in force in certain countries. This can also be done in table 6 for the territories shown therein.

Columns 10 and 12 of the table show that there is a considerable emphasis on transport and communications and industry respectively in some developments currently under way, although the expenditure involved is not always great. Despite its key importance in many areas the part of new investment allotted to electricity supply does not seem particularly high except in a few countries (Ghana, Southern Rhodesia and Ethiopia). This reflects the fact that in a number of areas electrification has not yet attained the stage in average use per head where dynamic growth requires much new regular annual investment for generating and distribution capacity.

### e) **Development of industrial output.**

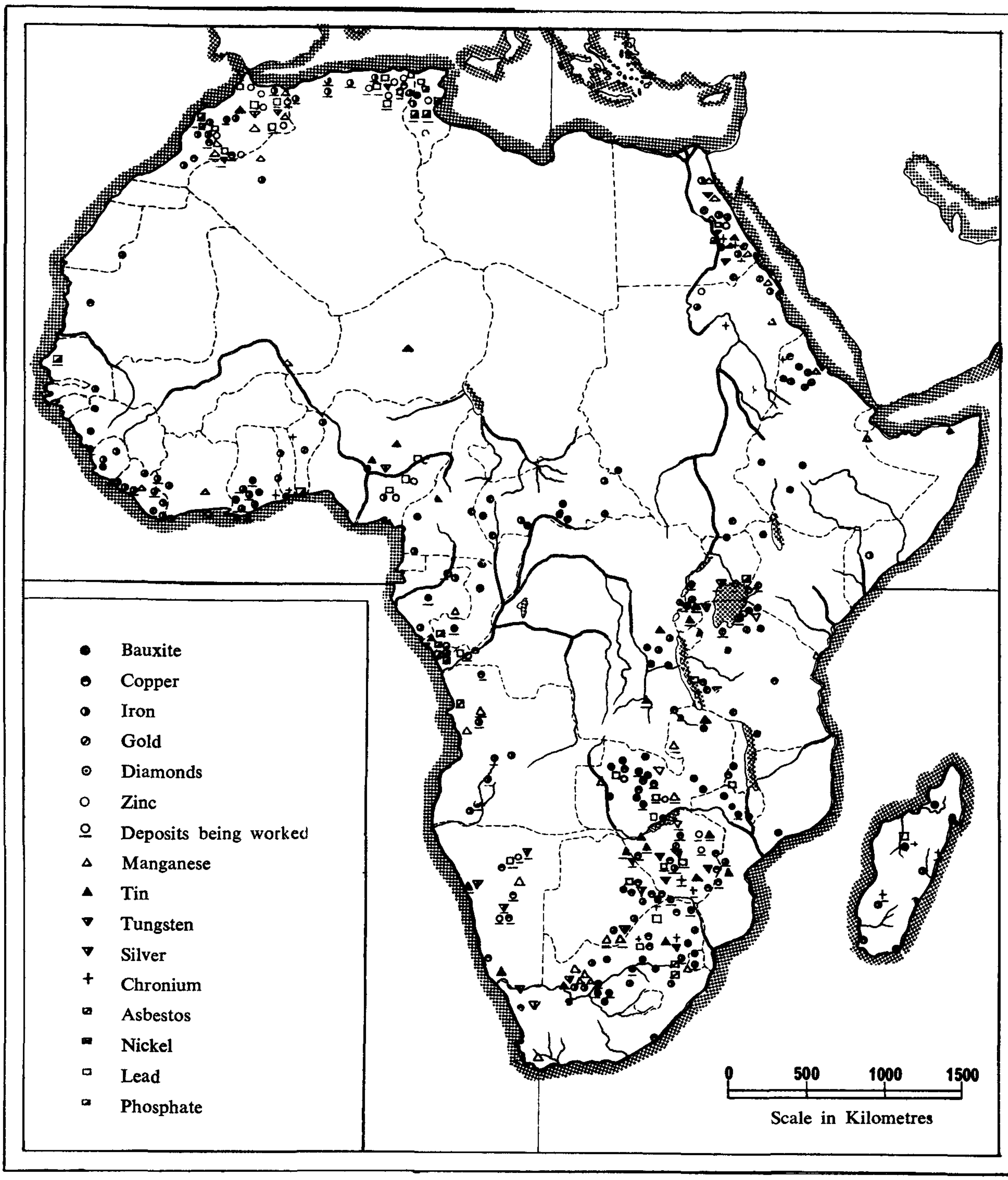
Growth in industrial production for a number of selected countries is analysed in table 7. In this table the production indices are shown in two different ways. The general index, covering all forms of industry, shows the over-all progress relative to 1958 as the reference year; while the indices relating to various separate industrial sectors show the change in each individual year relative to the previous year as 100.

The indices for separate sectors show that particularly rapid increases tend to occur in such industries as chemicals and textiles - two groups of basic importance for electricity consumption. It also emerges, however, that the rates of growth in output in the different fields are very uneven, and fluctuate widely from year to year. This is in part due to the step-like effect on growth trends which can arise at limited levels of output from the installing of new

[3] Those forming or crossing an international boundary respectively.

MAP 2

**LOCATION OF SOME MAIN MINERAL RESOURCES OF ECONOMIC INTEREST IN AFRICA**

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Compiled by the United Nations Economic Commission for Europe

productive capacity which may represent a major increment in the total. It also reflects in part the sensitivity of industry to short-term changes in the economic climate under such conditions — an adverse factor in developing electric power supply owing to the supply industry's low rate of capital turnover. It may also be noted here that another index of importance for electric power demand in Africa — the rate of new residential building construction — shows a similar tendency to fluctuate markedly from year to year. This question is studied further in part II of the study.

f) **National income**

What then is the outcome of the various demographic and economic tendencies discussed in this chapter in terms of over-all economic growth? Table 8 shows how total national income has evolved in selected countries (at current prices) between 1953 and 1961, together with the average level per inhabitant - calculated for comparative purposes in a single currency - in or around 1960.

The indices show a moderate rate of development. However, when changes in prices and in particular, the very rapid growth-rates for population are taken into account, average income per inhabitant (at constant prices) has changed comparatively little in recent years in many countries.

This is a basic factor in the climate for electric power development, since a minimum level of well-being is necessary before a modest household use of electricity can be supported economically over a wide coverage of the population. Comparison of average national income per head with the number of kWh used per inhabitant over a wide range of countries throughout the world brings out very clearly the closeness of the relationship between the two. Moreover, comparative study of changes in kWh requirements over a common period of time shows that characteristic rates of increase tend to be associated with different standards of living.

These questions are considered further in later parts of the study. However, to show how far national income per head and use of electricity are associated in African countries, the following average figures illustrate the position in a selected year (1957):

| **Country** | National income **expressed in US** dollars/inhabitant | **kWh inhabitant** |
|---|---|---|
| Ethiopia | 30 | 4 |
| Sierra Leone | 70 | 7 |
| Nigeria | 69 | 10 |
| Gambia | 56-70 | 28 |
| Kenya | 78 | 44 |
| UAR (Egypt) | 109 | 71 |
| Fed. of Rhodesia and Nyasaland | 132 | 189[a] |
| Cameroons | 142 | 211[b] |
| South Africa | 346 | 1362[c] |

[a] Excluding metal refining consumption
[b] Including consumption for metal refining
[c] Including consumption by energy-consuming industries

Fuller comparison on these lines would confirm that the widely varying economic structure of different African countries (i.e. the role of agriculture as against that of mining, metal refining etc.) and the varying levels of national product per inhabitant, together lead to very different levels of electricity consumption at the present time. In part this arises from differences in the ability of the economy and population to pay for electricity; and in part it is due to difficulties of economical supply under prevailing conditions. For the future development potential of electricity consumption on the other hand, the endowment in low-cost natural energy resources is likely to play a decisive part; and it is to this subject that chapter II will be devoted.

## C. OBSERVATIONS

Certain preliminary remarks on the broad economic setting of electricity supply in many African countries follow from the foregoing analysis. Low densities of population in most countries, and the low and comparatively stationary average income levels in rural areas, are factors which must tend to hold back the development of electric power supply systems in which improvements in plant utilization and productive efficiency can lead to a progressive lowering of kWh costs to the consumer - i.e. systems that are interconnected. These same factors must also tend to limit opportunities for advantageous cross-frontier links between adjacent systems at present. On the other hand, many opportunities may present themselves already for **local** cross-frontier interconnexions at low voltages, in order to improve supplies where insufficient local power production exists.

To the extent that this holds true, efforts have therefore to be oriented towards various means of overcoming this initial "vicious circle" of uneconomic supply on the one hand, and insufficient family income to support consumption on the other. Once such conditions have been overcome and more stable trends in economic growth have been set in motion, the manufacturing potential based on plentiful natural resources and the demand arising from rapid population growth can lead to immense new demands for electric power in most African countries.

## TABLE 1

**Estimated growth of population in African countries (1955-62) together with average density and rates of increase**
(thousands)

| Country and main region | 1955 | 1956 | 1960 | 1961 | 1962 | Average annual percentage rate of (1958-1961) | Area ($10^3 km^2$) | Average density (persons per $km^2$) relative to: Total land area (1961) | Total area of agricultural land |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **North Africa:** | | | | | | | | | |
| Algeria | 9,715 | 9,962 | 11,020 | ... | ... | 1.9(a) | 2381.7 | 5(b) | 23 |
| Libya | 1,105 | 1,118 | 1,195 | 1,216 | 1,244 | 1.8 | 1759.5 | 1 | 11 |
| Mauritania | 615 | 624 | ... | ... | 770 | ... | 1085.8 | 1(c) | ... |
| Morocco | 10,113 | 10,396 | 11,626 | 12,030 | 12,360 | 2.8 | 443.7 | 27 | 63 |
| Tunisia | 3,901 | 3,943 | 4,168 | 4,254 | 4,290 | 1.7 | 164.2 | 26 | 47 |
| Sudan | ... | 10,263 | 11,770 | 12,109 | 12,470 | 2.8 | 2505.8 | 5 | 37 |
| UAR (Egypt) | 23,063 | 23,643 | 25,952 | 26,557 | 27,303 | 2.5 | 1000.0 | 27(d) | 973 |
| **West Africa:** | | | | | | | | | |
| Cameroon | 3,955 | 3,992 | 4,097 | ... | 4,326 | 1.0(a) | 475.4 | 9(b) | 22 |
| Central African Republic | 1,111 | 1,126 | 1,210 | 1,227 | 1,250 | 1.9 | 617.0 | 2 | ... |
| Congo (Brazzaville) | 727 | 752 | 900 | ... | ... | ... | 34.2 | 3(b) | ... |
| Gabon | 389 | 394 | 440 | 448 | 453 | ... | 267.0 | 2(b) | ... |
| Chad | 2,481 | 2,550 | 2,660 | 2,680 | 2,720 | 1.0 | 1284.0 | 2 | ... |
| Gambia | 275 | 276 | 284 | 267 | 269 | 1.7 | 10.4 | 26 | 151 |
| Ghana | 4,620 | 4,691 | 6,777 | 6,960 | 7,148 | ...(e) | 237.9 | 29 | 125 |
| Liberia | ... | ... | 1,290 | ... | ... | ... | 111.4 | 12(b) | 60 |
| Nigeria | 31,971 | 32,572 | 35,091 | 35,752 | 36,475 | 1.9 | 923.8 | 39 | 151 |
| Sierra Leone | ... | ... | 2,450 | 2,450 | ... | 2.7 | 72.3 | 34 | 41 |
| Togo | 1,077 | 1,088 | 1,440 | 1,480 | 1,523 | ...(e) | 50.6 | 26 | 63 |
| Guinea | 2,570 | ... | 3,072 | 3,175 | 3,259 | ... | 245.9 | 13 | ... |
| Ivory Coast | 2,888 | 2,953 | 3,230 | 3,300 | 3,375 | 2.2 | 322.5 | 10 | ... |
| Dahomey | 1,615 | ... | 1,934 | 2,050 | ... | ...(e) | 115.8 | 18 | ... |
| Niger | 2,334 | 2,440 | 2,873 | 2,506 | 2,995 | ... | 1267.0 | 2(b) | ... |
| Senegal | 2,223 | 2,259 | 2,973 | 2,980 | ... | ...(e) | 197.2 | 15 | ... |
| Mali | 3,643 | ... | 4,100 | 4,207 | 4,305 | ... | 1204.0 | 4 | ... |
| Upper Volta | 3,335 | 3,407 | 3,635 | 4,400 | 4,500 | ... | 274.2 | 16 | ... |
| **North-East Africa:** | | | | | | | | | |
| Ethiopia | ... | ... | 20,000 | ... | ... | ... | 1184.3 | 17(b) | 31 |
| Somalia | 1,920 | 1,940 | 2,000 | 2,030 | 2,000 | 0.8 | 637.7 | 3 | 9 |
| French Somaliland | 63 | 68 | 67 | 68 | ... | —0.5 | 22.0 | 3 | 35 |
| **Central Africa:** | | | | | | | | | |
| Angola | 4,377 | 4,431 | 4,642 | 4,870 | 4,936 | 2.4 | 1246.7 | 4 | 15 |
| Burundi | 2,013 | 2,065 | 2,224 | ... | 2,600 | 1.7 | 27.8 | 80(b) | ... |
| Congo (Leopoldville) | 12,538 | 12,811 | 14,139 | 14,464 | 14,797 | 2.4 | 2345.4 | 6 | 27 |
| Kenya | 6,356 | 6,509 | 7,131 | 7,287 | 8,676 | 2.2 | 582.6 | 13 | 248 |
| Tanganyika | 8,454 | 8,605 | 9,239 | 9,399 | 9,560 | 1.8 | 937.0 | 10 | ... |
| Uganda | 5,896 | 6,046 | 6,677 | 6,845 | 7,016 | 2.5 | 239.6 | 29 | 225 |
| Zanzibar & Pemba | 289 | 293 | 309 | 315 | 320 | 1.7 | 2.6 | 119 | 152 |
| Rhodesia (Northern) | 2,130 | 2,180 | 2,420 | 2,480 | 2,550 | 2.5 | 746.3 | 3 | ... |
| Rhodesia (Southern) | 2,680 | 2,740 | 3,070 | 3,150 | 3,880 | 2.6 | 359.4 | 9 | ... |
| Nyasaland | 2,540 | 2,600 | 2,830 | 2,890 | 2,950 | 2.2 | 119.3 | 24 | 20 |
| Rwanda | 2,300 | 2,359 | 2,665 | ... | ... | 3.0(a) | 26.3 | 101(b) | 120 |
| **Southern Africa:** | | | | | | | | | |
| Bechuanaland, Basutoland & Swaziland | 1,175 | 1,199 | 1,275 | 1,296 | ... | ... | 622.7 | 2 | 186 |
| Mozambique | 6,040 | 6,105 | 6,482 | 6,640 | ... | 2.2 | 783.0 | 8 | 14 |
| Madagascar | 4,722 | 4,856 | 5,393 | 5,572 | 5,730 | 2.8 | 595.8 | 9 | 14 |
| Mauritius | 549 | 569 | 639 | 656 | 682 | 2.8 | 1.8 | 352 | 621 |
| Reunion | 278 | 295 | 336 | 346 | ... | 3.1(a) | 2.5 | 138 | 324 |
| South Africa | 13,993 | 14,334 | 15,822 | 16,236 | ... | 2.6 | 1223.4 | 13 | 15 |
| Total Africa(d) | 225,000 | ... | ... | 261,000 | ... | 2.1(f) | 30366.0 | 9 | 30 |

(a) For 1958 — 1960.
(b) For 1960.
(c) For 1958
(d) About 600 for non-barren land (total area is 95 per cent desert).
(e) Rate not computed because of apparent lack of comparability between estimates shown for 1958 and 1961.
(f) Refers to annual average over period 1950-1961.

TABLE 2

**Approximate distribution of urban and rural African and non-African population**
(percentage of total population — latest available year after 1950)

| Country and reference year | Urban population African | Urban population Non-African | Rural population African | Rural population Non-African | Percentage of total population of African origin (1956) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| Algeria 1954 | 7.1 | 5.8 | 82.5 | 4.6 | 89.0 |
| Morocco(a) 1954 | 15.6 | 3.2 | 79.1 | 2.1 | 93.0* |
| Tunisia(b) 1956 | 9.3 | 3.4 | 81.7 | 5.6 | 90.9 |
| UAR (Egypt) 1957 | 32.9 | | 67.1 | | 99.4 |
| Cameroon(c) 1957 | 5.5 | 0.3 | 94.0 | 0.2 | 99.5 |
| French Equatorial Africa(d) 1956 | 4.4 | 0.3 | 95.1 | 0.2 | 99.5 |
| Nigeria(e) 1952 | 5.0 | | 95.0 | | 99.9 |
| Togo(f) 1956 | 3.7 | 0.1 | 96.2 | — | 99.9 |
| French West Africa(g) 1956 | 4.1 | 0.3 | 95.4 | 0.1 | 99.5 |
| Kenya(h) 1957 | ... | 2.9 | ... | 1.3 | 96.0 |
| Tanganyika(i) 1957 | 2.5 | 1.0 | 95.9 | 0.6 | 98.4 |
| Uganda(j) 1957 | ... | 0.7 | ... | 0.6 | 98.8 |
| Fed. Rhodesia and Nyasaland(k) 1956 | 5.5 | 2.7 | 90.7 | 1.1 | 96.1 |
| Madagascar(l) 1956 | 5.6 | 0.7 | 92.9 | 0.8 | 98.5 |
| South West Africa 1951 | 9.4 | 6.7 | 78.9 | 4.8 | 87.9 |
| South Africa 1951 | 27.0 | 18.6 | 49.2 | 5.2 | 66.9 |

(a) Urban population of Casablanca, Marrakech, Fez, Rabat, Meknès, Oujda, Safi and Port Lyautey.
(b) Urban population of Tunis and Sfax.
(c) Urban population of Dakar, Saint Louis, Bamako, Conakry, Abidjan; in addition, figures for population of other towns 15,000 or more inhabitants.
(d) Urban population of Brazzaville, Bangui, Fort-Lamy and Pointe-Noire.
(e) Urban population of Kano, Ibadan, Ile Ife, Iwo, Lagos, Ogbomosho and Oshogbo.
(f) Urban population of Lomé.
(g) Urban population of Dakar, Saint Louis, Bamako, Conakry, Abidjan; in addition, figures for population of other towns with 15,000 or more inhabitants.
(h) Urban population of Nairobi, Mombasa, Nakuru, Kisumu, Eldoret, Kitale, Lamu, Nanyuki and Malindi.
(i) Urban population of Dar-es-Salaam, Tanga, Tabora, Mwanza, Dodoma, Lindi, Moshi, Arusha, Morogoro, Mikindani, Mtwara, Mbeya and Iringa.
(j) Urban population of Kampala, Jinja and Entebbe.
(k) Urban population of twenty cities and towns.
(l) Urban population of Tananarive, Majunga, Tamatave and Diégo-Suarez.

## TABLE 3

**Production of some main metallic and non-metallic minerals (other than energy products) in Africa (1961)**

| Country | Selected categories of mineral production in 1961 (thousand metric tons except where otherwise stated) — Metallic | | | | | | | | | | | | | | | Non-metallic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manganese ore | Iron ore | Copper ore | Lead ore | Zinc ore | Tin concentrates (tons) | Bauxite | Chrome ore | Vanadium ore (tons) | Tungsten ore (tons) | Nickel ore (tons) | Cobalt ore (tons) | Antimony ore (tons) | Gold (kg) | Silver (tons) | Diamonds (000 metric carats) | Phosphate rock | Asbestos |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| **North Africa:** | | | | | | | | | | | | | | | | | | |
| Algeria | — | 1,491 | 1 | 9 | 42 | — | — | — | — | — | — | — | 653 | — | — | — | 426 | ... |
| Morocco | 261 | 815 | 2 | 88 | 40 | 13 | — | — | — | — | 258 | 1,293 | 368 | — | 28(a) | — | 7,950(a) | — |
| Tunisia | — | 453 | — | 17 | 3 | — | — | — | — | — | — | — | — | — | 2 | — | 1,982 | — |
| Sudan | — | — | — | — | — | — | — | — | — | — | — | — | — | 47 | — | — | — | — |
| UAR (Egypt) | 10 | 211 | — | — | — | — | — | 1 | — | 50 | — | — | — | 31(c) | — | — | 627 | — |
| **West Africa:** | | | | | | | | | | | | | | | | | | |
| Cameroon | — | — | — | — | — | 69 | — | — | — | — | — | — | — | 17 | — | — | — | — |
| Central African Republic | — | — | — | — | — | — | — | — | — | — | — | — | — | 2 | — | 49 | — | — |
| Congo (Brazzaville) | — | — | — | 1 | — | 24 | — | — | — | — | — | — | — | 107 | — | — | — | — |
| Gabon | — | — | — | — | — | — | — | — | — | — | — | — | — | 475 | — | ... | — | — |
| Ghana | 188 | — | — | — | — | — | 199(b) | — | — | — | — | — | — | 25,909 | — | 3,214 | — | — |
| Liberia | — | 2,178 | — | — | — | — | — | — | — | — | — | — | — | 65 | — | 1,005(c) | — | — |
| Nigeria | — | — | — | — | — | 7,904 | — | — | — | — | — | — | — | 17 | — | — | — | — |
| Sierra Leone | — | 1,107(b) | — | — | — | — | — | — | — | — | — | — | — | — | — | 2,076 | — | — |
| Guinea | — | ... | — | — | — | — | 1,767 | — | — | — | — | — | — | ... | — | 1,117(c) | — | — |
| Ivory Coast | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 549 | — | — |
| Niger | — | — | — | — | — | 48 | — | — | — | — | — | — | — | — | — | — | — | — |
| Senegal | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 407 | — |
| Upper Volta | — | — | — | — | — | — | — | — | — | — | — | — | — | 107(d) | — | — | — | — |
| **North-East Africa:** | | | | | | | | | | | | | | | | | | — |
| Ethiopia | — | — | — | — | — | — | — | — | — | — | — | — | — | 320(c) | — | — | — | |
| **Central Africa:** | | | | | | | | | | | | | | | | | | — |
| Angola | 10 | 471 | 1 | — | — | — | — | — | ... | — | — | — | — | — | — | 1,147 | — | |
| Congo (Leopoldville) | 159 | — | 295 | — | 99 | 6,675 | — | — | — | 325 | — | 8,328 | — | 7,260 | 108 | 18,143 | — | — |
| Kenya | — | — | — | — | — | — | — | — | — | — | — | — | — | 382 | — | — | — | — |
| Tanganyika | — | — | — | — | — | 171 | — | — | — | 5 | — | — | — | 3,113 | — | 1,377 | — | — |
| Uganda | — | — | 13 | — | — | 30 | — | — | — | 76 | — | ... | — | 12(b) | — | — | — | — |
| Rwanda | — | — | — | — | — | 1,498 | — | — | — | — | — | — | — | — | — | — | — | — |
| Fed. Rhodesia & Nyasaland | | | | | | | | | | | | | | | | | | |
| — Northern Rhodesia | 27 | — | 567 | 15 | 30 | — | — | — | 236 | — | — | 1,708 | — | 133 | 23 | — | — | — |
| — Southern Rhodesia | — | 225 | 14 | — | — | 681 | — | 257 | — | 33 | 58 | — | 66 | 17,732 | 3 | — | — | 156 |
| **Southern Africa:** | | | | | | | | | | | | | | | | | | |
| Bechuanaland | 11 | — | — | — | — | — | — | — | — | — | — | — | — | 8 | — | — | — | 2 |
| Swaziland | — | — | — | — | — | 5 | — | — | — | — | — | — | — | 40 | — | — | — | 28 |
| Mozambique | — | — | — | — | — | — | 5 | — | — | — | — | — | — | 3 | — | — | — | ... |
| Madagascar | — | — | — | — | — | — | — | 4 | — | — | — | — | — | 11 | — | — | ... | — |
| South Africa | 549 | 2,530 | 52 | — | — | 1,454 | — | 397 | 1,291 | 16 | 2,600 | — | 10,708 | 713,558 | 71 | 3,788 | 297 | 177 |
| South West Africa | 22 | — | 25 | 63 | 20 | 307 | — | — | 1,039 | ... | — | — | — | ... | 57 | 906 | 1 | — |
| Total for Africa: | 1,237 | 9,481 | 970 | 193 | 234 | 18,879 | 1,971 | 659 | 2,566 | 505 | 2,916 | 11,329 | 11,795 | 769,349 | 292 | 33,371 | 11,690 | 363 |
| As percentage of World output | 22 | 4 | 26 | 10 | 8 | 11 | 8 | 50 | 32 | 3 | 1 | 67 | 38 | 71 | 4 | 95 | 33 | 22 |

(a) Former French zone only. (b) Exports. (c) 1960. (d) 1959.

## TABLE 4

**Production of selected raw materials in Africa — 1956—1961**

| Country | Primary production - thousand metric tons | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aluminium | | Copper | | Lead | | Tin (tons) | | Zinc | | Pig-iron | | Petroleum products (total) | | Super phosphates | | Cement | |
| | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 | 1956 | 1961 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| **North Africa:** | | | | | | | | | | | | | | | | | | |
| Algeria | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 79 | 55 | 669 | 1071 |
| Morocco | — | — | — | — | 28 | 25 | 10 | 10 | — | — | — | — | 77 | 208 | 50 | 77 | 648 | 630 |
| Tunisia | — | — | — | — | 24 | 19 | — | — | — | — | — | — | — | — | 79a) | 135 | 360 | 359 |
| Sudan | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 67 | 83 |
| UAR (Egypt) | — | — | — | — | — | — | — | — | — | — | — | — | 2367 | 4651 | 137 | 178 | 1351 | 2141 |
| **West Africa:** | | | | | | | | | | | | | | | | | | |
| Cameroon | — | 44 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Nigeria | — | — | — | — | — | — | — | 633 | — | — | — | — | — | — | — | — | ... | 332 |
| Senegal | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 146 | 182 |
| **North Africa:** | | | | | | | | | | | | | | | | | | |
| Ethiopia | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 27 | 30 |
| **Central Africa:** | | | | | | | | | | | | | | | | | | |
| Angola | — | — | 1 | 1 | — | — | — | — | — | — | — | — | — | 205 | — | — | 87 | 157 |
| Congo (Leopoldville) | — | — | 250 | 295 | — | — | 2816 | 2450 | 42 | 57 | — | — | — | — | — | — | 459 | 140 |
| Kenya | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 186 | 330 |
| Uganda | — | — | — | 13 | — | — | — | — | — | — | — | — | — | — | — | — | 60 | 66 |
| Fed. of Rhodesia & Nyasaland | — | — | 390 | 569 | 15 | 15 | 283 | 657 | 29 | 30 | 60 | ... | — | — | — | — | 579 | 438 |
| **Southern Africa:** | | | | | | | | | | | | | | | | | | |
| Mozambique | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 151 | 212 |
| Madagascar | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 21 |
| South Africa | — | — | 44 | 52 | — | — | 768 | 869 | — | — | 1356 | 2328 | 683 | 1462 | 566 | 643 | 2470 | 2598 |
| Total Africa | — | 44 | 685 | 930 | 67 | 59 | 3877 | 4619 | 71 | 87 | 1416 | 2328 | 3127 | 6526 | 911 | 1088 | 7260 | 8790 |
| As percentage of world production | — | — | 23 | 25 | 4 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | — | — | 3 | 4 | 3 | 3 |

a) Concentrated products.

TABLE 5

**Indices of land transport facilities and development of railway freight traffic in African countries**

| Country | Railways: Total length of track (km) | Railways: track per '000 km² | Railways: Net ton-km of freight (millions) 1956 | 1960 | 1961 | All-weather roads (km): Total length (km) | All-weather roads (km): Length per '000 km² |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **North Africa:** | | | | | | | |
| Algeria | 5239 | 2.2 | 1316 | 1728 | 1468 | ... | ... |
| Libya | 174 | 1.0 | 1 | 1 | — | ... | ... |
| Morocco | 2591 | 5.8 | 1531 | 1757 | 1839 | 16345 | 37 |
| Tunisia | 2098 | 12.8 | 907 | 971 | 953 | 13900 | 110 |
| Sudan | 5054 | 2.0 | 1319 | 1608 | 1746 | ... | ... |
| UAR (Egypt) | 5782 | 5.8 | 1616 | 2096 | 2050 | 19018 | 19 |
| **West Africa:** | | | | | | | |
| Cameroon | 504 | 1.1 | 97 | 122 | 134 | 3918 | 9 |
| Congo (Brazzaville) | 624 | 18.2 | 131 | 209 | 226 | ... | ... |
| Ghana | 1222 | 5.1 | 323 | 357 | 372 | 7200 | 30 |
| Nigeria | 3583 | 3.89 | 2116 | 1931 | 2304 | 21114 | 24 |
| Sierra Leone | 558 | 7.7 | 31 | 25 | 25 | ... | ... |
| Togo | 490 | 8.7 | 6 | 8 | 6 | ... | ... |
| Guinea | 701 | 3.1 | 38 | ... | ... | 7600 | 31 |
| Ivory Coast | 1318 | 4.1 | 146(a) | 213(a) | 334(a) | 16740 | 52 |
| Dahomey | 648 | 5.6 | 34 | 46 | 53 | ... | ... |
| Senegal | 1035 | 5.2 | 314(b) | 278(b) | 141(b) | ... | ... |
| **North-East Africa:** | | | | | | | |
| Ethiopia | 1175 | 1.0 | 130(c) | 162(c) | 191(c) | 4761 | 4 |
| **Central Africa:** | | | | | | | |
| Angola | 3849 | 3.1 | ... | ... | ... | ... | ... |
| Congo (Leopoldville) | 5967 | 2.5 | 2434 | ... | ... | 27062 | 12 |
| Fed. Rhodesia and Nyasaland | 5693 | 4.6 | ... | ... | ... | 70000 | 56 |
| — Rhodesia, N. & S. | 5138 | 4.6 | 6146 | 6890 | 6757 | ... | ... |
| — Nyasaland | 555 | 4.7 | 101 | 116 | 133 | ... | ... |
| East Africa (d) | 6765 | 3.8 | 2372 | 2666 | 2652 | 24780 | 14 |
| **Southern Africa:** | | | | | | | |
| Mozambique | 2732 | 3.5 | 1672 | 2020 | ... | ... | ... |
| Madagascar | 990 | 1.7 | 135 | 131 | 137 | ... | ... |
| South Africa | 29163 | 23.8 | 25464 | 30804 | 32524 | ... | ... |

(a) Abidjan — Ouagadougou line.

(b) Including Kidira-Bamako-Koulikoro line which lies in Mali.

(c) Including traffic of French Somaliland portion of Djibouti — Addis Ababa line together with some service traffic and baggage.

(d) Kenya, Tanganyika and Uganda including road and lake services.

## TABLE 6

**Relative distribution of economic activity and capital expenditure in development programmes (selected countries).**

| Country | Year | Percentage composition of gross domestic product | | | | | Plan Period | Annual planned capital expenditure (US dollars per inhabitant) | Percentage distribution of government capital expenditure on development programmes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mining | Manufacturing | Transport and communications | Agriculture | Other | | | Industry | Electricity | Transport and communications | Agriculture | Other |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| **North Africa:** | | | | | | | | | | | | | |
| Algeria | 1958 | 3 | 11 | 5 | 21 | 60 | ... | ... | ... | ... | ... | ... | ... |
| Morocco | 1961 | 6 | 15 | 21 | 27 | ...(a) | 1960/65 | 36 | 28 | 1 | 8 | 32 | 31 |
| Sudan | 1960 | — | 5 | 14(b) | 57 | 24 | 1959/61 | ... | 2 | 2 | 36 | 39 | 21 |
| UAR (Egypt) | 1956 | 1 | 12 | ... | 33 | 54(c) | 1960/65 | 35 | 23 | 4 | 16 | 23 | 34 |
| **West Africa:** | | | | | | | | | | | | | |
| Cameroon | 1956 | 3 | 5 | 6 | 49 | 37 | 1960/65 | 7 | — | — | 48 | 39 | 20 |
| Ghana | 1958 | 4 | 3 | ... | 60 | 33 | 1959/64 | 24 | 8 | 31 | 15 | 7 | 57 |
| Nigeria | 1957 | 1 | 3(d) | 9 | 63 | 24 | 1955/62(e) | 2 | 1 | 7 | 56 | 1 | 35 |
| Guinea | 1956 | 2 | 2 | 24 | 48 | 24 | 1960/63 | 13 | 21 | — | 18 | 26 | 35 |
| Ivory Coast | ... | ... | ... | ... | ... | ... | 1958/62 | 7 | 3(f) | 2 | 30 | 33 | 32 |
| **North-East Africa:** | | | | | | | | | | | | | |
| Ethiopia | 1959 | — | 2 | 5 | 62 | 31 | 1957/61 | 2 | 10 | 11 | 54 | 7 | 18 |
| **Central Africa:** | | | | | | | | | | | | | |
| Congo (Leopoldville) | 1959 | 17 | 8(d) | 9 | 30 | 36 | 1950/59 | 7 | — | 7 | 44 | 6 | 43 |
| Kenya | 1961 | — | 10 | 9 | 39 | 42 | 1957/60 | 3 | — | 1 | 14 | 38 | 47 |
| Tanganyika | 1961 | 4 | 7 | 7 | 57 | 25 | 1961/62-63/64 | 2 | 4 | 8 | 19 | 26 | 44 |
| Uganda | 1961 | 1 | 7 | 4 | 62 | 26 | 1961/62-62/63 | 2 | — | — | 29 | 15 | 55 |
| Fed. Rhodesia & Nyasaland | 1961 | 19 | 10 | 7 | 20 | 44 | 1959/63 | 5 | — | 44 | 35 | 2 | 19 |
| **Southern Africa:** | | | | | | | | | | | | | |
| South Africa | 1960 | 14 | 24(g) | 8(h) | 11 | 43 | ... | ... | ... | ... | ... | ... | ... |

(a) Distributed among other industries.
(b) Including trade.
(c) Including transport and communications.
(d) Including electricity, gas and water.
(e) Excluding plans for regions or territories.
(f) Expenditure on mineral prospecting.
(g) Relating to private enterprises only and including construction.
(h) Including transport only.

TABLE 7

**Development of industrial production indices in selected countries(a)**
(Except for the general indices, the previous year = 100)

| Country | Category | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| ALGERIA | General (1958 = 100) | 82 | 85 | 90 | 100 | 102 | 111 | 110 |
| | Mining | 144 | 76 | 100 | 91 | 90 | 142 | 90 |
| | Manufacturing | 67 | 109 | 106 | 116 | 102 | 106 | 98 |
| | Textiles | 63 | 100 | 125 | 143 | 95 | 111 | 109 |
| | Chemicals | 68 | 108 | 102 | 114 | 117 | 105 | ... |
| | Electricity(b) | 76 | 109 | 106 | 108 | 110 | 110 | 105 |
| CONGO (Leopoldville) | General (1958 = 100) | ... | ... | ... | ... | ... | ... | ... |
| | Manufacturing | 80 | 111 | 108 | 93 | 99 | ... | ... |
| | Textiles | 82 | 116 | 88 | 102 | 118 | ... | ... |
| | Chemicals | 82 | 108 | 106 | 98 | 89 | ... | ... |
| MOROCCO(c) | General (1958 = 100) | 94 | 95 | 95 | 100 | 100 | 110 | ... |
| | Mining | 79 | 102 | 103 | 108 | 107 | 105 | ... |
| | Manufacturing | 95 | 101 | 99 | 102 | 95 | 115 | ... |
| | Textiles | 102 | 80 | 117 | 110 | 105 | 113 | ... |
| | Chemicals(d) | 76 | 100 | 104 | 115 | 90 | 116 | ... |
| | Electricity | 91 | 105 | 101 | 101 | 99 | 106 | ... |
| FED. OF RHODESIA & NYASALAND | General (1958 = 100) | 83 | 94 | 103 | 100 | 119 | 127 | 131 |
| | Mining | 88 | 114 | 109 | 93 | 131 | 105 | 101 |
| | Manufacturing | ... | 116 | 114 | 102 | 104 | 106 | 106 |
| | Textiles | ... | 135 | 106 | 97 | 125 | 87 | 117 |
| | Chemicals | ... | 101 | 116 | 115 | 119 | 124 | 107 |
| | Electricity | ... | 110 | 96 | 104 | 112 | 119 | 107 |
| SOUTH AFRICA | Genera [illegible] 8 = 100) | ... | ... | ... | ... | ... | ... | ... |
| | Manufacturing | ... | 105 | 102 | 106 | 102 | 106 | 107 |
| | Textiles | ... | ... | ... | 102 | 104 | 131 | 118 |
| | Chemicals(d) | ... | ... | ... | 102 | 106 | 108 | 109 |
| TANGANYIKA | General (1958 = 100) | 87 | 89 | 96 | 100 | 100 | 111 | ... |
| | Mining | 99 | 103 | 97 | ... | 88 | 116 | ... |
| | Manufacturing | 105 | 101 | 112 | 106 | 103 | 110 | 106 |
| | Electricity | 109 | 102 | 116 | 72 | 99 | 83 | 100 |
| TUNISIA | General (1958 = 100) | ... | ... | 99 | 100 | 106 | 123 | 140 |
| | Mining | 99 | 96 | 98 | 102 | 91 | 100 | 90 |
| UAR (Egypt) | General (1958 = 100) | 80 | 84 | 90 | 100 | 103 | ... | ... |
| | Mining | 76 | 91 | 124 | 130 | 100 | ... | ... |
| | Manufacturing | 77 | 106 | 106 | 109 | 103 | ... | ... |
| | Textiles | 72 | 109 | 106 | 110 | 103 | ... | ... |
| | Chemicals(d) | 77 | 102 | 105 | 115 | 102 | ... | ... |
| | Electricity | 72 | 109 | 110 | 112 | 112 | ... | ... |

(a) So far as possible conforming to the United Nations International Standard Industrial Classification, but with some variation of coverage from country to country.

(b) Electricity and gas.

(c) Former French zone only.

(d) Including coal and petroleum products.

TABLE 8

**Estimated development of national income in selected countries**
(expressed in national currency units employed during the period concerned)

| Country | Currency unit | National Income (millions of national currency units) 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1960 value experssed in US dollars per inhabitant |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Algeria | NFr. | 6100 | 6500 | 7900 | 9100 | 10300 | 11700 | ... | ... | 214(a) |
| Congo (Leopoldville) | Fr.C | 44560 | 47340 | 49530 | 48820 | 48050 | 48185 | ... | ... | ... |
| Ghana(b) | £ G | ... | 332 | 343 | 360 | 381 | 432 | 464 | 492 | 193 |
| Kenya(c) | £ | 158 | 181 | 193 | 206 | 208 | 214 | 224 | 225 | 88 |
| Morocco(d) (e) | Fr. | 757 | 728 | 714 | 658 | 739 | 720 | 746 | 716 | 128 |
| Nigeria(b) | £ W.A. | 793 | 851 | 901 | 943 | ... | ... | ... | ... | 79(f) |
| Fed. of Rhodesia and Nyasaland | £ | 307 | 352 | 388 | 387 | 392 | 447 | 470 | 474 | 158 |
| Sudan | L.S. | ... | 278 | 307 | 301 | 312 | 338 | 346 | 382 | 85 |
| Tanganyika | £ | 142 | 147 | 152 | 152 | 167 | 177 | 186 | 187 | 59 |
| Tunisia(e) | Dinar | 246 | 233 | 249 | 238 | 270 | 258 | 290 | 274 | 166 |
| Uganda(c) | £ | 129 | 140 | 142 | 147 | 147 | 150 | 152 | 156 | 63 |
| UAR (Egypt) | L.E. | 869 | 918 | 947 | 1086 | 1188 | ... | ... | ... | 112(g) |

(a) Refers to 1959
(b) Refers to gross national product at market prices
(c) Refers to gross domestic product at factor cost
(d) Refers to milliards of francs
(e) Refers to gross domestic product at market prices
(f) Refers to 1957
(g) Refers to 1958

# Chapter II

# AFRICA'S ENDOWMENT IN NATURAL ENERGY RESOURCES

## A. INTRODUCTION

Experience in countries with a long history of economic development has shown how strong has been the influence of the initial pattern of energy resources on the mode of that development. For this reason it is important to be able to evaluate at the outset, in general terms at least, the type of natural endowment in sources of energy and their geographical distribution relative to other economic elements. This is one main purpose of the present chapter.

To a greater extent than is sometimes realized, it is possible to achieve such an evaluation in respect of water resources. At the same time it is vain in most cases, and particularly under African conditions, to expect anything like finality at the outset, particularly in the knowledge of mineral fuels. That this is true can be seen even in Europe where, after a long period of intensive settlement and industrialization, major natural gas reserves have been tapped only recently. Much can, however, be done to apply common methods and reasoned analysis in order to evaluate the likely pattern of energy resources and in principle, to do it comprehensively. It may also be possible to economize by co-ordinating the application of aerial and other survey activities so as to provide necessary data for resource evaluation in more than one field. Much is in any case known already, at least provisionally, about the main pattern of natural resources available for production of electric power in African countries. It is to a brief general evaluation of these resources that attention will now be given.

## B. THE RELATIVE STANDING OF AFRICA'S NATURAL ENERGY RESERVES

For a first rough appraisal of Africa's fuel and power resources one may compare their average distribution over the continent with that over the world's total land surface. What, however, should be the basis of definition for such a purpose?

It is evident that estimates of mineral fuel reserves derived from geological surveys, aeromagnetic or gravimetric reconnaissance, etc. only become more complete as their geographical coverage extends. Moreover, assessed reserves may be defined as those "measured or proved" plus those additionally taken as "indicated or inferred". For solid fuels such as brown coal an average calorific content throughout the deposit may have to be estimated and a defined depth must be assumed. Finally, the percentage regarded as economically recoverable may also be decided, though this may well be found to rise with the passing of time due to technical progress, better communications and the using up of alternative resources. For hydro-electric resources similar principles apply. There is a fixed upper limit which depends on the average amount of flow and its irregularity, the difference of level through which that flow passes and the availability of opportunities for water storage. There must be structurally and topographically suitable sites for installing generating plant. Sites that are technically feasible may become slightly more numerous and their capacities more ambitious as time passes. That part of their total producibility regarded as economically viable will also tend to rise with the passing of time as transmission facilities improve and loads increase. Alternative uses of water may also enter the picture and contribute to the return on capital investment.[4]

At any given time, therefore, knowledge of the physical magnitude of fuel and water resources is likely to be very incomplete. Their degree of economic feasibility may also be subject to change and its level will be that applying only to conditions in the country concerned. In many cases, however, the estimates available in practice for a given country's resources are simply the aggregate of the schemes already studied because of their immediate economic attractiveness. In newly developing countries, in particular, these are likely to constitute only a small part of the resources ultimately available. In making over-all comparisons, therefore, is is the total of proved, indicated and inferred reserves of different commercial fuels, and the combined output of all likely hydro-electric potential under defined conditions of

[4] Many other physical criteria and economic considerations enter into the detailed evaluation of energy reserves which are not referred to here.

flow that ought to be taken as the point of departure, rather than summations of individual projects, which have a different role. In principle at least the approach should be a comprehensive one.

Adopting for the moment these ideas, it is useful first of all to consider how Africa's principal natural sources of electric power compare with those over the world as a whole.[5] For this purpose the energy sources to be mainly considered at the outset will be those of conventional type, plus sources of nuclear fuel, i.e. those sources indicated below within the broad classification of different forms of primary energy available in Africa:

**Conventional sources**
**Commercial**

- Hard and brown coal (selected for comparison)
- Peat
- Crude petroleum ( " " )
- Natural gas ( " " )
- Hydro power ( " " )
- Uranium and thorium ( " " )

**Non-commercial**

- Fuel wood and wood waste
- Other products, including bagasse and various vegetable and other wastes.

**New sources**

- Wind power
- Solar energy
- Geothermal energy
- Tidal and wave power

The comparison is set out in outline in table 9. Owing to low average densities of population the distribution within Africa of all measured and probable reserves of the main forms of energy is more favourable relative to population than in terms of areal density. All estimates are necessarily highly provisional. Nevertheless it would seem that it is in respect of hydro-electric power and sources of nuclear fuel that the reserves are relatively most abundant. In fact, the estimates imply that 32 per cent of the world's exploitable hydro power is located in Africa, as are nearly 12 per cent of its uranium reserves and also 60 per cent of its thorium (these latter in terms of ores with over 0.01 per cent oxide content). For such resources, therefore, the endowment per inhabitant is well above the world average, particularly for hydro power (6,000 kWh per head and per year) and for thorium. For coal and crude petroleum the sources **so far established,** though adequate as totals, are below the world average.

These estimates for fuels refer to total known reserves, whether measured or proved or merely inferred from evidence so far incomplete. It can be seen that between 10 and 30 per cent of the various totals for solid and liquid fuels tend to constitute measured or proved reserves. For natural gas the ratio for the world's measured reserve is 20 per cent and for Africa 80 per cent. For uranium also the corresponding percentage is higher for Africa than for the world as a whole.

In any such comparison various differences of detail are necessarily involved. While the depth to which solid fuel reserves are defined is normally 1,200 m in the case of hard coal and 500 m for brown coal (for seams at least 30 cm in thickness), other definitions may be employed in certain countries. Again the percentage of the reserve that is considered economically recoverable under present conditions may vary widely, though in many cases it has been evaluated at between 50 and 100 per cent. Finally, the calorific content of the various fuels may also vary widely. In Africa, as elsewhere, coals often classified with hard coal may vary in average content between 2,650 kcal/kg (Bechuanaland) and the standard value (7,000 kcal/kg), as in Tanganyika.

## C. ENERGY RESOURCES OF AFRICAN COUNTRIES

Natural resources, which should go far to determine the future structure of electric power production in Africa and also that of its over-all energy economy, are very unequally distributed, particularly in respect of sources of commercial fuels. Moreover, wide differences exist between alternative estimates for certain countries. In addition, there are very large areas so far unsurveyed for this purpose which are geologically suited to offer various sources of energy. It therefore appears most realistic to consider the distribution of energy reserves in African countries first in terms of **maximum estimates** (i.e. including both measured and inferred reserves); and to consider at a subsequent stage various projects and estimates of exploitable possibilities.[6] Table 10 provides a starting point for a first tentative assessment of this kind and map 3 serves to clarify the geographical distribution of energy reserves within Africa. Associated data for certain selected countries are also included in tables 11-13.

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[5] Here it is the latest information communicated to the Central Office of the World Power Conference, London, that is taken as the basis of discussion.

[6] For this reason some of the data in Table 10 will differ from those in use elsewhere in the study and will not necessarily agree with certain of the estimates received in response to the inquiry and discussed elsewhere in this report.

a) **Hard and brown coal**

Data relating to eleven widely-distributed territories are shown in table 10, of which those for Southern Rhodesia, Swaziland and South Africa are of major importance when considered in terms of the population concerned (i.e. in tons per inhabitant). Relative to present levels of production, the reserves in all countries for which data are available give a considerable "life-expectancy", at least of the order of 200 years and generally much more. Not all of the reserves so far known, however, are **at present** economically recoverable in full. However, the notes appended to table 10 show that in several cases considerable reserves of low-grade coals and lignite are also available in addition to those listed under hard coal. In table 14 a short summary is given of the various localities where occurrences of coal exist.

In at least three of the countries - South Africa, Southern Rhodesia and Nigeria - supplies allow metallurgical coke to be produced. Conditions for coal production in the two first-named are very favourable and in the first the fact that seams are relatively level and at moderate depth allows production costs to be kept very low.

A considerable over-all addition to the total known coal reserves also exists in a number of the countries for which figures are not immediately available.[7] Even so, the total for Africa of 77 milliard tons, equivalent to around 300 tons for every inhabitant in 1960, is over 1700 times the present annual output of all types of coal on the African continent.

b) **Crude petroleum**

Although Africa's petroleum resources as so far established are more thinly spread than in various other areas of the world, they give promise of a greater potential when exploration is further advanced. In around eight million km$^2$ of the continent marine sedimentary deposits exist which - given suitable structural configuration (domes, anticlinal and other structures favourable to concentrations of oil or gas) - may suffice to increase the resources known at present several times over. Only a limited percentage of the area not ruled out by the presence to reasonable depth of only ancient igneous or metamorphic rocks, lavas, continental sediments of the type of the Karroo and Kalahari formations, etc., has so far been explored. This area includes most of north Africa, including the Sahara, to around longitude 30°E and as far south as approximately latitude 10°N; the area east of longitude 40°E; and some smaller regions near the coastline to the south of the Equator and also in the west of Madagascar.

The present level of production of crude oil in Africa, though rising, is still comparatively low. There is normally a relationship between extraction and proved reserves, the latter being commonly in the region of 15-20 times the prevailing output. On this basis production could certainly be intensified, probably by three times above the level of 1961, without further exploration. It can be seen from table 10 that in Algeria, Morocco, Nigeria and Angola, for example, reserves are equivalent to 60 or more times the production attained in 1960. The greatest potential reserves, however, occur in Libya, where estimates suggest that more than 300 tons per inhabitant may be present.

In addition to the data in table 10, column 5, certain other countries possess indications or are favourably situated - notably Ghana, Togo, Dahomey, Cameroon Republic and Congo (Brazzaville). The significance of the incompletely explored area is underlined by the fact that the 1.5 milliard tons so far indicated, giving the equivalent of 6 tons per inhabitant throughout Africa, or 100 years of production at the 1960 rate, has largely been identified during the years since 1956. It was in January of that year that the **Compagnie de recherches et d'exploitation de pétrole au Sahara** located deposits - since evaluated at some 150 million tons - in the neighbourhood of Edjeleh, near the frontier between Algeria and Libya, the reserves being at moderate depth (450-1400 m). Five months later the source at Hassi-Messaoud (now estimated at around 500 million tons), 600 km to the north-west of the former strike, was discovered.

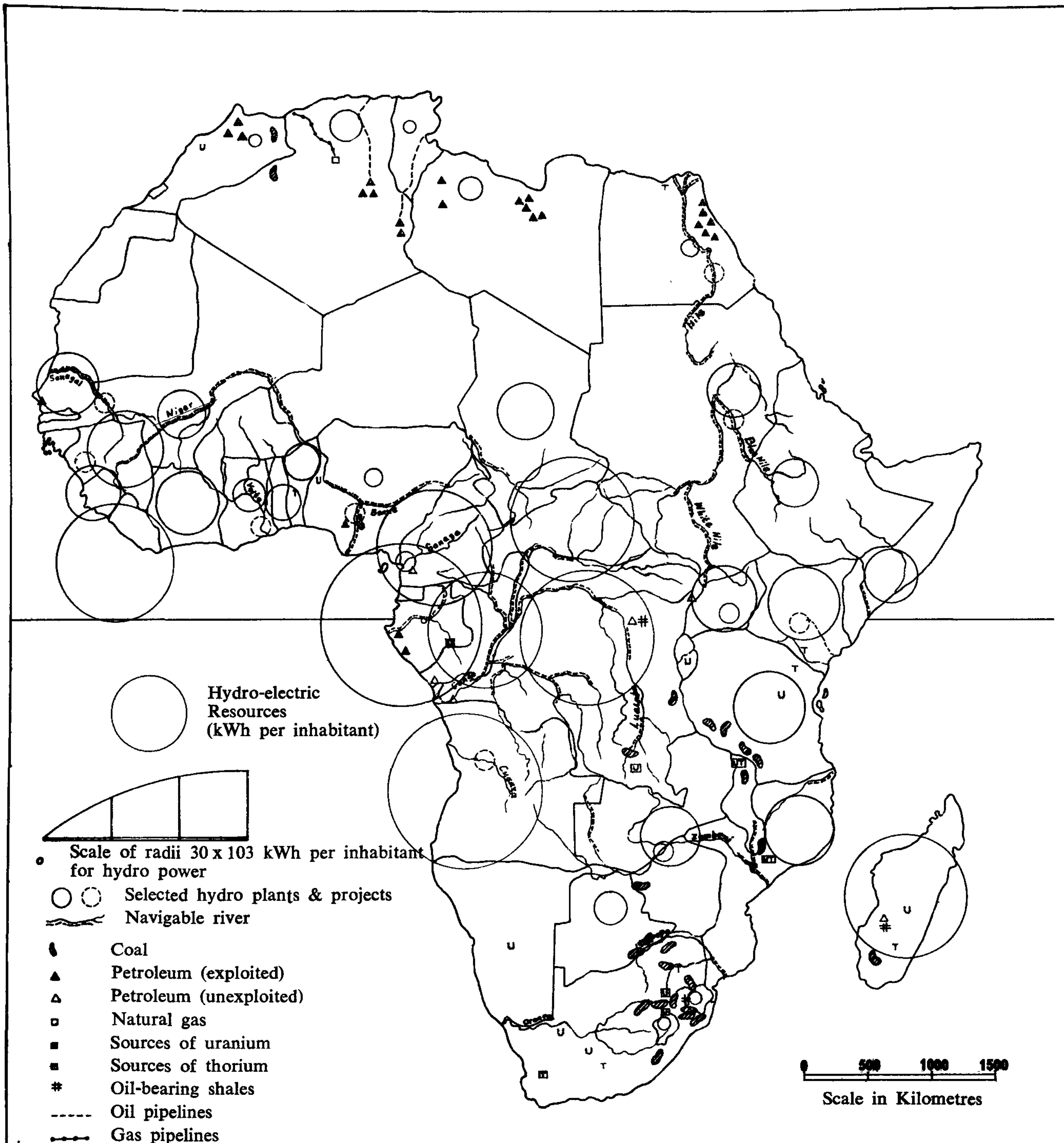
More recently, prospecting has been intensified both in north Africa and elsewhere - in Libya, Ethiopia and Somalia in the north and east, and in Nigeria (large reserves), Gabon, Mozambique and other areas. It is in Libya, as at Bahi and elsewhere (Zalten, Dahra, Gialo, Waha, Defa, etc.), within 150 km or so of the coast and with easier transport and prospecting conditions than in Algeria (since reserves are often at a depth of less than 1000 m), that particular success has been achieved and where further discoveries are likely.

As recently as 1959, no prospecting for oil had been undertaken in Basutoland, Bechuanaland, Chad, Ghana, Northern and Southern Rhodesia and Nyasaland, the Central African Republic, Sierra Leone, French Somaliland, South West Africa, Swaziland, Uganda, Upper Volta or South Africa (where present output is from oil shales). On the other hand, geological and geophysical prospecting had by that date been pursued in the Congo (Leopoldville), Dahomey, Ethiopia, Niger, Portuguese Guinea and the Sudan, while geological examinations had been made in Guinea, Liberia, Mauritania and Togo. There has also been some geophysical study in Gambia. Details of some localities where indications of prospects may exist are given in table 15. In general it should be noted that where an indication is given in table 10 that data on reserves are not available, this may be taken to imply that traces or possibilities, so far not fully evaluated, appear to exist.

[7] Some further summaries of the position in certain individual countries will be found in Annex II.

MAP 3

**BASIC DISTRIBUTION OF HYDRO-ELECTRIC RESOURCES AND FUEL RESERVES IN AFRICA**




The boundaries shown on this map do not imply endorsement or acceptance by the United Nations

Compiled by the United Nations Economic Commission for Europe

Some further details on petroleum reserves will be found in annex II, in the course of brief summaries of fuel reserves for certain areas.

### c) **Natural gas**

Generally speaking, natural gas is commonly found in association with oil reserves, although it may equally exist where the latter are not significantly present. From the number of territories where indications of oil or gas appear probable but are not so far evaluated numerically (see also table 15) it is evident that Africa's total reserves of natural gas, which have recently been estimated at 1800 to 2000 milliard $m^3$, will probably prove sensibly greater as investigations proceed.

Of the reserves evaluated in table 10, which give a total of 1575 milliard $m^3$, equivalent to 6000 $m^3$ per inhabitant throughout Africa or over 60 times the total African production reached in 1960, by far the greatest source is that of Algeria and the Sahara. This major reserve (equivalent so far to over 100,000 $m^3$ per inhabitant) is clearly of such a magnitude that it could support supplies to certain other African countries where sources of energy are scanty.

In addition to further sources of natural gas in Morocco and Nigeria, certain other occurrences, of varying practical value but not yet evaluated in numerical terms, are known or likely in a number of other countries. On present evidence, however, natural gas is somewhat localized in its distribution on the African continent.

### d) **Hydro-electric power**

In contrast to the distribution of coal, petroleum and natural gas reserves, hydro-electric power is very widely and bountifully spread over the continent. In at least 27 separate territories well over 1000 kWh per inhabitant and per year are available and for eight of these the figure is probably in excess of 20,000 kWh per head annually. In several others at least some hundreds of kWh per inhabitant could be produced each year. In conjunction with available fuel-based production this source of energy thus offers a firm foundation for the electrification of many parts of Africa, and often for substantial industrial development as well, once the investment required can be matched by a sufficient level of demand.

Many levels of definition may be used to specify the possibilities which exist. To a large extent the evaluation of Africa's hydro-electric resources is at an early stage, since the physical basis of flow and had required to determine the gross maximum potentiality (a fixed upper limit to mean annual production) is lacking for many areas. Furthermore, the seasonal flow regime, and its year-to-year variability, are also imperfectly documented, as is the opportunity for regulation offered by storage basins. The estimates worked out for most countries thus tend to refer only to a limited number of projects which happen to be easy of access and of a nature suited to the conditions likely to exist in the short term. A number of these are in fact summarized for various countries in annex III.

Various considerations entering into the appraisal of hydro-electric resources from an over-all standpoint were discussed (relative to European work and conditions) in document E/CN.14/EP/19 referred to at the beginning of this chapter. It would seem to be necessary to begin such an appraisal of the probable distribution of gross hydro potential in Africa as quickly as possible, using indirect methods and informed estimates wherever feasible to overcome the lack of basic data. In the absence of any such assessment at present, it is useful to maintain a comprehensive approach so far as possible for the purpose of comparing the total known resources which exist in the different countries. For this it is useful to adopt the concept of total installed and installable plant capacity (MW) and to apply mean levels of annual utilization so as to arrive at a broad idea of the possible production potential under average conditions. Such estimates of course remain subject to much uncertainty but they provide a first attempt at a common point of departure.

This method has been used in preparing the estimates shown in table 10 (column 11). For this purpose the definitions and latest capacity data published by the World Power Conference have been used where the latter are available. These show gross power available in MW (without allowance for loss of efficiency in generation) at arithmetic mean flow and at low-water flow (Q95) respectively.[8]

In cases where other estimates of producibility were not available, and after taking into account the nature of the stream flow regime in the country concerned, estimates for average productive potential were arrived at in some cases on the basis of either 4000 hours of annual generation at arithmetic mean flow or 8000 hours at low-water flow. Data calculated in this way may tend to give higher potentialities than those arrived at by summing the capacities and output of only those schemes and projects which have so far been studied. In all probability, on experience elsewhere, they still tend considerably to understate the hydro potential which will ultimately prove to be exploitable. For comparison supplementary data for certain countries, showing hydro-electric resources in MW according to alternative definitions, are also set out in table 13.

Among the rich sources of Africa's hydro-electric potential are such major rivers as the various branches of the Nile, as well as the Congo, Cuanza, Niger, Senegal, Shire, Zambesi, Limpopo, and various

[8] Power available at median flow (Q 50) is also defined on this system.

others. From a study of available data on Africa's hydro-electric production potential it would seem that the most massive concentrations exist in the Congo (Leopoldville), Angola, the Malagasy Republic and the Camerouns. The first offers some 500 milliard kWh annually, the second over 200 milliard kWh and the remainder around 100 milliard kWh each. These territories all contain the equivalent of between 20,000 and 50,000 kWh per head and per year. However, with much smaller resources numerically, the Central African Republic, Congo (Brazzaville), Gabon and Liberia also appear to possess hydro potentials comparable with those of the first group when considered in relation to the populations concerned. In all but a few countries (some of which possess alternative sources in the form of fuel reserves) the hydro-electric potential appears of some magnitude. There are, however, one or two cases where the actual development of water resources for energy production may be reduced by special factors. This may be true of Somalia, for example, where suitable outflow to the sea is largely restricted to the southern corner of the country (the Giuba etc.), the basin of which is also a region meriting agricultural development and therefore likely to use part of the available water for irrigation. In other countries, particularly in west Africa, the problems of regulating a very unequal seasonal flow may somewhat hold back development possibilities. This is true, for instance, of Mali, through which flow the Niger and the upstream portion of the Senegal. Probably the most important factor, in these and other areas, is however the lack of appropriate industries which would make up for the lack of a sizeable non-industrial demand at present.

From table 10 it can be seen that the percentage of total hydro resources already harnessed in African countries is negligible — averaging 0.6 per cent when considered over-all. Only in Morocco does the degree of exploitation of that part of the potential so far foreseen amount to a development of some magnitude. There would thus appear to be some 6000 kWh per year, at least, potentially available on the average for every inhabitant of the African continent.

For further short summaries of hydro resources in selected countries reference may also be made to annex III. Map 3 also shows the distribution of hydro-electric potential throughout the continent.

e) **Sources of uranium and thorium**

Uranium and thorium do not occur directly in a natural state. Sources of the first, such as pitchblende, occur in acid rocks (pegmatites); and of the second largely **in situ** as monazite and also as derived monazite sands. Large quantities of uranium are in addition present in phosphate rock and in shales of marine origin. Thorium often occurs in association with zircon and with gold. While a widely diffused content of these minerals thus exists in various deposits, potentially productive sources, which contain over 0.1 per cent $U_3O_8$ or $ThO_2$, are highly localized on the African continent.

For the evaluation shown in table 10 (columns 14-17) ores are defined as containing 0.1 per cent or more metal content and as including reserves both measured and indicated or inferred. The percentage economically recoverable is not usually evaluated accurately but is commonly over 50 per cent if substantial sources exist.

Africa is already an important source of production for these metals, and by 1959 was supplying 20 per cent of a total yearly world output of over 40,000 tons of $U_3O_8$. It should be noted that uses (metallurgical and chemical) additional to those associated with fuel elements and other aspects of nuclear energy exist for both uranium and thorium. The main distribution of sources of the two metals is shown on map 3. In principle these sources include the phosphate deposits of Algeria, Egypt, Morocco and Tunisia (which, however, have an uneconomic content at present); and probably granites and associated pegmatites in Ghana, the Ivory Coast, Madagascar, Morocco, Mozambique, Nigeria, Northern and Southern Rhodesia, South Africa and Tanganyika. While only a few of these occurrences are worked, one at Maunana in Gabon has already a sizable output (around 5,000 tons). In the past the world's main source was that of Shinkolobwe in the Congo (Leopoldville), where pitchblendes are associated with copper. Reserves also occur in neighbouring Angola.

In South Africa the large pitchblende reserves are associated with both the gold-bearing rocks of the Witwatersrand and with pyrites (sources of suphuric acid) and thus are economically workable.

While those uranium sources which have been numerically evaluated thus offer an average distribution equivalent to nearly one kg per inhabitant throughout Africa, sources of thorium are relatively even more abundant. They are known mainly in UAR (Egypt), South Africa and Madagascar, in all of which monazite production exists or has existed; in Nyasaland (rich sources on the western and eastern shores of lake Nyasa and others at Nkombwa); Nigeria (monazite); and in parts of east Africa. The South African reserves are in Cape Province, where monazite is associated with apatite and zircon. Taken as a whole sources of thorium are abundant in Africa and are of an order of magnitude sufficient to offer around 7 kg per inhabitant.

f) **Non-commercial sources**

Fuel wood is commonly a major source of domestic fuel supply in many countries and is abundant in many parts of Africa. Wood waste is also commonly available where paper industries exist. A particularly plentiful source of fuel for industry and domestic use alike is provided by sugar cane waste, rice wastes, husks and nut shells, etc., in certain African territories. It is particularly in those short of commercial fuels that such sources become of particular importance.

Consumption of non-commercial fuels tends to rise more slowly than that of other sources of energy so that, although they commonly make up as much as half the total energy supply in many less-industrialized countries, their percentage contribution usually declines slowly as total energy consumption rises.

Among African countries the cotton and sugar cane wastes of the Sudan are considered capable of supplying 500 million kWh per year. In the island of Réunion consumption of bagasse for energy purposes rose to 723,000 tons in 1961, showing an 80 per cent increase above the 1955 level. Kenya's non-commercial fuel use includes saw-mill waste, bagasse, rice husks, etc. In Mali fuel wood is used extensively for domestic purposes, consumption in 1961 exceeding 11 million $m^3$. Some 600 tons of nut-husks were also used in 1961 for industrial steam-raising, together with more than 5,000 tons of rice wastes. Such fuels are thus important in this and similar areas of high transport costs where alternatives are less easily available.[9]

g) **New sources of energy**

The new sources discussed here are primary natural energy resources of a non-conventional nature. New modes of electric power production — for example by magneto-hydrodynamic generation, fuel cells, etc. — are thus not included.

Of the various new primary sources which might contribute to Africa's needs, geothermal energy is not widely available. Kenya, Cameroon, the island of Réunion and Congo (Leopoldville) are probably at least four exceptions however. The third is entirely of volcanic origin and possesses an active volcano. No use has so far been made of such a source there for purposes of energy supply, however. Possibilities in Réunion, and near Mount Cameroun have not yet been studied, but explorations in Kenya, where temperatures of 100°C have been found in shallow bore-holes, are continuing. Possibilities may also exist in Ethiopia and Madagascar among other countries. The only plant in Africa so far utilising geothermal energy is that at Kisbukwa in the Congo (Leopoldville), where low-pressure steam is used to drive a 220 kW generating set. Other possibilities certainly exist in the eastern part of the country.

Tidal energy also offers a large new source of supply in some areas, as in Europe between the coasts of Britanny and the United Kingdom and elsewhere. Possibilities are not particularly noteworthy in Africa, but certain associated use of the sea as an energy source has been contemplated. In particular the coastal wave-surge or swell has been considered a feasible source in a few areas, particularly where it has a sufficient power to raise a usable volume of water over a specially constructed barrage installation. Interest is expressed in Réunion in the study of coastal wave-surges as a possible source of energy.

An experimental installation was also built some years ago off the coast near Abidjan to test the usable energy potential arising from differences in sea-water temperature at different depths.

Two other new primary energy sources on which a good deal of work has been carried out, without any very substantial practical application so far except for very small-scale installations, are wind power and solar energy. In certain African countries, however, possibilities and conditions for the use of wind power may exist. An experimental installation has for example been tested in Algeria in recent years. Elsewhere in north Africa interest is expressed in studying wind power possibilities in Ethiopia and neighbouring territories. Some wind power sites may also be available near the south-east coast of Madagascar. Under supply conditions in areas using mainly isolated small-scale local generation such a source, which does not normally offer substantial firm power, may well be of some auxiliary value, as for pumping, etc., where sufficient wind potential exists.

Solar energy is of course more generally available. Interest is expressed in the study of its application for small-scale water-heating, cooking, etc., in some areas where fuel supplies are costly and an interconnected public power system may not so far exist. In Mali the Ministry of Public Works is at present carrying out experiments in this direction. Ethiopia is also among the countries expressing interest in solar energy.

Experimental work in this field has been carried out in Israel and in one or two other countries in recent years. It appears likely that without large expenditure, which may be of doubtful practicability, the main possibilities for the application of solar energy lie in its small-scale local use as an auxiliary means of providing direct sources of heat.

The methods discussed above do not exhaust all the possible non-conventional primary power sources, which may be envisaged. They do, however, cover those which appear to be of most immediate relevance under African conditions.

[9] A few other special types of energy reserve are present in Africa which might, on further study, prove to be practically exploitable. One such example is given by the large supplies of gas (methane) which exist in the bottom waters of Lake Kivu in Congo (Leopoldville) and Rwanda. Large quantities of oil shale, of uncertain economic value, also occur in the first-named country and else where, including Gabon.

## D. OBSERVATIONS ON SOME IMPLICATIONS OF NATURAL RESOURCE DISTRIBUTION

From the distribution of natural energy resources analysed briefly in the foregoing pages, two important consequences follow. First, the unequal endowment of different territories throughout the African continent implies that some areas are basically deficient in internal sources of power while others are potentially areas of surplus. From table 10 and the maps included in this chapter, it can be seen, for instance, that (on present evaluations) some territories in west Africa are relatively deficient in internal sources of supply. This is particularly the case when the **composition** of commercial energy sources is taken into account. Some countries, for example, may possess hydro resources so far unused (for lack of demand plus lack of capital), and little else except non-commercial resources (fuel wood, waste products, etc.) or solar energy. Other countries are richly endowed in energy potential and also possess well-diversified reserves. Under African conditions, where many territories comprise separate regions quite distinct from one another geographically and economically and also separated by long distances, these contrasts are often very marked at the regional as well as at the national scale.

Some implications of this situation will be discussed further in Parts II and III of the study. However, it is clear that a basic diversity in natural sources of power offers — as it has already offered in other continents such as Europe, where similar diversity exists — many opportunities for mutually advantageous cross-frontier co-operation in electric power supply, including local interconnexions, joint development of common resources, co-operation in exchange of basic data, etc. These questions require further study in detail.

A second main consequence of the location of natural energy reserves in Africa is the complementarity of certain energy and non-energy resources. Mineral reserves of economic interest are both widely distributed and of great variety (the total endowment is even more varied than the evaluation in chapter I would suggest since only minerals mainly in large-scale demand were there covered). For electric power development it is the juxtaposition of non-energy reserves requiring large quantities of low-cost kWh with concentrations of power potential that is of particular interest, especially during the earlier stages of industrial activity. Study of the maps, tables and annexes pertaining to chapters I and II will show many examples of an association of mineral reserves of economic importance (sources of aluminium, tin, iron and steel, etc.) with particularly low-cost electric power potential. Thus in Guinea and Mali, among various other countries, rich bauxite reserves are associated with hydro power. A similar situation exists with respect to Nigeria's columbite production and tin smelter scheme; to the association of Ghana's bauxite with the Volta's hydro-electric resources or that of Congo (Leopoldville) with the Inga project, to say nothing of many other associated locations of power sources and varied mineral reserves in areas of Northern and Southern Rhodesia, Nyasaland, Sudan, Tanganyika, Uganda and elsewhere. Rich natural gas or brown coal reserves may equally favour special resource-based industrial development in certain particular cases if production costs are low enough. Linked with metal refining prospects are those for local manufacturing — to meet either African or extra-African needs — of finished products based on the raw materials produced. Associated sources of fuel and of iron and steel also offer prospects of industrial potential in some areas.

## TABLE 9

### ESTIMATED DISTRIBUTION OF NATURAL ENERGY RESOURCES IN AFRICA AS COMPARED WITH THAT IN THE WORLD AS A WHOLE

| | | | Total reserves (measured, indicated and inferred) | | Principal concentrations | | Total resources (as col. 4) | |
|---|---|---|---|---|---|---|---|---|
| Category | Unit | Region | Total | Of which measured or proved | Total | Countries in which total occurs | Units per inhabitant (1961 population) | $10^3$ units per $km^2$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Hard Coal | $10^9$ tons | World | 7,500 | 600 | 6,700 | China, USA & USSR | World 2,440 | 55.3 |
| | | Africa | 77 | 26 | 70 | S. Africa & N. & S. Rhodesia | Africa 295 | 2.5 |
| Brown Coal and Lignite | $10^9$ tons | World | 2,000 | 200 | 1,800 | Australia, USA and USSR | World 650 | 14.8 |
| | | Africa | ... | ... | 200 | Nigeria | Africa ... | ... |
| Peat | $10^9$ tons | World | 225(a) | ... | 200 | Finland, USA & USSR | World 73 | 1.7 |
| | | Africa | ... | ... | ... | ... | Africa ... | ... |
| Crude Petroleum(b) | $10^9$ tons | World | 122 | 36 | 24 | Middle East, USA & USSR | World 40 | 0.9 |
| | | Africa | 1.5 | 1.0 | 1.4 | Algeria, Libya and Nigeria | Africa 6 | 0.05 |
| Natural Gas | $10^9$ $m^3$ | World | 75,000 | 15,000 | 11,600 | Canada, Sahara, USA & USSR | World 24,500 | 554.0 |
| | | Africa | 1,575 | 1,275 | 1,200 | Algeria | Africa 6,040 | 52.0 |
| Hydro-electric Power | $10^9$ kWh | World | 5,000 | — | 2,700 | USA & USSR | World 1,630 | 37.0 |
| | | Africa | 1,600 | — | 750 | Congo (Leop.) & Angola | Africa 6,140 | 52.8 |
| Uranium(c) | | World | 2,000(a) | 93.6 | 1,300 | Sweden & USA | World 0.7 kg/inh. | 14.8 kg/$km^2$ |
| | $10^3$ tons | Africa | 234 | 22 | 200 | S. Africa | Africa 0.9 kg/inh. | 7.7 kg/$km^2$ |
| Thorium(c) | | World | 2,700 | ... | 900 | Canada, Brazil & India | World 0.9 kg/inh. | 20.0 kg/$km^2$ |
| | | Africa | 1,679 | ... | 1,650 | UAR (Egypt) | Africa 6.4 kg/inh. | 55.0 kg/$km^2$ |

a) The eventual total may be twice as high.

b) Including oil content of shales and bituminous sands.

c) With over .01 per cent oxide content.

TABLE 10

## NATURAL RESERVES OF PRIMARY ENERGY IN AFRICA

(Preliminary assessment only-Territories for which data are shown as not available are usually those where evaluations have not yet been completed)

| Country | Hard (measured and inferred) (a) | | | Crude Petroleum (total reserve at 1960/61)(b) | | | Natural Gas (total reserves at 1960/1961) | | | Hydro-electric Power (estimated exploitable potential) (c) | | | Uranium and Thorium (recoverable or inferred, with not less than 0.01% $U_3O_8$ or $ThO_2$ respectively) Uranium oxide | | Thorium oxide | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total ($10^6$ tons | Tons per inhabitant (1960) | As multiple of 1960 production | Total ($10^6$ tons) | Tons per inhabitant (1960) | As multiple of 1960 production | Total ($10^9$ $m^3$) | $10^3$ $m^3$ per inhabitant (1960) | As multiple of 1960 production | Total ($10^9$ kWh/year) | kWh per inhabitant (1960) | Per cent harnessed (1960) | ($10^3$ tons) | kg/inhabitant (1960) | ($10^3$ tons) | kg/inhabitant (1960) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| **North Africa** | | | | | | | | | | | | | | | | |
| Algeria | 20 | 2 | 170 | 677(d) | 61 | 78 | 1,200 | 110 | ... | 15* | 1,360 | 2.3 | — | — | — | — |
| Libya | — | — | — | 410 | 340 | — | ... | ... | ... | 1* | 840 | ... | — | — | — | — |
| Mauritania | — | — | — | — | — | — | — | — | — | ... | ... | ... | — | — | — | — |
| Morocco | 96(e) | 8 | 230 | 7(f) | 0.6 | 76 | 0.8 | 0.07 | 80 | 3(g) | 260 | 31 | — | — | — | — |
| Tunisia | — | — | — | ... | ... | ... | 0.15 | 0.04 | 25 | 1* | 240 | 5 | — | — | — | — |
| Sudan | — | — | — | — | — | — | — | — | — | 50* | 4,250 | ... | ... | ... | — | — |
| UAR (Egypt) | — | — | — | 72 | 3 | 20 | ... | ... | ... | 15(h) | 580 | 1.8 | ... | ... | 1,650(i) | 64 |
| **West Africa** | | | | | | | | | | | | | | | | |
| Cameroons | ... | ... | ... | ... | ... | ... | ... | ... | ... | 80-100* | 19,530)<br>24,410) | 1 | — | — | — | — |
| Central African Republic | — | — | — | ... | ... | ... | ... | ... | ... | 28 | 23,140 | 0.1 | — | — | — | — |
| Congo (Brazzaville) | — | — | — | ... | ... | ... | ... | ... | ... | 24 | 26,670 | 0.1 | — | — | — | — |
| Gabon | — | — | — | 7-21 | 16-48 | 9-26 | 28 | 6.3 | 400 | 48 | 109,090 | ... | 6 | 14 | ... | ... |
| Chad | — | — | — | — | — | — | ... | ... | ... | 13* | 4,890 | ... | — | — | — | — |
| Gambia | — | — | — | — | — | — | — | — | — | ... | ... | — | — | — | — | — |
| Ghana | — | — | — | ... | ... | ... | ... | ... | ... | 9 | 1,340 | ... | — | — | — | — |
| Liberia | — | — | — | — | — | — | — | — | — | 25* | 19,380 | — | — | — | — | — |
| Nigeria | 406(j) | 12 | 710 | 315(k) | 9 | 360 | 375(l) | 11 | — | 17 | 480 | 0.6 | ... | ... | } 15 | 0.4 |
| Sierra Leone | — | — | — | — | — | — | — | — | — | 10* | 4,080 | — | ... | ... | | |
| Togo | — | — | — | ... | ... | ... | ... | ... | ... | 2* | 1,390 | ... | ... | ... | ... | ... |
| Guinea | — | — | — | — | — | — | — | — | — | 25* | 8,330 | ... | — | — | — | — |
| Ivory Coast | — | — | — | — | — | — | — | — | — | 20 | 6,190 | 0.2 | — | — | — | — |
| Dahomey | — | — | — | ... | ... | ... | ... | ... | ... | 3 | 1,550 | — | — | — | — | — |
| Niger | — | — | — | — | — | — | — | — | — | ... | ... | — | — | — | — | — |
| Senegal | — | — | — | ... | ... | ... | ... | ... | ... | 16* | 5,380 | — | — | — | — | — |
| Mali | — | — | — | — | — | — | — | — | — | 13*(m) | 3,170 | — | — | — | — | — |
| Upper Volta | — | — | — | — | — | — | — | — | — | ... | ... | ... | — | — | — | — |
| **North-East Africa** | | | | | | | | | | | | | | | | |
| Ethiopia | ... | ... | ... | ... | ... | ... | ... | ... | ... | 45* | 2,250 | 0.1 | — | — | — | — |
| Somalia | — | — | — | — | ... | ... | ... | ... | ... | 1* | 5,000 | — | — | — | — | — |

**Central Africa:**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angola | 8 | 2 | ... | 4 | 0.9 | 60 | ... | ... | ... | 230* | 49,550 | — | 15(n) | 3 | ... | ... |
| Congo (Leopoldville) | 90 | 6 | 550 | ... | ... | ... | ... | ... | ... | 530* | 37,480 | 0.5 | 8 | 1 | ... | ... |
| Kenya | ... | ... | ... | ... | ... | ... | — | — | — | 50(o) | 7,010 | 0.3 | ... | ... | ... | ... |
| Tanganyika | 400(p) | 43 | 200,000 | — | — | — | — | — | — | 75* | 8,120 | 0.1 | ... | ... | ... | ... |
| Uganda | — | — | — | ... | ... | ... | ... | ... | ... | 45* | 6,740 | 0.9 | ... | ... | ... | ... |
| Zanzibar and Pemba | — | — | — | — | — | — | — | — | — | ... | ... | — | — | — | — | — |
| Fed. Rhodesia & Nyasaland<br>Rhodesia (Northern)<br>Rhodesia (Southern)<br>Nyasaland | 6,613(q) | 790 | 1,860 | — | — | — | — | — | — | 36 | 4,330 | 3.6 | ... | ... | 9 | ... |

**Southern Africa:**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bechuanaland, Basutoland, & Swaziland | 5,022(r) | 3,940 | — | — | — | — | — | — | — | 3(s) | 2,350 | ... | — | — | — | — |
| Mozambique | 700 | 110 | 2,590 | ... | ... | ... | ... | ... | ... | 45* | 6,940 | — | — | — | — | — |
| Madagascar | 300 | 56 | ... | — | — | — | — | — | — | 114(t) | 21,140 | — | 1 | — | 2 | 0.4 |
| South Africa | 63,355(u) | 4,000 | 1,660 | 4(v) | 0.3 | ... | — | — | — | ... | ... | ... | 204(w) | 13 | 12 | 0.8 |
| Other territories | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| TOTAL AFRICA (for reserves included and total population | 77,002 | 314 | 1,780 | 1,503(x) | 6.0 | 107 | 1,579 | 6.0 | 62 | 1,602 | 6,530 | 0.6 | 234 | 0.95 | 1.688 | 7.0 |

a) Not including low-grade coal, brown coal and lignite in Tunisia (20 million tons not exploitable economically), Basutoland, Bechuanaland (2650 kcal/kg) and Swaziland; Nigeria (about 200 million tons); Rhodesia and Nyasaland (about 50 million tons); Sierra Leone (about 2 million tons) and Tanganyika.
b) In general, includes proved, measured, indicated and inferred reserves.
c) Provisional only, based in general on average annual generation from capacity in MW at arithmetic mean flow or at Q95, with 100% efficiency and with 4000 or 8000 hours assumed generation/year respectively. Exploitable potential depends in several cases on storage possibilities and alternative water requirements, which may modify the estimates shown. For certain countries, including Algeria, Kenya and Tanganyika, estimates are rough maxima only.
d) Not including part of probable reserves of Sahara zone.
e) Anthracite.
f) The latest official estimate (probably for proved reserves) gives 1 million tons.
g) The latest official estimate gives 1—1.1 x $10^9$ kWh.
h) Refers to expected situation by 1985.
i) Probably incomplete. Refers to 8 $km^2$ of a probable total area of 200 $km^2$.
j) Figures refer to indicated and inferred reserves of hard coal (over 7000 kcal/kg) and exclude more than 73 million tons of high-grade brown coal (partly unworked). The latest official estimate gives 267 million tons of hard coal indicated by drilling, plus 82 million tons inferred (seams of over 3 ft. 6 ins.)
k) Inferred portion of reserves (270 million tons) speculative at present. Estimated proved reserves 68 million tons.
l) Estimated proved reserves 85 milliard $m^3$. This figure is, however, considered probably below the eventual total.
m) Probably an incomplete estimate.
n) In phosphate-bearing rocks.
o) Existing and projected output totals only 1.94 x $10^9$ kWh. and the figure shown is a maximum estimate.
p) Of which 300 million tons measured reserves (60% recoverable). Refers to main coalfield (Ruhuhu). The total may be considerably higher.
q) Refers to reserves (of which 1760 million tons measured reserve) in S. Rhodesia. Figures for N. Rhodesia not available. Estimates for Nyasaland give 50 million tons (see also note (a)).
r) Refers to hard coal in Swaziland to 500 metres (90% recoverable) and excludes 506 million tons (measured reserve) of low-grade coal in Bechuanaland (reserves likely to be much greater) and some lignite of low quality in Basutoland.
s) Refers to approximate figure for Basutoland only.
t) The potential so far evaluated amounts to 2700 MW, giving 17 x $10^9$ kWh.
u) Of which 21,443 million tons of measured reserves (5000 kcal/kg).
v) Refers to estimated oil content of oil shales (not recent estimate) from which total output is provided.
w) In ore to be mined for gold.
x) Provisional estimate based on reserves shown in table.

TABLE 11

**Assessment of hard coal reserves for selected countries (millions of metric tons) according to successive levels of definition(a)**

| Country | Measured reserve: Million tons | Measured reserve: Estimated percentage economically recoverable | Measured reserve: Average calorific value (kcal/kg) | Indicated & inferred reserve | Total (cols. 2 & 5) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| Algeria | 9 | ... | ... | 11 | 20 |
| Basutoland(b) | ... | ... | ... | ... | ... |
| Bechuanaland | 506(c) | 100 | 2,640(c) | ...(c) | ... |
| Congo (Leopoldville) | ... | ... | 4500-6000 | ... | 90 |
| Madagascar | 100 | ... | 6,500 | 200 | 300 |
| Morocco(d) | 14.8 | 100 | 7,000 | 81 | 95.8 |
| Nigeria(e) | ... | ... | ... | 406 | ... |
| S. Rhodesia | 1,760 | ... | ... | 4,853 | 6,613 |
| South Africa | 21,443 | 100 | 5,000(f) | 41,912 | 63,355 |
| Swaziland(g) | 2,022 | 90 | 7,000 | 3,000 | 5,022 |
| Tanganyika(h) | 300 | 60 | 7,000 | 100 | 400 |

a) Based on latest data reported to the World Power Conference and other supplementary information on probable calorific content.

b) Seams of coal have been found in West Basutoland but the quality is generally indifferent and it is thought coal does not exist in payable quantities.

c) The estimate of measured reserves refers to two coalfields only. The indicated and inferred reserves, which have not yet been recorded, vastly exceed this figure. Coals occur with average calorific values up to about 6000 kcal/kg.

d) Anthracite.

e) Estimate refers to seams 60 cm or more in thickness. Probably only seams more than 105 cm thick are economically workable and these account for 359 million tons of the reserves quoted. The calorific value of a bulk sample was 7,980 kilocalories per kilogram. There are also 73.2 million tons of brown coal indicated or inferred.

f) The average calorific value quoted is based only on coal burned by the Electricity Supply Commission in 1960, which supplied 80 per cent of the Republic's electric power.

g) Coals up to a depth of 500 metres are included. No information is available on coals at a greater depth.

h) The estimate relates only to the Ruhuhu coalfield: other coalfields are either small or contain inferior coals.

TABLE 12

**Assessment of petroleum and natural gas reserves for selected countries (1960/61) according to successive levels of definition.(a)**

| Country | Proved (millions of metric tons) | Measured (millions of units — metric tons or $m^3$ respectively) | Indicated & inferred (millions of units — metric tons or $m^3$ respectively) | Total (millions of units — metric tons or $m^3$ respectively) |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| **Crude Petroleum:** | | | | |
| Algeria(b) | — | 600 | ... | ... |
| Angola | 2.1-4.1 | — | — | ... |
| Gabon | 7-21 | — | — | ... |
| Libya | 410 | ... | ... | ... |
| Morocco | — | 2 | 5 | 7 |
| Nigeria(c) | — | 45 | 270 | 315 |
| UAR (Egypt) | — | 510 | ... | ... |
| **Natural Gas:** | | | | |
| Algeria | — | 1200000 | ... | ... |
| Morocco | — | 800 | — | 800 |
| Nigeria(d) | — | 75000 | 300000 | 375000 |
| Tunisia | — | ... | ... | 150 |

a) Based on latest data reported to the World Power Conference, plus other information for Tunisia.
b) Refers to proved recoverable reserves.
c) Data are speculative.
d) Indicated and inferred reserves are very speculative as some 38 separate accumulations are each defined by only a single well.

TABLE 13

**Assessment of potential hydro-electric capacity for selected countries (as at 1960 or later) according to successive levels of definition.(a)**
(MW)

| Country | Gross theoretical capacity in MW with flows at: | | |
|---|---|---|---|
| | Q95 | Q50 | Arithmetic mean flow |
| 1 | 2 | 3 | 4 |
| Basutoland | 310P | 450P | 290P |
| Cameroon | 4800 | 18300 | 28700 |
| Central African Republic | 3500 | 10500 | 13800 |
| Chad | ... | 2500 | 4300 |
| Congo (Brazzaville) | 3000 | 9000 | 11300 |
| Dahomey | ... | 150 | 500 |
| Gabon | 6000 | 18000 | 21900 |
| Ghana | ... | ... | 1270A |
| Guinea | 500 | 3500 | 8000 |
| Ivory Coast | 500 | 3500 | 7300 |
| Madagascar | 14300 | 49000 | 80000 |
| Mali | ... | 1000 | 4400 |
| Morocco | 580 | 770 | 675 |
| Nigeria | 345 | 1375 | 860 |
| Fed. Rhodesia & Nyasaland | 4680 | ... | ... |
| Senegal | ... | 1100 | 5500 |
| South Africa | ... | ... | ... |
| Swaziland(b) | 700 | ... | ... |
| Togo | ... | 200 | 600 |

a) Based on latest data reported to the World Power Conference.
b) Further development not yet investigated.

TABLE 14

**Summary of localities where coal reserves or indications exist**

| Territory | Location of reserve or remarks on areas investigated |
|---|---|
| ALGERIA | There are well-known deposits in the region of Kenadza to the south of Oran and 700 km from the sea. The reserves comprise the basins of Columb Béchar, Abadla and Ghorassa. There are also small lignite deposits at Smendou near Constantine, and others not far from Algiers. |
| ANGOLA | There are comparatively limited occurrences of bituminous coal and other small lower-grade deposits. |
| CAMEROON | There appear to be indications (thin beds of low-grade lignite) to the north-east of Douala. |
| CONGO (Leopoldville) | Deposits exist in two sources of mediocre quality, since they are of Karroo age. These are at Lukuga (the main reserve of the country) and at Luéna. No other sources appear to exist. |
| ETHIOPIA | Some thin beds of low-grade lignite exist in the southern part of Ethiopia. |
| MADAGASCAR | The usable reserves mainly suitable for industrial furnaces, are in the south of the island at Sakoa. |
| MOROCCO | The reserve consists of anthracite suitable for thermal power production, found at Djerada, to the south of Oujda. These reserves are comparatively important and have been exploited for more than 25 years. Other deposits exist in three other regions, including the High Atlas, but are without particular economic interest. Lignite deposits, which appear to be of relatively little use, also exist at a number of localities throughout the country. |
| MOZAMBIQUE | The reserves are relatively the principal resource. They are located in the region of Tete in the valley of the Zambezi. |
| NIGERIA | The coals of Cretaceous or Tertiary age, occur in the area of Enugu, some 250 km to the north of Port Harcourt. Other lower-grade lignite reserves, which may comprise some 200 million tons in all, occur in a number of areas throughout the country. |
| N. RHODESIA | There are occurrences in the Kandabwe area in the district of Gwembe and elsewhere. |
| S. RHODESIA | The reserves are important and are distributed among a number of deposits, particularly that of Wankie, roughly 350 km north-west of Bulawayo. These reserves are sufficient to allow supply to other areas. Lower-grade deposits exist in the Sabi valley and at Tuli. |
| NYASALAND | Resources, known at four localities but particularly near the northern end of Lake Nyasa, have not been definitively evaluated but appear likely to contain some 50 million tons of lower-grade fuel, which is difficult to work. |
| SOUTH AFRICA | Very important reserves of reasonable quality exist and also other low-grade deposits. The conditions for exploitation are very favourable and allow of low-cost production. The quantities available would seem all but inexhaustible (as can be seen from table 10).<br>The coals of the best quality are mined in Natal (Klip river, Vryheid, etc.). In the Transvaal, which supplies two-thirds of total output, coal fields exist at a number of points, including Witbank, Vereeniging, the basin of Limpopo, Northern Waterberg etc., but these various deposits do not provide coking coal, which is produced in Natal. Coals of moderate quality are also produced in the Orange Free State at Vierfontein etc. Other coal deposits exist in Cape Province. |
| SWAZILAND | Reserves of hard coal exist and also lower-grade brown coals, the total being of considerable magnitude. |
| TANGANYIKA | The reserves are of considerable importance and are distributed among eight basins within the country, notably in the Ruhuhu river area east of Lake Nyasa, and in the area of Lake Rukwa. |
| TUNISIA | Deposits of lignite exist at Cap Bon and elsewhere, some of which were formerly worked. |
| UGANDA | Possibilities do not appear favourable for the extraction of coal, although investigations were made in the Karroo formations in this area. |

## TABLE 15

**Summary of localities where petroleum and natural gas exist or are considered possible (selected countries)**

| Territory | Location of reserves or remarks on areas investigated |
|---|---|
| ALGERIA (including Sahara) | The more important fields are referred to separately in the text. There are some seven separate sources of petroleum and at least four for natural gas. These include Edjeleh, Zarzaitine and El Adeb Larache. Various other sources exist (Tin Fouye, Tiguentourine, etc.). In the Triassic deposits farther north a number of occurrences of oil are linked with the well-known Hassi Messaoud field. A number of occurrences in the Western region also exist towards Columb Béchar. The natural gas field of Hassi R'Mel, 450 km south of Algiers, is one of the world's largest. |
| ANGOLA | Reserves of oil exist in the Cuanza basin (Tobias etc.). The Cabinda area is also considered promising. |
| CAMEROON | Investigations have been made at various sites around Douala, and have suggested positive results. A small gas field exists near by at Logbaba. |
| CONGO (Brazzaville) | At Pointe Indienne, north of Pointe Noire, oil and natural gas have been found to exist and some oil is produced. Other areas have also been under study. |
| GABON | The petroleum deposits, costly to exploit, occur in the region of Port Gentil, in several separate localities containing widely distributed but apparently limited reserves. Investigations have also been made elsewhere. |
| IVORY COAST | Geological investigations have been made at Port Bouet and at Berou. |
| KENYA | Investigations have continued in the north and in the coastal area, so far with uncertain results. |
| LIBYA | Very large oil reserves and producing fields have been located at Zelten, Mabruk and other locations and in the eastern extension of the Algerian fields in the region of Edjeleh. |
| MADAGASCAR | Bituminous sands exist around Bemolanga over areas of considerable size. The oil content is apparently not richly concentrated. Two deposits of oil-bearing shales are also known. |
| MOROCCO | The oil and natural gas reserves exist in the Rharb and Essaouira areas, towards the coast, and also in the south-west. Investigations have been undertaken into favourable structures in certain other areas. |
| NIGERIA | The producing oil fields are in the area of Port Harcourt (Afam, Bomu, Ebebu and Oloibiri). Some indications have also been found elsewhere in the basin of the Lower Niger. Gas from the Afam field is used for electricity generation. |
| SENEGAL | Investigations have been in progress which have given positive indications in the region of Dakar. So far only uneconomic supplies of oil and gas have been located. |
| SOMALIA | A small amount of gas has been found at Darin. Both for oil and gas of low economic importance, indications have been found at Dagah Shabel. |
| TUNISIA | A number of areas have been under study. Only a small output of natural gas at Cap Bon is so far exploitable. |
| UAR (Egypt) | The large producing reserves from some thirteen fields, are situated near the Gulf of Suez. A number of occurrences exist on the eastern side and some three areas of occurrences have been located on the western side and also under the Red Sea. Some investigations have also been made in the Western Desert area. |

## Chapter III

# THE ENERGY SITUATIONS AS A WHOLE

## A. INTRODUCTION

To understand fully some of the problems which underlie the production of electricity in different parts of Africa it is necessary to consider them against the background of the energy economy as a whole, taking into account its present situation, trends and prospects. The availability of suitable fuels and their cost is particularly important in this connexion, In the world as a whole, moreover, the evolving role of electricity in the total use of all forms of energy shows characteristic trends and it is essential to evaluate that role on the economic development of African countries. For these chapter III presents a short analysis of the output and consumption of different forms of primary energy in Africa in so far as these are of concern for electric power development.

## B. MAIN TENDENCIES OF AFRICA'S ENERGY SUPPLY AND CONSUMPTION

Superficially, recent trends in production and use of primary energy in Africa — more particularly for those forms which enter into international trade — show certain resemblances to those in other parts of the world. Reference to table 16, which analyses African and world trends in solid and liquid fuels, natural gas and hydro-electric power between 1955 and 1961 shows that, on the production side, coal has declined more rapidly in relative importance in Africa than elsewhere, while the relative contribution of crude oil has risen far more rapidly than in the world as a whole. Hydro-electric power has also gained relatively in stature in the total African input of primary energy, though much more slowly than crude oil. Notwithstanding the great importance of hydro resources in Africa as compared with other regions, the present contribution of this form of energy is **below** the world average when compared on the same basis.[9a]

It is pertinent at this point to observe that we are here comparing the production of primary sources of energy which is either exported, consumed directly for final end-uses or converted to secondary forms of energy. The primary or secondary energy finally applied by consumers may be used for very different purposes — i.e. to supply heat, light, motive power or chemical energy. In columns 2-10 of table 16 it is only the **production** from primary commercial sources that is reviewed.

[9a] For comparative purposes all primary fuels are expressed in the Table in tons of coal equivalent (7000 kcal/kg) on the basis of their average calorific content. 1000 $m^3$ of natural gas is expressed as 1.33 tons coal equivalent. Hydro-electricity is converted to coal equivalent by taking 0.5 kg of standard coal as representing 1 kWh (2000 kWh per ton).

From the production shown in columns 2-10 of the table a part — some crude oil for example — is exported outside Africa. On the other hand some fuels, including a certain amount of crude and most of the refined oil products, are imported. There is also a certain amount of fuel use for bunkering of ocean-going shipping, trans-continental airlines, etc. Some 4.4 million tons of petroleum products were devoted to this purpose in 1960. The remaining primary energy that is applied for internal use, either (after losses in transport and stocking) for direct consumption by industry, transport, agriculture, households etc. or for conversion to secondary forms of energy, including thermal electricity, is shown in columns 11-16 of the table. Here it has to be remembered that the total input of commercial forms of primary energy for use within Africa constitutes little more than half the true input of inanimate energy within the region. A quantity of primary fuel of the same order of magnitude as the total commercial input is applied within the continent — in industry and households — in the form of non-commercial sources of supply such as wood, wood waste, bagasse and other waste products. This contribution to the energy economy represents a slowly declining proportion of total consumption, however.

The total apparent consumption in Africa of primary energy from commercial sources (column 15 of the table) is seen to have increased fairly rapidly over the ten-year period covered, although the average quantity used per inhabitant is very low (little more than 10 per cent of that used in Europe, for example). While solid fuels have declined from 70 to 60 per cent of the total over the decade (refined oil fuels and hydro power having correspondingly increased their contribution) natural gas was still furnishing much less than one per cent of the input by the end of the period. The relatively small part played by hydro power and the importance of liquid fuels in the total can be seen by comparison with the world as a whole. Comparison between Africa's total production (columns 3 plus 5, 7 and 9) and its total apparent inland consumption brings out some trends of basic interest. From being a net importer of energy between 1951 and 1960 (mainly through imported oil products) the continent achieved an over-all balance in 1961, the small difference being partly needed to allow for various losses and deductions. There was in fact a small export surplus in petroleum during 1961.

To elucidate these tendencies and their causes as they have operated within African countries reference may be made first of all to table 17. This table shows trends in output of the three main fuels — coal, natural gas and crude petroleum — in sixteen countries which produce one or more of the three. Of the ten coal-producing territories all except Mozambique and South Africa have since 1956 experienced relatively important declines in production, particularly due to the changing situation of the energy market relative to coal. In north and west-central Africa, the period has witnessed a rapidly rising output of petroleum and in north Africa a spectacular advance in production of natural gas. The over-all effect on primary fuel production can be seen at the foot of the table — a slowly increasing output of coal that overwhelmingly reflects the trend in the largest producer — South Africa — and an explosive rise in natural gas and crude petroleum extraction elsewhere in the years following 1956.

To throw further light on the changing energy supply situation in African countries the various aspects of production, consumption, international trade and future plans and prospects will next be considered separately. To this end reference will be made to tables 18-22 respectively. These tables allow an analysis to be made of the development of the energy supply in the different countries, more particularly between 1955 and 1961.[10]

### a) Production

Between 1955 and 1961 a radical change came over the energy supply situation in Africa. So far as the main commercial fuels are concerned it has already been shown that crude oil and natural gas output began a very rapid growth which is likely to persist for some time. Hydro-electricity production also rose considerably in some areas — particularly in the UAR (Egypt), the Camerouns, Congo (Leopoldville) and Rhodesia.

In Algeria the opening-up of petroleum supplies from Hassi-Messaoud began early in 1958 with the bringing into operation of a 60 cm pipeline over the 700 km to the Mediterranean coast at Bougie and another from Edjeleh to the Gulf of Gabès. By 1961 the output of crude reached over 8 million tons from the increasing number of wells (89 by 1961) in the Hassi Messaoud field alone. Transport capacity from these nearly doubled by 1961, reaching 14 million tons annually. It is foreseen that this pipeline, plus that from Edjeleh, will be able to transport some 25 million tons to the coastal area by 1965. While some refining is already done at Hassi Messaoud, a very large refinery has been planned near the coast at Maison-Carrée (6,750 tons per day) and another is envisaged at Gué de Constantine, for completion within a few years.

Petroleum production is also increasing in other north African fields, as at Zelten and Dahra in Libya. Pipe-lines have existed since 1961 to the ports of Brega and Es Sider respectively. Conditions for production are favourable (production costs are lower than those either at Hassi Messaoud or in Venezuela) and it is envisaged that some 30-40 million tons of crude can be exported by 1965. Refining is being established for internal use.

The UAR (Egypt), which has traditionally been the main petroleum producer in Africa, also continues to increase output fairly regularly. By 1962 production had reached 4.4 million tons. The State-protected industry plans to develop internal refining capacity, which already comprises the Alexandria refinery (3,850 tons per day), to a total of nearly 17,000 tons daily through two installations at Suez, thereby reducing the need for imported oil products. Tunisia's oil reserves are still under investigation but construction of a refinery was completed at Bizerta in October 1963 with capacity of one million tons and with an initial output of 600,000 tons from crude purchased on the world market. Finally, output from Moroccan reserves, and some refining, complete the oil production of north Africa. In this last-named country coal production has been considerably affected by the competition from other fuels and efforts have been made to stabilize output.

Other African territories also show increasing activity in petroleum production. Nigerian output is expected to increase to between 5 and 7 million tons after 1965 and known reserves are rising rapidly. While all the output of crude has been exported, a refinery which might process 20 per cent of production is planned and another has also been foreseen at Tema in neighbouring Ghana which could deal with part of Nigerian output. Elsewhere in west and west-central Africa production is developing for export in Gabon (petroleum products are imported); in Angola, where rich resources have been discovered

[10] It should be noted that differences in definition between certain of the categories included in tables 16-20 respectively lead to some apparent differences in data. Although explanatory details are added as appropriate it should, for example, be noted that in tables 18-20 natural gas production is converted to manufactured gas equivalent. In the same Tables hydro-electricity conversion it at its calorific equivalent rather than as in table 16.

near Luanda and production (500,000 tons in 1962) has prompted construction of a refinery; and in the Congo (Brazzaville) (100,000 tons in 1961).

The economic implications of this activity will be discussed later. It is clear however that, as with coal supplies, various energy needs of other African countries might well be met from Algeria and elsewhere, as well as various extra-African requirements and also demands within the producing countries themselves, from this rising indigenous source of supply.

A somewhat similar position exists in respect of natural gas. In respect of Algerian sources it is planned to export liquified gas by special tankers for use in Europe. Experimental work also proceeds for supplying Europe by an under-water pipeline passing under the western Mediterranean and through Spain. Gas transport in the coastal region (Hassi R'Mel - Arzew - Oran - Algiers) has also been provided for by the building of a pipeline during 1962. In the second of these localities petrochemical processing plants are envisaged. One of these would deal with liquified methane for extra-African export. The gas source of Hassi R'Mel could certainly provide a basis for the development of industry and agriculture in various parts of north-west Africa, including possibly some energy-deficient areas for which it has not yet been considered, as well as meeting normal export demands.

Libya, Tunisia and Morocco are among the remaining territories which also possess some natural gas and the two latter have a certain amount of production. Algeria remains so far the principal source for this low-cost source of energy, however.

b) **Consumption**

Further light is thrown on the present state of the over-all energy economy when the balance of consumption in a recent year (1961) is taken into account. For this purpose the analysis of African energy consumption presented in table 20 may be compared with the corresponding analyses of production for 1955 and 1961 respectively (tables 18 and 19). It can be deduced first of all that the over-all output of coal from seven producing territories — 95 per cent of it from the two main sources of South Africa and Southern Rhodesia — balances the total consumption of 44 million tons achieved in 1961. This of course neglects the question of requirements for special qualities.

Only in three of main coal producing countries (including the two mentioned above) did coal remain the main source of commercial fuel by 1961, however. In virtually all other countries the total tonnage of oil fuels consumed was either roughly equal or (as in nearly all cases) considerably in excess of the quantity of coal used within the country. It is of interest to note that the total quantity of crude produced — nearly 24 million tons — was well above the consumption tonnage for refined oil fuels of all kinds — 16 million tons. Were it not for South Africa's low-cost coal consumption, in fact, oil products would overwhelmingly preponderate in African energy consumption. This is particularly true of all north African countries, but it also applies to others such as Nigeria and Ghana.

The amount of coal used **directly** in Africa for end-uses is small. This can be seen from the consumption of manufactured gas (about one milliard $m^3$) and thermal electricity (over 33 milliard kWh). It may be estimated that the over-all use of coal in producing secondary forms of energy in those territories where they are produced probably uses up around 15 million tons at least (about 35 per cent of total coal consumption). Natural gas supplies about one-third of the total gas consumption, nearly all in Algeria, where it accounts for 80 per cent of total gas consumption. Manufactured gas is used only in South Africa, Algeria, the Federation of Rhodesia and Nyasaland and — to a small extent — in Tunisia and UAR (Egypt). Of the total supply of electricity it can be seen that in 1961 only 22 per cent was from primary sources (hydro power) and this mainly in a few countries (Cameroun, Congo (Leopoldville), the Federation of Rhodesia and Nyasaland, and Morocco, Uganda and UAR (Egypt).

The total apparent input of primary energy from the main commercial sources for consumption purposes is analysed (on the basis of the conventions used and explained in this chapter) in columns 8 and 9 of table 20. In appraising these totals it has to be remembered that **commercial** sources of energy supply varying percentages of **total** energy requirements in different African countries. In the aggregate the figure of 70 million tons of coal equivalent shown as the total consumption recorded in column 8 probably represents no more than 60 per cent, and perhaps less, of the ultimate total of primary inanimate energy applied.

The average per inhabitant of 310 kg of coal equivalent is very low when contrasted with, say, the European level of use which, partly due to needs for winter heating, may be 8 - 10 times as great. The disparity is in fact even more marked since only a few territories reach the African average.

Here, however, it should also be noted that the summing of energy by calorific content leads to **apparent** differences between countries which arise from inequality in the part played by hydro-electricity in national totals. In other words the method appears to understate consumption in countries where hydro power is important and, conversely, to overstate the total in those which rely on electricity from secondary sources. The effect of this on Africa's energy consumption as a whole can be seen by comparing the average specific value per inhabitant in table 20 (310 kg) with that in table 16, column 16 (318 kg). For the African region as a whole the apparent difference due to using the two methods is thus of the order of 20 per cent.

The situation of energy consumption in Africa to-day is one characterized by rapid substitution. In the field of transport, for example, railways have traditionally taken much of the directly-used hard coal. In the case of Nigeria, about half the internal production has been used in this way. Coal exports to neighbouring Ghana have also been used in part by the railways. At present a switch to diesel locomotives is in progress in several countries, including Nigeria, Ghana, Northern and Southern Rhodesia and Nyasaland. This will tend to reduce the demand for coal for essential inland transport.

A similar substitution is afoot in many parts of the world in respect of the important fuel needs of steam-generating power plants. It has been common, where coal-fired thermal plants are a main source of electricity supply, for these to take up to one-fifth of a coal producing country's total consumption, largely for sizes and qualities of coal less suited to other uses. Since electricity production is a highly dynamic economic sector, the percen.age of total coal used in this way has commonly increased fairly rapidly. During the last few years, however, many countries using coal-fired plants have tended, where plants are suitably sited in relation to transport facilities, to switch to oil firing or to dual firing.

This tendency has increased the annual consumption of fuel oil very rapidly in a number of countries during the last few years. In Africa it has been somewhat less marked since a large part of total electricity production has, in many countries, been from diesel and hydro-electric generation. In some African countries, however, a sizable part of the total coal available has been consumed by steam power plants, as in Nigeria (20 per cent). The move to hydro power that will certainly occur, plus that towards oil firing, is thus a further potential source of net substitution in Africa.

On the other hand there is interest in a number of countries, in west and north Africa particularly, in setting up an iron and steel industry or other special industries which will require coal supplies wholly or in part. Such basic industries exist in few countries at present but chemical and metallurgical complexes may be foreseen in some, supplementing the mining industries, cement works, textile and ceramics factories and various handicraft activities which exist more characteristically today.

Other factors underlying the changing structure of energy consumption include the rapid increase in demand in consuming sectors for which requirements are largely prescribed or specialized. In the aggregate, for example, the total number of road motor vehicles is rising in Africa by around five per cent annually - creating a growing demand which provides the main source of consumption for liquid fuels at present. Bunkering requirements for ocean-going shipping and fuel requirements for international airlines also take a large part of the energy consumed in certain countries, particularly those with port facilities. Some four million tons of oil fuel were employed in African countries in 1961 for marine bunkering - equal to none than one-fifth of the total use for all purposes - although the requirement is a fluctuating one and in many cases does not expand. Well over one million tons of petrol were consumed by civil airways and around 7 million tons for road transport - forms of consumption that are far more dynamic.

### c) International trade

A Key factor in the energy economy of Africa at present is the past played by fuel imports and exports, and particularly those of crude and refined oil products respectively. During the period 1955-61 African coal production has risen modestly in the aggregate. In the case of crude petroleum, production has risen in the same period from 2 to nearly 24 million tons, while a small net import of crude has become a large net export amounting to nearly 16 million tons. Production of refined oil fuels in Africa - confined in 1955 to Morocco, Egypt and South Africa - amounted at that time to some 20 per cent of the total African consumption, the rest being imported. By 1961 a small output of refined products had spread to three other countries while the total output had doubled and now sufficed to provide some 30 per cent of the total oil products available - including both production and net imports.[11]

The details of this evolution in sources of supply are set out in tables 18-20. However, their implications are of even greater magnitude. Study of the foregoing tables shows that energy consumption in many individual countries has risen only very slowly. The countries where crude oil has latterly been produced have in large measure been exporting the output outside Africa and importing refined petroleum products. This has been the case in Nigeria and various other countries prior to the planning of local refining that is now under way. In the case of this particular country the crude export has latterly (1960) matched the refined import in tonnage. In terms of the balance of payments, however, the exchange produced in that year a net deficit equal to 10 million dollars. The relatively lower value of crude as compared with refined products, due to the high delivered cost of the latter in many areas, has had the effect of converting a physical equilibrium in Africa's production and consumption of commercial forms of energy into a net deficit when expressed in monetary terms.

The effect of this import situation on the cost of fuels for electricity production is discussed below. To clarify and compare the trends in production and net import of different forms of energy in different African countries an analysis of the various tendencies for coal, refined fuels and all commercial forms of

[11] Part of this availability, however, consists of non-energy products, such as lubricants.

primary energy combined is set out in table 21 in the form of indices based on 1955 as 100. It is seen that the modifying of net energy imports in producing and non-producing countries respectively, in the overall balance for Africa (they were virtually eliminated by 1961) has been a very variable process. The extent to which internal refining capacity has been provided for in different countries is often a primary factor in the total energy situation at present.

What part do fuel imports actually play in the economy of the different countries? To answer this question it is useful to eliminate food from the assessment and to consider the cost of imported mineral fuels in relation to various main categories of non-food imports. Such a comparison is set out, for certain countries, in terms of average percentage values relating to a two - or three - year period prior to 1960, in table 22. While manufactured goods are shown to account for some 70-80 per cent of total non-food imports in most cases, imports of industrial and building materials play a very variable role in the countries studied. As a result, eight out of fifteen countries pay most for imported mineral fuel (i.e. after manufactured goods); while in seven others fuel is relatively a little less important than industrial materials in the total import expenditure. In every case studied mineral fuels (i.e. oil, coal or processed solid fuels) accounted for between 6 and 16 per cent of total non-food imports over the period reviewed. Part of this of course may be largely irreplaceable in so far as it refers to special qualities for transport, industrial or other needs. Nevertheless, the total burden on the economy is often a fairly heavy one.

### d) **Plans for future development of energy supply**

Medium-term co-ordinated forecasts for development in different categories of energy production or demand are not generally available for the various territories of Africa and in fact would be difficult to prepare at present. Some projects due to be implemented over the next few years are known however and it is possible to piece together their implications.

From such indications as are available it has been estimated that around 45 million tons of coal may be produced in Africa in 1965 — a figure reflecting a certain stabilizing of the present output capacity and assuming that various projects for expanded petroleum output and refining are realised. These latter include a possible 35-40 million tons of crude petroleum output in Algeria — plus 1.5 milliard $m^3$ of natural gas by around 1965 (with an export of 335,000 tons of liquified gas) and a comparable output of crude in Libya. Production of crude in Nigeria may reach 10 million tons in 3-5 years and in Gabon an output of one million tons is considered likely by 1965.

In the same period refineries will be built in Egypt (sufficient to refine all internal production); Ethiopia (of which half the capacity would be for export); Kenya; and other producing countries, including those referred to above. There is thus a strong impetus towards using the economic potential of Africa's oil reserves both to supply internal requirements and to improve the balance of payments position by more profitable exports. It has been estimated that the total net loss of the various African producing territories due to importing refined products against exports of crude may be of the order of 120-130 million dollars — a situation that may soon be largely remedied. The new African sources of refined products might also be in a position to supply some inter-African requirements more economically than is at present the case, where suitable communications exist.

The following figures[12] sum up for Africa as a whole some estimates of total petroleum output and consumption covering the immediate future up to 1967 (in millions of tons):

| Year | Production | Consumption | Refinery capacity |
|---|---|---|---|
| 1962 | 38.8 | 30 | 9 |
| 1963 | 50.0 | 33 | 16 |
| 1964 | 62.0 | 36 | 23 |
| 1965 | 72.0 | 39 | 30 |
| 1966 | 80.0 | 42 | 37 |
| 1967 | 90.0 | 45 | 44 |

The various African projects for the extension or introduction of new refinery capacity by 1965 (based on the same source as the above table) are set out in table 23. They show that refining capacity will in fact exist in all the main regions of Africa instead of being localized in the extreme north and south. There should thus be some prospect of improved conditions for obtaining oil fuels in the fairly near future.

To complete this review of energy production and consumption trends in Africa it is necessary to bring together the short-term forecasts in a consolidated form and relate them to past development. This is done in the following summary table, which includes broad estimates for total primary energy production in Africa (coal, petroleum, and natural gas, with hydro-electricity at 2,000 kWh/ton), the whole expressed in millions of tons of coal equivalent:

| Category | 1951 | 1960 | 1962[a] | 1965[a] |
|---|---|---|---|---|
| Coal | 30 | 43 | 44 | 44 |
| Petroleum | — | 14 | 50 | 98 |
| Natural Gas | — | — | — | 2 |
| Total Commercial (inc. hydro power) | 31 | 58 | 100 | 152 |

12 Based on estimates given in World Petroleum (April 1962)

## C. THE ROLE OF ELECTRIC ENERGY IN RELATION TO THE ENERGY ECONOMY AS A WHOLE

Demand for electricity, as a principal secondary form of energy use, expands within the setting of energy demand as a whole. Moreover, the availability of fuels for thermal power production and their comparative cost per kWh produced is a function of the total energy situation. It is for these reasons that the present chapter is concerned with the main tendencies of the energy economy and, equally, why an attempt must be made to place the production and use of electric power in Africa briefly within its total context.

### a) Fuel supplies for thermal power production

Most of Africa's electricity production is either from steam-generating plants or — more commonly — from diesel generators which often work in isolation. While the prices of oil fuels may commonly fluctuate around the equivalent of 25-35 US dollars per ton on the world market, in some inland situations they may vary from 75-150 dollars per ton. A considerable part of this difference can sometimes be explained by heavy duties and taxes. The remainder is attributable to variable transport charges. It is for this reason that the tendencies of refining and costs of supply from African sources are of such importance in the present context.

In table 24 an attempt has been made to analyse comparatively the delivered cost per metric ton of fuel for power production, using as a basis mainly the information supplied by interested governments — information which may generally be taken to apply to the situation at the end of 1962. For comparative purposes figures have been converted to a common currency (US dollars/ton). Except where otherwise stated they refer to diesel oil. In some cases however figures are also given for other fuels and in the case of Morocco for varieties of coal. Figures used for the Sudan are expressed directly in US mills per kWh produced and a coefficient must be applied to arrive at an estimated fuel cost.

It is likely that in some cases there may be problems involved in arriving at truly comparable figures and the data should therefore be treated with due caution. Nevertheless the values per ton (adjusted by inspection for any differences in calorific content) bring out clearly the great advantage at present of situations near the coast or near to sources of production (Ghana, Morocco, or Tunisia) as opposed to inland locations, (Ethiopia, Mali and Sudan). The same point is brought out by the data for diesel oil and coal pertaining to the Federation of Rhodesia and Nyasaland.

### b) Electricity consumption in relation to total use of primary energy

To evaluate the position of electricity in the total energy supply of a given country it is instructive — and useful for forecasting purposes — to study the evolution of consumption relative to that of the total input of primary energy. If we combine the calorific content of all primary solid, liquid and gaseous fuels and hydro power employed the last converted at 2,000 kWh per ton) the result may be taken as an index of gross energy consumption from commercial sources — i.e. the input of primary energy required before losses in conversion and use. We may next convert the electricity consumed to the same unit or else convert the calorific content of all primary energy to electricity equivalent) and then express the one as a percentage of the other.

This has been done, in preparing table 25, for the years 1955 and 1961 (columns 7 and 8). For the same years data have been calculated to show the total consumption of primary energy per inhabitant (columns 4-6) and also the percentage of hydro production in total electricity production (columns 2-3). We thus arrive at a rough empirical basis for evaluating in broad terms the part played by electric power in the energy economy of different countries.

Over the six-year period hydro power has somewhat increased its contribution to Africa's total electricity supply — from 13 to 22 per cent over-all. Total apparent gross consumption per inhabitant of primary energy (i.e. from commercial sources) has also risen in Africa over the period, though at a far more modest rate. In a few cases very low consumption levels have been doubled, but elsewhere they have slightly fallen or have remained roughly constant. Meanwhile, as in other parts of the world, consumption of electricity has risen steeply in African countries.

The result of these trends is seen in columns 7 and 8 of table 25. It is usual for a large part of the total energy supply to be furnished by hydro-electric power wherever hydro resources are plentiful. Under such conditions, in Europe and elsewhere, between 40 and 70 per cent of the total primary energy input is often furnished from this source. In African countries it can be seen that a considerable part of the total primary energy supply is already consumed in the form of electricity. Despite the low level of kWh consumption per inhabitant, electric energy already plays an important role in the energy use of most of the territories, being equivalent to between 20 and over 70 per cent of the total input in many cases. Net replacement of other forms of energy by electricity is also proceeding rapidly in Africa. This can be seen by the increase in the percentage contribution of electric power between 1955 and 1961. In the aggregate (and allowing for margins of uncertainty in data for some countries) this index has risen from 22 to 29 per cent over the period under review.

## D. OBSERVATIONS

Changes in the composition of the energy supply of African countries due to replacement and net substitution of one form of primary energy by another, is already proceeding quickly in most parts of Africa. A good deal of the rapid rise in energy consumption per head that appears likely over the next few years seems certain to be assured by liquid fuels. This process will be assisted by a far wider spread of refining capacity than exists at present. It would therefore seem that the cost of oil fuels for electricity generation, which at present are the source of a large part of total electric power output, may be able to be reduced from the very high levels now obtaining in most of the less accessible areas. In addition, coal for steam generating plants should be easily available. This fact could influence the middle stages of electrification in some countries where limited demands and high capital and transmission costs hold back for a time any full development of generation from hydro-electric resources.

Despitt comparatively low levels of consumption, electricity already holds a place in the total energy supply from commercial sources that is fully comparable with that which it enjoys, say, in Europe. It seems natural, and fully in accord with the trend of economic development in Africa, that a large part of the total primary energy employed should in most areas come to be consumed in the form of electric power. This is all the more explicable since manufactured gas is so far used only to a limited extent, and conditions in many areas at present tend to militate against forms of supply which require piped distribution networks. It appears virtually certain that the relative position of electric energy will continue to grow steadily in the total structure of energy consumption even though at present the contribution of hydro-electric power in the total is still far below that which is its ultimate destiny.

## TABLE 16

**Production and apparent consumption of primary energy from commercial sources for Africa and the world** (1951-1961)

(Expressed in calorific content as coal equivalent with hydro-electricity converted at 2000 kWh/ton)

| | | Production (million tons and as percentage) | | | | | | | | Consumption for internal use | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hard coal and lignite | | Crude petroleum | | Natural gas | | Hydro-electricity | | As percentage of total | | | | Total apparent consumption | |
| Region | Year | Total | As percentage | Total | As percentage | Total | As percentage | Total | As percentage | Hard coal and lignite | Refined liquid fuels | Natural gas | Hydro-electricity | $10^6$ tons | kg per inhabitant |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| WORLD | 1951 | 1,665 | 56 | 806 | 28 | 304 | 10 | 188 | 6 | 58 | 25 | 11 | 6 | 2,851 | 1,131 |
| | 1955 | 1,810 | 52 | 1,029 | 30 | 400 | 12 | 236 | 6 | 53 | 28 | 12 | 7 | 3,401 | 1,268 |
| | 1956 | 1,890 | 51 | 1,118 | 30 | 434 | 12 | 256 | 7 | 52 | 29 | 12 | 7 | 3,599 | 1,317 |
| | 1960 | 2,202 | 48 | 1,399 | 31 | 622 | 13 | 344 | 8 | 49 | 29 | 14 | 8 | 4,496 | 1,489 |
| | 1961 | 2,164 | 46 | 1,487 | 32 | 677 | 14 | 360 | 8 | 47 | 30 | 15 | 8 | 4,599 | 1,487 |
| AFRICA | 1951 | 30 | 91 | 3 | 9 | 0 | — | 0 | — | 70 | 30 | — | — | 38 | 203 |
| | 1955 | 38 | 88 | 3 | 7 | 0 | — | 2 | 5 | 66 | 31 | — | 3 | 58 | 346 |
| | 1956 | 39 | 88 | 3 | 7 | 0 | — | 2 | 5 | 67 | 30 | — | 3 | 60 | 354 |
| | 1960 | 43 | 66 | 18 | 28 | 0 | — | 4 | 6 | 60 | 34 | — | 6 | 73 | 378 |
| | 1961 | 44 | 55 | 31 | 39 | 0 | — | 5 | 6 | 60 | 34 | — | 6 | 75 | 381 |

TABLE 17

**Production of coal, crude petroleum and natural gas in Africa**
(Thousand metric tons and million m3)

| Country | Category(a) | 1951 | 1956 | 1960 | 1961 | 1962 |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **North Africa:** Algeria | C | 247 | 307 | 119 | 78 | 53 |
| | N | — | — | ... | 231 | ... |
| | P | 7 | 34 | 8632 | 15659 | 20496 |
| Libya | C | — | — | — | — | — |
| | N | — | — | — | — | — |
| | P | — | — | — | 700 | 9200 |
| Morocco | C | 394 | 482 | 412 | 410 | ... |
| | N | — | 7 | 9 | 8 | ... |
| | P | 76 | 97 | 92 | 80 | 127 |
| Tunisia | C | — | — | — | — | — |
| | N | — | 6 | 7 | 7 | 7 |
| | P | — | — | — | — | — |
| U.A.R. (Egypt) | C | — | — | — | — | — |
| | N | — | — | — | — | — |
| | P | 2591 | 2397 | 3505 | 3819 | 4468 |
| **West Africa:** Congo (Brazzaville) | C | — | — | — | — | — |
| | N | — | — | — | — | — |
| | P | — | — | 52 | 103 | 123 |
| Gabon | C | — | — | — | — | — |
| | N | — | — | 7 | 7 | 9 |
| | P | — | — | 800 | 774 | 827 |
| Nigeria | C | 560 | 800 | 571 | 607 | 634 |
| | N | — | — | — | — | — |
| | P | — | — | 870 | 2303 | 3324 |
| Senegal | C | — | — | — | — | — |
| | N | — | — | — | — | — |
| | P | — | — | — | 2 | ... |
| **Central Africa:** Angola | C | — | — | — | — | — |
| | N | — | — | — | — | — |
| | P | — | 9 | 67 | 104 | 472 |
| Congo (Leopoldville) | C | 217 | 420 | 163 | 73 | ... |
| | N | — | — | — | — | — |
| | P | — | — | — | — | — |
| Tanganyika | C | — | 2 | 2 | 2 | ... |
| | N | — | — | — | — | — |
| | P | — | — | — | — | — |
| Fed. of Rhodesia & Nyasaland | C | 2300 | 3552 | 3564 | 3072 | 2820 |
| | N | — | — | — | — | — |
| | P | — | — | — | — | — |
| **Southern Africa:** Mozambique | C | 78 | 218 | 270 | 321 | ... |
| | N | — | — | — | — | — |
| | P | — | — | — | — | — |
| Madagascar | C | ... | ... | ... | 2 | ... |
| | N | — | — | — | — | — |
| | P | — | — | — | — | — |
| South Africa | C | 26632 | 33602 | 38173 | 39564 | 41280 |
| | N | — | — | — | — | — |
| | P | 36 | 37 | 35 | 35 | 35 |
| Total Africa P | C | 30428* | 39381* | 43274* | 44129* | ... |
| | N | — | 13* | 23* | 253* | ... |
| | P | 2710* | 2574* | 14053* | 23563* | ... |

a) C = Coal
N = Natural gas
P = Crude petroleum

## TABLE 18

**Gross production and net import in African countries (in 1955) of primary commercial sources of energy and refined oil fuels**

| Country | Coal & Lignite ($10^6$ tons coal equivalent) | | Crude Petroleum ($10^6$ tons) | | Refined oil fuels ($10^6$ tons) | | Natural gas production ($10^9$ m$^3$ (a) | Hydro power production $10^9$ kWh | Total primary energy ($10^6$ tons coal) equivalent) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Net import | Production | Net import | Production | Net import | | | Production (b) (c) | Net Import |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **North Africa:** | | | | | | | | | | |
| Algeria | 0.30 | 0.27 | 0.06 | -0.06 | — | 1.73 | — | 0.29 | 0.41 | 2.80 |
| Libya | — | 0.07 | — | — | — | 0.16 | — | — | — | 0.31 |
| Morocco | 0.47 | -0.19 | 0.10 | — | 0.08 | 0.76 | 0.02 | 0.77 | 0.71 | 0.95 |
| Tunisia | — | 0.04 | — | — | — | 0.43 | 0.01 | — | 0.01 | 0.69 |
| Sudan | — | 0.05 | — | — | — | 0.26 | — | — | — | 0.44 |
| UAR (Egypt) | — | 0.11 | 1.83 | 1.01 | 2.46 | 2.06 | — | 0.02 | 2.38 | 4.52 |
| **West Africa:** | | | | | | | | | | |
| Cameroon | — | 0.12 | — | — | — | 0.08 | — | 0.01 | — | 0.12 |
| Equatorial Africa(d) | — | 0.13 | — | — | — | 0.08 | — | 0.03 | — | 0.13 |
| Gambia | — | 0.01 | — | — | — | — | — | — | — | 0.01 |
| Ghana | — | 0.12 | — | — | — | 0.31 | — | — | — | 0.59 |
| Liberia | — | 0.03 | — | — | — | 0.02 | — | 0.01 | — | 0.03 |
| Nigeria | 0.76 | -0.10 | — | — | — | 0.30 | — | 0.07 | 0.77 | 0.35 |
| Sierra Leone | — | 0.03 | — | — | — | 0.03 | — | — | — | 0.08 |
| Togo | — | 0.02 | — | — | — | 0.01 | — | — | — | 0.02 |
| West-Central Africa(e) | — | 0.03 | — | — | — | 1.46 | — | 0.01 | — | 2.22 |
| **East and South Africa:** | | | | | | | | | | |
| Ethiopia | — | 0.01 | — | — | — | 0.06 | — | 0.02 | — | 0.10 |
| Somalia | — | 0.02 | — | — | — | 0.01 | — | — | — | 0.02 |
| French Somaliland | — | 0.03 | — | — | — | ... | — | — | — | 0.03 |
| Angola | — | 0.03 | — | — | — | 0.10 | — | 0.02 | — | 0.18 |
| Congo (Leopoldville) | 0.48 | 0.29 | — | — | — | 0.38 | — | 1.33 | 0.65 | 0.86 |
| East Africa(f) | — | 0.03 | — | — | — | 1.03 | — | 0.31 | 0.04 | 1.58 |
| Zanzibar & Pemba | — | 0.02 | — | — | — | 0.01 | — | — | — | 0.02 |
| Fed. Rhodesia & Nyasaland | 3.31 | — | — | — | — | 0.33 | — | 0.22 | 3.34 | 0.51 |
| Mozambique | 0.17 | 0.22 | — | — | — | 0.08 | — | — | 0.17 | 0.35 |
| Madagascar | — | 0.01 | — | — | — | 0.09 | — | 0.05 | 0.01 | 0.15 |
| Mauritius | — | 0.01 | — | — | — | 0.03 | — | 0.03 | — | 0.06 |
| Reunion | — | 0.02 | — | — | — | 0.01 | — | — | — | 0.02 |
| South Africa | 32.15 | -0.56 | 0.04 | 0.94 | 0.85 | 2.05 | — | 0.01 | 32.20 | 3.73 |
| Other territories | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Total (for countries included) | 37.64 | 0.87 | 2.03 | 1.89 | 3.39 | 11.87 | 0.03 | 3.20 | 40.69 | 20.87 |

a) In manufactured gas equivalent.
b) i.e. excluding data in col. 6.
c) Hydro-electricity at 860 kcal/kWh.
d) Including Central African Republic, Chad, Congo (Brazzaville) and Gabon.
e) Including Dahomey, Guinea, Ivory Coast, Niger, Mali, Senegal and Upper Volta.
f) Including Kenya, Tanganyika and Uganda.

## TABLE 19

**Gross production and net import (in 1961) in African countries of primary commercial sources of energy and refined oil fuels**

| Coutry | Coal & lignite ($10^6$ tons coal equivalent) | | Crude petroleum ($10^6$ tons) | | Refined oil fuels ($10^6$ tons) | | Natural gas production ($10^9$ m$^3$) (a) | Hydro power production $10^9$ kWh | Total primary energy ($10^6$ tons coal equivalent) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Net Import | Production | Net Import | Production | Net Import | | | Production (b) (c) | Net import |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **North Africa:** | | | | | | | | | | |
| Algeria | 0.08 | 0.21 | 15.79 | —15.17 | 0.17 | 1.72 | 0.51 | 0.34 | 20.96 | —16.94 |
| Libya | — | 0.04 | 0.87 | —0.68 | — | 0.32 | — | — | 1.13 | —0.38 |
| Morocco | 0.41 | —0.09 | 0.08 | 0.13 | 0.21 | 0.73 | 0.02 | 0.95 | 0.64 | 1.17 |
| Tunisia | — | 0.05 | — | — | — | 0.47 | 0.02 | 0.02 | 0.01 | 0.76 |
| Sudan | — | 0.02 | — | — | — | 0.44 | — | — | | 0.68 |
| UAR (Egypt) | — | 0.30 | 3.83 | 0.99 | 4.26 | 1.19 | — | 1.01 | 5.10 | 3.38 |
| **West Africa:** | | | | | | | | | | |
| Cameroon | — | 0.16 | — | — | — | 0.11 | — | 0.91 | 0.11 | 0.16 |
| Equatorial Africa(d) | — | 0.01 | 0.88 | —0.83 | — | 0.18 | 0.02 | 0.04 | 1.16 | —0.82 |
| Gambia | — | 0.01 | — | — | — | 0.01 | — | — | — | 0.01 |
| Ghana | — | 0.05 | — | — | — | 0.41 | — | — | — | 0.66 |
| Liberia | — | 0.08 | — | — | — | 0.05 | — | 0.02 | 0.00 | 0.08 |
| Nigeria | 0.61 | —0.05 | 2.30 | —2.26 | — | 0.78 | — | 0.10 | 3.61 | —1.82 |
| Sierra Leone | — | 0.01 | — | — | — | 0.40 | — | — | — | 0.61 |
| Togo | — | 0.04 | — | — | — | 0.03 | — | — | — | 0.04 |
| West-Central Africa(e) | — | ... | — | — | — | 1.66 | — | 0.08 | 0.01 | 2.49 |
| **East and South Africa:** | | | | | | | | | | |
| Ethiopia | — | 0.01 | — | — | — | 0.12 | — | 0.07 | 0.01 | 0.19 |
| Somalia | — | 0.03 | — | — | — | 0.02 | — | — | — | 0.03 |
| French Somaliland | — | 0.02 | — | — | — | ... | — | — | — | 0.02 |
| Angola | — | 0.01 | 0.10 | 0.12 | 0.20 | 0.08 | 0.01 | 0.13 | 0.16 | 0.28 |
| Congo (Leopoldville) | 0.07 | 0.32 | — | — | — | 0.41 | — | 2.50 | 0.39 | 0.88 |
| East Africa(f) | — | 0.04 | — | — | — | 1.18 | — | 0.66 | 0.08 | 1.81 |
| Zanzibar & Pemba | — | 0.02 | — | — | — | 0.01 | — | — | — | 0.02 |
| Fed. Rhodesia & Nyasaland | 3.07 | 0.07 | — | — | — | 0.52 | — | 2.44 | 3.38 | 0.55 |
| Mozambique | 0.32 | 0.24 | — | 0.46 | 0.40 | 0.06 | — | 0.11 | 0.34 | 0.94 |
| Madagascar | — | 0.18 | — | — | — | 0.12 | — | 0.07 | 0.01 | 0.18 |
| Mauritius | — | 0.01 | — | — | — | 0.05 | — | 0.02 | — | 0.08 |
| Réunion | — | 0.04 | — | — | — | 0.03 | — | — | — | 0.04 |
| South Africa | 39.57 | —1.06 | 0.03 | 1.48 | 1.43 | 2.44 | — | — | 39.60 | 4.53 |
| Other territories | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Total (for countries included) | 44.13 | 0.42 | 23.88 | —15.76 | 6.68 | 13.54 | 0.58 | 9.46 | 76.70 | 0.63 |

a) In manufactured gas equivalent.
b) i.e. excluding data in col. 6.
c) Hydroelectricity at 860 kcal/kWh.
d) Including the Central African Republic, Chad, Congo (Brazzaville) and Gabon.
e) Including Dahomey, Guinea, Ivory Coast, Niger, Mali, Senegal and Upper Volta,
f) Including Kenya, Tanganyika and Uganda,

TABLE 20

Apparent gross consumption of primary commercial sources of energy and of their main secondary derivatives (oil fuels, gas and electricity) in 1961

| Country | Coal (consumed directly or converted) ($10^6$ tons coal equivalent) | Total oil fuels ($10^6$ tons) | Gas ($10^9$ $m^3$ manufactured gas equivalent) | | Electricity ($10^9$ kWh) | | Total apparent consumption of primary energy (coal equivalent) [b] | |
|---|---|---|---|---|---|---|---|---|
| | | | Total consumption[a] | Of which natural gas | Total consumption[a] | Of which hydro-electric | $10^6$ tons | kg/inhabitant |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **North Africa** | | | | | | | | |
| Algeria | 0.32 | 1.46 | 0.64 | 0.51 | 1.44 | 0.34 | 2.86 | 254 |
| Libya | 0.04 | 0.22 | ... | ... | 0.11 | 0.00 | 0.38 | 307 |
| Morocco | 0.35 | 0.83 | 0.02 | 0.02 | 1.05 | 0.95 | 1.73 | 145 |
| Tunisia | 0.05 | 0.45 | 0.03 | 0.02 | 0.31 | 0.02 | 0.73 | 172 |
| Sudan | 0.02 | 0.41 | ... | ... | 0.10 | 0.00 | 0.64 | 52 |
| UAR (Egypt) | 0.30 | 4.98 | 0.01 | 0.00 | 3.72 | 1.01 | 7.90 | 297 |
| **West Africa** | | | | | | | | |
| Cameroon | ... | 0.11 | ... | ... | 0.92 | 0.91 | 0.28 | 66 |
| Equatorial Africa(c) | ... | 0.17 | 0.02 | 0.02 | 0.09 | 0.04 | 0.27 | 49 |
| Gambia | ... | 0.01 | ... | ... | 0.01 | 0.00 | 0.01 | 41 |
| Ghana | 0.06 | 0.39 | ... | ... | 0.39 | 0.00 | 0.64 | 92 |
| Liberia | ... | 0.05 | ... | ... | 0.12 | 0.02 | 0.08 | 58 |
| Nigeria | 0.56 | 0.76 | ... | ... | 0.66 | 0.10 | 1.71 | 47 |
| Sierra Leone | 0.01 | 0.08 | ... | ... | 0.05 | 0.00 | 0.13 | 52 |
| Togo | ... | 0.03 | ... | ... | 0.01 | 0.00 | 0.04 | 28 |
| West-Central Africa(d) | ... | 0.59 | ... | ... | 0.34 | 0.08 | 0.89 | 37 |
| **Esta and South Africa** | | | | | | | | |
| Ethiopia | 0.01 | 0.11 | ... | ... | 0.12 | 0.07 | 0.19 | 9 |
| Somalia | ... | 0.02 | ... | ... | 0.01 | 0.00 | 0.03 | 22 |
| Angola | 0.01 | 0.21 | 0.01 | 0.01 | 0.16 | 0.13 | 0.35 | 71 |
| Congo (Leopoldville) | 0.40 | 0.40 | ... | ... | 2.14 | 2.50 | 1.25 | 64 |
| East Africa(e) | 0.04 | 1.01 | ... | ... | 0.81 | 0.66 | 1.64 | 69 |
| Zanzibar & Pemba | ... | 0.01 | ... | ... | 0.01 | 0.00 | 0.02 | 51 |
| Fed. Rhodesia & Nyasaland | 2.79 | 0.51 | 0.07 | 0.00 | 4.00 | 2.44 | 3.92 | 460 |
| Mozambique | 0.56 | 0.17 | ... | ... | 0.16 | 0.11 | 0.82 | 124 |
| Madagascar | 0.01 | 0·11 | ... | ... | 0.11 | 0.07 | 0.18 | 32 |
| South Africa | 38.50 | 3.33 | 0.76 | 0.00 | 26.06 | 0.00 | 43.50 | 2.414 |
| Other territories | ... | ... | ... | ... | . ... | ... | ... | ... |
| Total (for countries included)! | 44.03 | 16.31 | 1.56 | 0.57 | 42.80 | 9.46 | 70.20 | 310* |

a) Not included in total (columns 8 and 9)
b) Hydro-electricity at 860 kcal/kWh.
c) Including Central African Republic, Chad, Congo (Brazzaville) and Gabon.
d) Including Dahomey, Guinea, Ivory Coast, Niger, Mali, Senegal and Upper Volta.
e) Including Kenya, Tanganyika and Uganda.

TABLE 21

**Growth of net fuel imports in African countries — 1955 — 1961 — and of production of coal and all commercial forms of primary energy**

(indices for 1961 based on 1955 = 100)

| Country | Coal and Lignite production | Coal (total net import) | Refined oil fuels (total net import) | Total primary energy (coal equivalent) | |
|---|---|---|---|---|---|
| | | | | Production | Net import |
| 1 | 2 | 3 | 4 | 5 | 6 |
| **North Africa:** | | | | | |
| Algeria | 27 | 78 | 99 | 5,112 | ...(a) |
| Libya | — | 57 | 200 | ... | ...(a) |
| Morocco | 87 | —50 | 96 | 90 | 123 |
| Tunisia | — | 125 | 109 | 100 | 110 |
| Sudan | — | 40 | 169 | ... | 155 |
| UAR (Egypt) | — | 273 | 58 | 214 | 75 |
| **West Africa:** | | | | | |
| Cameroon | — | 133 | 138 | ... | 133 |
| Equatorial Africa(b) | — | 8 | 225 | ... | ... |
| Gambia | — | 100 | — | ... | 100 |
| Ghana | — | 42 | 132 | ... | 112 |
| Liberia | — | 267 | 250 | ... | 267 |
| Nigeria | 80 | —50 | 260 | 469 | ...(a) |
| Sierra Leone | — | 33 | 1,333 | ... | 762 |
| Togo | — | 200 | 300 | ... | 200 |
| West Central Africa (c) | — | ... | 114 | ... | 112 |
| **East and South Africa:** | | | | | |
| Ethiopia | — | 100 | 200 | ... | 190 |
| Somalia | — | 150 | 200 | ... | 150 |
| French Somaliland | — | 67 | ... | ... | 67 |
| Angola | — | 33 | 80 | ... | 156 |
| Congo (Leopoldville) | 15 | 110 | 108 | 60 | 102 |
| East Africa(d) | — | 133 | 115 | 200 | 115 |
| Zanzibar and Pemba | — | 100 | 100 | ... | 100 |
| Fed. Rhodesia and Nyasaland | 93 | ... | 158 | 101 | 108 |
| Mozambique | 188 | 109 | 75 | 200 | 269 |
| Madagascar | — | 1,800 | 133 | 100 | 120 |
| Mauritius | — | 100 | 167 | ... | 133 |
| Reunion | — | 200 | 300 | ... | 200 |
| South Africa | 123 | —189 | 119 | 123 | 121 |
| Other territories | ... | ... | ... | ... | ... |
| Total (for countries included) | 117 | 48 | 114 | 188 | 3 |

a) Net import in 1955 changed to net export in 1961.
b) Including Central African Republic, Chad, Congo (Brazzaville) and Gabon.
c) Including Dahomey, Guinea, Ivory Coast, Niger, Mali, Senegal and Upper Volta.
d) Including Kenya, Tanganyika and Uganda.

TABLE 22

**Imports of mineral fuels as a percentage of total non-food imports for selected countries**

**(for reference periods between 1956 and 1958)**

| Country | Reference year (average) | Value of imports as percentage of total non food imports | | | |
|---|---|---|---|---|---|
| | | Mineral fuels | Industrial materials | Total[a] (including building materials) | Imports of manufactured goods |
| 1 | 2 | 3 | 4 | 5 | 6 |
| **North Africa** | | | | | |
| Morocco | 1956-1958 | 11 | 28 | 39 | 61 |
| Tunisia | 1956-1958 | 15 | 8 | 27 | 73 |
| Sudan | 1957-1958 | 10 | 12 | 23 | 77 |
| UAR (Egypt) | 1956-1958 | 14 | 19 | 34 | 66 |
| **West Africa** | | | | | |
| Cameroon | 1958-1959 | 7 | 14 | 21 | 79 |
| Ghana | 1956-1958 | 9 | 8 | 23 | 77 |
| Nigeria | 1956-1958 | 7 | 8 | 20 | 80 |
| Guinea | 1956-1958 | 6 | 11 | 23 | 77 |
| Ivory Coast | 1957-1958 | 16 | 10 | 32 | 68 |
| **North-East Africa** | | | | | |
| Ethiopia | 1956/7-1958/9 | 12 | 5 | 20 | 80 |
| **Central Africa** | | | | | |
| Congo (Leopoldville) | 1957-1958 | 10 | 4 | 16 | 84 |
| Kenya | 1957-1958 | 15 | 8 | 27 | 73 |
| Tanganyika | 1956-1958 | 12 | 0 | 21 | 79 |
| Uganda | 1956-1958 | 9 | 1 | 16 | 84 |
| Fed. of Rhodesia and Nyasaland | 1956-1958 | 6 | 14 | 24 | 76 |

a) Refers to total of columns 3 and 4, plus building materials.

TABLE 23

**Petroleum refineries under construction or planned in African countries**

| Country | Number of refineries | | Capacity (thousands of metric tons) | |
|---|---|---|---|---|
| | 1962 | 1965 | 1962 | 1965 |
| 1 | 2 | 3 | 4 | 5 |
| Algeria | 1 | 2 | 200 | 2,700 |
| Tunisia | 0 | 1 | — | 1,000a) |
| Morocco | 1 | 2 | 250 | 1,500 |
| Libya | 0 | 1 | — | 400 |
| UAR (Egypt) | 3 | 3 | 6,150 | 7,050 |
| Ethiopia | 0 | 1 | — | 500 |
| Sudan | 0 | 1 | — | 800 |
| Cape Verde Is. | 0 | 1 | — | 750 |
| Liberia | 0 | 1 | — | 700 |
| Ivory Coast | 0 | 1 | — | 800 |
| Senegal | 0 | 1 | — | 1,200 |
| Nigeria | 0 | 1 | — | 1,000 |
| Ghana | 0 | 1 | — | 1,200 |
| Angola | 1 | 1 | 500 | 500 |
| N. & S. Rhodesia | 0 | 1 | — | 1,000 |
| Kenya | 0 | 1 | — | 1,800 |
| Tanganyika | 0 | 1 | — | 400 |
| Mozambique | 1 | 1 | 600 | 600 |
| S. Africa | 2 | 4 | 1,725 | 6,125 |
| Madagascar | 0 | 1 | — | 600 |
| Total | 9 | 27 | 9,075 | 30,625 |

a) Entered into service in November 1963.

## TABLE 24

**Average cost of diesel oil and other fuels for electric power production delivered at the generating plant, in selected countries** (provisional)

| Country | National currency unit | Cost per unit (delivered at plant) | Apparent delivered cost (US dollars) per metric ton) | Remarks (relating to col. 3) |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Cameroon | Fr. CFA | 18.34—32.17 per kg | 76.4—134.0 | Refers to gas-oil, the price depending on transport cost |
| Ethiopia | Eth. dollars | 222 per ton | 89.4 | — |
| Fed. Rhodesia & Nyasaland | Pence | 35 per gallon | 100.0 | Refers to diesel oil |
| Nyasaland | £ | £ 3.16.0 per ton | 10.64 | Coal delivered at the power station |
| Gabon | Fr. CFA | 13508 per ton | 54.0 | At Libreville |
| | Fr. CFA | 19.9 per litre | 88.4 | Refers to gas-oil at Lambaréné |
| Gambia | Pence | 23.0 per gallon | 65.7 | — |
| Ghana | Pence | About 10 per gall. | 28.6 | Delivered in Accra. Slightly higher inland. |
| Kenya | Shilling | 335.34 per ton | 47.0 | At Nairobi South |
| | Shilling | 116.21 per ton | 16.3 | Refers to furnace oil at Kipevu. |
| Madagascar | Fr. CFA | 15-25 per litre | 66.6-111.0 | According to point of use |
| Mali | Fr. CFA | 30.70 per litre | 136.3 | — |
| Morocco | Dirham | 216.65 per ton | 42.8 | Fuel oil at Agadir |
| | Dirham | (69.89 per ton | 13.8 | Refers to coal (large and small fines respectively) |
| | | (92.95 per ton | 18.4 | at Roches Noires. |
| | Dirham | (55.73 per ton | 11.0 | Ditto at Oujda |
| | | (78.58 per ton | 15.5 | |
| Réunion | Fr. CFA | 10.9 per kg | 43.6 | Refers to gas-oil |
| Sierra Leone | Shilling | 130 per ton | 18.2 | Refers to furnace fuel |
| | Shilling | 3.33 per gallon | 117.7 | Refers to diesel oil |
| Sudan | — | — | 31 | Refers to total production cost (mills/kWh) Khartoum. |
| Sudan | — | — | 47 | Ditto at Wad Medani |
| Togo | Fr. CFA | 860 per hectare | 38.2 | Refers to fuel oil (light) |
| | Fr. CFA | 740 per hectare | 32.9 | Refers to Bunker C fuel |
| | Fr. CFA | 12.93 per litre | 54.3 | Refers to gas oil |
| Tunisia | Dinar | 7 per ton | 12.2 | Heavy fuel oil |
| | Dinar | 3.039-3.415/hl. | 14.2-15.9 | Gas oil at Sousse, Sfax and Gafsa |

TABLE 25

**Development of electric power consumption in relation to the total consumption of primary energy from commercial sources, for selected countries** — 1955-1961

(Calorific content of solid, liquid and gaseous fuels and hydro-electricity converted to coal equivalent) ([a])

| Country | Percentage of hydro production in total electricity production | | Total consumption of primary energy per inhabitant (kg per inhabitant in coal equivalent)([a]) | | | Total gross consumption of electricity as percentage of total consumption | |
|---|---|---|---|---|---|---|---|
| | 1955 | 1961 | 1955 | 1961 | 1961 as index (1955=100) | 1955 | 1961 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **North Africa**: | | | | | | | |
| Algeria | 33 | 24 | 232 | 265 | 114 | 19.2 | 24.1 |
| Libya | — | — | ... | 307 | ... | ... | 14.4 |
| Morocco | 88 | 92 | 192 | 175 | 91 | 23.2 | 25.1 |
| Tunisia | — | 6 | 174 | 172 | 99 | 20.0 | 21.2 |
| Sudan | — | — | 40 | 52 | 130 | 4.8 | 7.6 |
| UAR (Egypt) | — | 27 | 243 | 312 | 128 | 12.5 | 22.4 |
| **West Africa**: | | | | | | | |
| Cameroon | 74 | 99 | ... | 144 | ... | ... | 75.4 |
| Equatorial Africa([b]) | — | — | 26 | 49 | 188 | 12.5 | 16.6 |
| Ghana | — | — | ... | 92 | ... | ... | 30.4 |
| Liberia | 35 | 19* | ... | 58 | ... | ... | 75.0 |
| Nigeria | 30 | 15 | 34 | 48 | 141 | 11.0 | 18.9 |
| Sierra Leone | — | — | ... | 52 | ... | ... | 19.2 |
| Togo | — | — | ... | 28 | ... | ... | 12.5 |
| West Central Africa([c]) | — | — | 29 | 38 | 131 | 10.9 | 18.4 |
| **North East Africa**: | | | | | | | |
| Ethiopia | 45 | 55 | 5 | 10 | 200 | 27.2 | 27.2 |
| Somalia | — | — | ... | 22 | ... | ... | 16.6 |
| **Central Africa**: | | | | | | | |
| Angola | 42 | 78 | 41 | 83 | 202 | 13.8 | 19.5 |
| Congo (Leopoldville) | 92 | ... | 118 | 112 | 95 | 36.3 | 49.0 |
| Zanzibar & Pemba | — | — | ... | 51 | ... | ... | 25.0 |
| Fed. Rhodesia and Nyasaland | 10 | 70 | 555 | 568 | 102 | 29.1 | 41.2 |
| **Southern Africa**: | | | | | | | |
| Mozambique | ... | ... | 86 | 129 | 150 | 4.8 | 9.4 |
| Madagascar | 75 | 59 | ... | 37 | ... | ... | 26.1 |
| Reunion | 19* | 6 | ... | 114 | ... | ... | 25.0 |
| South Africa | — | — | 2387 | 2414 | 101 | 23.2 | 29.9 |
| Total (for countries included) | 13 | 22 | 305* | 325* | 106* | 22.5* | 29.2 |

a) Electricity expressed in coal equivalent at 2000 kWh/ton.
b) Includes Central African Republic, Chad, Congo (Brazzaville) and Gabon.
c) Includes Dahomey, Guinea, Ivory Coast, Mali, Mauritania, Niger, Senegal and Upper Volta.

TABLE 26

**Calorific equivalents used for conversion of fuels in terms of standard coal(a)**

| Category | kcal/kg | Equivalence in standard coal |
|---|---|---|
| **Solid fuels (kg)** | | |
| Imported coal | 7,000 | 1.00 |
| Coal — S. Africa | 6,900-7,100 | ” |
| Coal — S. Rhodesia | 6,900-7,100 | ” |
| Coal — Nigeria | 6,900 | 0.98 |
| Coke (of coal) | 6,300-7,500 | 0.9-1.07 |
| Charcoal | 7,500 | 1.07 |
| Fuel wood | 3,500 | 0.5 |
| **Liquid fuels (kg)** | | |
| Crude petroleum | 9,100 | 1.3 |
| Refined products: (gasoline, kerosene, fuel oils) | 10,500 | 1.5 |
| **Gaseous fuels ($10^3$ $m^3$)** | | |
| Natural gas(b) | 9,300 | 1.33 |
| Refinery gases | 12,300 | 1.75 |
| Manufactured gas | 4,200 | 0.6 |
| Liquid butane (kg) | 11,700 | 1.67 |
| Liquid propane (kg) | 11,900 | 1.7 |
| **Electricity (1000kWh)** | — | 0.5 t or 0.125 t |

a) Refers to Chapters 2 and 3.
b) One $m^3$ of natural gas is taken as equivalent to 2.22 $m^3$ of manufactured gas equivalent.

## Part II

# ELECTRIC POWER SUPPLY IN AFRICA
# THE PRESENT SITUATION AND ITS RECENT DEVELOPMENT

## Chapter IV

## CONSUMPTION OF ELECTRIC ENERGY

### A. INTRODUCTION

The preceding chapters have touched on various influences which affect the development of electricity consumption in different countries of Africa. On the one hand economic growth leading to higher total national output — in mining, manufacturing, agriculture, transport and services — presupposes a rising consumption of kilowatt-hours per unit of product and per worker employed. On the other hand this higher average output per head of population, reflected in a gradually rising purchasing power per family unit, leads to a demand for more light and power in the average home. Rising population and a growing number of family units also means that the number of potential household consumers is increasing. At the same time public lighting, public services such as water supply, hospitals and transport systems, and commerce, administration and other special requiriments of urban life — all will tend to expand as the economy grows.

Today a growing supply of electricity is everywhere recognized as essential if such a development is to proceed. In African countries, as has already been shown in chapter I, the levels of national income per head and of kWh consumed per inhabitant do in fact tend to go hand in hand. Nevertheless, when conditions in many different countries of the world are compared, the actual rate at which electricity demand can rise is seen to bear some relation to the level of existing consumption. Particularly during the early stages, this is largely because "... prosperity awaits power and power awaits prosperity". To gain the advantages of productive efficiency and low-cost distribution a certain concentration of electricity demand is required. On the other hand, consumers cannot afford power until a degree of economic growth already exists. Low densities of population, long distances between centres, a lack of diversified natural resources and a shortage of easily exploitable energy reserves — these and several other limiting factors may all militate against consumption growth.

In Africa it is in fact often difficult to separate the aspect of consumption from that of production and distribution. Nevertheless, because electric power cannot readily be stored, it is finally the demands of consumers which determine the scope of the productive system. For that reason it is convenient to analyse the tendencies of electric energy consumption in African countries before reviewing the characteristics of power production and transmission.

### B. CHARACTERISTICS OF ELECTRICITY CONSUMPTION

#### a) **General tendencies**

For Africa as a whole the trend of consumption over the last twenty-five years has broadly resembled the world trend, though in some recent years the actual rate of growth has been a little higher. The main details can be seen from a study of table 27, which covers the evolution of consumption since 1938. Africa's total electric power requirements are currently growing at a rate which implies a doubling of consumption in 8-9 years. Average use per inhabitant is now a little below the world level as it existed in 1938.

These average figures conceal the very great dispersion between different African countries. In fact, as can be seen from table 28, the actual volume of consumption varies from country to country in a ratio of about 2,700 to one. The table presents data covering total gross and net consumption in 1961. For certain countries these data remain provisional, notably as concerns some indices of development since 1955 and 1960 respectively.

Pursuing the analysis, it is necessary to gain some idea of the average use in different countries in terms of kWh consumed per inhabitant. This is shown in table 29. The different territories are arranged in increasing order of gross consumption per head in 1961. At the same time average annual percentage rates of consumption growth for the five-year period 1956-1961 (and also for the decade 1948-1958) have been calculated for comparative purposes. Reference should also be made to map 4, which shows consumption in the different territories by circles proportionate in area to kWh per inhabitant. The more densely populated areas are also delineated on the map, as are all towns with population above 100,000.

Consumption per head in 1961 varied in the different countries within the range of 750 to one. Many of those with (for Africa) relatively high population densities, as in parts of west and east Africa, are still characterized by low specific consumption. The countries of North Africa fall broadly within the middle range, while the southern part of the continent includes adjoining regions of very high and very low average use. In various territories of the interior consumption per inhabitant tends to be very low.

Because average consumption per head for Africa as a whole is greatly influenced by the highest levels reached it does not reflect the general situation very closely. The median value for the different countries is some 35 kWh/head only, while the upper quartile value is only 90 kWh and the lower quartile as low as 10 kWh per inhabitant. For countries using 20 kWh per head or under, the average rate of increase in consumption between 1956 and 1961 was 14.5 per cent. Between 20 and 40 kWh per head the corresponding average growth rate was 13.8 per cent, while for countries using over 80 kWh per inhabitant the mean rate of increase fell to 6.2 per cent.

The figures may be set out as follows:

| Range of consumption per head | Average annual growth rate |
|---|---|
| (in 1961) | (1956-1961) |
| Under 20 | 14.5 per cent |
| 20 — 39 | 13.8 " " |
| 40 — 79 | 8.8 " " |
| 80 and over | 6.2 " " |

There is thus in Africa a tendency — though with many exceptions — for consumption per head and average rates of consumption increase to be inversely correlated — a fact that may be noted in some high-consumption regions of Europe but which cannot be explained by the same factors under conditions obtaining in Africa.

### b) Some characteristic examples

Closer study of consumption in different parts of Africa brings out the existence of some characteristic types of development. Entirely different conditions and rates of increase may also exist within the areas of separate main supply systems in the same territory. Frequently up to 90 per cent of total consumption may be concentrated around one main town. The endowment in natural energy reserves and relative economic prospects arising from non-energy natural resources of economic interest are among factors involved in the assessment. The same applies to population density, rate of population growth, differences in climate and average income per head. Limited production possibilities may tend to hold back consumption in some areas. In this connexion differences in methods used by undertakings to assess future consumption prospects probably help to explain some of the departures from what may be regarded as a normal trend.

To analyse electric power consumption in the setting of the various economic determinants which influence it in different areas the reader is referred in the first instance to data presented in part I of the present study — for example, in respect of population density and growth, natural resources, primary energy use etc. Here attention will simply be drawn to some characteristic types of growth which appear to exist in certain groups of territories.[13]

Reference to table 29 (columns 2 and 3 shows that, owing to differences in growth of consumption and population respectively, the number of kWh consumed per inhabitant has risen at very different rates between 1956 and 1961. Moreover, in some countries figures are greatly inflated in the latter year (though not always in the former) by relatively heavy industrial consumption which may suffice to transform a low average use into one apparently much higher. This is true, for example, of the Cameroun Republic (up to 90 per cent used in bauxite reduction in 1961) and of Northern Rhodesia.

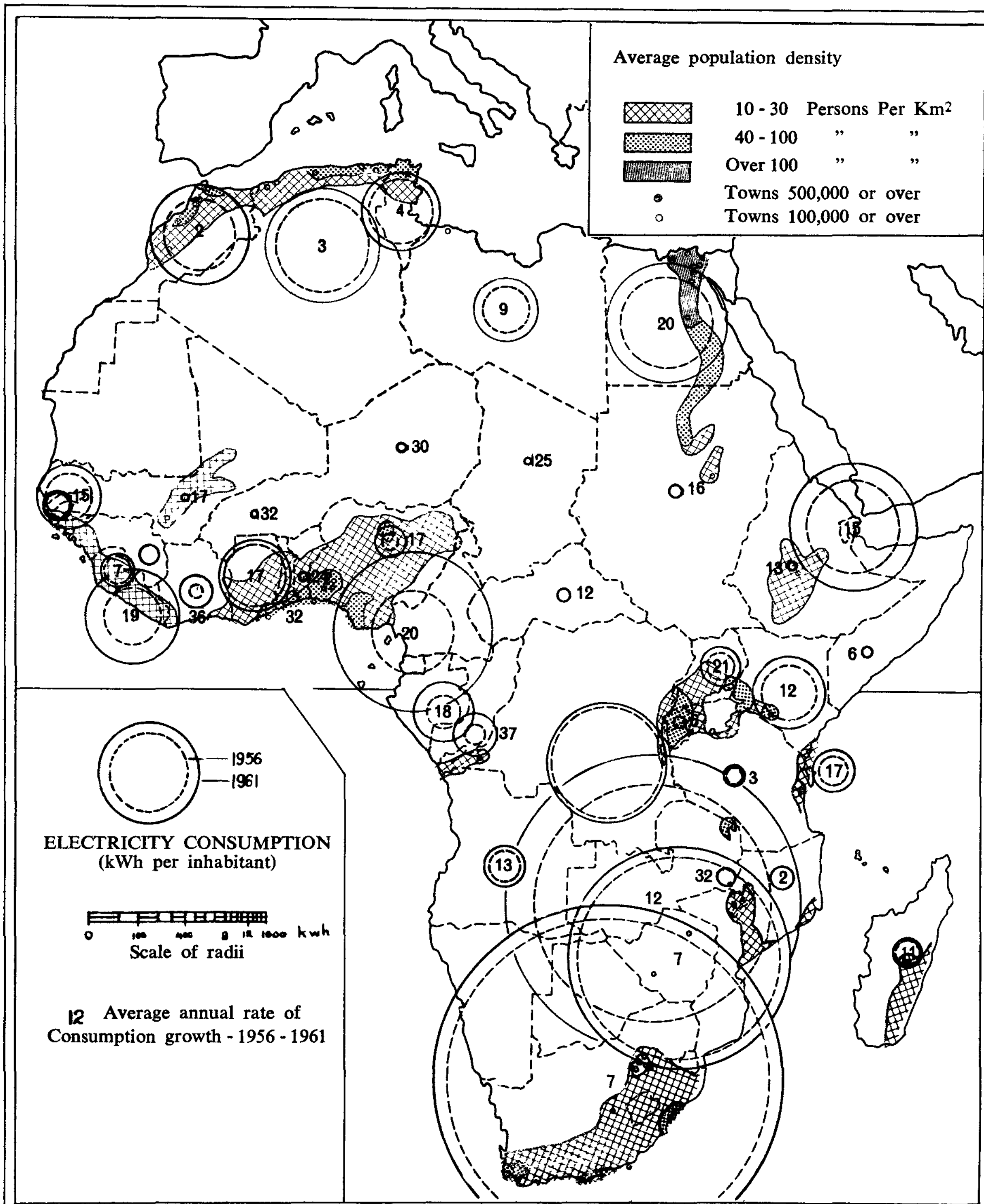
Countries may be broadly grouped in various ways i.e. according not only to kWh used per head but in respect of possession of exploitable energy reserves, energy-intensive natural resource potential etc. In practice one may various reasons distinguish territories possessing characteristically low rates of consumption growth; those showing higher rates

[13] In comparing levels of consumption and also the development of supply in different countries it may be noted that two further factors — comparative levels of education and differences in the period during which electrification has been pursued — may both help to explain the situation existing in particular areas. Recent studies have shown that the primary school enrolment ratio for different African territories — i.e. estimated primary enrolment relative to the 5-14 year age-group of the population — may vary from about 4 to nearly 100 per cent.

If the year in which gross electricity consumption was under one million kWh is taken as near to the commencement of electrification, a number of African territories were in this position between 1931 and 1938 and others as recently as 1948 or 1949. In a few cases, on the other hand, electricity supply systems had their origin in the late nineteenth century.

MAP 4

## DISTRIBUTION OF GROSS ELECTRICITY CONSUMPTION IN AFRICA RELATIVE TO POPULATION 1956-1961




The boundaries shown on this map do not imply endorsement or acceptance by the United Nations

Compiled by the United Nations Economic Commission for Europe

which have of late been tending to decline; others again where consumption is accelerating or seems likely to accelerate; and yet a further group where high but fairly constant growth rates seem to prevail.

Examples of the first group (around 0 - 7 per cent per year) include Dahomey, Somalia, Madagascar, Ghana, Tunisia and Morocco (5 - 90 kWh per head respectively) where the highest characteristic growth rate appears to be around 7 per cent. It would appear, rather surprisingly, that there is no particularly close correlation between low growth rates and low population density.

At the other extreme a number of territories show more or less constant growth rates maintained at a high level (9 - 20 per cent annually). Most of the countries of north Africa, with medium consumption per head (51 - 140 kWh) fall in this group, i.e. Algeria, Egypt, French Somaliland and Llbya. The same group includes Senegal, Reunion and the Sudan (15 - 17 per cent annual increase) of which only the last has a lower than average consumption (6 kWh per inhabitant).

Between these extremes a certain number of countries, including Ethiopia, Nigeria and Togo (6-17 kWh per head in 1961) appear to be characterized by an actual or potential acceleration of electric power demand towards high rates of increase. This seems to be due as much to general expansion as to special industrial requirements. On the other hand a further group has shown some tendency for the annual increase in consumption to slow down, though in some cases this probably heralds a re-acceleration when incipient or impending economic growth can come fully into play. This situation appears to characterize the Cameroun Republic, Liberia, Mali, Tanganyika and Uyanda — territories among others, which possess hydro-electric resources and a sizable industrial potential based on mineral reserves, but where present consumption varies between 4 and over 200 kWh per head.

As an example of a territory where quite different trends exist in separate regional power supply areas Gabon, with its divergent trends in the Libreville and Port Gentil - Lambaréné regions, may be cited. In the one, possessing a maximum load of 1.6 MW and a 30 per cent growth rate for consumption, there is promise of an expanding network and studies are in progress for paper pulp and cellulose industries. In the other the maximum load is at present 2.3 MW and there are projects for a petrol refinery, a cement works and other new industries. The forecast growth in consumption is here put at 7 per cent annually. Gabon as a whole falls within the area of medium consumption (48 kWh per inhabitant), and possesses an annual growth rate of 18-20 per cent.

### c) The separate sectors of consumption

Examination of the breakdown of electricity use in Africa throws some further light on consumption characteristics. Available information relative to 1961 has been analysed in table 30 in terms of the three main consumption categories — industrial; domestic and other low-voltage consumption; and use for transport purposes, respectively.

In Africa there is a general tendency for industry to account for a smaller percentage of total net consumption than in many other areas, where around 70 per cent would be regarded as a normal contribution. Only six countries in Table 30 approach this level and in eight industry's role is nearer 30 per cent only. Information on transport consumption is scanty. In Europe around 5 per cent of total requirements is commonly used in this way. In the three African countries for which information is available and for which significant consumption exists — the Malagasy Republic, Morocco and Tunisia — transport uses between 3.5 and 7.5 per cent — a normal figure.

The balance of total requirements is taken by the low-voltage sector, which includes public lighting, public service and administration — including hospitals, water supply, etc. — commercial requirements, agriculture and, of course, consumption by households. In Africa this sector is often predominant, particularly in countries where total consumption is low, because various essential public services such as water pumping take a prominent role, while small-scale handicraft consumption, which is classified within the same group, is also of some potential importance. It is only after large-scale industries have taken a firm hold that industrial demand can be expected to predominate.

Comparison between tables 29 and 30 does in fact confirm the existence of this situation in Africa. It is in the countries with above-average consumption per head where the relative contribution of industry is high. It is also in some of these where declining rates of increase have tended to occur.

These three main consumption sectors will next be discussed separately.

(i) **Industry:** Mining for copper, iron and tin ores, gold and various other important minerals, including coal, already plays a large part in African output, though commonly it does not predominate in the total national product of the countries concerned. Smelters and mineral processing are becoming increasingly important and usually require large quantities of low-cost power. The products of cement works, textile factories and paper works are three key requirements for economic advancement and all require relatively important quantities of electricity in their manufacture, as also do petroleum refineries. Sugar processing is already important locally. A number of African countries, particularly these such as Liberia which possess important iron ore reserves, are at present interested in setting up domestic iron and steel industries. In a few of these metallurgical coke is already available.

Conditions in respect of location and raw materials may in principle be favourable for such a development in some of the regions where consumption is at present comparatively low.

Some specific consumption figures for various energy-intensive products, certain of which could later be of importance in Africa, were given in part I, chapter I. The possibilities and trends of primary aluminium production will be discussed in part III. Here it may be mentioned that the electrolytic plant established in 1957 at Edea in the Cameroun (52,200 tons production in 1962) already accounts for 90 per cent of total electricity use in that country. Bauxite extraction potential is also great in Guinea, among other countries, and this source of power demand seems certain to loom larger in the near future. Apart from the ancillary demands that they in turn create, the immediate importance of these various industrial requirements is that additionally they often furnish electric power for public supply in areas where generation is lacking as well as making possible improved water supply and other essential amenities.

Information on the detailed breakdown of industrial electric power consumption is at present scanty for many parts of Africa. Table 31 shows the development in some main sectors between 1955 and 1960 for two contrasted countries — the Malagasy Republic and Tunisia. The data show the relative importance of various special and general categories of demand pertaining to countries with differing industrial structure.

(ii) **Transport:** There are in Africa no fewer than fourteen land-bound or inland states -more than in the rest of the world together - which in all comprise nearly one quarter of the continent's total land area and over 14 per cent of its population. For this reason, and because of the great distances in many cases between consuming centres and points of production, the development of low-cost means of surface transport and adequate transport capacity for economic development is a matter of primary importance in many areas. A number of inland states, such as the Central African Republic, Chad, Niger and Mali, have no rail services. In other cases, as with the states of the Federation of Rhodesia and Nyasaland, most outgoing freight must travel over considerable distances, in this particular case through running rights across Mozambique to the ports of Beira or Lourenço Marques. Between 25 and 30 per cent of Rhodesian coal supplies are used by rail services. At the same time adequate means of large-scale and low-cost transport are essential to the further development of electric power production itself, not only to assist the transfer of fuel but also to make possible the easier moving of large items of power-generating equipment.

In various parts of the world diesel traction is introduced as a precursor of electrification. Diesel locomotives are currently being supplied for use in Nyasaland and elsewhere in Africa where conditions would already make for improved working with them. Electrification of railways has proved to be strongly justified in various countries outside Africa when the density of traffic becomes sufficient. Electric traction is efficient in dealing with severe gradients; it avoids the need for coal where this is not easily available and where hydro power is present; and finally, it is ideal for flexible and rapid transport where dense traffic is involved since it can increase line capacity by greater speed and the avoidance of halts for water, etc. Despite the heavy initial capital expenditure, there is also an economic incentive due to lower costs when the density of traffic exceeds a necessary minimum, particularly, as has been found in some areas, where higher specifications are possible — i.e. 25 kV AC single-phase as against 1500-3000 V DC.

An outline survey of railway track conditions in Africa is presenttd in table 32. It can be seen that the amount of electrification at present is limited except in north Africa, and particularly in Morocco, where 35 per cent of the track is electrified with overhead lines at 3000 V DC; and in South Africa (16 per cent with similar specifications). Despite the comparatively limited freight traffic in the Congo (Leopoldville), some 10 per cent of track there has electric traction with overhead lines at 25 kV AC. Over Africa as a whole only some 7.3 per cent of track is so far electrified, although freight traffic in parts of east Africa (particularly Kenya), Nigeria, Angola and the Sudan might be approaching the point where electrification would perhaps be feasible. In Africa it seems likely that this form of surface transport would be particularly economic in view of the conditions to be satisfied and the presence of abundant hydro power.

(iii) **Household and other low-voltage consumption:** Despite the vast potential market for household use of electricity, the subject is difficult to appraise realistically in terms of population owing to the existence, in nearly all countries of Africa, of socio-economic groups which may be entirely different in character from one another. If the problem of measuring the demand-promoting characteristics of actual and potential domestic consumers remains a major and costly source of difficulty in Europe it is enormously more complicated still in most African countries.

Cash incomes per head of population commonly remain for the mass of population too low at present to support any home use of electricity which, relatively speaking, is still costly. In Uganda, to take one not untypical example, average annual cash income per head, even in the more densely populated areas of the country, varies from about £ 8 to £ 19. The average cost per kWh to the consumer there — though relatively very favourable for Africa — is nearly 1.7 pence. Under these conditions, and with wage rates in some countries remaining stable for many years despite changes in the cost of living, it is not surprising that the number of consumers of electricity, though rising, remains very low. In Guinea, for example, where consumers have increased very rapidly since 1951, there were still, in the Conakry area, only some 7,720 by 1958 in a total population of around three million, as against 1,235 in 1951. After 15 years' operation and promotional activity by the Electricity Board of Uganda, the number of consumers still amounts to some 34,000 in a population of 7 million. Assisted wiring schemes and hire purchase have been used to encourage consumption. Unit installations have been supplied at a constant charge to avoid metering and wiring, despite the possibilities of abuse. The charge made under this arrangement is 8.50 shillings per month for the one amp. unit and 20 shillings for the five amp. unit.

Provision for consumption in rural areas for agricultural and household purposes raises problems in all countries unless very large consumption per farm is possible. Steady growth in the number of farming consumers and in specific consumption per farm have begun to occur of late in some areas of south and east Africa.

Rates of growth in the number of family units are normally more significant than data for population growth as indicators of domestic demand for electricity provided they reflect the demand for housing. In fact, however, there appears to be great variability in African countries in the rates at which new residential building construction is proceeding. In part this probably reflects *short-term fluctuations* in the economic situation, a question discussed in chapter I; while variations in statistical data also contribute to the uncertainty surrounding this subject. However, table 33, which sums up the data available in terms of building authorizations or units constructed between 1956 and 1961, shows very great variation from one territory to another, as can be seen from the indices for activity in 1961 relative to that in 1956 as base. Particularly in parts of north and west Africa and for some areas of very low population density, it would seem that the potential market for domestic electricity requirements is increasing very rapidly. It appears that it might be useful if more attention were given than is at present the case to trying to assess characteristics of household and other forms of low-voltage demand — actual and potential alike — for very simple levels of consumption and equipment so that ways could be sought to raise the use of electricity from all sources in the more populous areas as quickly as possible.

Percentages of population served or connected in some main towns and urban areas of Africa appear not to differ too widely from those elsewhere, to judge from some scattered data brought together in table 34 — to which information relating to a non-African country — France — has been added for comparison. It is outside the principal towns that the problem of economic distribution or isolated generation has everywhere to be solved. One means of reducing the difficulty while awaiting fuller development of an expanding area of effective demand is that of using small mobile diesel generators, a subject that is discussed further in the next chapter.

## C. THE COST OF ELECTRICITY TO THE CONSUMER

In nearly all African countries the cost per kWh to the consumer is high. In general this reflects of course an inadequate scale of production, insufficient over-all density of consumption plus low load factors. It also reflects very high fuel costs and very high costs of maintenance and operation. Generating plant is frequently old and there is insufficient capital and demand alike to justify introducing new high-efficiency equipment.

This, however, is only a generalized picture. Reference to table 35, which attempts a comparison (expressed for convenience in mills, or tenths of a U.S. cent, per kWh) between the average revenue received per kWh sold in a selection of 18 widely-distributed territories, shows how wide is the range of cost of the average kWh to the consumer. With one exception the ratio between the highest and lowest specific costs included is as 1 : 7, with a rough median at a little below 50 mills (4.3 pence) per kWh. Where supply systems are large and interconnected, with a substantial and well-diversified demand which can be satisfied from large-scale hydro-electric production (Federation of Rhodesia and Nyasaland, and Uganda) charges are comparatively moderate. In other cases where costs may reach up to 100 mills (8.5 pence) per kWh or more, consumption can average as low as 4-7 kWh per head (Mali and Togo) and diesel fuel charges may be very high.

Average revenues per kWh shown in table 35 approximate to mean charges per kWh for a variety of different types of use. Tariff structures employed by most African electricity undertakings are fairly sophisticated. A selection of various types of tariff in use in some fifteen supply areas is summarized in annex IV. These are mainly degressive in form, commonly with a fixed annual charge corresponding to the power taken plus an energy charge inversely proportionate to hours of use.

The normal tariffs are usually strongly promotional in that there is a considerable reduction for higher rates of consumption, with special off-peak and night tariffs for high-voltage and low-voltage consumers, the latter commonly being specially designed for air-conditioning, water heating etc. While tariffs commonly comprise a fixed item and a proportional item, in some cases there is also a component proportional to average hourly wages. In such cases, as in Tunisia for example, there is thus a relationship, adjusted at 3 monthly intervals, between the cost of energy and that of materials and labour. Tariffs are generally weighted considerably in favour of industry in respect of low rates per kWh, as is normal elsewhere, those for low-voltage use being often high by comparison except where consumption is considerable. In certain cases there is a flat-rate charge for lighting. In Ghana this is on the basis of separate monthly charges for 40 watt and 60 watt lamps.

There are sometimes important differences, as is understandable, in tariffs applied to different regions within a country. In Tunisia the area of supply is divided into tariff zones, a coefficient of between 1.0 and 1.3 being applied, of which the maximum figure relates to isolated networks supplied by diesel plants. This particular system is at present under review, however, with a view to modification.

## D. THE FURTHER DEVELOPMENT OF CONSUMPTION

For its further development in Africa, consumption by industry is due to increase very rapidly wherever suitable natural resources exist (see also annex V, containing summaries of prospects for 20 selected countries). Widespread sources of bauxite, iron, copper, tin and various ores which can be used to produce ferro-alloys, plus phosphates, nuclear fuel sources and many basic vegetable products, are associated with low-cost hydro power, natural gas and accessible coal and oil. There is thus an early prospect of developing basic industries, including in some cases iron and steel as well as large electrochemical complexes, and in addition the possibility of setting up associated groups of light industries for manufacture of finished products required for internal needs in Africa and for export. In varying degree some limiting factors at present, in different countries where suitable natural resources occur, are the existence of an energy supply (notably an adequate public electricity system), a sufficient source of suitably skilled labour and appropriate means of surface transport. Where these needs can be met it seems likely that the principle of setting up carefully planned industrial estates has much to recommend it. Although the specific consumption per unit of product would be much lower on such estates for manufacturing purposes than the thousands of kWh per ton required for certain primary products, experience elsewere shows clearly that a high and increasing number of kWh would be needed per worker employed (often many thousands of kWh per worker and per year)[14] to ensure the viability of the enterprise and augment the productivity of skilled labour. Prospects in certain fields are discussed further in part III of this study. Map 5 also presents an example of a current development.

In all except a few countries of the world there remains enormous scope for household use of electricity, which everywhere is still growing steadily. This can be seen by comparing different levels of household consumption per head (not per consumer) in different European countries with similar social and economic structures and living standards. While in countries such as Turkey and Cyprus (with total gross consumption of 100 and 460 kWh per inhabitant respectively in 1961) household use varied from 16 to 81 kWh per head, it ranged between 160 and 700 or more in another group with (among themselves) similar though much higher levels of per capita national income[15].

In Africa the vast potential demand for home use of electricity is, at the initial stage, often a matter of supplying current (and possibly equipment) for little more than lighting purposes for a few hours during the evening, and for radio. From the point of view of an economically well-balanced supply, therefore, the initial household demands of the average African consumer tend to be characterized by high peaks with maximum demands which may coincide with system peaks, and are thus not easily assimilated. Nevertheless, household consumption is rising rapidly in some areas (requirements per African household in Salisbury, S. Rhodesia have of late trebled in seven years, for example) and is almost certain to become more diversified on a wide front as average income rises. To judge by experience elsewhere, this last requirement is largely a function of higher labour productivity induced by increased electrification in industry.

Transport consumption, the third main source of expanding demand in Africa, offers more scope there than elsewhere since its improvement would remove a bottleneck in many areas and have a "multiplying effect" on economic activity in general. While suitable natural sources of power exist, however, the necessary capital often does not.

Population in most parts of Africa is growing very rapidly — on the average by over two per cent

14 Independently of industrialization and degree of electrification and living-standards, industrial consumption per wage and salary earner in industry of all kinds in Europe was at least 4000 kWh in 1961, and many times mare where hydro resources are plentiful.

15 Higher levels of household use than this do of course exist in certain countries, though house heating is a non-comparable factor in some of these.

per year. But total national product must increase far more rapidly than population if economic growth is to occur. Everywhere it has been found that a rising national product requires in addition a more rapidly rising use still of electric energy, so that kWh applied per unit of total product should also increase steadily. How do African economies stand on this basis?

Some conservative population projections[16] for certain countries are given in table 36. In contrast with those for Europe, for instance, projections for many African countries are already in need of revision, as they tend to be overtaken by events. Even so, it is clear that growth-rates for electricity consumption almost everywhere are far higher than those for population.

When present kWh consumption is related to national income (expressed in common currency) it is possible to take the measure of the development problem more clearly. The following figures show gross electricity consumed in kWh, expressed firstly in terms of kWh per inhabitant and secondly in terms of kWh per dollar of national income in 1961:

To evaluate these figures reference may be made to a similar analysis for European countries, covering also trends in kWh per unit of national product over the period 1950-1958.[17] By comparison the above figures indicate fairly normal ratios of relative electrification at the higher African levels of consumption per head (the lowest European data show about 0.5 kWh per dollar of product), at 100 kWh/head in a few countries about 1950, rising smoothly to nearly 4 kWh/dollar where consumption is 3000 kWh/head. The comparison suggests that the African ratios in column 3 corresponding to the lower levels of consumption per head will probably rise rapidly, perhaps doubling in under ten years.[18]

To sum up this discussion, table 37 presents some official estimates of average rates of consumption growth for the immediate future. Most of the rates foreseen are higher than those experienced in 1961, but do not appear excessive. In certain cases, in fact, the estimates may appear somewhat conservative. This would not be surprising, since recent experience outside Africa, in regions highly electrified, has shown that factors which make for a rising consumption of electricity have of late been generally underestimated—an error likely to prove more costly than that due to over-optimism.

| Country | kWh per inhabitant (1961) | kWh per US dollar of national income (1961) |
|---|---|---|
| Sudan | 9 | 0.15 |
| Tanganyika | 15* | 0.25 |
| Nigeria | 17 | 0.25* |
| Ghana | 56 | 0.30 |
| Tunisia | 61 | 0.37 |
| Uganda | 36 | 0.57 |
| Kenya | 59 | 0.67 |
| Morocco | 86 | 0.67 |
| Algeria | 119* | 0.60 — 0.70 |
| UAR (Egypt) | 140 | 1.17* |
| Fed. Rhodesia and Nyasaland | 469 | 2.97 |

## E. OBSERVATIONS

Electricity consumption in Africa is in most territories not merely very low (the median is under 35 kWh per head) and often concentrated round a few towns, but is also well below the average for the continent as a whole. Of late consumption over-all has been doubling about every eight years.

In many regions, and particularly in various inland states, there is an urgent need to raise the use of electricity in order to increase the output of goods and services of all kinds. While in many parts of the continent the latent demands which must arise from the presence of rich natural resources now appear to be on the point of gathering momentum, there are a number of regions where there is so far little evidence of this. These are generally areas where there is special difficulty in breaking the vicious circle of high cost per kWh (as exemplified by table 35) and low levels of average income plus costly and insufficient means of transport.

Levels of electricity use appear to be developing satisfactorily in a majority of African countries when considered in relation to existing national income. There has of late been a fairly clear inverse relationship also between average consumption per head and the rate at which consumption is increasing. It is the rate of growth of real national income, however, that commonly remains insufficient. If this is to rise more rapidly, use of electricity must grow even more swiftly than it is growing at present. It would seem that detailed study of the future medium-term perspective of electric power demand is needed in many African countries in order to evaluate more clearly the need for capital expenditure.

[16] Based on the United Nations report on the subject referred to in the list of references.

[17] See document ST/ECE/EP/2 (particularly Figure 2), United Nations, Geneva, 1960. (The full reference is given in Annex I).

[18] The actual consumption per inhabitant in African and European countries should not be directly compared, since large groups within the African populations do not yet consume electricity. European and African ratios discussed above would be roughly comparable if sections of non-consuming African populations were not included.

TABLE 27

**Gross consumption of electric energy in Africa and in the World — 1948—1961**

| YEAR | WORLD: Gross consumption ($10^9$ kWh) | WORLD: Index of increase (preceding year listed=1) | WORLD: kWh per inhabitant | AFRICA: Gross consumption ($10^9$ kWh) | AFRICA: Index of increase (preceding year listed=1) | AFRICA: kWh per inhabitant |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1938 | 460.0 | — | 210 | 7.5 | — | 45* |
| 1948 | 809.7 | 1.76 | 350 | 13.4 | 1.79 | 66* |
| 1950 | 962.0 | 1.19 | 400 | 16.0 | 1.19 | 77 |
| 1955 | 1544.0 | 1.60 | | 26.4 | 1.65 | |
| 1956 | 1694.9 | 1.10 | 610 | 28.8 | 1.09 | 125 |
| 1957 | 1804.5 | 1.06 | | 31.5 | 1.09 | |
| 1958 | 1908.0 | 1.06 | | 33.8 | 1.07 | |
| 1959 | 2098.2 | 1.10 | | 36.7 | 1.09 | |
| 1960 | 2299.9 | 1.10 | | 40.0 | 1.09 | |
| 1961 | 2453.3 | 1.07 | 800 | 43.1 | 1.08 | 561 |

TABLE 28

**Development of electric energy consumption and of its main constituents — 1955-1961 ($10^6$ kWh)**

| Country | Total available for consumption | Total net consumption | Generating, transmission and transforming losses | Indices of net consumption for 1961: Industry 1955=100 | Industry 1960=100 | Domestic etc. 1955=100 | Domestic etc. 1960=100 |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **North Africa:** | | | | | | | |
| Algeria | 1435(a) | ... | ... | ... | ... | ... | ... |
| Libya(b) | 101.0 | ... | ... | ... | ... | ... | ... |
| Morocco | 1030 | 874.0 | 156.0 | 110 | ... | 141 | ... |
| Tunisia | 285(a) | 240 | 45 | 120* | 102* | 132* | 102* |
| Sudan(c) | 103.1 | 93.0* | 10.1* | 230(d) | 116(d) | 230(d) | 116(d) |
| UAR (Egypt) | 3722 | 3137.0 | 585 | ... | ... | ... | ... |
| **West Africa:** | | | | | | | |
| Cameroon | 950* | 924.2* | 25.8* | 458 | 102 | 242 | 110 |
| Central African Republic | 9.4(e) | 7.1 | 1.0* | 274 | 122 | 272 | 119 |
| Gabon | 21.7 | ... | ... | ... | ... | ... | ... |
| Chad | 9.0 | ... | ... | ... | ... | ... | ... |
| Congo (Brazzaville)(c) | 30.9 | ... | ... | ... | ... | ... | ... |
| Gambia | 5.1 | 4.3 | 0.8 | 181(f) | ... | 153(f) | ... |
| Ghana | 389.6 | 350* | 39.6 | 162(g) | 104(g) | 162(g) | 104(g) |
| Liberia | 112* | 102 | 10 | 350* | ... | ... | ... |
| Nigeria(h) | 434.1 | 354.1 | 83.0* | ... | ... | ... | ... |
| Sierra Leone(j) | 48.0 | ... | ... | ... | ... | ... | ... |
| Togo | 10.0 | 9.5 | 0.5 | ... | ... | ... | ... |
| Guinea | 27.0* | 25.0* | 2.0* | ... | ... | ... | ... |
| Ivory Coast | 92.8 | 85.2 | 7.6 | ... | ... | ... | ... |
| Dahomey | 10.5* | 9.6 | 1.0* | — | — | 344 | 100 |
| Niger | 9.2 | ... | ... | ... | ... | ... | ... |
| Senegal | 152(a)* | 138 | 14 | 237(d) | 119(d) | 237(d) | 119(d) |
| Mali | 15.7 | 13.1 | 2.6 | 204 | ... | 198 | ... |
| Upper Volta | 10.0 | ... | ... | ... | ... | ... | ... |
| **North-East Africa:** | | | | | | | |
| Ethiopia | 124.4 | 108 | 16.4 | 318 | ... | 220 | ... |
| French Somaliland | 10.7 | 9.7 | 1.0 | ... | ... | ... | ... |
| Somalia | 12* | 11 | 1* | 140(i) | 106(i) | 140(i) | 106(i) |
| **Central Africa:** | | | | | | | |
| Angola(j) | 142.6 | ... | ... | ... | ... | ... | ... |
| Congo (Leopoldville) | 2137* | 1987* | 150* | ... | ... | ... | ... |
| Kenya | 429.0 | 356.6 | 72.4 | 176 | ... | 191 | ... |
| Tanganyika(a) | 140.0* | 121.0 | 19.0 | ... | ... | ... | ... |
| Ruanda-Urundi(j) | 18.7 | ... | ... | ... | ... | ... | ... |
| Uganda(c) | 243.8 | 209.2 | 34.6 | 391(k) | 104 | 153(k) | 101 |
| Zanzibar & Pemba | 11.9 | ... | ... | ... | ... | ... | ... |
| Fed. Rhodesia & Nyasaland | 4000 | 3697.6 | 302.4 | 165 | 103 | 199 | 106 |
| — N. Rhodesia | 2273.7(l) | 2103.7 | 170* | ... | 104 | ... | 109 |
| — Nyasaland | 35(l) | 31.9 | 3.1 | ... | 143 | ... | 113 |
| — S. Rhodesia | 1691.3(l) | 1562.0 | 129.3* | ... | 102 | ... | 105 |
| **Southern Africa:** | | | | | | | |
| Mozambique(j) | 88.1 | ... | ... | ... | ... | ... | ... |
| Madagascar(j) | 107.3(m) | 94.2 | 13.1 | 400 | ... | 129 | ... |
| Reunion | 46.1 | 43.2 | 2.9 | 243(a) | ... | 277(a) | ... |
| South Africa | 24556* | 21456* | 3100* | ... | ... | ... | ... |
| South-West Africa | 208.0* | ... | ... | ... | ... | ... | ... |

(Note: Data in this table remain provisional for a number of the countries included)

a) Does not include self-producers output.
b) Refers to 1960 and public supply only.
c) Refers to public supply only.
d) Based on production only.
e) 1.3 million kWh of production not accounted for in consumption.
f) Based on 1956 = 100.
g) Refers to total consumption.
h) Refers to supply from Electricity Corporation of Nigeria (year beginning 1 April). The total available for consumption is stated to be 662 million kWh.
i) Based on estimated production.
j) Refers to 1960.
k) Refers to 1956 = 100.
l) Figures refer to generation (including Kariba) plus net imports. For the actual totals available to consumers see Table 42.
m) The corresponding figure for 1961 is 113.2

TABLE 29

**Average annual rates of increase in gross consumption of electric energy in Africa (1948—1961) and gross consumption per inhabitant in 1956 and 1961**

(territories arranged in increasing order of consumption per head in 1961 — column 3)

| Country | Gross consumption in kWh per inhabitant) | | Mean annual percentage rate of consumption growth | | Annual rate of consumption growth 1960-1961 (1960 = 100) P |
|---|---|---|---|---|---|
| | 1956 | 1961 P | 10 year average (1948-1958) | 5 year average (1956-1961) | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| Upper Volta | 1 | 2 | ... | 32.0 | 128 |
| Chad | 1 | 3 | ... | 24.6 | 112 |
| Mali | 2 | 4 | ... | 16.9 | 102 |
| Dahomey | 2 | 5* | ... | 24.0 | 100 |
| Ethiopia | 4 | 6 | 6.5 | 13.3 | 124 |
| Somalia | 5 | 6* | ... | 6.2 | 106 |
| Togo | 2 | 7 | 14.3 | 32.0 | 124 |
| Rwanda-Urundi | 6 | 7* | ... | 6.2 | ... |
| Central African Republic | 5 | 8 | ... | 12.1 | 116 |
| Sudan | 5 | 9 | 14.9 | 16.1 | 116* |
| Guinea | ... | 9* | ... | ... | ... |
| Nyasaland | 3 | 12 | ... | 31.5 | 124 |
| Mozambique | 13 | 13(a) | 7.8 | 1.6 | ...(b) |
| Tanganyika | 14 | 15* | 17.0 | 2.5 | 107(b) |
| Nigeria | 10 | 18 | 12.5 | 16.9 | 118 |
| Gambia | 17 | 19 | 20 | ... | 112 |
| Madagascar | 14 | 20 | 9.8 | 11.2 | 105 |
| Sierra Leone | 17 | 20(a) | 15.4 | 6.5 | ... |
| Ivory Coast | 7 | 28 | ... | 36.0 | 138 |
| Angola | 17 | 29(a) | 17.4 | 13.2 | ... |
| Congo (Brazzaville) | 10* | 33* | ... | 37.3 | 117 |
| Uganda | 16 | 36 | 20 | 21.1 | 103(b) |
| Zanzibar & Pemba | 19 | 38 | 13.4 | 16.6 | 106 |
| Gabon | 24 | 48 | 20 | 18.1 | 111 |
| Libya | 37 | 51(a) | 10.1 | 8.5 | ... |
| Senegal | 33 | 51 | 16.9 | 15.4 | 119 |
| Ghana | 49 | 56 | 6.2 | 11.1 | 104 |
| Kenya | 38 | 59 | 13.7 | 11.7 | 108(b) |
| Tunisia | 53 | 61 | 7.0 | 4.4 | 102* |
| Morocco | ... | 86 | 9.6 | 1.9 | 104* |
| Liberia | 41 | 87* | 20 | 18.5 | 113* |
| Mauritius | 72 | 96 | 11.8 | 9.0 | ... |
| Algeria | 86 | 119* | 9.2 | 8.5 | 108 |
| Reunion | 24 | 133 | 20 | ... | 117 |
| UAR (Egypt) | 66 | 140 | 11 | 19.5 | 140.0(c) |
| Congo (Leopoldville) | 136 | 148* | 17.6 | 4.3 | ...(a) |
| French Somaliland | 78 | 157 | 20.1 | 15.1 | 119 |
| Cameroon | 70 | 229 | 20 | 20 | 104* |
| Fed. Rhodesia & Nyasaland | ... | 469 | ... | ... | 105(a) |
| S. Rhodesia | 451 | 537 | 15.3 | 6.5 | 116(a) |
| N. Rhodesia | 590 | 917 | ... | 12.1 | 83(a) |
| South Africa | 1240 | 1512* | 8.1 | 6.7 | 105 |
| Total Africa: | 125 | 165 | 9.6 | 8.5 | 108 |
| World: | 610 | 800 | 8.9 | 7.8 | 107 |

a) Refers to 1960.
b) Refers to production.
c) The high rate of increase in 1961 was due to the operation of the Aswan hydro-electric plant.

TABLE 30

**Consumption of electric energy by main consumer-groups in 1961 — $10^6$ kWh**

| Country | Net consumption by: Industry $10^6$ kWh | Industry As percentage of Col. 6 | Domestic and allied low-voltage consumers | Transport | Total net consumption |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| North Africa: | | | | | |
| Algeria | ... | ... | ... | — | ... |
| Libya(a) | ... | ... | ... | ... | ... |
| Morocco | 484.0 | 55 | 324.0 | 66.0 | 874.0 |
| Tunisia | 130.8 | 54 | 101.9 | 77 | 240.4 |
| Sudan(b) | 5 | 5 | 88* | — | 93.0* |
| UAR (Egypt) | 2502 | 80 | 535 | 100 | 3137 |
| West Africa: | | | | | |
| Cameroon | 876 | 95 | 48.2 | — | 924.2 |
| Central African Republic | 2.2 | 31 | 4.9 | — | 7.1 |
| Gabon | ... | ... | ... | — | ... |
| Chad | ... | ... | ... | ... | ... |
| Congo (Brazzaville) | ... | ... | ... | ... | ... |
| Gambia | 2.0 | 47 | 2.3 | — | 4.3 |
| Ghana | 50* | 14* | 300* | — | 350* |
| Liberia | 66* | 65* | 36* | — | 102 |
| Nigeria(c) | 203 | 57 | 151.1 | — | 354.1 |
| Sierra Leone | ... | ... | ... | ... | ... |
| Togo | 3.1 | 31 | 6.4 | — | 9.5 |
| Guinea | ... | ... | ... | — | 25.0* |
| Ivory Coast | ... | ... | ... | — | 85.2 |
| Dahomey | ... | — | 9.6 | — | 9.6 |
| Niger | ... | ... | ... | ... | ... |
| Senegal | 110* | 79* | 28* | — | 138 |
| Mali | 7.2 | 54 | 5.9 | — | 13.1 |
| Upper Volta | ... | ... | ... | ... | ... |
| North East Africa: | | | | | |
| Ethiopia | 50 | 46 | 58 | — | 108 |
| French Somaliland | 2.9 | 30 | 6.8 | — | 9.7 |
| Somalia | 3* | 27* | 8* | — | 11 |
| Central Africa: | | | | | |
| Angola | ... | ... | ... | ... | ... |
| Congo (Leopoldville) | ... | ... | ... | ... | 1987* |
| Kenya | 111.9 | 31 | 244.7 | — | 356.6 |
| Tanganyika(d) | ... | ... | ... | — | 121.0 |
| Ruanda-Urundi(e) | ... | ... | ... | ... | ... |
| Uganda(d) | 140.7 | 67 | 68.5 | — | 209.2 |
| Zanzibar and Pemba | ... | ... | ... | ... | ... |
| Fed. Rhodesia and Nyasaland | 2748.3 | 74 | 949.3 | — | 3697.6 |
| — N. Rhodesia | 1889.8 | 90 | 213.9 | ... | 2103.7 |
| — Nyasaland | 17 | 53 | 14.9 | — | 31.9 |
| — S. Rhodesia | 841.5 | 54 | 720.5 | ... | 1562.0 |
| Southern Africa: | | | | | |
| Mozambique(e) | ... | ... | ... | ... | ... |
| Madagascar(e) | 37.2 | 39 | 53.7 | 3.3 | 94.2 |
| Réunion | 31.7 | 73 | 11.5 | — | 43.2 |
| South Africa | ... | ... | ... | ... | 21456* |
| South West Africa | ... | ... | ... | ... | ... |

(Note: Data in this table remain provisional for a number of the countries included)

a) Refers to 1960 and to public supply only.
b) Refers to public supply only.
c) Refers to supply from Electricity Corporation of Nigeria (year beginning 1 April). Total available for consumption stated to be 662 million kWh.
d) Does not include self-producer's output.
e) Refers to 1960.

TABLE 31

**Breakdown of industrial electric energy consumption in Madagascar and of total consumption in Tunisia** — 1955 and 1960

($10^6$ kWh)

| Category | | Consumption of electric power 1955 | 1960 |
|---|---|---|---|
| 1 | | 2 | 3 |
| MADAGASCAR: | (Industry) | | |
| Sugar processing | | 4.148 | 16.940 |
| Rice processing | | 1.214 | 1.570 |
| Food preservation | | 1.524 | 4.383 |
| Textiles | | 0.755 | 4.930 |
| Cement Works | | — | 2.379 |
| Miscellaneous | | 1.693 | 7.018 |
| | Total Industry: | 9.334 | 37.210 |
| TUNISIA: | (Industry) | | |
| Extractive industries | | 26.965 | 23.508 |
| Metals and mechanical construction | | 14.995 | 17.931 |
| Chemical industries | | 2.346 | 2.377 |
| Non-metallic construction materials | | 30.657 | 38.658 |
| Food industries (oils, drinks, tobacco) | | 19.845 | 26.536 |
| Construction industry | | 2.170 | 0.874 |
| Textiles, clothing, leather and rubber products | | 3.174 | 4.218 |
| Wood, furniture and paper | | 3.127 | 3.624 |
| Other industries | | 2.132 | 2.396 |
| | Total Industry: | 105.411 | 120.122 |
| Air and roadways (Transport) | | 0.855 | 0.550 |
| Railways and trolley bus services | | 12.326 | 9.888 |
| Water transport | | 0.463 | 0.621 |
| Pipelines | | 0.077 | — |
| | Total Transport: | 13.651 | 11.059 |
| | (Domestic & Other) | | |
| Households | | 38.966 | 51.915 |
| Commercial & Services | | 5.931 | 7.029 |
| Public services, administration and public lighting | | 20.200 | 27.846 |
| Agriculture | | 8.681 | 11.324 |
| Others | | 4.582 | 5.397 |
| | Total Domestic: | 78.360 | 103.511 |
| TOTAL NET CONSUMPTION: | | 197.422 | 234.692 |

TABLE 32

**The state of electrified railways in Africa as at 1961—62([a])**

| Country | Electrified track | Width of gauge (metres) | Lenght of track in km: total | Of which electrified | Electric system and type of conductor |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| North Africa: | | | | | |
| Algeria | Bone—Le Kouif | 1.450 | 5,239 | 322 | 3,000 V d.c. OH |
| Morocco | Marrakech — Casablanca — Fez | 1.435 | 2,591 | 919 | 3,000 V d.c. OH |
| Tunisia | | 1.435 | 2,098 | — | — |
| Libya | | 950 | 174 | — | — |
| UAR (Egypt) | Cairo — Helvan | 1.435 | 5,782 | 33 | 1,500 V |
| Sudan | | 1.067 | 5,054 | — | — |
| | TOTAL | | 20,938 | 1,274 | |
| West Africa: | | | | | |
| Mali | | 1.000 | 640 | — | — |
| Senegal | | 1.000 | 1,035 | — | — |
| Guinea | | 1.000 | 701 | — | — |
| Sierra Leone | | 762 | 558 | — | — |
| Liberia | | 1.067 | 80 | — | — |
| Ivory Coast | | 1.000 | 1,318 | — | — |
| Upper Volta | | 1.000 | — | — | — |
| Ghana | | 1.067 | 1,222 | — | — |
| Togo | | 1.000 | 490 | — | — |
| Dahomey | | 1.000 | 648 | — | — |
| Nigeria | | 1.067 | 3,583 | — | — |
| Cameroon | | 1.000 | 504 | — | — |
| Congo (Brazzaville) | | 1.067 | 624 | — | — |
| | TOTAL: | | 11,403 | — | — |
| East & South Africa: | | | | | |
| Ethiopia | | 1.000 | 1,175 | — | — |
| East Africa b) | | 1.000 | 6,765 | — | — |
| Fed. Rhodesia (N. & S.) | | 1.067 | 5,138 | — | — |
| Nyasaland | | 1.067 | 555 | — | — |
| Mozambique | | 1.067 | 2,732 | — | — |
| Angola | | 1.067 | 3,849 | — | — |
| Madagascar | | 1.000 | 990 | — | — |
| Congo (Leopoldville) | Elizabethville region | 1.067 | 5,967 | 580 | 25,000 V 1/50 OH |
| South Africa | Capetown & Johannesburg regions: Johannesburg & Durban | 1.067 | 29,163 | 4,656 | 3,000 V d.c. OH |
| | TOTAL | — | 56,334 | 5,236 | — |
| | GRAND TOTAL: | — | 88,675 | 6,510 | — |

a) Based on data from World Railways.
b) Refers to Kenya, Tanganyika and Uganda.

## TABLE 33

**Development of residential building construction in selected African countries**

(authorizations in 000m2 or number of units)

| Country | 1956 | 1959 | 1960 | 1961 | Index for 1961 (1956=100) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| **North Africa:** | | | | | |
| Algeria (a) | 16,128 | 31,862 | 39,320 | 31,554 | 196 |
| Libya (b) (c) | 66 | 55 | 65 | 78 | 118 |
| Morocco (c) (d) | 893 | 898 | 1,009 | 894 | 100 |
| Tunisia (c) | 184 | 201 | 283 | 375 | 204 |
| **West Africa:** | | | | | |
| Cameroon (c) (f) | ... | 18 | 15 | 19 | 106(e) |
| Central African Republic (f) | 22 | 16 | 23 | 20 | 91 |
| Gabon (c) (f) | 13 | 31 | 49 | 66 | 508 |
| Togo | ... | 38 | 41 | 46 | 121(e) |
| Guinea | 72 | ... | ... | ... | ... |
| Ivory Coast (c) | 35 | 69 | 201 | 326 | 931 |
| Senegal (c) (g) | 83 | 134 | 106 | 166 | 200 |
| **North East Africaa:** | | | | | |
| Ethiopia (c) | 20 | 55 | 54 | 56 | 280 |
| **Central Africa:** | | | | | |
| Kenya (b) (c) | 281 | 217 | 195 | 43 | 15 |
| Uganda (b) (c) | 68 | 38 | 29 | 12 | 18 |
| Tanganyika (b) (c) | 95 | 74 | 71 | 45 | 47 |
| **Southern Africa:** | | | | | |
| Mozambique (b) (c) | 58 | 90 | 112 | 77 | 133 |
| South Africa (a) (b) (d) | 18,458 | 10,075 | 10,662 | 9,706 | ... |

a) Figures refer to number of dwelling units.
b) Refers to dwellings completed.
c) Total floor area.
d) Series partly modified from 1959.
e) Based on 1959 = 100.
f) Refers to total construction.
g) Prior to 1957, buildings completed.

## TABLE 34

**Occupation of types of private dwelling in selected countries and degree of equipment with electricity and gas**

| Country | Date of latest survey | Total number of occupied dwellings of type considered (thousands) | Type of dwelling | Average number of: Rooms per dwelling | Average number of: Persons per room | Percentage of dwellings with: Electricity | Percentage of dwellings with: Gas |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Algeria | 1954 | 308.5a) | European type (urban only)(b) | 2.3 | ... | 83.9 | 57.1 |
| Mozambique | 1950 | 19.2 | Total (type not specified) | 4.4 | ... | 57.3 | 91.1 |
| Fed. Rhodesia and Nyasaland | 1956 | 48.9 | Urban in 16 towns | 4.2 | 0.8 | ... | ... |
| Senegal | 1955 | 11.5 | Total European type in Dakar | 2.3 | 1.5 | 96.4 | ... |
| South Africa | 1951 | 564.2 | Urban | 3.7 | ... | ... | ... |
| United Arab Republic | 1960 | 1532.2 | Urban | 3.6 | 1.6 | 18.7 | 0.1 |
| Zanzibar | 1958 | 20.3 | Urban | ... | 1.8(c) | ... | ... |
| | | 7846.0 | Urban | 2.8 | 1.0 | 95.4 | 77.6 |
| France | 1954 | 5555.5 | Rural | 2.3 | ... | 89.5 | 49.8 |
| | | 13401.5 | Total | 2.6 | ... | 93.0 | 66.1 |

a) Urban dwellings only. Total, including rural, = 386.9.
b) Represents 21.5 per cent of total dwellings.
c) Kitchens not included.

TABLE 35

**Average revenue per kWh sold in selected countries**

| Country | National currency unit | Average revenue per kWh sold in 1961: National currency unit per kWh | Average revenue per kWh sold in 1961: Mills per kWh | Remarks (relating to col. 3) |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Cameroon | Fr. CFA | 16.69 | 69.5 | Cost of supply at Yaoundé (excluding depreciation and interest) |
| Central African Rep. | Fr. CFA | 21.25 | 85.0 | — |
| Ethiopia | Eth. cent. | 8.9 | 35.8 | 11.1 excluding off-peak consumers |
| Fed. Rhodesia & Nyasaland | Pence | 1.22 | 14.2 | — |
| Gabon | Fr. CFA | 16.86 | 67.4 | At Port Gentil & Lambaréné |
| Gambia | Pence | 4.0 | 46.7 | Of which lighting 9d., domestic 3d., and commercial 6d. and 4d. |
| Ghana | Pence | 4.5 | 52.5 | — |
| Kenya | E.A. cent | 20.59 | 28.8 | — |
| Mali | Fr. CFA | 25.51 | 102.0 | — |
| Morocco | Dirham | 0.099 | 19.6 | — |
| Nigeria | Pence | 3.8 | 44.4 | Refers to 1960/61. |
| Reunion | Fr. CFA | 20.3 | 81.2 | — |
| Senegal | Fr. CFA | 5 | 20.0 | Approximate and refers to industry. |
| Sierra Leone | Pence | 10.22 | 119.2 | — |
| Somalia | Som. cent. | 110-120 | 154-168 | Refers to industry and domestic use respectively at Mogadiscio. |
| Sudan | L.Sud. | ... | 60 | Of which 45 for agriculture and 115 for public lighting. |
| Togo | Fr. CFA | 25.02 | 100.1 | — |
| Tunisia | Millme. Dinar | 20.70 | 36.0 | — |
| Uganda | EA cent. | 10.4 | 14.6 | Refers to 1960. |

Note: Data in this table remain provisional for a number of the countries included)

TABLE 36

**Population projections for selected African countries to 1975, based on medium assumptions(a)**

| Country | Projection (thousands) 1965 | 1970 | 1975 |
|---|---|---|---|
| Angola | 4,730 | 5,000 | 5,310 |
| Basutoland | 741 | 827 | 937 |
| Bechuanaland | 404 | 455 | 517 |
| Congo (Leopoldville) | 15,200 | 16,500 | 17,600 |
| Gambia | 323 | 340 | 360 |
| Liberia | 1,370 | 1,440 | 1,520 |
| Libya | 1,340 | 1,500 | 1,700 |
| Madagascar | 5,900 | 6,360 | 6,810 |
| Mauritius | 727 | 797 | 855 |
| Mozambique | 6,780 | 7,200 | 7,660 |
| Nigeria | 36,800 | 39,600 | 42,300 |
| South Africa | 17,000 | 19,200 | 21,900 |
| Swaziland | 288 | 329 | 375 |
| Tanganyika | 9,620 | 10,300 | 11,000 |
| Tunisia | 4,600 | 5,180 | 5,900 |

a) For the source see Annex I, reference No. 5.

## TABLE 37

**Actual and future rates of increase in annual consumption of electric power as planned or forecast for selected African countries**

| Country | Actual percentage rate of increase in consumption (1960-1961) P | Planned or forecast mean annual rate of consumption growth P | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Per cent per year | Period | | | | | | | | |
| | | | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1980 |
| 1 | 2 | 3 | 4 | | | | | | | | |
| Central African Republic | 16 | 19* | | | | | | | | | |
| Cameroon | 4 | 12 | | | | | | | | | |
| Dahomey | 0 | 1—5* | | | | | | | | | |
| Ethiopia | 24 | 22 | | | | | | | | | |
| UAR (Egypt)(a) | 12 | 11.5 | | | | | | | | | |
| French Somaliland | 19 | 18.8 | | | | | | | | | |
| Gabon | 11 | 30.0(b)<br>7.0(c) | | | | | | | | | |
| Ghana | 4 | 15—20 | | | | | 31 | | | 6.5 | |
| Ivory Coast | 38 | 35* | | | | | | | | | |
| Kenya | 8 | 7.5—15 | | 7.5 | 10 | | 15 | | | | |
| Liberia | 13 | 20* | | | | | | | | | |
| Madagascar | 5 | 7.2 | | | | | | | | | |
| Mali | 2 | 15 | | | | | | | | | |
| Morocco | 4* | 14 | | | | | | | | | |
| Nigeria | 18* | 17* | 21 | | 14 | | | | 10 | 8 | |
| Reunion | 17.5 | 17.5 | | | | | | | | | |
| Fed. Rhodesia & Nyasaland | 6 | 5(d) | | | | | | | | | |
| Somalia | 6 | 3—6* | | | | | | | | | |
| Sudan | 16 | 15* | | | | | | | | | |
| Tanganyika | 7 | 7—10 | | | | | | | | | |
| Uganda | 3 | 10 | | | | | | | | | |

a) The figure in column 2 refers to the 10-year annual average ending 1961. Consumption of electro-thermal and electro-chemical industries is not allowed for in the rates shown.
b) Refers to Libreville.
c) Refers to Port Gentil and Lambaréné.
d) Earlier Federal Power Board estimates gave 7.2 per cent which for various reasons has lately exceeded actual growth experienced.

## Chapter V

# ELECTRIC POWER SUPPLY SYSTEMS IN AFRICA

## A. INTRODUCTION

This chapter surveys various basic aspects of power supply in Africa — the organizational arrangements, types of generating plant and their mode of operation, output, transmission and distribution of electric energy to meet the needs of consumers. In Africa particularly, these different aspects of the supply situation are closely inter-related. Various separate problems encountered in developing production to meet the growing needs of consumers as economically as possible can sometimes be made less intractable if they are considered together as an integrated whole. Problems encountered and possibilities open on opposite sides of a common frontier may complement one another in such a way as to make possible mutually adpantageous solutions through co-operation. Not only the present administrative, technical and economic problems of production, therefore, but their further development in relation to all factors involved, should be taken into account in planning for an adequate and secure supply of electricity.

The present chapter sets out some basic data and considerations for a first examination of Africa's problems of electricity production and supply. This chapter should, however, be studied in conjunction with those of part I, particularly chapter II and III, as well as with chapter IV.

## B. ORGANIZATION OF ELECTRICITY UNDERTAKINGS AND SYSTEM OPERATION

The organization of undertakings is considered here only briefly and in so far as it may be linked with the approach to questions of financing and capital expenditure; the balancing of costs and revenue on a regional basis; the choice of different types of plant; and other similar considerations which influence the economy of production and forward planning to meet statutory requirements.

### a) **Organization and financing**

Power supply undertakings are organized in Africa in many different ways. In certain countries one or more ministries possess over-all responsibilities for electricity, either simply as a single utility or in conjunction with water supply or gas. Private authorized companies or undertakings are then responsible for production and distribution alike. Various types of independent service ensure public supply on this pattern under government concession in, among other countries, Dahomey, French Somaliland, Gabon (responsibility for electricity and water in some areas and electricity only in others), Kenya, the Malagasy Republic, Reunion, Senegal, Tanganyika and Togo (two companies). Within this group some variations of structure exist.

One variant of this type of organization involves the separation of production and distribution, the latter being assured by undertakings, possibly private, which purchase the power in bulk from the undertaking responsible for generation. This system is followed in Morocco, where ten companies purchase some power from the single company that is responsible, under the Ministry of Public Works, for generation and transmission and distribute it to consumers in their areas of operation.

With a number of differences on points of detail, the principle of a public authority set up by special Charter or Act of Parliament has been adopted by several countries. This may have replaced earlier private bodies, as in the Sudan, or these latter may continue to exist to serve certain outlying areas, as in Ethiopia. The Ethiopian Electric Light and Power Authority is a public corporation responsible for generating, transmitting and distributing electric energy. It produces nearly 60 per cent of the country's total output, the remainder being supplied by private companies with similar functions or produced by private industrial enterprises.

In the UAR (Egypt) there is an Electricity Commission for the whole country which, through its Technical Bureau, undertakes planning and design for the interconnected power system separately from the special administration set up to deal with the Aswan Dam and other hydro schemes. Of a number of undertakings which produce and supply power the largest (that for Cairo) is also a publicly-owned enterprise under the central Government. In Ghana also the public supply of electricity is assured by a government service for production, the Electricity Division of the Ministry of Communications and Works, which operates throughout the country. Most of Liberia's public supply is also under government control through the Monrovia Power Authority, much of the remainder being generated for iron ore mining and rubber production. The Electricity Corporation of Nigeria is another public body of relatively long standing which was set up for the generation and public supply of electricity. In Tunisia and Uganda too there are public bodies — the **Société Tunisienne de l'Electricité et du Gaz** and the Uganda Electricity Board respectively — which are responsible for electricity production and distribution throughout these territories.

In otser cases over-all control over the development of supply is exercised in various ways. Thus in the Cameroun Republic, where both public and private organs exist which serve respectively towns supplied from diesel plants or those supplied from the large hydro plant on the Sanaga River used for aluminium reduction, capital expenditure for public supply by the former is made through the appropriate Ministry. Municipal authorities also supply separate individual communities from diesel or small hydro plants. At the other extreme, under the Federal system of the Federation of Rhodesia and Nyasaland, there has been a Federal Power Board[19] which was set up initially in 1956 to construct the Kariba Dam, furnish power to other undertakings and, in conjunction with the Electricity Supply Commissions for Southern Rhodesia and Nyasaland respectively, to investigate development of further facilities for bulk supplies within the area. The separate Electricity Supply Commissions themselves generate, purchase and transmit electricity within their respective territories. In addition private undertakings, local authorities and licensed bodies may all exist either for purposes of public supply or to furnish power to meet special industrial or other requirements. Further details on these and other organizational arrangements in force in different areas are summarized in Annex VI. It should also be noted that in several countries — including Ethiopia, Gabon, Mali, Morocco, Nigeria and Tunisia — separate public bodies exist for the development of water resources, commonly for hydro-electric power and also for multi-purpose uses.

The importance of the administrative structure in force as power supply develops arises from several contrasting considerations. Private undertakings may be able to tap sources of capital or expertise not otherwise available. On the other hand central government control — through a ministry, a separate power authority or through control over natural resources plus a central body for generation and main transmission to local undertakings — also raises issues of public management and policy. A public service is in a position to frame an over-all tariff system which can seek to balance or compensate the differences in cost of supply in different areas. It can consider and plan for the over-all use of different natural power sources, taking into account the respective advantages of high-voltage transmission, possible cross-frontier supplies of power, isolated generation from different types of plant, fuel import considerations and the role of power in the different sectors of the national economy. The planning of a gradual transition to an integrated system can be pursued in the light of all necessary economic, technical and demographic data and considerations. On the other hand there is a strong case for independent powers allowing for the exercise of sound commercial practice in administration, particularly in such fields as tariffs and depreciation, in order to place the industry on a sound financial basis. Where the raising of the necessary capital is of paramount concern, this point gains special weight.

Some details on the capital expenditure undertaken in recent years for electric power development in eleven selected territories are presented in annex VII. The information does not allow any calculations to be made of **specific** capital costs for plants or transmission lines. In a number of cases, however, a breakdown is made between expenditure on thermal plants, hydro plants, transmission lines and distribution respectively. As in regions outside Africa, transmission and distribution have commonly accounted for nearly half the total in recent years.

### b) Mode of operation

The various types of generating capacity, production, transmission and other characteristics of the different power systems in use are discussed in later sections of this chapter. Here it is only some main principles of operation that are considered.

Apart from those states — fewer than ten in all — where large-scale production is already in force, operating conditions are mainly imposed by the limited volume of total demand, its concentration in a few major consuming centres (which are often widely separated) and the wide dispersal of such remaining requirements as may exist. Production in plants operated by industrial self-producers may also suffice (as is the case in the Cameroun Republic) to make available substantial contributions to public supply. In the island of Reunion and elsewhere, back-pressure plants operated for sugar refining may similarly be in a position to supply some power to meet public requirements. In many of the industrial installations

[19] Under an agreement between the Governments of Southern and Northern Rhodesia, that was signed on 25 November 1963, the functions of the Federal Power Board in respect of generation and transmission in these territories are due to be transferred to a Central African Power Corporation, which will continue to develop a single system under the joint ownership or control of the governments concerned after the ending of the Federation.

plants are operated at a fairly even load, in contrast to the variable load diagram characteristic of public supply plants working more or less independently. Nevertheless the reliance on capacity from industrial plants must be regarded as a temporary measure in view of the rapid rate of load growth. In any case it is essential to build up an adequate public supply service as quickly as possible.

In these circumstances areas where small communities requesting public power supply are far removed from existing plants — as for example in areas of Chad, Niger, Mali and many other territories in west Africa and elsewhere — a use of small-scale isolated generating capacity is inevitable. This can be, and is, usually furnished by diesel generators. In practice five types of development with diesel generating equipment can be distinguished, as may be seen from the example of Ghana. In this particular country diesel sets are used to supply large towns such as Accra, Takoradi and Kumasi. They are also installed to supply various small centres surrounding the city of Accra. On the other hand, diesel generators are used to provide power for separate outlying centres of population and they also provide the means of production for private mining concerns, as at Tarkwa. Finally, a number of outlying rural communities are also supplied with power from small diesel installations.

Other solutions are in principle available, however, particularly mobile diesel plants, very small hydro plants and, in some cases, gas turbines. In such cases there is often a logic of development which allows an optimum solution to be reached. Expenditure on mobile diesel generators may allow potential local demands to be satisfied until new large-scale generating capacity is brought into service, after which it can be transferred to other areas. Such plant can be moved to points where transmission facilities exist. This type of installation may then be more economic in capital cost than large and heavy units for permanent siting. The same type of consideration may apply in principle to mobile gas turbine units where peak loads have to be satisfied. On the other hand permanent diesel sets may serve for standby or supplementary use after large hydro plants have been brought into operation, as has often been the case in recent years.

In the relatively large consuming centres steam generating capacity, large concentrations of diesel plant and, in suitable cases, hydro-electric plants (industrial or for public supply) are the means of production. In most cases, however, and even though demand is usually growing rapidly, the scale of production is such that relatively small and often partly absolete steam-generating units remain in service and further units, or diesel sets, are added as demand passes the limits of existing output. In the case of Tunisia, for example, one steam generating plant — the La Goulette 70 MW thermal station — carries the bulk of the national load, including 74 per cent of the total peak demand on the interconnected system (57 MW in 1961). From such producing centres in the different countries transmission lines of comparatively low voltage (commonly around 30-60 kV) are usually spreading gradually over limited distances to secondary demand centres. It is evident that generating costs will often be high under such plant and operating conditions. On the other hand, when sizable new plants are introduced the increment of capacity is commonly in excess of immediate needs, so that requirements can be met for some years ahead from the capacity available or from the addition of new generating groups for which provision may have been made.

In these circumstances fully integrated operation to take advantage of diversity in daily load diagrams, possible diversity in flow characteristics of hydro plants, and differences in operating cost of thermal plants, so as to arrive at a near-optimum use on the load diagram of the generating capacity available, is restricted to comparatively few areas. Even in Egypt, where the maximum interconnected load in 1961 (excluding the existing Aswan plant) reached 461 MW (over 500 MW in 1962) and this annual load factor was as high as 67 per cent, it has been found quite feasible to operate the system according to a load programme, with telephone contacts as necessary, without recourse to central load dispatching. In this particular case, however, careful studies of load growth in relation to industrialization, irrigation and reclamation and domestic load demand for 15 years ahead are being made. These have shown the likelihood of a peak demand rising very rapidly — to 2460 MW by 1978.

In two other countries of north Africa — Algeria and Morocco — a considerable degree of interconnexion already exists. In the latter over 90 per cent of production is met from hydro plants with substantial storage, so that only one 25 MW steam generating plant using waste coal is kept in service while the other — the 34 MW Roches Noires station of unusual design — is kept as a cold reserve. There are considerable 150 kV and 60 kV transmission networks. It has been found useful to retain four 5 MW alternators and the electrical equipment of the obsolescent Casablanca steam plant in use purely to improve the power factor and the transport capacity. In this country work is now under way to install a central load dispatching system.

A modern load dispatching service, operating continuously with highly sophisticated equipment, already exists in Algeria's nationalized and mainly thermal power system, although the maximum peak demand experienced has reached only 280 MW. Large new increments of thermal and hydro-electric capacity (200 and 114 MW respectively) are exspected to come into service by 1964, however. In this particular case advanced methods of frequency control are in use in the interconnected network, this being achieved through co-ordination between a remote 95 MW hydro plant with appropriate storage and the modern Alger Port thermal plant, the latter supporting the voltage but remaining free to work at optimum efficiency in relation to the load.

The interconnected system of the Federation of Rhodesia and Nyasaland's Federal Power Board offers a further example of well-integrated supply. A lengthy spine of main transmission at 330 kV exists from Kitwe in N. Rhodesia southward through the key Kariba hydro plant (output now 700 MW as a first stage, with possible extension to 1500 MW) and thence southward to Salisbury and Bulawayo in S. Rhodesia. The Board's maximum non-simultaneous load in 1961/62 was 480 MW out of a total interconnected maximum for the Federation of 1007 MW and Kariba, at very low costs, generated 90 per cent of the Board's total output. A further 400 MW of thermal plant is interconnected to this network in the southern industrial areas, but other blocks of power, as at Livingstone, Wankie etc. in the west, are not linked to it. The system is, however, interconnected in the north with the adjoining plants of the Congo (Leopoldville), with which large quantities of power can be interchanged. The Electricity Supply Commission of S. Rhodesia, which also operates plants and lines throughout its area for bulk supply to most of the municipal electric systems, is interconnected on the east (at Umtali) with neighbouring Mozambique at 110 kV and, at low voltage, with S. Africa over the Limpopo River at Beitbridge in the south.

Other emerging areas of interconnexion include the extensive networks of Kenya and Uganda. In the latter, in addition to the 132 kV line linking the two countries for the supply of power from Owen Falls under a long-term agreement (Kenya is also linked with neighbouring Tanganyika) lines at 33 and 66 kV are rapidly extending from the area of Jinja and Kampala towards the northern and western frontiers of Uganda at Gulu, Kasese and Hoima. Every incentive exists to stimulate consumption in this particular country, since the available capacity of Ugand's Owen Falls plant still remains in excess of present demand.

These various instances of types of supply and system development in progress in different countries serve to introduce the analysis of generating plant, production and transmission in African countries that is comprised in the following sections.

## C. GENERATING PLANT CHARACTERISTICS

### a) **Existing plant capacity**

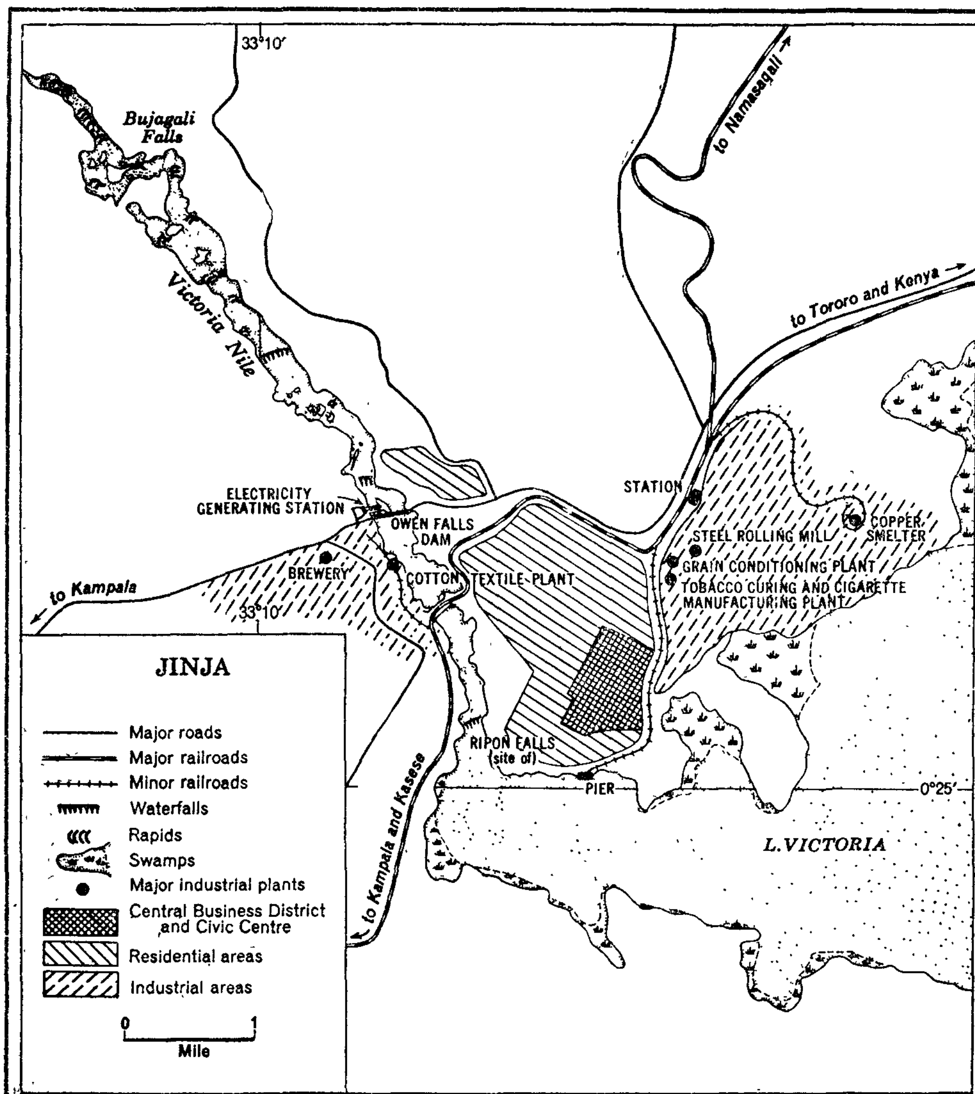
A complete breakdown of the generating capacity installed in African countries is fraught with some difficulty and, as is normal in many parts of the world, certain of the data must be regarded as provisional. In table 38 an attempt is made first of all to bring together information on the installed thermal and hydro-electric capacity in different countries at the end of 1961 and its development since 1955. In principle a distinction is made between generating capacity in service for public supply and that owned by industrial and other self-producers generating entirely or mainly for their own use. Many of the latter, however, often contribute some power to a public network, while they may equally take power from it. Information on the maximum hourly peak demand in 1961 is included for interconnected systems in various countries. In certain cases the data refer, however, to non-simultaneous demand.

Thermal generating capacity is mainly concentrated in South Africa, the UAR (Egypt), Southern and Northern Rhodesia, Algeria, Nigeria and Ghana. The last-named has until now relied entirely on diesel plant. Diesel generators provide the entire non-hydro output in a number of territories, including the Central African Republic, French Somaliland, Gambia, Liberia, the Malagasy Republic and Mali. In most of these the diesel equipment is divided fairly equally between public supply and self-producers. Free piston gas turbine sets have been installed in various countries — four in Algeria, two in the Congo (Leopoldville), five in Egypt, eighteen in the Ivory Coast, eight in Nigeria and fourteen in Tunisia. Some extensions of this type of plant, which is particularly useful for meeting small-scale peak-load requirements since it is very quickly brought on load and is comparatively inexpensive in capital cost, are being made in some areas. The Electricity Corporation of Nigeria, for example, is installing a 5.56 MW simple cycle plant for peak load duty at the Ijora power station in Lagos, where it will also contribute to the base load of the existing steam generating sets.

Large-scale hydro-electric generating capacity is mainly concentrated at Le Marinel and other plants in the Congo (Leopoldville); in the Federation of Rhodesia and Nyasaland (particularly the Kariba scheme); in Egypt (the existing Aswan Dam, completed in 1961); in Morocco (El Ouidane and Al Fourer); in the Cameroun Republic (at Edéa); in Algeria (Agrioun, etc.); and in Uganda (Owen Falls). Elsewhere much smaller plants are generally in service. Although no hydro-electric capacity is included in the table for South Africa, a small plant has been installed comparatively recently by the Electricity Supply Commission (ESCOM) at Sabie, which generated 2.9 million kWh in 1962. Much larger multipurpose developments for the conservation of water resources, including irrigation and industrial use, are now envisaged in that country, more particularly in upper reaches of the Orange River and on the Fish River (both outside the present ESCOM area).

## MAP 5

**Economic Development in the Neighbourhood of a large Hydro-electric Plant - The Owen Falls Dam in Uganda***




* Adapted by permission from map in reference 15 (Annex I)

Apart from the Cameroun and Congo (Leopoldville) plants, and some capacity in Northern Rhodesia, most of the hydro capacity is operated for public supply. Very rapid advances have been made in hydro-electric construction in recent years and as a result the situation has changed completely between 1955 and 1961, as can be seen from the indices shown in columns 12 and 13 of table 38. Most of the larger plants did not in fact exist in the earlier year.

The development of hydro-electric production potential is most clearly expressed by information on the aggregate producibility of such plants under normal operating conditions and in an average year — i.e. a year characterized by stream-flow conditions near the long-term mean. Availability of seasonal storage capacity expressed in terms of energy storable in existing reservoirs in an equally vital index in most parts of Africa. Details for certain countries concerning these two indices are brought together in table 39 for the years 1955 and 1961. Although information is incomplete the figures, together with those in the preceding table, give an idea of the typical operating economy of hydro plants in Africa.

b) **Development projects**

Schemes already under construction or actively projected to increase hydro-electric production, transmission or thermal generating facilities include some important developments which should serve to provide an underpinning needed to assist rapid economic growth.

Hydro-electric construction is especially noteworthy. It includes the successive stages of the Aswan High Dam project in Egypt which, by 1970, should reach its full capacity of 2100 MW, thereby supplementing the existing Aswan Dam (345 MW) so as to supply about 12 milliard kWh yearly in all. Main transmission lines at 500 kV (2 x 900 km) are envisaged to transfer power to Cairo, with a further 1000 km of branch lines at 220/132 kV. A number of important steam-generating plants and extensions are also provided for, including the Cairo West plant (3 x 87 MW in single block units).

Other important schemes in varying stages of implementation include the Akosombo plant (768 MW) in Ghana; the Niger Dams project (320 MW) in Nigeria (where a number of large gas turbine units are also due to be installed); the 21 MW Hale plant in Tanganyika which, with suitable transmission, is due for completion in 1964 to supply industrial development in Tanga and Dar-es-Salaam); the Djen-Djen scheme in Morocco (114 MW) also due for completion by 1964; and the Roseires dam in the Sudan, which has as its main purpose irrigation in the Gezira region but which may also supplement at a later stage the new 15 MW Sennar scheme. The latter, together with 30 MW of new steam-generating capacity and 15 MW of diesel plant, will provide a further 60 MW in all within the area of the Sennar dam.

These, among other new plants and transmission networks, by no means exhaust the major projects actively envisaged but which may not be due for immediate construction. Thus, to develop aluminium reduction from rich bauxite reserves, plans exist for the 330-360 MW Souapiti project on the Konkouré in Guinea, which would produce 3.2 milliard kWh per year. Rich bauxite reserves in Mali might justify construction of two plants near Kayes on the Senegal and another nearby in the area of the Bakoy. In Kenya the Seven Forks scheme, which would give 240 MW plus a further 130 MW downstream, allowing a production of 1900 million kWh in all, is actively projected for construction after immediate possibilities have been fully absorbed. The existing Kariba and Owen Falls schemes (on the Zambezi in Rhodesia and the Victoria Nile in Uganda respectively) could be greatly extended — the first to 1500 MW and the second to 150 MW plus a further 180 MW downstream, when demand conditions make this necessary. Similarly, in the Ivory Coast, the capacity of Ayamé I plant, which can produce 100 million kWh, will be doubled through the building of a second plant. In Liberia, in addition to a 10 MW scheme which is due to be completed by 1965, further extension to 40 or 50 MW will be possible on the St. Paul River. As an example of a project requiring international assistance, the development of the Mono River for use by Dahomey and Togo has been the subject of a joint application for Special Fund assistance.

The details merely illustrate a few of many possibilities which already exist but which may in some cases be held back by problems of financing. Further details on these and other schemes are also summarized in annex III and V. Annex V brings together in outline certain aspects of the immediate development situation in some 21 countries. Information presented in chapter I, and in maps 2, 3 and 4, also allows the development perspective to be evaluated more clearly as a whole.

## D. PRODUCTION OF ELECTRIC ENERGY

An analysis of the main features of electric power production in Africa has provided information which is brought together in tables 40-43. In order to follow on logically from the tables on plant capacity table 40 first examines the use made of the generating capacity in service. This has been done by comparing the output obtained in 1955, 1960 and 1961 from the installed capacity, the result being expressed in hours of operation per year.

Table 40 shows in most cases a steady increase in the "utilization factor". Exceptions in some countries, as in Northern and Southern Rhodesia, arise from the introduction of new large-scale hydro plant, leading to a reduced use of thermal plant for fuel-saving or where there is a temporary excess of capacity. Except where hydro-electric plants are used by industrial enterprises average use of plant is fairly low. This is inevitable in many African territories at present in view of the preponderance of production in separate or inadequately interconnected plants and because of a lack of widespread water storage. It should be borne in mind however that by definition the figures refer to installed or name-plate capacity, which is likely to be some ten per cent in excess of capacity actually operating, so that the figures tend to understate the use made of generating capacity.

Tables 41 and 42 serve to complement one another. The first shows the details of production and cross-frontier exchanges; while the second presents information on total availability of energy for consumption, its origin and its development since 1955.

In more than half of the 23 countries showing hydro-electric output the importance of this form of production has increased between 1955 and 1961. In thirteen countries it takes a preponderant role while in five — the Central African Republic, Cameroun, Congo (Leopoldville), Morocco and Uganda — between 90 and 100 per cent of total output has for some years been from hydro power. Angola, Ivory Coast, Kenya, Mozambique and Southern Rhodesia constitute a further group of territories where this form of generation is already substantial relative to total production.

Although natural conditions are basically favourable, cross-frontier transfers or exchanges of power have not yet been developed in Africa to play a role comparable to that which they play, for example, in Europe. Of the seven territories which imported or exported energy in 1961, all use hydro power to a relatively large extent. Although details are discussed in the section dealing with international interconnexion it can be seen that large contributions were made to consumption in Kenya and in the area served by the Federal Power Board in the Federation of Rhodesia and Nyasaland by Uganda and Tanganyika, and by Congo (Leopoldville) and Mozambique respectively. On the whole the countries importing or exporting power are among those where rates of increase in consumption have been comparatively moderat in recent years.

An important index in the evolution of supply undertakings where total consumption is still at an early stage is that showing the part played by public supply production in a country's total power generation. Self-producers play an important role in highly industrialized countries, particularly in industries where back-pressure generation can supply energy in addition to steam required for special processes, and it is clear that in Africa industries based mainly on large quantities of low-cost hydro power are among those where industrial self-production is destined to play a greater part than it does at present. In addition industry frequently contributes useful amounts of power to public networks. Although the requirements of self-producers tend to increase in line with industrial output their rates of growth are usually less than that of total power consumption, however. As a result the percentage contribution of self-producers in the total often tends to fall even though their output may continue to increase.

Table 43 confirms that in Africa there is some tendency for public supply production to take an increasing part of the total output. This is partly because of its very high rate of increase in many areas. It is also a consequence of the fact that as public supply becomes less costly, better integrated and therefore more reliable, there is a greater incentive for many industries to take their power from the public network rather than to invest in independent generating plant. This is an important factor in the approach to public supply load-building.[20]

a) **Interconnected systems**

Information on daily load conditions is not so far available for many African countries. Figure I shows however a typical week-day load diagram for the interconnected system of the Federation of Rhodesia and Nyasaland (Federal Power Board). This illustrates a fairly normal distribution and amplitude of peak demand but it represents a well-diversified load. In certain other interconnected systems in Africa annual load factors are comparatively high. Thus in Uganda, where exports to Kenya are made under long-term contract, the average annual load factor[21] is over 70 per cent — a very high figure.

Annexes VIII and IX present some details on selected individual steam generating and hydro-electric plants in service in particular countries. Annex VIII shows that the most advanced steam power plants in service at present in Africa are those of Alger port and Cairo South (with 84 - 89 kg/cm$^2$ and 500 - 540°C). Elsewhere steam conditions are in general considerably less advanced and many plants have comparatively old units in service, so that generating efficiency is not particularly high. Details are not included for stations in South Africa, but the average generating efficiency in the steam plants of that country's ESCOM system varied in 1961-62, according to age, from 30.9 per cent (generated) — 28.2 per cent sent out — down to 9.9 per cent.

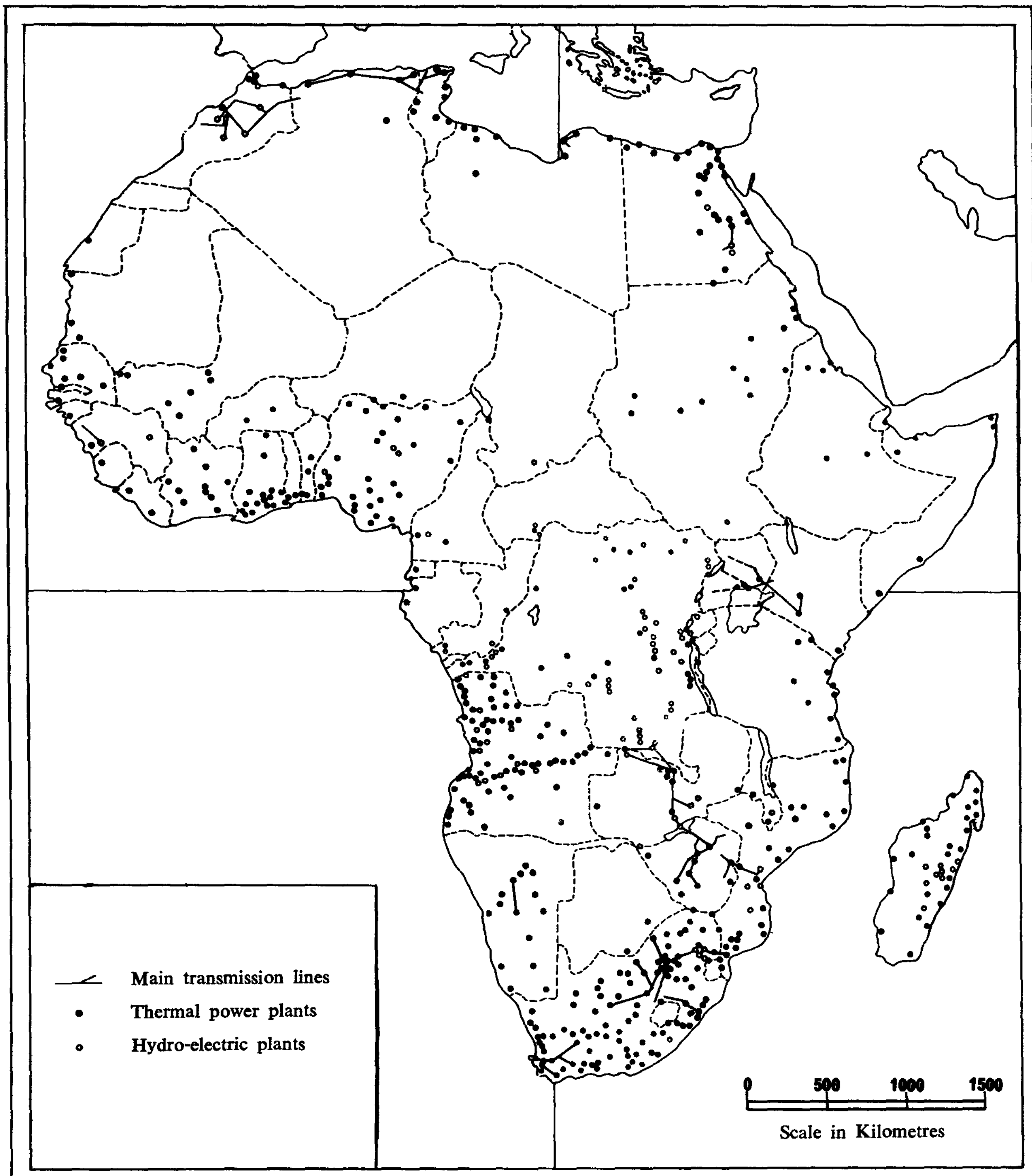
Principal features of generating capacity and production in various mainly interconnected power systems referred to earlier in this chapter, and their

[20] It should be remembered that the data in Table 43 are intended to give only summary general indications. Many details are incomplete and provisional.

[21] Hours of use of maximum capacity expressed as a percentage of the number of hours in a year.

MAP 6

## SOME MAIN TRANSMISSION LINES AND ELECTRIC POWER PLANTS IN AFRICA




The boundaries shown on this map do not imply endorsement or acceptance by the United Nations

Compiled by the United Nations Economic Commission for Europe

recent development, can be studied from the information presented in table 38 - 43.

b) **Production in isolated areas**

Operating costs of diesel generators, which are the principal sources of production where needs must be met from isolated plants, are commonly at least five times as great as where efficient and integrated fuel-burning plants are in use. Some details of selected diesel plants in service in a few of the many countries where they are employed are set out in annex V.

Study of map 6 (which shows the main distribution of electric power plants in Africa) in conjunction with a map of main communications indicates that, as would be expected, a large proportion of the plants in use are sited along principal railways, highways or along the coast. Study of the seasonal regime of production in many countries shows also a comparatively even distribution of power requirements throughout the year in many areas.[22]

Nevertheless, as can be seen from the figures included in table 24, fuel costs vary largely in relation to the geographical situation of the plant. Study of table 40 also shows how a comparatively low annual use of capacity is a frequent characteristic of territories with a large proportion of isolated generating equipment. In certain countries where production costs are high, the cause has been attributed to a combination of many factors — including high fuel costs (due not only to transport charges but to import duties, taxes, handling charges, etc.); high operating and maintenance costs (due to large supervisory staffs and methods of using cooling water); large fixed charges (due to high depreciation expenses); and an incomplete payment of accounts.

## E. TRANSMISSION AND DISTRIBUTION

Transmission and sub-transmission networks in African territories are necessarily of a voltage consistent with the loads to be carried. In most cases they radiate from a few principal towns to surrounding districts, though in some systems they serve to link hydro-electric plants with consuming centres — either within the country, as in Morocco and Egypt, or also beyond the frontier, as in Uganda and Northern Rhodesia.

Systems at 132 kV or above exist so far in ten different territories — in Morocco and Egypt in the north and in Ethiopia, Kenya, Nigeria, Tanganyika, Uganda, the Federation of Rhodesia and Nyasaland, South Africa and the Congo (Leopoldville). Only the systems of the Federal Power Board in Northern and Southern Rhodesia and of ESCOM in South Africa possess extra HV lines, the voltages being 330 kV (5070 km) and 275 kV (645 km) respectively. Tunisia, Senegal and Sudan have some hundreds of kilometres of line at between 90 and 110 kV, but in the remaining territories transmission is commonly at 66 kV or below.

The details of transmission systems for which information is available are set out in table 44. They show that in terms of total length the most extensive high voltage networks — outside those of the Federal Power Board in Rhodesia and of ESCOM in South Africa — appear to exist in Morocco, Tunisia and Kenya — all over 1000 km — plus Nigeria and Ethiopia.

## F. INTERNATIONAL INTERCONNEXIONS

The cross-frontier links at present in existence in Africa include those between Uganda, Kenya and Tanganyika on the one hand, and the links already referred to between the Federation of Rhodesia and Nyasaland and Congo (Leopoldville), Mozambique and (of local importance only) South Africa. In addition, Morocco, Algeria and Tunisia have each been linked by connexions at comparatively low voltage although transfers do not appear to be made at the present time. The main details of cross-frontier lines in service in 1961 are set out in table 45.

Study of maps 3, 4 and 6, together with the data contained in table 10 and other appropriate tables, would suggest a number of areas where possible development of exchanges could take place due to contrasts in availability of power, in appropriate natural resources, or in consumption. In the case of Uganda, for example, there is at present an excess of producibility in the Owen Falls plant — a temporary situation so far as existing plant is concerned which will inevitably arise wherever large blocks of power are brought into service to meet an emerging load. In this particular case a considerable amount of power is already exported under a 50-year contract to Kenya. Other adjoining countries (Rwanda and Burundi, Sudan, Tanganyika and Congo (Leopoldville) are not at present receiving supplies. The many possibilities which may already exist in Africa, or which will undoubtedly arise as systems extend and consumption increases, are likely to offer scope for mutually beneficial co-operation the economic advantages of which for operating purposes may well be proportionately greater than the quantities of power actually exchanged.

[22] While in a number of countries of West and Central Africa maximum output tends to occur about the month of May, production in North Africa is particularly concentrated to meet peak requirements during the winter months.

## G. OBSERVATIONS

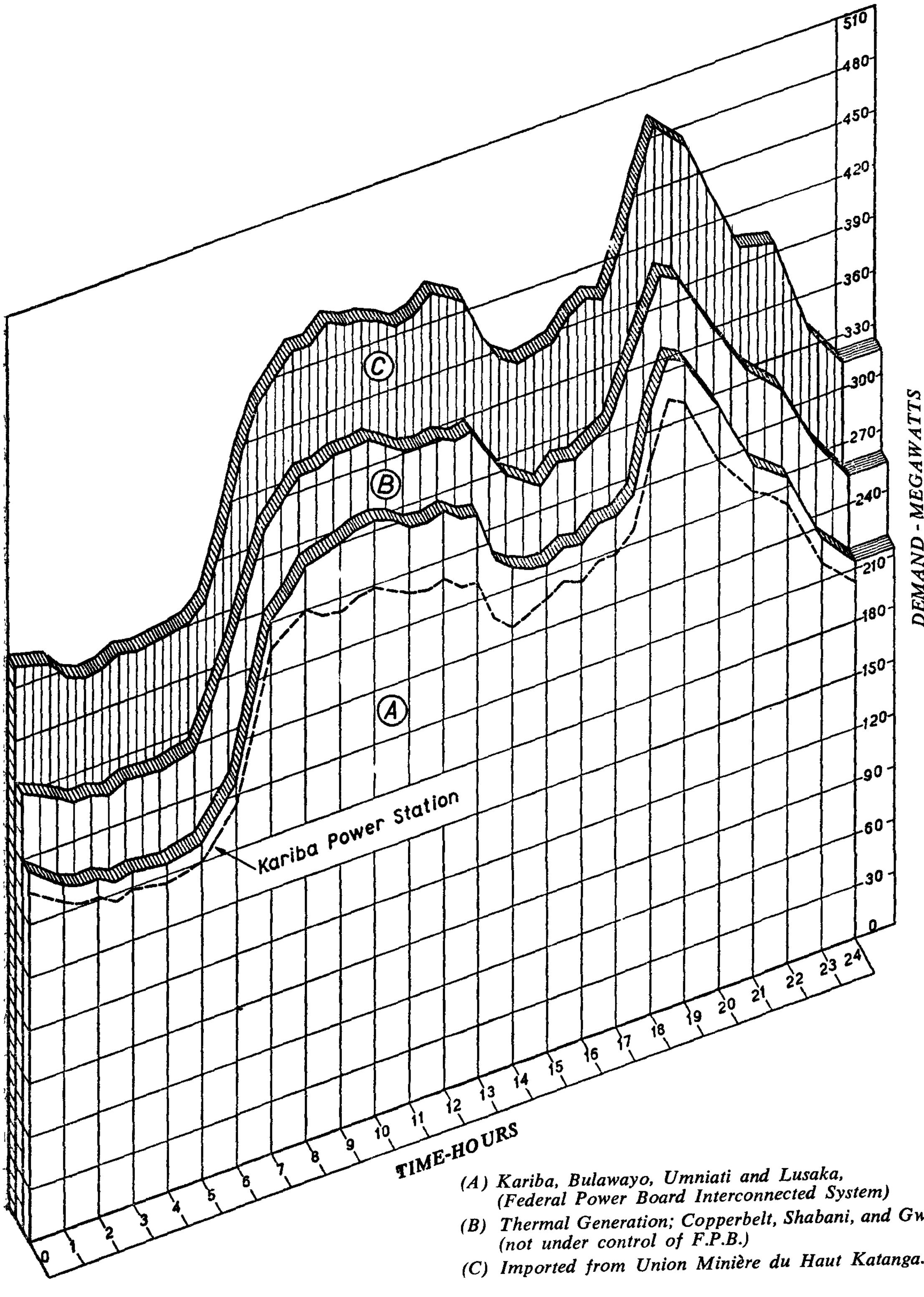
It would seem that productive facilities in African countries are at present fairly well adapted to existing levels of electric power use but that by applying capital to the spread of productive potential in regions with low consumption, much incipient new demand could probably be stimulated which would serve in turn to improve the over-all economy of supply even where special industrial demands do not exist. High fuel costs are one factor which inflates production costs in many inland areas but other causes — high maintenance costs and depreciation charges, high import duties for fuel, an inability to reap the benefits of interconnexion owing to insufficient load density, among others — may together be almost equally important. In addition fuel-using plants operate at comparatively low levels of use and generating efficiency in many areas.

On the other hand careful attention to the alternatives available to make the best use of scarce capital can help to overcome initial difficulties. Use of mobile diesel sets (possibly mobile gas turbines also) and small automatic hydro plants in areas where time must be given to build up an initial load are among the measures which may prove useful in order to secure a maximum return from a minimum of expenditure.

While these considerations apply particularly to the less electrified areas, interconnected systems also need to be extended as rapidly as useful load can be stimulated in order to reduce the over-all cost of electricity to all types of consumer.

**FIGURE 1**

Typical Daily Load Curve - Interconnected System of the Federation of Rhodesia and Nyasaland in a Recent Year




(A) *Kariba, Bulawayo, Umniati and Lusaka, (Federal Power Board Interconnected System)*

(B) *Thermal Generation; Copperbelt, Shabani, and Gwanda, (not under control of F.P.B.)*

(C) *Imported from Union Minière du Haut Katanga.*

TABLE 38

INSTALLED THERMAL AND HYDRO-ELECTRIC GENERATING CAPACITY IN SELECTED COUNTRIES AT THE END OF 1961

| Country | Installed thermal capacity at 31 December 1961 (MW) | | | | Total thermal capacity (MW) | Indices of total thermal capacity at 31 December 1961 | | Installed hydro capacity at 31 Dec. 1961 (MW) | | Total hydro capacity (MW) | Indices of total hydro capacity at 31 December 1961 | | Annual hourly peak demand in 1961 (MW) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Steam | | Diesel | | | | | | | | | | |
| | Public supply | Self-producers | Public supply | Self-producers | | 1960=100 | 1955=100 | Public supply | Self-producers | | 1960=100 | 1955=100 | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| **North Africa:** | | | | | | | | | | | | | |
| Algeria(a) | 253 | | ... | | 253 | ... | 112 | 186 | ... | 186 | ... | 100 | ... |
| Libya(a) | 30.4 | ... | ...(b) | ... | 30.4 | ... | 129 | — | — | — | — | — | ... |
| Morocco | ... | ... | ... | ... | 80 | 90P | 100 | 290 | ... | 290P | 100 | 100 | 216.1(c) |
| Tunisia | 70.3 | ... | 17.7 | (18.2) | 88.0(d) | 99(d) | 103(d) | 25.4 | ... | 25.4(d) | 103(d) | 150(d) | 57(interconn.) |
| Sudan | 30 | | 15 | | 45(s) | 118(d) | 290(d)(s) | 6 | | 6 | 118(e)(s) | 290(e)(s) | ... |
| UAR (Egypt) | 595.1 | 221 | 31.5 | 91.2 | 938.8 | 108 | 145 | 350 | — | 350 | 100 | 5800 | 461 |
| **West Africa:** | | | | | | | | | | | | | |
| Cameroon | 8 | | | | 8 | 100 | 114(g) | 162 | | 162 | 100 | 249(g) | ... |
| Central African Republic | — | | 1.43 | | 4.93(h) | ... | ... | 3.5 | ... | ... | ... | ... | ... |
| Gabon(d) | 12.9 | | | | 12.9 | 126 | 167(i) | — | — | — | — | — | — |
| Chad | 2.8 | | | | 2.8 | 103 | 215(g) | — | — | — | — | — | ... |
| Gambia | — | — | 2.77 | — | 2.77 | 100 | 182 | — | — | — | — | — | 1.3 |
| Ghana | — | — | 55.46 | 65.39(j) | 120.85 | 117 | 151 | — | — | — | — | — | 31.2(Dec.) |
| Liberia | — | — | 15.19 | 18 | 33.19 | ... | 317(k) | — | 4 | 4.0 | ... | 134(k) | 10.3(l) |
| Nigeria | 182.76 | | | | 182.76 | 123 | 286 | 18 | | 18 | 91(m) | 92(m) | 95(n) |
| Sierra Leone | 5 | — | 9.4 | 18.6 | 33.0 | 156 | 300(o) | — | — | — | — | — | ... |
| Togo | — | — | 2.16 | 6.00 | 8.16 | ... | ... | 1.6 | — | 1.6 | ... | ... | 1.9 |
| Ivory Coast | 10.0 | ... | 16.00 | ... | 26.00 | ... | ... | 19.2 | — | 19.2 | ... | ... | ... |
| Dahomey | ... | ... | ... | ... | 4.5(h) | 180(p) | ... | ... | ... | ... | 180(p) | | ... |
| Niger(q) | 2.9 | | | | 2.9 | 138 | 263 | — | — | — | — | — | ... |
| Senegal | 51 | ... | 17 | ... | 68 | 121 | 195* | — | — | — | — | — | ... |
| Mali | — | — | 7.63 | 1.57 | 9.20 | ... | ... | 0.5 | — | 0.52 | ... | ... | 4.3 |
| Upper Volta(q) | 4.4 | | | | 4.4 | 137 | 366 | — | — | — | — | — | ... |
| **North East Africa:** | | | | | | | | | | | | | |
| Ethiopia | 5.0 | — | 10.00 | 4.00 | 19.00 | 107 | 149 | 30 | ... | 30.00 | 106 | 650 | 30 |
| Somalia | 7.9(r) | | | | 7.9(r) | ... | 100 | — | — | — | — | — | ... |
| French Somaliland | — | — | 5.25 | .40 | 5.65 | — | 175(d) | — | — | — | — | — | ... |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Central Africa:** | | | | | | | | | | | | | |
| Angola(t) | 13.5 | 60.8 | ...(f) | ...(f) | 74.3 | ... | 217 | 24.3 | 3.2 | 27.5 | ... | 234 | ... |
| Congo (Leopoldville)(u) | 65.8 | | 13.5 | | 79.3 | ... | 136(v) | 68.1 | 694.9 | 763 | ... | 234(v) | |
| Kenya | 16.5 | — | 45.82(w) | — | 62.32 | 100 | 137 | 25.9 | — | 25.9 | 100 | 102 | 21.8 |
| Ruanda-Urundi(q) | | 7.2 | | | 7.2 | 100 | 133 | 8.3 | | 8.3 | 635 | 1380 | ... |
| Tanganyika(d) | | 26.3 | | | 26.3 | 127 | 162 | 20.2 | ... | 20.2 | 100 | 105 | ... |
| Uganda(d) | | 11.3 | | | 11.3 | 100 | 64 | 121.2 | ... | 121.2 | 100 | 202 | ... |
| Zanzibar & Pemba | | 3.6 | | | 3.6 | 100 | 157 | — | — | — | — | — | ... |
| Rhodesia (Northern) | 35.3(x) | 205.5(x) | ... | ... | 240.8 | 100 | 113 | 11.1 | 32 | 43.1 | 100 | 116 | ... |
| Nyasaland | 11.7 | — | 8 | 5 | 11.7 | 123 | 202 | 0.6 | — | 0.6 | 100 | 200 | 1007(z) |
| Rhodesia (Southern) | 480 | 21(x) | ... | ... | 501 | 100 | 140 | 563 | — | 563 | 188 | 56300 | ... |
| **Southern Africa:** | | | | | | | | | | | | | |
| Mozambique(q) | 36.8 | 37.7 | ...(f) | ...(f) | 74.5 | 128 | 175 | 47.4 | — | 47.4 | 100 | 378 | ... |
| Malagasy Rep.(y) | — | — | 21.50 | 30.54 | 52.04 | 100 | 151 | 30.4 | — | 30.44 | 114 | 186 | 26.7(z) |
| Réunion | — | 27.2(y) | 4.6 | 0.40(y) | 32.2 | ... | 131(a) | 3.7 | 0.2(y) | 3.9 | ... | ... | 4.2 |
| South Africa(u) | | 4193 | | | 4193 | 108(u) | 108(u) | — | — | — | — | — | ... |
| S.W. Africa | 38 | 46 | ...(f) | ...(f) | 84 | 131(g) | 191(g) | — | — | — | — | — | ... |

Note: Data in this table remain provisional for a number of the countries includede.

a) Figures refer to public supply in 1960.
b) Included in col. 2.
c) Maximum simultaneous demand during 1961. At 31 December the corresponding figure was 149.6 MW.
d) Refers to public supply only.
e) Estimate and based on public supply only.
f) Included in steam generating capacity.
g) Based on 1957 = 100.
h) Refers to total plant capacity of all kinds.
i) Refers to 1961 (1957 = 100).
j) Installed in mines.
k) Estimated and referring to 1956 = 100.
l) Refers to maximum demand for Monrovia in 1962.
m) Refers to plant under controlled in S. Cameroons (to September 1961 only).
n) Year ending 31 March 1961.
o) Col. 8 based on public supply in 1955.
p) Refers to 1960 (1957 = 100).
q) Refers to 1960 and to 1959 and 1956 = 100 respectively.
r) Refers to 1959. Does not include self-producer's installations.
s) Refers to hydro and thermal capacity combined.
t) Refers to 1960.
u) Refers to 1957 for Congo (Leopoldville) and, for S. Africa, to 1956 (with indices in cols. 7 and 8 based on 1955 = 100).
v) Refers to 1957 (1955 = 100).
w) Including 2 x 2.2 MW gas turbines.
x) Refers to total thermal capacity.
y) In kVa (MVA for Réunion) except for column 14.
z) Refers to non-simultaneous demand.

## TABLE 39

**Total production potential of hydro-electric plants already in service (selected countries only) in 1955 and 1961**

| Country | Mean annual producibility (yearly production potential under average conditions in $10^6$ kWh) P | | | | Seasonal storage energy capacity P ($10^6$kWh) | | | |
|---|---|---|---|---|---|---|---|---|
| | Public supply | | Self-producers | | Public supply | | Self-producers | |
| | 1955 | 1961 | 1955 | 1961 | 1955 | 1961 | 1955 | 1961 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Congo (Leopoldville) | ... | ... | ... | 2000* | ... | ... | ... | 1500* |
| Ethiopia | 75 | 200 | 20 | 30 | 15 | 150 | — | — |
| Ivory Coast | ... | 100 | ... | ... | ... | ... | ... | ... |
| Kenya | 145 | 145 | — | — | — | —(b) | — | —(b) |
| Madagascar | — | 175.9 | — | — | — | 83 | — | — |
| Mali | 0.7 | 1.0 | — | — | — | — | — | — |
| Morocco | 777 | 951 | ... | ... | ... | 1100 | ... | ... |
| Reunion | 1.2 | 2.3 | ... | 0.4 | — | — | — | — |
| Fed. Rhodesia & Nyasaland | 13 | 2229 | 205 | 243 | ... | ... | ... | ... |
| Tunisia | — | 26 | ... | ... | — | 45 | ... | ... |
| Uganda | ... | 430 | ... | ... | ... | ... | ... | ... |

a) Refers to total supply. b) Diurnal storage only.

## TABLE 40

**Hours of annual utilization of public supply hydro and thermal installed capacity in selected African countries**

| Country | 1955 | | 1960 | | 1961 | |
|---|---|---|---|---|---|---|
| | Hours of annual use | | Hours of annual use | | Hours of annual use | |
| | Thermal plants | Hydro plants | Thermal plants | Hydro plants | Thermal plants | Hydro plants |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **North Africa:** | | | | | | |
| Algeria | 2,622 | 1,548 | 3,862 | 1,871 | ... | ... |
| Libya | 2,619 | — | 3,322 | — | ... | — |
| Morocco | ... | 2,652 | ... | 3,210 | ... | 3,280 |
| Tunisia | 2,668 | ... | 2,562 | 1,787 | 2,970 | 870 |
| Sudan | 2,563 | — | 1,692 | — | 2,290 | — |
| UAR (Egypt) | 2,900 | 1,050 | 3,130 | 825 | 3,150 | 3,300 |
| **West Africa:** | | | | | | |
| Cameroon(a) | ... | ... | ... | 5,543 | ... | ... |
| Gabon | ... | — | 1,922 | — | 1,682 | — |
| Chad | ... | — | 2,963 | — | 3,214 | — |
| Gambia | 1,733 | — | 1,500 | — | 1,840 | — |
| Liberia(a) | 5,000(b) | 4,666(b) | 3,375(c) | 5,300(c) | ... | ... |
| Nigeria(a) | 2,540 | 3,744 | 2,937 | 5,280 | 2,340 | 5,610 |
| Sierra Leone | 2,000 | — | 2,670 | — | ... | — |
| Togo | 2,300 | — | ... | — | ... | — |
| Dahomey | 1,680(d) | — | 2,133 | — | ... | — |
| Niger | 2,273(b) | — | 2,724 | — | ... | — |
| Senegal(e) | 1,762(b) | — | 2,268 | — | 2,230 | — |
| Upper Volta | 2,083(b) | — | 1,773 | — | ... | — |
| **North East Africa:** | | | | | | |
| Ethiopia(a) | 1,722 | 3,286 | 1,569 | 916 | 1,550 | 1,250 |
| French Somaliland | 1,700 | — | 3,000 | — | ... | — |
| Somalia | 983 | — | 1,250 | — | ... | — |
| **Central Africa:** | | | | | | |
| Angola | ... | 1,933 | ... | 3,486 | ... | ... |
| Congo (Leopoldville)(a) | ... | 4,080 | ... | ... | ... | ... |
| Kenya | 1,245(b) | 6,834(b) | 1,330 | 5,676 | 1,340 | 5,090 |
| Tanganyika | 2,154 | 4,031 | 2,951 | 4,653 | 2,700 | 4,620 |
| Uganda | — | 1,322 | — | 3,283 | — | 3,590 |
| Zanzibar & Pemba | 2,130 | — | 3,111 | — | 3,310 | — |
| Fed. Rhodesia & Nyasaland | | | | | | |
| — Nyasaland | 931 | 4,333 | 2,632 | 5,333 | 2,930 | 3,170 |
| — N. Rhodesia | 2,900 | 2,600 | 2,756 | 1,982 | 1,190 | 2,250 |
| — S. Rhodesia(a) | 3,113 | 2,000 | 2,651 | 3,487 | 1,050 | 3,920 |
| **Southern Africa:** | | | | | | |
| Mozambique | 1,699 | ... | 1,146 | ... | ... | ... |
| Madagascar(e) | 2,158 | 1,763 | 1,858 | 1,475 | 1,830 | 1,485 |
| South Africa(e) | 4,254 | — | ... | — | ... | — |
| South-West Africa | 3,450(d) | — | 2,970 | — | 2,480 | — |

a) Refers to utilization of total capacity. b) Refers to 1956. c) Refers to 1959.
d) Refers to 1957. e) Refers to total public supply production.

## TABLE 41

**Total production and exchange of electric power in Africa in 1961 ($10^6$ kWh)**

| Country | Production | | | | Cross-frontier transfer | |
|---|---|---|---|---|---|---|
| | Thermal | Of which percentage from diesel plants | Hydro | Total | Import | Export |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **North Africa:** | | | | | | |
| Algeria(a) | 1091 | ... | 344 | 1435 | — | — |
| Libya(b) | 101.0 | ... | — | 101.0 | — | — |
| Morocco | 79.0 | — | 951.0 | 1030.0 | — | — |
| Tunisia(a) | 263 | 10 | 22.0 | 285.0 | — | — |
| Sudan(a) | 103.1 | 25* | — | 103.1 | — | — |
| UAR (Egypt) | 2710 | 7 | 1012 | 3722 | — | — |
| **West Africa:** | | | | | | |
| Cameroon | 12* | 100 | 938* | 950* | — | — |
| Central African Republic | 0.1 | 100 | 9.3 | 9.4 | — | — |
| Congo (Brazzaville)(a) | ... | ... | ... | 30.9 | — | — |
| Gabon | 21.7 | 31* | — | 21.7 | — | — |
| Chad | 9.0 | ... | — | 9.0 | — | — |
| Gambia | 5.1 | 100 | — | 5.1 | — | — |
| Ghana | 389.6 | 100 | — | 389.6 | — | — |
| Liberia | 91* | 100 | 21* | 112* | — | — |
| Nigeria(c) | 427.2 | 26 | 6.9 | 434.1 | — | — |
| Sierra Leone(d) | 48.0 | ... | — | 48.0 | — | — |
| Togo | 10.0 | 100 | — | 10.0 | — | — |
| Guinea | ... | ... | ... | 27.0 | — | — |
| Ivory Coast | 19.4 | 10* | 73.4 | 92.8 | — | — |
| Dahomey | 10.5* | 100 | — | 10.5* | — | — |
| Niger | 9.2 | ... | — | 9.2 | — | — |
| Senegal(a) | 152 | 10* | — | 152* | — | — |
| Mali | 14.7 | 100 | 1.0 | 15.7 | — | — |
| Upper Volta | 10.0 | ... | — | 10.0 | — | — |
| **North East Africa:** | | | | | | |
| Ethiopia | 55.8 | 50* | 68.6 | 124.4 | — | — |
| Somalia | 12* | 100 | — | 12* | — | — |
| French Somaliland | 10.7 | 100 | — | 10.7 | — | — |
| **Central Africa:** | | | | | | |
| Angola(d) | 31.4 | ... | 111.2 | 142.6 | — | — |
| Congo (Leopoldville) | 100* | ... | 2500* | 2600* | — | 463 |
| Kenya | 83.2 | 70* | 131.8 | 215.0 | 214 | — |
| Tanganyika(a) | 71.0 | ... | 93.3 | 164.3 | — | 25* |
| Uganda(a) | — | — | 434.8 | 434.8 | — | 191 |
| Zanzibar & Pemba | 11.9 | ... | — | 11.9 | — | — |
| Fed. Rhodesia & Nyasaland | 1000 | ... | 2475 | 3476 | 524 | — |
| — N. Rhodesia | 426 | ... | 233 | 659.0 | 463(e) | — |
| — Nyasaland | 33 | ... | 2 | 35 | — | — |
| — S. Rhodesia(f) | 576 | ... | 2206 | 2782.0 | 61 | — |
| **Southern Africa:** | | | | | | |
| Mozambique(d) | 47.1 | ... | 100* | 147.1 | — | 59 |
| Madagascar | 46.8 | 100 | 66.4 | 113.2 | — | — |
| Reunion | 43.4 | 26 | 2.7 | 46.1 | — | — |
| South Africa(g) | 24553 | ... | 3 | 24556 | ... | ... |
| Ruanda-Urundi(d) | 13.1 | ... | 5.6 | 18.7 | — | — |
| South West Africa | 208.0 | ... | — | 208.0 | ... | ... |

Note: Data in this Table remain provisional for a number of the countries included.

a) Refers to public supply only.
b) Refers to 1960 and to public supply only.
c) Production of Electricity Corporation of Nigeria for year beginning April. Total production stated as 662 million kWh.
d) Refers to 1960.
e) This import, from hydro-electric production in the Katanga area of the Congo (Leopoldville), rose to 498 million kWh in 1962.
f) Including Federal Power Board, Kariba.
g) Refers to about 95 per cent of total production.

TABLE 42

**Electric energy available for consumption in Africa in 1961 and its development since 1955**

(106 kWh)

| Country | Total available for consumption (1961) | Of which net import balance in 1961 (+ or —) | Hydro production as percentage of total production | | Availability for consumption in 1961 as an index P | |
|---|---|---|---|---|---|---|
| | | | 1955 | 1961 | 1955=100 | 1960=100 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **North Africa:** | | | | | | |
| Algeria(a) | 1435 | — | 33 | 24 | 163 | 108 |
| Libya(a) | 101.0 | — | — | — | 164 | ... |
| Morocco | 1030.0 | — | 88 | 92 | ... | 104* |
| Tunisia(a) | 285 | — | — | 8 | 131 | 102 |
| Sudan(a) | 103.1 | — | — | — | 230 | 116* |
| UAR (Egypt) | 3722 | — | — | 27 | 262 | 140 |
| **West Africa:** | | | | | | |
| Cameroon | 950* | — | 74(c) | 99 | 2380(c) | 104* |
| Central African Republic | 9.4 | — | 98 | 99 | 230 | 116 |
| Congo (Brazzaville)(a) | 30.9 | — | ... | ... | ... | 117 |
| Gabon | 21.7 | — | — | — | 271 | 111 |
| Chad | 9.0 | — | — | — | 450 | 112 |
| Gambia | 5.1 | — | — | — | 215 | 112 |
| Ghana | 389.6 | — | — | — | 162 | 104 |
| Liberia | 112* | — | 35 | 19* | 368* | 113* |
| Nigeria(d) | 434.1 | — | 30(e) | 15(e) | 230(f) | 118* |
| Sierra Leone(g) | 48.0 | — | — | — | ... | ... |
| Togo | 10.0 | — | — | — | 270(a) | 124(a) |
| Guinea | 27.0* | — | ... | ... | ... | ... |
| Ivory Coast | 92.8 | — | — | 79 | 500* | 138 |
| Dahomey | 10.5* | — | — | — | 344 | 100 |
| Niger | 9.2 | — | — | — | 368(f) | 116 |
| Senegal(a) | 152* | — | — | — | 237 | 119 |
| Mali | 15.7 | — | 8 | 6 | 194 | 102 |
| Upper Volta | 10.0 | — | — | — | 400(f) | 128 |
| **North East Africa:** | | | | | | |
| Ethiopia | 124.4 | — | 45 | 55 | 177(h) | 124(h) |
| Somalia | 12* | — | — | — | 140* | 106* |
| French Somaliland | 10.7 | — | — | — | 177(i) | 119 |
| **Central Africa:** | | | | | | |
| Angola(g) | 142.6 | — | 42 | 78 | 278 | ... |
| Congo (Leopoldville) | 2137* | —463 | 92 | 96* | 180* | ... |
| Kenya | 429.0 | +214 | 68 | 61 | 188 | 108 |
| Tanganyika(a) | 140* | —25* | 69 | 57 | 125* | 107 |
| Ruanda-Urundi(g) | 18.7 | — | 30 | 30 | 217(g) | ... |
| Uganda(a) | 243.8 | —191 | 99 | 100 | 545 | 103 |
| Zanzibar & Pemba | 11.9 | — | — | — | 243 | 106 |
| Fed. Rhodesia & Nyasaland | 4000 | +524 | 10 | 71 | 175(j) | 105 |
| — N. Rhodesia | 1122.0(k) | +463 | 18 | 35 | 55(j) | 83 |
| — Nyasaland | 36.0 | — | 19 | 6 | 522(j) | 124 |
| — S. Rhodesia | 2843.0(k) | +61 | — | 79 | 254(j) | 116 |
| **Southern Africa:** | | | | | | |
| Mozambique(g) | 88.1 | —59 | ... | 68 | 280(i) | ... |
| Madagascar | 113.2 | — | 75 | 59 | 182 | 105 |
| Reunion | 46.1 | — | 19* | 6 | 271(a) | ... |
| South Africa | 24556* | ... | — | — | 149 | 105 |
| South-West Africa | 208.0* | ... | — | — | 137(l) | 109 |

(Note: Data in this table remain provisional for a number of the countries included).

a) Refers to public supply only.
b) Refers to 1960 and to public supply only.
c) Based on 1956.
d) Production of Electricity Corporation of Nigeria for year beginning 1 April. Total production stated as 662 million kWh.
e) Based on total hydro and thermal production.
f) Refers to 1956 = 100.
g) Refers to 1960.
h) Refers to 12 months ending 12 September of year stated.
i) 1960 (1955 = 100).
j) Based on production only.
k) Owing to imports to N. Rhodesia from S. Rhodesia actual consumptions were 2274 and 1691 respectively.
l) Refers to 1957 = 100.

**TABLE 43**

**The part played by public supply in total electric power production and in total hydro-electric production respectively** — 1955—1961 (provisional)

| Country | 1955 Percentage of public supply output: In total production | 1955 Percentage of public supply output: In total hydro production | 1961 Percentage of public supply output: In total production | 1961 Percentage of public supply output: In total hydro production |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| **North Africa:** | | | | |
| Algeria | 100 | 100 | 100 | 100 |
| Libya | 100 | — | 100 | — |
| Morocco | 100 | 100 | 100 | 100 |
| Tunisia | 92 | — | 90 | 100 |
| Sudan | 100 | — | 100 | — |
| UAR (Egypt) | 57 | 100 | 82 | 100 |
| **West Africa:** | | | | |
| Cameroon | 80* | 100 | 7 | 4 |
| Central African Republic | 100 | 100 | 100 | 100 |
| Congo (Brazzaville) | ... | ... | ... | ... |
| Gabon | 100 | — | 100 | — |
| Chad | ... | — | ... | — |
| Gambia | 100 | — | 91 | — |
| Ghana | 24 | — | 45 | — |
| Liberia | 33 | 0(a) | 33 | 0(a) |
| Nigeria | 95 | 100 | 98 | 100 |
| Sierra Leone | 33 | — | 80 | ... |
| Togo | 100 | — | 100(b) | — |
| Guinea | ... | ... | ... | ... |
| Ivory Coast | ... | ... | ... | ... |
| Dahomey | ... | ... | ... | ... |
| Niger | 100 | — | 100 | — |
| Senegal | ... | — | ... | — |
| Mali | ... | ... | ... | ... |
| Upper Volta | 100 | — | 100 | — |
| **North East Africa:** | | | | |
| Ethiopia | 82 | 100 | 84 | 90* |
| Somalia | 85 | — | 90* | — |
| French Somaliland | ... | ... | ... | ... |
| **Central Africa:** | | | | |
| Angola | 60 | 100 | 69(b) | 77(b) |
| Congo (Leopoldville) | 4 | 4 | 12 | 11 |
| Kenya | ... | ... | ... | ... |
| Tanganyika | ... | ... | ... | ... |
| Uganda | ... | ... | ... | ... |
| Zanzibar & Pemba | 100 | — | 100 | — |
| Fed. Rhodesia & Nyasaland | | | | |
| — Rhodesia (Northern) | 4 | 6 | 11 | 10 |
| — Rhodesia (Southern) | 96 | 100 | 97 | 100 |
| — Nyasaland | 100 | 100 | 100 | 100 |
| **Southern Africa:** | | | | |
| Bechuanaland, Basutoland & Swaziland | ... | ... | ... | ... |
| Mozambique | 40 | — | 77(b) | 100(b) |
| Madagascar | 92 | 100 | 72 | 100 |
| Mauritius | 38 | 100 | 38 | 100 |
| Reunion | ... | ... | 36 | ... |
| South Africa | ... | — | ... | — |
| Ruanda-Urundi | 58 | ... | 48(b) | ... |
| South West Africa | 32(c) | — | 41 | — |

(Note: Data in this table remain provisional for a number of the countries included).

a) The total output is from self-producers.
b) Refers to 1960.
c) Refers to 1957.

TABLE 44

**Main Specifications of Transmission Networks in service in 1961 (selected countries)**

| Country | Total length of internal transmission networks (circuit km) | | | | | | Total Length (km) |
|---|---|---|---|---|---|---|---|
| | Below 70 kV | | 70-110 kV | | Over 110 kV | | |
| | Length | Voltage | Length | Voltage | Length | Voltage | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **North Africa:** | | | | | | | |
| Morocco | 5885 | 20—60 | — | — | 1194 | 150 | 7079 |
| Tunisia | 2172 | 20—60 | 290 | 90 | — | — | 2462 |
| Sudan | ... | ... | 180* | 110 | — | — | 180* |
| UAR (Egypt) | ... | 63 | ... | ... | ... | 132 | ... |
| **West Africa:** | | | | | | | |
| Cameroun | ... | ... | — | — | — | — | ... |
| Central African Republic | 88 | 63 | — | — | — | — | 88 |
| Gambia | 29 | 11 | — | — | — | — | 29 |
| Ghana | ... | Below 20 | — | — | — | — | ... |
| Liberia | 145 | 69 | — | — | — | — | 145 |
| Nigeria | ... | ... | 674(a) | 100 | 210(b) | 100-200 | 884 |
| Sierra Leone | 10 | 33 | — | — | — | — | 10* |
| Togo | — | — | — | — | — | — | — |
| Guinea | ... | 60 | ... | ... | — | — | ... |
| Ivory Coast | 350* | 90-30 | — | — | — | — | 350* |
| Dahomey | 288 | ... | — | — | — | — | 288* |
| Senegal | 400* | 30 | 150* | 90 | — | — | 550* |
| Mali | 57 | 15-30 | — | — | — | — | 57 |
| **North East Africa:** | | | | | | | |
| Ethiopia | 220 | 36-70 | | | 418 | 121-135 | 638 |
| Somalia | ... | ... | — | — | — | — | — |
| French Somaliland | — | — | — | — | — | — | — |
| **Central Africa:** | | | | | | | |
| Congo (Leopoldville) | ... | ... | ... | ... | 285(c) | 300c) | ... |
| Kenya | 820 | 33-66 | — | — | 400 | 132 | 1220 |
| Tanganyika | 70* | 33 | — | — | ... | 132 | |
| Uganda | ... | 33-66 | — | — | 265(d) | 132 | ... |
| Zanzibar & Pemba | ... | ... | ... | ... | ... | ... | ... |
| Fed. Rhodesia & Nyasaland | 2590 | 33-66 | 1030 | 88-110 | 1450 | 330 | 5070 |
| — N. Rhodesia | ... | ... | ... | ... | ... | 330 | ... |
| — Nyasaland | 100 | 33 | — | — | — | — | 100 |
| — S. Rhodesia | 1390 | 33-66 | 920 | 88-110 | ... | 330 | 2310 |
| **Southern Africa:** | | | | | | | |
| Malagasy Rep. | 174 | 20-60 | — | — | — | — | 174 |
| Réunion | 274 | 15-63 | — | — | — | — | 274 |
| South Africa | 4350 | 33-66 | 3670 | 88 | 2645(e) | 132-275 | 10665 |

a) Includes 480 km under construction in 1960 at less than 100 kV.
b) Includes 65 km under construction in 1960 at between 100 and 200 kV.
c) Sited in Congo but owned by Rhodesian authorities.
d) Relates to 132 and 66 kV combined.
e) Of which 645 circuit-km at 275 kV.

TABLE 45

**Main specifications of international interconnexions in service in 1961**

(selected countries)

| Country | Cross-frontier interconnexions | | | |
|---|---|---|---|---|
| | Territory with which connected | Voltage (kV) | No. of circuits | Year of entry into service |
| 1 | 2 | 3 | 4 | 5 |
| **North Africa:** | | | | |
| Morocco | Algeria | 22 | ... | ... |
| Tunisia | Algeria | 90 | 2 | 1953-1956 |
| Sudan | — | — | — | — |
| UAR (Egypt) | — | — | — | — |
| **West Africa:** | | | | |
| Cameroun | — | — | — | — |
| Central African Rep. | — | — | — | — |
| Gambia | — | — | — | — |
| Ghana | — | — | — | — |
| Liberia | — | — | — | — |
| Nigeria | — | — | — | — |
| Togo | — | — | — | — |
| Guinea | — | — | — | — |
| Ivory Coast | — | — | — | — |
| Dahomey | — | — | — | — |
| Senegal | — | — | — | — |
| Mali | — | — | — | — |
| Upper Volta | — | — | — | — |
| **North East Africa:** | | | | |
| Ethiopia | — | — | — | — |
| Somalia | — | — | — | — |
| French Somaliland | — | — | — | — |
| **Central Africa:** | | | | |
| Congo (Leopoldville) | N. Rhodesia | 220 | 1 | 1956 |
| Kenya | Uganda | 132 | 2 | 1958 |
| | Tanganyika | 33 | 1 | 1950 |
| Tanganyika | Kenya | 33 | 1 | 1950 |
| Uganda | Kenya | 132 | 2 | 1958 |
| Zanzibar & Pemba | — | — | — | — |
| Fed. Rhodesia and Nyasaland | | | | |
| — N. Rhodesia | Congo (Leopoldville) | 220 | 1 | 1956 |
| — Nyasaland | — | — | — | — |
| — S. Rhodesia | Mozambique | 110 | 1 | 1957 |
| | S. Africa | 11 | ... | ... |
| **Southern Africa:** | | | | |
| Malagasy Republic | — | — | — | — |
| Réunion | — | — | — | — |
| South Africa | S. Rhodesia | 11 | ... | ... |

Part III

# THE PERSPECTIVE FOR ELECTRIC POWER DEVELOPMENT

Chapter VI

## PROBLEMS AND PROSPECTS AT THE NATIONAL LEVEL

### A. INTRODUCTION

The immediate problems of developing a viable and expanding electric power industry in Africa may be classified in various ways. On the one hand there are problems which affect the development of public supply production as a whole, such as the cost of fuel imports or the lack of foreign exchange; and on the other there are problems which differ in intensity according to the characteristics of the region in which they are tackled.

From the second point of view the different regions of Africa comprise areas of three main types — first, those around expanding centres of population; where electric power consumption is overwhelmingly concentrated and development is following a more or less normal course; second, those which may lack dense settlement and an adequate use of electricity but which possess economic potential due to the presence of important sources of power and/or other natural non-energy resources; and lastly, "problem areas" — those which are sparsely populated, not specially attractive economically and far from sources of power or good communications. It is mainly the second and third of these types of area that raise **special** development problems. While the situation in areas of the third type is summed up elsewhere in this study — for example in chapter I and at the beginning of chapter IV — the problems of areas of high potential vary according to the economic attractiveness of the products they have to offer. Their development prospects may rest on the scope for international co-operation. They may equally be affected by internal requirements for raw materials, for processed materials for manufactured goods or for any of these as products for exports, either to satisfy inter-African requirements or to meet other external demands.

It is possible therefore to divide some main problems which emerge into those which underlie the meeting of national requirements for electric power from internal sources; those which involve co-operation between different African territories in meeting their common needs; and those which are linked more particularly to the prospects of satisfying external needs for non-energy products through export based particularly on use of surplus power potential. In the present chapter the internal questions of developing an adequate supply of power will be discussed, while the following two chapters concentrate on the aspects of international co-operation and the meeting of export demands respectively. All three can deal only briefly with these large questions in the context already provided in parts I and II, the aim being more particularly to focus attention on some basic problems which appear to justify further attention.[23]

### B. MEETING INTERNAL REQUIREMENTS FOR ELECTRIC POWER

In any type of area it would seem of importance at the earliest stage to give high priority to making two kinds of basic review — a preliminary assessment of natural energy resources made as comprehensively as possible from the point of view of location; and an appraisal, both regionally and for a period of some years ahead, of those elements which underlie both potential growth in demand for power and possible changes in the means of satisfying it. These two inquiries complement one another and make possible a projection (or alternative projections) of likely electricity requirements and a further plan for covering possible means of supply. These evaluations need to be revised every few years. Although they will contain errors, the mere focusing of attention clearly on the questions which present themselves is already a large step forward. Comparison of studies in different countries can often be illuminating and may also show possibilities for co-operative action.[24]

23 Some additional questions of detail were dealt with in separate reports submitted to the African Electric Power Meeting held at Addis Ababa in October 1963 under the auspices of the Economic Commission for Africa.

24 Documents to which reference may be made and which concentrate on these two subjects in greater detail are referred to in the list of sources of information (annex I).

One urgent need is to spread essential consumption more widely among the population — more particularly in areas away from the centres of the main towns — and to increase the specific use per existing consumer. This includes expanding consumption to meet essential internal needs in industry and handicrafts, services, agriculture and transport as well as for the simpler household uses .Expressed in economic terms[25] this means raising electricity consumption much more rapidly than either the value of total national product (expressed in constant prices) or the index of industrial production.

So far as industrial use of power is concerned the idea of setting up industrial estates near suitable power sources and communications appears to merit further consideration, particularly as a means of dealing with the lighter industries required to expand essential manufactures for internal use.[26] Industries of this type can be grouped near one another and in suitable proximity to sources of production of the basic raw materials they need. Questions involved in planning electric power supply in conjunction with locational economic planning for industry may therefore prove worthy of attention.

To provide a concrete example of the economy of supply under conditions discussed in this chapter, table 46 illustrates relative magnitudes which may occur in the growth of consumption in a less-electrified territory — the Central African Republic. This table supplements the information concerning some recent trends in use of electric power in less electrified areas that is presented elsewhere in the study.

Some main types of problems which arise in seeking to promote electrification to meet internal needs in Africa will next be discussed.

#### a) **Financial questions**

Particularly in dealing with "problem areas" referred to earlier, questions concerned with the provision of adequate capital for maintaining an expanding supply of power will certainly merit further consideration. Where sufficient capital cannot be assured from revenue it will commonly be necessary to pay special attention to various combinations of approach — in the designing of tariff systems, promotional and credit activities and accounting methods — so as to make possible a viable and expanding enterprise. Such questions involve possible methods of internal financing on which certain African experience already exists. They include the issue of shares or bonds under carefully framed conditions; the possibility of combining interest-free loans or government subsidies with suitably adjusted tariffs where special areas of costly supply are involved; special methods of adjusting depreciation provision; and so on. It is not intended to deal with such questions in detail here, as a number of special reports have been prepared on certain aspects of them. The relevance in this connexion of studying the advantages of different types of basic organization of electric power supply have already been discussed more fully in chapter V.

#### b) **Development of a system permitting falling unit costs**

In a highly developed and regularly expanding system, continuing economies in the cost of furnishing kilowatts and kilowatt-hours are possible from a variety of sources. Construction of larger and better-integrated thermal and hydro-electric plants allows economies of scale to be attained by reducing such parameters as the specific volume of buildings, weight of components, number of employees per kW, etc. At the same time regular new increments of thermal capacity designed for higher steam pressures and temperatures still allow an annual rise in **average** thermal efficiency of perhaps 1 - 2 per cent to be achieved. As loads grow the use of higher voltages reduces transmission losses. More complete integration and central control of plants which may be widely diversified in type of operation, efficiency and geographical location, makes for an improved use of every kW available and also spreads the existing load to be met to the maximum extent.

i) **System interconnexion** To realise these advantages it is clear that the elements of an interconnected system are required. Such a system allows large plants to be introduced; it allows thermal plants to be operated on the total load in accordance with their age and efficiency and overflows in hydro plants due to lack of demand to be minimized; and it allows maintenance and overhaul programmes to be planned in the most effective way. An interconnected system also tends in turn to make international interconnexion easier and more worthwhile.

Conditions favouring a given level of interconnexion on a particular system are reflected by that system's average density of production. Thus in Switzerland 50 kV lines were first built about 1908, when production amounted to some hundreds of millions of kWh. When production reached around four milliard kWh 150 kV was introduced, and by 1952 (at 14 milliard kWh of output) 220 kV lines were brought into service. At present 380 kV transmission is being fully introduced at a time when production is around 24 milliard kWh per year and consumption amounts to 3480 kWh per head. In this particular country, which relies on hydro power, cross-frontier exchanges are highly developed with neighbouring countries depending on mixed hydro-thermal output.

[25] See the analysis made in chapter IV.
[26] Map 5 illustrates how such concentrations have tended to appear naturally around sources of low-cost Power.

In the above example, and in Europe as a whole, there is a high average density of production relative to area. To give the basis for a broad consideration of the position in Africa, table 47 shows the density in kWh per $km^2$ in different territories in 1961. The low average density in most African countries is illustrated by the fact that, taking **total** area into account, the mean value for Africa (1420 kWh/$km^2$) is about one per cent of that of France, which is near the European average. Comparison of the figures with those of table 44 and other information in Chapter V provides a basis for a preliminary review of economic conditions in Africa governing the introduction of transmission networks.

ii) **Development of generating plant** While, according to E.W. Golding,[27] it may cost around 2.5-5.5 pence (29-64 mills) per kWh to transmit a maximum demand limited to one MW over 150-300 km at a moderate load factor (say around 35 per cent), costs rise steeply at still lower levels of demand, so that under such conditions local generation remains initially more economic. Local small-scale generation may in principle be possible from wind power generators, from solar energy of from installations using organic wastes, but it is most commonly achieved in practice through diesel-driven plants, gas turbines or small automatic hydro power installations.

Diesel plants and low-capacity standardized hydro plants have an important part to play in promoting the earlier stages of electrification in many parts of Africa. Both types have relatively low capital costs (around £ 50/kW for diesel plant of some hundreds of kW and £100/kW or less for hydro equipment in the region of 100 kW).[28] It is also possible to envisage a use of mobile units not only to build up load while developing more advanced plants, but to postpone for a time any strengthening of a transmission line that is fully loaded.

It has been shown earlier, in chapters III (table 24) and V, that costs of generation from existing diesel plants are high in Africa, not only due to fuel transport over long distances, but because of high costs of maintenance, age of equipment and various other analysable causes. Diesel units, like other types of plant, have however been subject to some technical progress in recent years. It would seem that the most effective use of this type of equipment in Africa is a subject which would justify further consideration.

In this connexion it may be of interest to refer to an example of current use of diesel generating capacity that illustrates the present level of technique — that on the island of Jersey, between Great Britain and France.[29] Here the maximum load has risen from 9 MW in 1952 to 35 MW in 1962 — a year when consumption increased by 26 per cent. Throughout, the power supply has been assured by diesel generation. With the bringing into service of four new Mirrless sets (two of them built on site without works testing) the total capacity will amount to over 50 MW — the largest diesel station in Europe. The new sets, giving 5 MW and with a termal efficiency of 40 per cent, run on residual fuel oil, and the station as a whole is claimed to have the lowest generation costs for a diesel plant — 0.78 pence (9.2 mills) per kWh. For comparative purposes it may be added that average cost per kWh to the consumer in Jersey is at present 2.16 pence (25.4 mills).[30]

iii) **Problems concerning choice of plant** At the point in demand growth where construction of larger new plants becomes feasible, problems of choice arise — between developing steam generating units, hydro plants (whether storage, with or without pumping, or run-of-stream), augmenting diesel sets, building gas turbine stations for peak load, considering the role of nuclear power, etc. The scope to be accorded to transmission may raise another key problem of choice. These choices are influenced, **inter-alia,** by such questions are fuel import cost, postponement of heavy capital expenditure, transport limits for large generating units on the one hand; and by needs to minimize foreign exchange through use of local labour, developing local industries such as cement production to serve other requirements, and providing for future plant extensions economically, on the other. The "multiplier effect" on demand for power through such local economic development is another over-all consideration.

It is not intended here to enter into these matters in further detail. Since they underlie much of the development strategy of an emerging power supply system all possible exchange of experience in this field would seem highly useful.

## C. SUMMARY

A number of crucial questions of development in meeting essential internal needs for electric power have been emphasized in this chapter because they appear to need the fullest possible consideration at the outset.

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27 Technical Report No. C/T118 — Electrical Research Association, London, 1956.

28 That this figure for hydro plant may be applied to African conditions is also suggested by the fact that the same order of specific cost is quoted in Uganda for hydro-electric equipment installed for use in remote areas.

29 The area of Jersey is 116 $km^2$, the average rate of population growth 2.8 per cent and mean population density 534 persons per $km^2$ (1961).

30 Now that the base load is large enough to support a sizable generating plant, a 180 MW oil-fired steam plant will later be developed with 30 MW units, plus a 15 MW gas turbine set to meet the peak demand.

The problems which they pose may be arranged in the following main groups:

— problems of evaluating the future growth of power requirements, available resources and means for future power supply;
— problems arising in promoting to meet essential needs economically, consumption including the study of such possible solutions as the setting up of industrial estates;
— problems of financing from internal sources, including related questions of tariff design, promotional and accounting methods, etc.;
— problems of system development to reduce costs, including:
  — interconnexion on and distribution questions;
  — the economy of diesel plants and small automatic hydro plants;
  — questions of choice and economic policy relative to plant and line construction.

TABLE 46

**Energy sold and number of consumers in the Central African Republic (Bangui)**

| Year | Lighting ($10^3$ kWh) | Street lighting ($10^3$ kWh) | Power ($10^3$ kWh) | High voltage ($10^3$ kWh) | Total ($10^3$ kWh) | Number of consumers: Light | Power (low voltage) | High voltage | Subscribed demand (kW) (a) | Average price (CFA/kWh) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1954 | 1,117 | 25.91 | 598 | 665 | 2,406 | 912 | 136 | 7 | 2,872 | 21.95 |
| 1955 | 1,253 | 35.85 | 551 | 826 | 2,656 | 1,019 | 143 | 10 | 3,210 | 21,80 |
| 1956 | 1,447 | 45.83 | 625 | 990 | 3,107 | 1,310 | 142 | 12 | 3,937 | 21.20 |
| 1957 | 1,747 | 49.30 | 819 | 1,055 | 3,690 | 1,336 | 157 | 12 | 4,592 | 20.20 |
| 1958 | 1,992 | 49.40 | 1,194 | 1,210 | 4,447 | 1,435 | 192 | 14 | 4,794 | 20.95 |
| 1959 | 2,124 | 55.92 | 1,430 | 1,567 | 5,177 | 1,532 | 228 | 16 | 5,318 | 21.87 |
| 1960 | 2,372 | 65.64 | 1,682 | 1,815 | 5,935 | 1,682 | 296 | 18 | 5,842 | 21.75 |
| 1961 | 2,734 | 75.71 | 2,071 | 2,213 | 7,093 | 1,764 | 375 | 19 | 6,657 | 21.25 |

a) Determined by multiplying connected load by certain factors. Maximum demand is limited by relays properly set.

TABLE 47

**Density of electric power production in relation to area in 1961**

| Country | Density of total production in 1961 ($kWh/km^2$) | Gross consumption in kWh per inhabitant |
|---|---|---|
| 1 | 2 | 3 |
| **North Africa:** | | |
| Algeria | 603 | 119* |
| Libya(a) | 57 | 51 |
| Morocco | 2311 | 86 |
| Tunisia | 2236 | 61 |
| Sudan | 41 | 9 |
| UAR (Egypt) | 3722 | 140 |
| **West Africa:** | | |
| Cameroon | 1998 | 229 |
| Central African Republic | 15 | 8 |
| Congo (Brazzaville) | 904 | 33* |
| Gabon | 81 | 48 |
| Chad | 7 | 3 |
| Gambia | 490 | 19 |
| Ghana | 1638 | 56 |
| Liberia | 1005 | 87* |
| Nigeria | 470 | 18 |
| Sierra Leone(a) | 664 | 20 |
| Togo | 177 | 7 |
| Guinea | 110 | 9* |
| Ivory Coast | 288 | 28 |
| Dahomey | 91 | 5* |
| Niger | 7 | ... |
| Senegal | 771 | 51 |
| Mali | 13 | 4 |
| Upper Volta | 37 | 2 |
| **North East Africa:** | | |
| Ethiopia | 105 | 6a) |
| Somalia | 18 | 6* |
| French Somaliland | 486 | 157 |
| **Central Africa:** | | |
| Angola(a) | 114 | 29 |
| Congo (Leopoldville) | 1109 | 148* |
| Kenya | 369 | 59 |
| Tanganyika | 175 | 15 |
| Uganda | 1815 | 36 |
| Zanzibar & Pemba | 4577 | 38 |
| Rhodesia (North) | 883 | 917 |
| Rhodesia (South) | 7741 | 537 |
| Nyasaland | 294 | 12 |
| **South Africa:** | | |
| Mozambique(a) | 188 | 13 |
| Madagascar | 190 | 20 |
| Reunion | 18440 | 133 |
| South Africa | 20072 | 1512* |
| Average for Africa | 1420 | 165 |

a) Refers to 1960.

# Chapter VII

## POSSIBLE FIELDS OF INTER-AFRICAN CO-OPERATION

### A. INTRODUCTION

Earlier chapters have shown that there are a number of fields in which mutually advantageous co-operation between two or more countries can improve to prospects of meeting electric power requirements economically. It is the purpose of the present chapter to draw attention briefly to certain main types of co-operative action which it may be of interest to consider in greater detail — in particular the following:

— co-operation in building generating plants or in exchanging electric power across frontiers;

— co-operation in obtaining fuel supplies for electricity production;

— other common arrangements to facilitate relevant supplies from African sources.

### B. CROSS-FRONTIER CO-OPERATION FOR GENERATION OR EXCHANGE OF ELECTRIC POWER

Reference to Map 3 shows how extensive are the rivers of Africa which form common frontiers or which cross such frontiers successively. Many important rivers, such as the Congo or the Limpopo, provide example of the first type; while the Niger, the Nile and many others afford example of the second. Other rivers again, such as the Zambezi, are both contiguous and successive in different sections of their watercourses. As has been seen in part I, many such waterways offer massive opportunities for hydro-electric development or for multi-purpose schemes comprising also irrigation, water supply and flood control. Many of the most important are navigable over long stretches.

It is not intended here to enumerate the projects for hydro-electric or multi-purpose schemes which exist in Africa. Some examples have been given earlier and many more will undoubtedly arise. Possibilities for joint construction of schemes clearly exist and offer great scope. Other types of case exist in Europe, where collaboration in the building of plants — hydro-electric, pure pumped storage or thermal — for export of power to adjoining countries has taken place with the plants themselves located wholly within a single country which may have surplus low-cost resources available.

This introduces one type of case of a cross-frontier transfer of electric energy where there will normally be a long-term contract for a given supply under defined conditions. In some instances help in building the plant may be repaid by a transfer of power. Other similar examples may occur where a large plant can be built economically in excess of immediate requirements — as was the case in recent years in Uganda — so that there is a clear advantage in arranging a contractual export of power where cost and other conditions are suitable.

Wherever there is great diversity in the pattern of power output or demand, or both, there may equally be a potential case for contractual seasonal exchanges or for occasional transfers to meet emergency conditions. This may arise because water resources are abundant on one side of a frontier and deficient on the other; because the seasonal characteristics of stream flow are different in different areas; or because a seasonal surplus of energy from hydro plants in one country allows fuel saving in thermal plants in another country, with a compensating return of power at times of low water or off-peak running of the thermal capacity so as to allow conservation of water storage. Again, the hours of peak demand may differ noticeably in different countries, thereby increasing the diversity effect. All such co-operative measures may have great economic significance where the density of consumption is sufficient to justify transmission, even though the quantities of power exchanged may seem relatively small. Where, as in Europe, expanding groups of countries are able to co-operate in this way through useful diversity in types of production, functional co-operation between operating services and constant exchange of information may do much to ensure maximum economy.

Although in most parts of Africa this latter degree of co-operation may not be immediately feasible, examples of contractual transfers already occur[31]

[31] See chapter V.

and many local interconnexions may be possible, particularly to supply relatively remote areas. In certain parts of west, north and east Africa, conditions may already favour some further mutual assistance through power transfers or exchanges. Study of possible co-operation of this kind between Guinea and neighbouring countries has already been envisaged. Some degree of initial cross-frontier interconnexion has been attained in north Africa, for example between Algeria, Tunisia and Morocco, and might be extended. In Gambia supplies to the more remote areas near the frontier, from Senegal, have been though worthy of study. Co-operation between Uganda and a number of adjoining territories may be feasible. Transfers between Northern and Southern Rhodesia and neighbouring territories might be further developed; and so on.

To assist study of seasonal regimes of electricity production in Africa, table 48 shows some indices of seasonal variation in output in 1962.

## C. CO-OPERATION IN OBTAINING FUEL SUPPLIES FOR ELECTRICITY PRODUCTION

In chapter III it was shown that the different reserves of fuel, fuel exploitation and oil refinery facilities are all very unequally distributed in Africa. Various types of co-operation might be possible to facilitate the supply of fuels for power production from African sources in such a way as to alleviate costs and transport charges over great distances. Crude oil is already exported for refining in neighbouring countries in some cases and various kinds of offsetting or compensating arrangements might be feasible. It is possible, for instance, that hydro power might be supplied in return for refined oil fuels; or assistance might be given to exploit a given fuel deposit as part of a barter arrangement. The rapid development of refineries in various countries where they have not previously existed should open up many new possibilities for lowering costs by taking advantage of favourable locations.

The existence of surplus energy resources in some countries and deficiencies in others, a circumstance that is common in respect of hydro power in many parts of the world, may equally apply to low-cost fuel reserves. Enormous reserves of natural gas in Algeria, and perhaps elsewhere in north Africa, are due to be exploited for export outside Africa. This is possible in view of the comparative proximity to the coast and the possibility of using pipelines or transporting liquified gas. To the south of the Sahara, in various regions of west Africa such as Senegal, there exist areas of comparative energy deficiency for which it might be economically feasible to envisage imports from north African sources.

## D. OTHER COMMON ARRANGEMENTS

One common problem throughout Africa is the absence of an African source of equipment for electric power production and transmission. All necessary natural sources of metal production occur abundantly on the continent but the manufacturing of electrical equipment nowhere exists. While labour for civil engineering work, production of concrete etc., can often be provided without insuperable difficulty from internal resources, all forms of generating, transmission and distribution equipment must be imported, producing a serious difficulty in terms of foreign exchange. If centres for manufacturing certain kinds of equipment could be developed, possibly by some co-operative scheme, a major bottleneck would be overcome.

An even more basic problem is that of shortage of capital for development. The study of co-operation in this field is not within the realm of the present report. It would seem, however, that the African Development Bank already actively proposed through the Economic Commission for Africa would be a valuable agent for facilitating appropriate development projects in the field of electric power.[32]

[32] The Project for an African Development Bank (E/CN. 14/FMAB/13) United Nations, New York, 1963.

## TABLE 48

**Variations in monthly electricity production in selected African countries in 1962 relative to the annual average**

| Country | Indices of monthly production (monthly average in 1962 = 100) | | | | | | | | | | | | Average monthly production (1962) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | $10^6$ kWh | Index (1961 = 100) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **North Africa:** | | | | | | | | | | | | | | |
| Algeria(a) | 130 | 119 | 106 | 100 | 96 | 86 | 86 | 93 | 92 | 94 | 96 | 104 | 96.0 | 80 |
| Morocco | 107 | 97 | 102 | 98 | 98 | 95 | 95 | 89 | 95 | 104 | 107 | 113 | 88.9 | 104 |
| Tunisia(a) | 103 | 95 | 98 | 92 | 95 | 96 | 99 | 103 | 100 | 103 | 105 | 111 | 24.0 | 102 |
| **West Africa:** | | | | | | | | | | | | | | |
| Central African Republic | 89 | 92 | 105 | 100 | 101 | 93 | 101 | 84 | 94 | — | 116 | — | 1.0 | 128 |
| Chad(a) | 69 | 68 | 106 | 116 | 127 | 110 | 102 | 85 | 94 | 116 | 116 | 88 | 0.9 | 126 |
| Ghana | 98 | 105 | 99 | 99 | 101 | 99 | 99 | 101 | 102 | 101 | 103 | 106 | 35.9 | 110 |
| Nigeria | 95 | 90 | 95 | 92 | 98 | 95 | 100 | 104 | 100 | 111 | 110 | 110 | 62.5 | 117 |
| Togo | 102 | 102 | 102 | 117 | 105 | 92 | 83 | 88 | 89 | 97 | 106 | 125 | 0.6 | 110 |
| Ivory Coast | 102 | 94 | 104 | 101 | 103 | 89 | 87 | 88 | 89 | 108 | 114 | 120 | 10.0 | 129 |
| Senegal | 96 | 90 | 95 | 99 | 91 | 101 | 102 | 110 | 97 | 110 | 108 | 105 | 14.3 | 113 |
| Upper Volta | 69 | 76 | 105 | 105 | 115 | 97 | 88 | 75 | 85 | 103 | 107 | 86 | 1.1 | 136 |
| **Central Africa:** | | | | | | | | | | | | | | |
| Kenya(a) | 83 | 83 | 100 | 99 | 103 | 99 | 109 | 106 | 103 | 105 | 108 | 107 | 20.0 | 112 |
| Tanganyika(a) | 97 | 90 | 99 | 95 | 101 | 100 | 103 | 105 | 103 | 107 | 103 | 99 | 14.9 | 109 |
| Uganda(a) | 101 | 93 | 99 | 92 | 97 | 98 | 103 | 104 | 102 | 104 | 102 | 103 | 37.8 | 104 |
| Rhodesia (N.) | 96 | 88 | 98 | 96 | 82 | 108 | 112 | 106 | 104 | 105 | 104 | 106 | 160.0 | 107 |
| Rhodesia (S.) | 95 | 90 | 102 | 96 | 107 | 101 | 101 | 107 | 99 | 104 | 99 | 96 | 141.0 | 102 |
| Nyasaland | 94 | 97 | 100 | 94 | 106 | 97 | 109 | 106 | 100 | 106 | 97 | 94 | 3.2 | 114 |
| **Southern Africa:** | | | | | | | | | | | | | | |
| Madagascar(a) | 98 | 90 | 103 | 99 | 107 | 103 | 103 | 99 | 95 | 113 | 98 | 99 | 6.8 | 99 |
| Mauritius(a) | 89 | 81 | 95 | 100 | 103 | 102 | 103 | 103 | 105 | 108 | 106 | 116 | 6.4 | 121 |
| South Africa | 93 | 89 | 99 | 96 | 103 | 105 | 108 | 106 | 101 | 103 | 99 | 97 | 2175.0 | 106 |

a) Refers to public supply production

## Chapter VIII

# SPECIAL ELECTRIC POWER REQUIREMENTS FOR EXPORT

### A. INTRODUCTION

In Africa, natural resources which make possible extensive mineral mining and ore reduction, production of fertilizers, phosphates, various chemical products, rayon and paper pulp — to name a few products which consume large quantities of electricity in their processing — are all present in abundance and in varying proximity to sources of low-cost energy. Where other essential ingredients can be assured, prospects for major industrial electrification schemes for export purposes — which in turn exert a "multiplier" effect on the economy, stimulate other demands for power and also assist the electrification of regions in which they are located — are likely to be favourable. Their practicability then rests mainly on potential future demand for the primary product in question in world markets, and in meeting essential needs for manufactures in Africa itself.

It is this type of prospect for electric power development that is discussed, in its essentials only, in the present chapter.

### B. LOW-COST SOURCES OF PRODUCTION

The general perspective on African mineral resources and the situation in respect of other related economic categories was analysed in chapter I of the present study.[33] Some average specific consumption figures in kWh per ton were there given which show orders of magnitude for a few products and illustrate their need, where production must be on a large scale, for bulk consumption of electric power at very low cost, usually taken at a more or less even load throughout the year. In view of its competitive role at present aluminium reduction, by electrolysis from a mixture of alumina and cryolite, may be taken as an example for discussion purposes.

In this particular field the primary need, under the Hall-Héroult process, is for some 16000 kWh per ton of aluminium produced. In different parts of the world the industry is therefore sited wherever sufficiently cheap, abundant and regular supplies of power exist. In many cases, as already in Africa on the Sanaga river and prospectively on the rivers Congo, Cuanza, Konkouré, Kouilou and Zambezi, hydro-electric power is the most appropriate source. Because an even flow, low construction cost and accessibility are required, the lower reaches of large rivers may often provide for the more suitable sites. On the other hand natural gas may sometimes offer a suitable source of electric power, as in the southern United States of America or in the case of the Lacq deposits in south-western France. In a few favourable areas where brown coal can be extracted easily, for example in the central United States and in Western Germany, it too is used, or its use is planned, for the same purpose.

In Africa, in addition to cheap power, adequate port facilities and an economic superstructure of essential facilities are required, as well as much capital expenditure. Large bauxite reserves may exist locally, possibly in proximity to other minerals which would allow a major energy-consuming metallurgical and industrial complex to be set up where several basic products and perhaps some manufactures could be produced together. Alternatively, alumina produced from African sources of bauxite may be imported and reduced to aluminium at the complex for re-export.

Where the necessary power and mineral resources exist to create such a complex the scale of investment, production and export involved, relative to the existing economy of the territory concerned, is usually very great. This may be illustrated by reference to one of the existing African projects — that of Sounda, near the port of Pointe-Noire, situated in Congo (Brazzaville) on the Kouilou-Niari. This hydro-electric scheme would allow an even production throughout some 8000 hours per years amounting to 6800 million kWh.

A concentration of power of this order would allow an annual production of 250-300,000 tons of aluminium, plus other electro-metallurgical products such as ferro-manganese, magnesium, etc. (200,000 and 50,000 tons respectively, requiring a further one milliard kWh) and various electro-chemical products,

[33] For development in the earlier post-war period see also — Economic Survey of Africa Since 1950; United Nations, New York, 1959.

including phosphates. Reserves of manganese ore and dolomite (for magnesium) exist in the region. In economic terms the rate of capital investment would be of an order equivalent to that for the entire territory at the present time, while the total value of the country's national product and exports respectively would probably be increased several times over. Such projects are thus of major importance, both indirectly for the electric power industry and directly for economic development as a whole.

## C. PROSPECTS FOR HIGH-CONSUMPTION INDUSTRIAL PROCESSES

What, then, of the likely role of aluminium and similar energy-intensive products in the world economy? In addition to the existing African output of primary aluminium at Edéa in Cameroun (52,000 tons in 1962), production of alumina from local bauxite reserves is carried on at Fria in Guinea. Several other high-consumption processed products are also produced in Africa for export purposes and certain important projects have been detailed in earlier chapters. If conditions are favourable their number and relative importance in various African economies may be greatly increased in the near future.

Aluminium perhaps offers particularly interesting prospects after a relative stagnation of output in various countries over the last two years — a circumstance shared by copper, tin and lead, as the following figures show:

**World output of selected raw materials**[a]
(thousands of metric tons)

| Year | Zinc | Lead | Tin | Copper | Aluminium |
|---|---|---|---|---|---|
| 1955 | 2380 | 1730 | 173 | 2700 | 2710 |
| 1960 | 2540 | 1880 | 147 | 3670 | 3780 |
| 1961 | 2690 | 1930 | 141 | 3670 | 3720 |
| 1962 | 2810 | 1930 | 146 | 3810 | 4080 |

[a] Excluding the output of a few countries.

Aluminium alloys can now be produced with a very wide range of properties — in sheet form and as extrusions, forgings, castings, wires and tubes, etc. — and where necessary can withstand considerable stresses. There has been a considerable expansion of demand for land transport components (which now take around one-fifth of total consumption), building, household equipment, the electrical industry and packaging. The remainder is taken mainly by various components for mechanical construction. The aircraft industry, on the other hand, provides one example of a sector of relatively **reduced** demand.

Demand for electrical construction, which is traditionally associated with copper, is now extending in some limited degree to aluminium also. For reasons of cost and also because of favourable design features, aluminium is being applied on a small scale for such equipment as substations, as well as in cable manufacture. For assisting communications in difficult or undeveloped terrain, sheet aluminium trackways have recently been developed for laying rapidly from rolls mounted on caterpillar tractor vehicles.

Aluminium offers an example of a commodity the production and consumption of which share many of the characteristics of the electric power industry itself. On the supply side its production has been marked by continuing technical progress. As one index of this, the quantity of electricity required in processing has been reduced steadily over the last twenty years. Between 1939 and 1960 the average specific consumption in kWh per ton has fallen by at least 25 per cent. Greater reductions still have been made in the consumption of carbon and of fluorides for processing. New techniques are continuing to be evolved and two new reduction processes are currently under study in Canada and France. The number of kWh required can apparently be reduced further to around 14,000 per ton, and tests with cathodes made from titanium and other substances suggest that further gains in efficiency of up to 15 per cent are possible even in existing processes.

These prospects suggest that reductions in cost that have enhanced the competitive position of aluminium in recent years can continue and increase its range of demand still further among ferrous and non-ferrous metals alike.

How far can such prospects be evaluated on the demand side? Again, an analogy with electricity consumption seems in order.

Evidence to suggest the probability in most countries of a continuing rise in the use of electric energy comes from a comparative analysis of many different countries, and in particular from the way in which levels of consumption in kWh per head tend to rise with average income per head. This is because of the versatility of electricity, its competitiveness in relation to other forms of energy and its key role in economic development.

When in a similar way we compare the apparent consumption per head of aluminium in different countries, as is done in table 49, and bear in mind also its continuing application to new uses, there appears to be considerable scope, in the long term, for higher consumption in many parts of the world.[34]

[34] The table is based on data in a report of Alcan International, Montreal referring to 1962, and other sources.

Broadly speaking, the average apparent use of aluminium appears to rise at present with average income, starting from about 0.3 lb (o.11 kg) per head at low income levels and rising to nearly 16 lb (6 kg) and, in fact, even more. This correlation does not of course imply that world demand will be unaffected in the future by short-term economic fluctuations such as have slowed down consumption between 1960 and 1962. Neither would it remain valid if cheaper substitutes were found (or, in the present context, if revolutionary new production processes were developed).

It remains to refer briefly to the prospects for some other industries of particular interest in Africa which require high specific consumption of electricity. When we compare the industrial electricity consumption of various European countries where such industries are well-developed it emerges that the highest consumption per head in 1961 over a group of ten countries[35] occurred in the following industrial sectors:

| Industrial sector | Average number of kWh used per inhabitant |
|---|---|
| Chemical industry | 286 |
| Iron & steel industry | 195 |
| Mechanical & electrical construction | 144 |
| Non-ferrous metals | 107 |
| Wood industries, including paper | 106 |
| Textiles & associated industries | 75 |
| **Total** (all mining & manufacturing): | 1,207 |

Taking a country where hydro power is practically the sole source of electricity (Switzerland) the kWh consumption for the main energy-intensive industrial processes works out as follows:

| Industrial Sector | Year | Consumption: KWh $10^6$ | Consumption: KWh per worker |
|---|---|---|---|
| Non-ferrous metals | 1959/60 | 1119 | 94800 |
| | 1961/62 | 1264 | 93600 |
| Chemical industry | 1959/60 | 1549 | 55700 |
| | 1961/62 | 1710 | 58800 |
| Paper manufacturing | 1959/60 | 581 | 41500 |
| | 1961/62 | 640 | 39500 |
| Industries of earth & stone | 1959/60 | 585 | 32900 |
| | 1961/62 | 737 | 35600 |
| Iron and steel | 1959/60 | 525 | 35700 |
| | 1961/62 | 562 | 34700 |
| Leather & rubber | 1959/60 | 38 | 11200 |
| | 1961/62 | 52 | 13000 |
| Textiles | 1959/60 | 436 | 8000 |
| | 1961/62 | 485 | 8500 |
| Total Industry | 1959/60 | 6299 | 13800 |
| | 1961/62 | 7194 | 13800 |

While consumption of this type in highly electrified countries can be seen to be still rising steadily in all fields it is also true that the effects of technical progress and other factors of labour productivity may operate differently in different countries.

Demand for fertilizers and other basic chemical products seems virtually certain to continue to grow rapidly, both in Africa itself and in other parts of the world with comparable needs. The same should apply in varying degree to all the other groups studied. Certain other possible forms of demand — for example the wide scope throughout the world for use of radioactive isotopes — might be of interest in the same connexion. Where forecasts have been made for power requirements arising from large energy-consuming industrial sectors of the type referred to above it has been assumed that consumption per unit of product will in most cases fall slowly with continuing technical progress, but that the use of electricity in the processing and manufacture of such products will continue to rise at a steady pace. Because of its ample sources of low-cost electricity, African export potential in such fields should be very substantial for a long time to come.

It therefore seems evident that industrial prospects in Africa for the different products of special interest in respect of export to world markets are of primary concern in planning the expansion of electricity supply. They need careful attention not only in their own right, but equally as a key factor in the early growth of electrification throughout the continent.[36]

[35] The countries were Austria, Belgium, France, Federal Republic of Germany, Italy, Norway, Netherlands, Sweden, Switzerland, and the United Kingdom.

[36] For a recent study of African industrial development see: Industrial Growth in Africa — A Survey and Outlook (E/CN.14/INR/1); Economic Commission for Africa, Addis Ababa, 1962.

TABLE 49

**Apparent specific consumption of aluminium in selected countries**

(in pounds per head of population)

| Country | Apparent consumption per inhabitant | | | | |
|---|---|---|---|---|---|
| | 1958 | 1959 | 1960 | 1961 | 1962 |
| 1 | 2 | 3 | 4 | 5 | 6 |
| **African territories:** | | | | | |
| East Africa(a) | ... | ... | ... | 0.3 | 0.3 |
| Ghana | ... | 1.1 | 0.7 | 1.0 | 1.7 |
| Nigeria | ... | 0.2 | 0.3 | 0.3 | 0.3 |
| Fed. of Rhodesia & Nyasaland | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 |
| South Africa | 1.4 | 1.4 | 1.8 | 1.9 | 2.3 |
| UAR (Egypt) | 0.2 | 0.3 | ... | 0.2 | 0.3 |
| **Other conntries:(b)** | | | | | |
| India | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| Turkey | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 |
| Brazil | 1.0 | 1.1 | 1.3 | 1.4 | 1.4 |
| Argentina | 1.4 | 1.0 | 1.4 | 2.1 | 2.0 |
| Yugoslavia | 1.9 | 2.0 | 2.8 | 3.1 | 3.2 |
| Denmark | 5.5 | 6.6 | 7.8 | 7.4 | 8.9 |
| France | 8.3 | 8.9 | 10.9 | 10.8 | 11.9 |
| United Kingdom | 12.8 | 14.9 | 17.7 | 15.8 | 15.8 |

a) Refers to Kenya, Tanganyika and Uganda.
b) Arranged in increasing order to consumption per head.

# ANNEX I

## SOME GENERAL SOURCES OF INFORMATION

The following selcted list of bibliographical references covers some main sources of information consulted in preparing the present study. The list includes a number of references of more general interest and is not intended to be exhaustive.

In addition to 16 replies[a] received to a questionnaire circulated to participating governments in November 1962, reference has also been made to a number of separate reports issued by African electricity supply undertakings and other national organizations.


1. Statistical Year Book (1962); United Nations New York, 1963. (also issues for earlier years).

2. World Energy Supplies (1958-1961); Statistical Papers, Series J. No. 6; United Nations, New York, 1963. (also issues for earlier years).

3. New Sources of Energy: Proceedings of the United Nations Conference on New Sources of Energy, Vol. I; United Nations, New York, 1963.

4. Economic Applications of Atomic Energy; United Nations, New York, 1957.

5. The Future Growth of World Population: Population Studies No. 28, United Nations, New York, 1958.

6. Electric Power in Asia and the Far East — 1956/1960: Economic Commission for Asia and the Far East; United Nations, New York, 1962.

7. Economic Bulletin for Africa, Vol. II, No. 2: Economic Commission for Africa, Addis Ababa, June 1962. (Particularly chapters I-III and V).

8. The Situation and Future Prospects of Europe's Electric Power Supply Industry in 1961/62; ST/ECE/EP/17, United Nations, Geneva, 1963.[b]

9. Survey of Energy Sources, 1962; Central Office of the World Power Conference, London, 1962.

10. A Review of the Natural Resources of the African Continent; United Nations Educational, Scientific and Cultural Organization, Paris, 1963.

11. Enery Resources: Report to the Committee on Natural Resources of the National Academy of Sciences, National Research Council, by M. King Hubbert, Washington, D. C., 1962.

12. R. Woodtli: **l'Europe et l'Afrique — 1 Le potentiel minéral africain; Centre de Recherches Européennes.** University of Lausanne, 1961.

13. Non-ferrous Metals — Recent Developments and Short-Term Prospects; Organization for Economic Co-operation and Development, Paris, May 1963.

14. G. Hamdan: The Political Map of the New Africa; Geographical Review, Vol. LIII, No. 3, New York, July 1963.

15. B. S. Hoyle: The Economic Expansion of Jinja, Uganda. Geographical Review, Vol LIII, No. 3, New York, July 1963.

16. J. Chardonnet: Geographie Industrielle, Vol. I., **Les sources d'énergie,** Paris, 1962.

17. A. Grauer: The Electrical Power Industry in Canada. Proceedings of the Thirteenth British Electrical Power Convention, Eastbourne, 1961.

18. Oxford Economic Atlas of the World, 2nd Edition, Oxford, 1959.

19. The Middle East and North Africa: Oxford Regional Economic Atlas, Oxford, 1960.

20. A Boyd and P. van Rensburg: Atlas of African Affairs; London, 1962.


[a] Including supplementary data received subsequently.

[b] Preceding annual reports relating to 1957, 1958/59, 1959/60 and 1960/61 respectively, were issued as documents E/ECE/359; ST/ECE/EP/2; ST/ECE/EP/9 and ST/ECE/EP/11. (United Nations Geneva, 1959, 1960, 1961 and 1962). A further analysis relating to the post-war period as a whole will be found in document E/ECE/367 — Developments in the Situation of Europe's Electric Power Supply Industry during the Post-war Period — United Nations, Geneva, 1959.

21. R. Vogt: Electricity Supply in Africa (Map); 4th Edition, Pretoria, 1963.

22. The Growth of World Industry — 1938-1961 (National Tables): United Nations, New York. 1963.

23. **Panorama de l'industrie minière du Continent Africain en 1962:** Annales des Mines, Paris, July-August 1963.

24. P. Sevette: **L'économie de l'énergie dans les pays en voie de développement,** Presses Universitaires, Paris, 1963.

25. A. J. Dilloway: Assessment of Hydro-electric Potential in Regions Subject to Rapid Economic Development (Fifth World Power Conference — Section B — Vienna, 1956).

26. Methods for Comprehensive Evaluation of Hydro-electric Resources (document E/CN.14/EP/19); prepared by the Secretary of the Economic Commission for Europe for the African Electric Power Meeting organized by the Economic Commission for Africa in Addis Ababa, in October, 1963.

27. The Geographical Distribution of Gross Surface Hydro-electric Potential in Europe; document ST/ECE/EP/10, United Nations, Geneva, 1961.

28. Methods of Forecasting Future Demand for Electric Energy (document E/CN.14/EP/20); prepared by the Secretary of the Economic Commission for Europe for the African Electric Power Meeting organized by the Economic Commission for Africa in Addis Ababa in October, 1963.

# ANNEX II

## SHORT SUMMARY OF DETAILED INDICATIONS ON COMMERCIAL FUEL RESERVES (SELECTED COUNTRIES)

### CAMEROON

**Hard Coal:** There appear to be no important reserves which might serve to assist power production.

**Crude Petroleum:** Prospecting is in progress and indications exist in the region near Douala, which are still under study. The same remarks apply to the possibility of discovering **natural gas.**

### DAHOMEY

**Coal:** There are no known coal reserves, altough some deposits of **lignite** exist in the southern part of the country which appear to have no special economic value.

**Crude Petroleum:** Reserves have not yet been clearly evaluated positively although geological and geophysical prospecting have been in progress. There are some indications of **natural gas** in the area of Grand Popo, but it is not certain whether these are of economic interest.

**Uranium:** Some investigations have been made, and in the central and southern part of the country it would appear that some sources may exist. These have not so far been exploited.

### GABON

| | Millions of units | Observations |
|---|---|---|
| Petroleum (tons) | 6 | Provisional estimate |
| Natural gas ($m^3$) | 500 | " " |
| Uranium & thorium bearing ores (tons) | 1 | At about 5% oxide content |

### GHANA

**Coal** and **lignite** reserves do not exist in the country. So far **petroleum** and **natural gas** reserves may be considered to be negligible. There are no known sources of **uranium** or **thorium** and sources of **geothermal energy** do not exist.

### KENYA

**Coal:** Thin strips of coal have ween noted in drillhole cores from sediments of the coast hinterland though no evidence has been obtained that workable seams exist.

**Lignite:** Bore-holes drilled to a depth of 180 ft. revealed only thin seams of no economic value.

**Petroleum:** Prospecting for oil is proceeding in the Coast and Northern Provinces and elsewhere.

**Geothermal energy:** Numerous steam jets are known in the area between Lake Rudolf and Lake Magadi, and for many years steam escaping from natural vents in the volcanic rocks near Eburru has been used by farmers as a source of water. The East African Power & Lighting Co. in their recent search for geothermal power, drilled near Orgaria, south of Lake Naivasha, to a depth of 3096 feet, where although the temperature was 400°F no steam was found.

Systematic ground and bore-hole temperature measurements are now being carried out in the Naivasha-Suswa area in connexion with geothermal prospecting. Temperatures in excess of 100°C have been encountered in shallow bore-holes at a depth of 100-200 feet. It is hoped to continue this survey northwards where small geysers and hot springs occur and where a water-table is known to exist.

**Uranium or Thorium: Carbon dioxide** under pressure was discovered at a depth of 450 feet in a bore-hole at Esageri, south-east of Eldama Ravine on the western side of the Rift Valley. The pressure of gas escaping from the bore-hole was 80 lbs. per square inch — a sample of the gas at the time was found to consist of 97.2% $CO_2$. A second carbon dioxide gusher was obtained in a bore-hole sunk near Kerita spring, near Uplands on the east flank of the Rift Valley. Carbon dioxide has also been reported from springs and holes at other localities. One company has given consideration to the exploitation of carbon dioxide under pressure as a power source.

**Radioactive deposits.** A radioactive survey covering the whole of Kenya was carried out by the Department in 1961 and a bulletin describing the work has been edited for publication. Results of the survey have been disappointing but it should be noted that though the effective covering of the survey was only a small fraction of the country it cannot be claimed that the occurrence of radioactive deposits of value is ruled out. It appears that the only likely deposits will be in pegmatites and carbonatite centres where radioactive minerals have already been discovered.

## MALI

**Coal:** Coal reserves are not known and appear non-existent.

**Petroleum:** The area where reserves may occur is extensive, and is of the order of 750,000 km². Investigations have recently been undertaken and in 1962 the Azaoak basin, to the east of Gao, has been the subject of aero-magnetic survey. Since the results appear encouraging investigations will be continued by means of other geophysical and geological techniques. Aero-magnetic prospecting is also going on in basin of Taddenni.

**Solar energy:** In the absence of a well-developed public energy supply and in view of the high transport costs for fuels, there is much interest in the possibilities of using solar energy. A laboratory of the Ministry of Public Works is conducting experiments in water-heating and cooking from this source.

**Non-commercial sources:** Fuelwood is used extensively, solely for domestic purposes, the consumption in 1961 rising to 11.2 million steres. Consumption has, however, remained nearly constant for some time, since it amounted to 10.5 million steres in 1955.

Nut-husks are used for steam-raising in industry, and consumption has doubled since 1955 and has reached a level of about 600 tons in 1961. Rice wastes are also used extensively, consumption in 1961 having amounted to 5,200 tons as compared with 3,000 tons in 1955.

## MOROCCO

**Coal:** Coal reserves have been evaluated at about 100 million tons and there is no usable brown coal or lignite.

**Petroleum:** There is a proved reserve of at least one million tons of petroleum, although alternative estimates are higher (7million tons .

**Uranium & thorium:** Source of uranium and thorium have not been determined.

**Natural gas:** Reserves of natural gas have been evaluated at 500 million m³.

There are no sources of geothermal energy.

## NIGERIA

**Coal:** Reserves indicated by drilling 267 million tons. Inferred reserves by drilling give 82 million tons. Coal reserves are calculated for coal over 3 ft. 6 in. thick. Coal (Enugu No. 3 seam) has about 12,000 BTU/1b but deterio rates with storage to about 9,000 BTU/1b.

**Lignite:** Reserves indicated by drilling 73 million tons. Average moisture content for lignite is 36% as mined. Lignite (Ogwashi-Asaba : about 10,000 BTU/1b.

**Petroleum:** Estimated proved reserves 68 million tons. Average calorific value, say, 18,500 BTU/lb. (net).

**Natural gas:** Estimated proved reserves 85,000 million cubic metres or 3,000,000 million cubic feet, average calorific value 1,000 BTU/cubic foot (net).

As only about ten per cent of the oil and gas discoveries so far made in Nigeria have been appraised it is reasonable to assume that the ultimate reserves of both oil and gas will prove to be many times these figures.

**REUNION**

There are no known reserves of coal, lignite, petroleum or natural gas. Since the island of Reunion is, however, entirely of volcanic origin, with volcanic activity still in progress, it is possible that geothermal sources of energy are available. No studies have so far been made in this field.

There is interest in Reunion in the study of means of utilizing the energy potential of coastal wave surges.

**TUNISIA**

The official estimate for natural fuel reserves gives 150 million m$^3$ of natural gas. In addition it is estimated that 20 million tons of lignite are available, although not economically exploitable. The average calorific content is 3,500 kcal/kg.

**UGANDA**

There are no known coal reserves. Petroleum prospecting has been carried out. Sources of uranium-bearing ores thought to be of little importance. Thorium-bearing ores are not of major importance but may exist in some degree.

Studies have been made of the possibility of using geothermal sources in the area of Burangen.

# ANNEX III

## SHORT SUMMARY OF DETAILS CONCERNING HYDRO-ELECTRIC RESOURCES AND PROJECTS IN SELECTED COUNTRIES

**CAMEROON**

An official estimate has given the hydro potential as 4,000 MW, capable of supplying 15-20 milliard kWh per year.

The existing plant on the **Sanaga** at **Edéa** comprises 160 MW with a mean annual production of 1,250 million kWh, and is partly used for the aluminium processing of the **Compagnie Camerounaise de l'Aluminium** (ALUCAM).

Various projects and studies for the construction of hydro-electric plants also exist. At 45 km above **Edéa**, at the Herbert Falls, a new barrage has been envisaged to regulate the flow during the dry season. This would comprise 150 MW and would allow a mean annual production of 1,000 million kWh. Among various other projects there is that at Nachtigall (60 km from Yaoundé) giving 80 MW and that at **Ekom** on the **Nkam** giving between 10 and 50 MW (80 to 250 million kWh per year). A number of other small projects also exist.

**CENTRAL AFRICAN REPUBLIC**

There is a considerable hydro-electric potential, and several hydro stations could probably be built at reasonable cost if it were not for the fact that electric energy demand is at present too low to justify immediate construction. The **Société Equatoriale de l'Energie Electrique** has partially developed the hydro-electric plant of the **Buali Falls** on the **M'Bali** river. While there is a head of 173 m and a flow varying from 550 m$^3$/s to about 26 m$^3$/s the plant so far built uses a head of only 53 m. The ultimate total installed capacity will be 8.8 MW, although it is likely that a higher development will be possible.

**DAHOMEY**

The hydro potential, which has not been definitely studied, is so far totally unexploited. The Mono a river forming part of the common frontier with Togo, is the subject of joint studies.

## ETHIOPIA

Total hydro potential is estimated at 145 milliard kWh per year, of which economically usable potential amounts to about 45 milliard kWh. Nearly 55 per cent of this potential is on the **Blue Nile** and 3 per cent is on the **Awash.**

## FRENCH SOMALILAND

There are no known energy resources except **Lake Assal** (Somalia) for hydro-electric power.

## GABON

There are no established hydro-electric resources.

## GAMBIA

There are no established hydro-electric resources.

## GHANA

From the **Akosombo** scheme, which is under construction, and from fifteen other projects there is a total producibility of 8809.2 million kWh.

## KENYA

The combined output of the **Seven Forks** scheme (240 MW) and further development down- stream (130 MW), operating at 60 per cent load factor, would give 1944 million kWh per year.

## MADAGASCAR

Among the sites favourable for the installation of hydro-electric plants are:

— those for which preliminary projects have been established, giving a total of 2700 MW and 17 milliard kWh annually.

— those considered possible, which might provide 300 MW.

— other numerous possibilities which have not been investigated.

## MALI

The only existing plant is that of **Félou,** near **Kayes** on the Senegal river (520 kW giving 1 million kWh).

The two great rivers of the Niger and the Senegal represent a very considerable hydro potential but are difficult to harness in view of the absolute need to regulate the flows with a view to improving low-water conditions. Such regulation would be of interest for purpose of agriculture, navigation and energy production.

Of the various sites already studied, the following may be mentioned:

| | Average capacity | Low-water capacity |
|---|---|---|
| **Niger** | | |
| Sotuba | 4 MW | 2 MW |
| Sankarani | 12.5 MW | 11 MW |
| Markala | 1 MW | .35 MW |
| **Senegal** | | |
| Gouina | 300 MW | 300 MW (with annual regulation) |

## MOROCCO

The latest official estimates give 1000 - 1100 GWh per year.

## NIGERIA

There is a very large exploitable potential particularly in the basins of the **Niger** and the **Benue.**

A general study of hydro power possibilities on the above rivers shows the possibility to construct dams which would provide for energy needs over the next 40 years.

The various sites are at:

**Ielwa** (on the Niger)

**Makurdi** (on the Benue)

**Jebba** (the most important project which would meet energy needs and would assist irrigation and navigation on the **Niger** and the **Benue.** The **Jebba** project would include the construction of dams at **Kurussa,** 100 km up-stream from **Jebba,** and in the **Shiroro gorge** on the **Kaduna,** the latter to be implemented considerably later on.

The installed capacity available would give 1,250 MW initially rising to 1,730 MW, the power produced being transmitted to the main consuming centres. The cost of energy from these schemes would be substantially lower than existing kWh costs.

## REUNION

The official estimate of hydro-electric resources gives a total in the region of 500 million kWh per year.

## TOGO

It has been decided to undertake a full evaluation of the hydro-electric resources of Togo.

**FEDERATION OF RHODESIA & NYASALAND**
(N. Rhodesia, Nyasaland, S. Rhodesia)

Ample resources of hydro-electric power exist. It is estimated that the evaluated potential is some 4,300 MW which, at a 75 per cent load factor, would provide 28,260 million kWh per annum. At present some 700 MW of this potential has been developed. In addition, there are several other large rivers, the hydro-electric resources of which have not been investigated.

There is thus substantial hydro-electric potential to be exploited. Most of this falls between the **Zambezi** river and its tributaries, as well as at the **Murchison Falls** on the **Shire** river flowing southward from Lake **Nyasa** and also on some smaller rivers in the southern part of **Southern Rhodesia.**

Hydro resources are well distributed within the three territories, with very low-cost power available from the **Kariba Dam.** While the installed capacity of the **Kariba** scheme offers 700 MW in its first stage, it could ultimately provide 1,500 MW, with an average annual production of 8,500 million kWh.

Of the other potentialities, there is at present a 4MW plant at the **Victoria Falls.** The **Nkula** project on the **Shire** river could give 24 MW and it is considered that, the **Kafue gorges** scheme, on the basis of a higher flow availability than had previously been allowed for, could offer between 760 and 1200 MW.

**SOMALIA**

The **Giuba,** in the southern part of the country, contains in particular the hydro-electric potential. Part of the flow is likely to be required, however, for irrigation as the river flows through the main agricultural area of the country. There is a project to produce 200 million kWh in this river which would, however, appear to require a substantial investment and the setting-up of appropriate industries creating adequate demand for power:

There is no hydro-electric production at present. Wind power is also available for small-scale uses, such as pumping.

**SENEGAL**

There is so far no production of hydro-electric power in Senegal.

**SUDAN**

There are substantial possibilities for hydro-electric production, particularly on the **Nile,** the **Blue Nile** and the **Atbara** river. Capacities available in individual projects vary from 7 MW to 800 MW.

A number of installations are under construction, such as the **Roseires Dam** on the **Blue Nile,** 125 miles up-stream from the **Sennar Dam.** Any output from the **Roseires Dam** would be available for part of the year only, when stored water was available. This project is required to make use of the water available under the 1959 Agreement with Egypt and much of the water will be used for the irrigation of the **Gezira** area. More power may subsequently be developed by increasing the storage at **Roseires** as this would make additional power available at **Sennar.**

The hydro-electric potential, which is so far unexploited, has been estimated to give 1,000 to 2,000 MW.

**TANGANYIKA**

No definitive evaluation of hydro resources is yet available. There is however a 17.5 MW plant on the river **Pangani,** producing 80 million kWh per year, 25 million kWh of which is exported to Mombasa (Kenya). Some 70 MW are available on this river, giving 325 million kWh per year. Some smaller hydro plants, with a total producibility of around 10 million kWh are also in service.

**TUNISIA**

The official estimate of usable hydro-electricity gives 45 million kWh per year. This is based on a capacity available at arithmetic mean flow of 22.5 MW. The corresponding figure at low water is 17.6 MW.

**UGANDA**

Important hydro resources exist and some estimates quote a potential of 3,000 MW giving 15,000 to 18,000 million kWh per year, mainly on the **Victoria Nile.** The development perspective appears to be favourable in this area.

Among the existing hydro-electric plants is the **Owens Falls** scheme of 120 MW giving 430 million kWh per year, part of the production from which is exported to Nairobi (Kenya).

## ANNEX IV

# STRUCTURE OF ELECTRICITY SUPPLY TARIFFS IN SELECTED COUNTRIES

### CENTRAL AFRICAN REPUBLIC

| LOW-VOLTAGE<br>**Lighting tariff:** | | | Tariff for **Bangui**<br>(Francs) CFA |
|---|---|---|---|
| 1st rate (35 hours of use) | = | 1.00 | 33.00 |
| 2nd rate (36-70 hours of use) | = | 0.80 | 26.40 |
| 3rd rate (above 70 hours of use) | = | 0.75 | 24.75 |
| **Tariff for handicrafts and small industry, air-conditioning and refrigeration:** | | | |
| 1st rate (50 hours of use) | = | 0.67 | 22.00 |
| 2nd rate (51-150 hours of use) | = | .5 | 16.5 |
| 3rd rate (above 150 hours of use) | = | 0.4 | 13.2 |
| **Public lighting:** | = | .67 | 22.0 |
| **Special night tariff for air-conditioning, water heating** (from 9.30 p.m. to 5.30 a.m.) | | | |
| | = | 0.4 | 13.20 |

**HIGH-VOLTAGE**

| | | | |
|---|---|---|---|
| Fixed charge corresponding to 50 hours of use per kW: 50 x 11.55 | = | 577.50 | |
| Proportional charge | = | 0.35 | 11.55 |
| Additional lighting charge | = | 0.25 | 8.25 |
| Off-peak tariff | = | 8.10 | |

— With rebate of 30% of the proportional charge for each kWh recorded by the off-peak meter.
— If off-peak consumption is below 5 hours the consumer loses any reduction for the month in question.
— Off-peak hours are defined as from 9.30 p.m. to 5.30 a.m.
— The right is reserved to modify off-peak hours according to the needs of operation, but taking into account that this period should include at least 2,920 hours per year.

### ETHIOPIA

The tariff rates are as follows:

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 $\cos \varphi = 0.89$ | | Eth. cents | 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 ” ” ” | 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. cents | 1 per KVArh |
| Service Charge, three-phase | | Eth. doll. | 5 per month |
| **Rebate on total charges:** | | | |
| Exceeding 100,000 " " " | 10% | | |
| " 400,000 " " " | 20% | | |
| " 700,000 " " " | 30% | | |
| " 1,000,000 " " " | 40% | | |

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

## FRENCH SOMALILAND

| | 1st rate | 2nd rate | 3rd rate | 4th rate |
|---|---|---|---|---|
| — Structure of tariffs (in Fr.): | 1st rate | 2nd rate | 3rd rate | 4th rate |
| — Low voltage, domestic use and lighting | 22 | 20 | 17 | 13[1] |
| — Power (general tariff): | 18 | | | |
| — High voltage (basic tariff): | 14.5 | | | |

## GABON (Libreville)

| | Frs. CFA **per kWh.** |
|---|---|
| (A) ELECTRICITY: | |
| (Lighting and domestic use) | |
| Three-part degressive tariff: | 33 |
| — 1st rate — lighting and domestic use (0-40 hrs. monthly of the capacity subscribed) | |
| — 2nd rate — 40-130 hours of use | 30.5 |
| — 3rd rate — beyond 130 hours of use | 21.5 |
| Cooking: | .5 |
| — single charge only | 29 |
| — uses other than lighting, domestic use and cooking (single charge only) | 22 |
| Industrial use: (high-voltage consumers) | |
| — single charge | 16 |
| Air conditioning: (2 possibilities) | |
| (1) Connected for lighting and domestic use (degressive): | |
| — 0-40 hours monthly use | 33 |
| — 40-130 hours monthly use | 30.5 |
| — beyond 130 hours monthly use | 17.5 |
| (2) Connected on a separate circuit (single charge) | 17 |
| (B) WATER: | |
| Water — per $m^3$ | 41 |

## GABON (Port Gentil & Lambaréné)

| | Port Gentil per KWh | Lambaréné per KWh |
|---|---|---|
| Lighting and domestic use, power equal to or above 1 kVA: | | |
| — 1st rate | 34 | 45 |
| — 2nd rate | 15.3 | 30 |
| Lighting for consumers with power below 1 kVA: | | |
| — 1st rate | 30.6 | 40 |
| — 2nd rate | 15.3 | 30 |
| Power (low-voltage): | 25.5 | 35 |

| | Port Gentil per KWh | Lambaréné per KWh |
|---|---|---|
| Public lighting: | | |
| — 1st rate | 23. | 40 |
| — 2nd rate | 13.8 | 40 |
| Power (high-voltage) | | |
| — proportional charge | 14.5 | 22 |
| — fixed payment | (5,830) | (6,000) |
| Special group: | | |
| — proportional charge | 7.6 | — |
| — fixed payment | (12,725) | — |

1) Reduced to 20, 18, 16 and 13 in 1962.

GHANA (Government Electricity Supply Tariffs)

| Tariff | Class of Consumers | Rate | |
|---|---|---|---|
| 1. Lighting | All Commercial and General Lighting Consumers | Accra, Tema, Kumasi and Sekondi-Takoradi | 11d. per unit. |
| | | All other Stations | 1s. per unit. |
| | | Minimum charge | £ Gl per month. |
| 2. Domestic | All Private Residences | (i) A monthly fixed charge as follows:- | |
| | | Up to 500 sq. ft. of enclosed floor area | 6s. |
| | | For each additional 100 sq. ft. Up to 1,000 sq. ft. | Add 1s. per 100 sq. ft. |
| | | From 1,000 sq. ft. to 3,000 sq. ft. | Add 9.6d. per 100 sq.ft |
| | | From 3,000 sq. ft. to 5,000 sq. ft. | Add 8.4d. per 100 sq.ft |
| | | Over 5,000 sq. ft. | Add 6d. per 100 sq. ft. |
| | | (ii) In addition a running unit charge of:- 2d. per unit in Accra, Tema, Kumasi and Sekondi-Takoradi. 3d. per unit in all other Stations The assessed fixed charge is the minimum charge per month. | |
| 3. Power | Commercial and Industrial Power Supplies other than Lighting | (i) A monthly fixed charge based on the brake horse-power or KVA installed with a minimum fixed charge of £G2 per month as following: | |
| | | Up to 50 KVA or b.h.p. | 10s. per KVA or b.h.p. or part per month. |
| | | 51 to 200 KVA or b.h.p. | 8s. per KVA or b.h.p. or part per month. |
| | | 201 to 1,000 KVA or b.h.p. | 6s. per KVA or b.h.p. or part per month. |
| | | Over 1,000 KVA or b.h.p. | 5s. per KVA or b.h.p. or part per month. |
| | | The assessed monthly Fixed Charge is the minimum charge per month. | |
| | | (ii) In addition a running unit charge of:- 2d. per unit in Accra, Tema, Kumasi and Sekondi-Takoradi. 3d. per unit in all other Stations. | |
| 4. Flat Rate Lighting | | Charge per month per Lamp: Up to 40 Watts 4s. 6d. 60 Watts 6s. | |

## IVORY COAST (Abidjan & Bingerville)

**High-voltage tariffs** (from 20 April 1961) in Francs:

| | | 0—250 kVA | 251—500 kVA | 501—1000 kVA | above 1000 kVA |
|---|---|---|---|---|---|
| (1) | **Annual fixed payment** per kVA and per consumer | 4,100 | 3,670 | 3,140 | 2,950 |
| (2) | **Charge per kWh** effectively consumed: | | | | |
| | **Day** (6 a.m. to 6.30 p.m.) | | | | |
| | 1st monthly charge for 0—50 hours of use | 10.4 | 9.9 | 9.4 | 9 |
| | 2nd monthly charge for 51-125 hours of use | 9.4 | 8.3 | 7.3 | 7 |
| | 3rd monthly charge above 125 hours of use | 6.2 | 5.2 | 4.1 | 4 |
| | **Peak hours** (6.30 p.m. to 9.30 p.m.) | 13.6 | 13.1 | 12.5 | 12 |
| | **Night** (9.30 p.m. to 6 a.m.) | | | | |
| | 1st monthly charge from 0-25 hours of use | 9.4 | 8.3 | 7.3 | 7 |
| | 2nd monthly charge from 26-70 hours of use | 7.8 | 6.8 | 6.2 | 5.8 |
| | 3rd monthly charge beyond 70 hours of use | 5.7 | 4.7 | 3.6 | 3.4 |

(3) An annual guaranteed use of 1000 kWh per kVA and per consumer is implied for the above high-voltage tariffs.

**Low-voltage tariffs**

(1) **Lighting and domestic use:**

(a) Below or equal to 0.66 kVA, the energy will be sold at 20.9 Frs. per kWh.

(b) Above 0.66 kVA the energy will be sold at 26.2 Frs. per kWh.

(2) **Domestic use without hourly restriction:**
A special tariff of 12.5 Frs. per kWh will be allowed for air-conditioning, water heating, electric cookers and washing machines.

(3) **Domestic use at off-peak hours** (11.30 a.m. to 2.30 p.m., and 8. p.m. to 7.00 a.m.)
A special tariff of 8.3 Frs. per kWh will be allowed to low-voltage users who consume exclusively during these periods for water-heating and air-conditioning purposes.

(4) **Public lighting:**
The price will be 12.5 Frs. per kWh, for consumption taken between 6.30 p.m. and 6.00 a.m.

(5) **Small power and handicrafts:**
The energy will be sold at 15.7 Frs. per kWh.

## MALI

At the beginning of 1962 a uniform tariff system has been set up taking into account the different types of use and following that of **Bambako,** according to the following principles:

— complete equality of treatment for all consumers;

— choice of a tariff system which will be compatible with the interests of small consumers to encourage the largest possible use of energy among the inhabitants;

— increase of the degressive aspects of tariffs by adjustment to the fixed charge.

| | | | | | | |
|---|---|---|---|---|---|---|
| High Voltage | Two-part Tariff | | Fixed annual charge per kW — 144P | or | 5,760 Frs. |
| | | | Charge per kWh[1] (Peak load 0.825P | or | 33 Frs. |
| | | | (During peak Hrs. 0.60 P | or | 24 Frs. |
| | | | (Off-peak Hrs. 0.45 P | or | 18 Frs. |
| | Single Tariff | | Per kWh 0.825P | or | 33 Frs. |
| | | | For power not above 25 kW | | |
| Low Voltage | Lighting and domestic use | | The 1st 30 hours per month per kWh P | or | 40 Frs. |
| | | | The next 30 hours per month per kWh | | 36 Frs. |
| | | | The remainder per kWh | | 26 Frs. |
| | Public lighting | | The 1st 120 hrs of use per month per kWh | | 36 Frs. |
| | | | The remainder | | 24 Frs. |
| | Power | Two-part hourly tariff | Fixed annual charge per kW | | 5,760 |
| | | | Proportional Energy Charge[1] (Peak Load | | 36 Frs. |
| | | | (During peak hours | | 30 Frs. |
| | | | (During off-peak hours | | 24 Frs. |
| | | Single tariff | Per kWh | | 36 Frs. |

[1] Peak hours are between 6.30 a.m. and 12.30 p.m. and 3 p.m. and 6 p.m. respectively. Off-peak hours are from 12.30 p.m. to 3 p.m. and from 10 p.m. to 6.30 a.m.

## MALAGASY REPUBLIC

The tariffs are of a degresive type with sectors for all high-voltage industrial energy. For low-voltage there are two main types of tariff:

- degressive, with sectors for all domestic uses;
- uniform, separately for lighting and domestic use.

## MOROCCO

The tariffs are two-part, with a fixed charge and an energy charge per kWh.

## REUNION

The tariff structure is as follows:

**Ligthing and domestic tariff** (Réunion, except St. Denis, from 1 Jan. 1962):

| Charge (F. CFA) | | | | Off-peak Tariff | Specifications (Special and public supply respectively) |
|---|---|---|---|---|---|
| 1st rate | 2nd rate | 3rd rate | 4th rate | | 1st 15 hours x Power per month<br>2nd " " " " " " |
| 33.85 | 27.81 | 20.90 | 12.71 | | 3rd " " " " " " |
| 30.47 | 25.03 | 18.81 | 11.44 | | 4th-beyond 45 hours per month |
| | | | | 12.71 | (The charges include tax) |
| | | | | 11.44 | off-peak water heating |

**Other low-voltage uses** (Réunion except St. Denis, from 1 Jan. 1962):

| Power 1st rate | 2nd rate | 3rd rate | Lighting |
|---|---|---|---|
| 28.46 | 22.41 | 17.74 | (1st 600 hours x Power per year — power) |
| 25.61 | 20.17 | 15.97 | (2nd 1200 hours x Power per year — power) |
| (a) | (b) | (c) | (3rd beyond 1800 hours per year — power) |
| 28.46 | 17.85 | 12.71 | |
| 25.61 | 16.06 | 11.44 | |
| | | | 30.47 — 1st rate with annual use 1,500 hr. x power |
| | | | 11.44 — 2nd rate with annual use beyond 1,500 hr. |

(a) At peak (600 hr.)
(b) During peak hours (1,200 hr).
(c) During off-peak hours (above 1,800 hr).

**High-voltage tariff** (Réunion, except St. Denis):

| Fixed Annual Charge | At Peak | Single tariff: During high-load hours | Single tariff: During off-peak hours | Proportional tariff: 1st rate | Proportional tariff: 2nd rate | Proportional tariff: 3rd rate |
|---|---|---|---|---|---|---|
| kVA | | | | | | |
| 4,824 | 19.73 | 13.20 | 7.59 | 18.88 | 14.70 | 7 |
| 1,296 | — | 13.20 | 7.59 | | | |
| 1,044 | 19.73 | 13.20 | 7.59 | | | |
| 324 | — | 13.20 | 7.59 | | | |
| 4,344 | 17.76 | 11.88 | 6.83 | 16.99 | 13.23 | 6 |
| 1,164 | — | 11.88 | 6.83 | | | |
| 936 | 17.76 | 11.88 | 6.83 | | | |
| 288 | — | 11.88 | 6.83 | | | |
| 5,868 | 22.19 | 13.97 | 8.29 | 22.19 | 16.45 | 8 |
| 2,340 | — | 13.97 | 8.29 | | | |
| 5,280 | 19.97 | 12.57 | 7.46 | 19.97 | 14.80 | 7 |
| 2,100 | — | 12.57 | 7.46 | | | |

## SIERRA LEONE

There are Domestic, Commercial and Power and Bulk Rate tariffs. According to the latest situation, the first varies according to monthly consumption up to 100 kWh per month (charge £ 2:4 shillings), after which units are charged at 3 pence per kWh.

The Commercial Tariff operates at one shilling per kWh for the first 100 kWh and 9 pence per kWh thereafter, with a minimum monthly charge.

The Power and Bulk Rate is 8 shillings per month per horse-power or kVA and kW of installed equipment plus 2 pence per kWh for all units used.

## TOGO

The tariff structure is as follows:

| | |
|---|---|
| **Domestic lighting:** | |
| — from 0-100 hours | 35.7 Fr. CFA per kWh |
| — above 100 hours | 28.6 Fr. CFA per kWh |
| — Small users | 30.3 Fr. CFA per kWh |
| **Low-voltage power:** | |
| — from 0-100 hours | 25.0 Fr. CFA per kWh |
| — from 100-300 hours | 21.4 Fr. CFA per kWh |
| — above 300 hours | 17.9 Fr. CFA per kWh |
| — Air-conditioning | 21.4 Fr. CFA per kWh |
| **High voltage:** | |
| — Monthly charge for 35 hours per kW installed | 16.1 Fr. CFA per kWh |
| — Proportional charge | 16.1 Fr. CFA per kWh |
| — Supplement for high-voltage lighting | 17.9 Fr. CFA per kWh |

## TUNISIA:

The tariffs at present in force are an extension of those which were drawn up in connexion with the authorization given to the main Company for the production and distribution of electric power. The price of electric energy includes in general two elements:

- — a fixed charge which applies to the subscribed power;
- — a proportional charge per kWh.

Consumption is divided in several parts in which the magnitudes are related to the subscribed power. The tariffs for these parts are degressive in character. Each price is composed of three factors including a fixed item, a proportional item and an item proportional to average hourly salaries. There is thus a relationship between the cost of energy and that of basic materials and labour. Adjustments are made in principle every three months in agreement with the Control Administration.

Tunisia is divided into tariff zones for each of which a coefficient is allotted:

1. North region (Tunis, Cap Bon, Bizerta) — basic tariff with a coefficient of 1.
2. Western region and the region of Sousse — coefficient of 1.1.
3. Region of Sfax — coefficient of 1.15.
4. Region of Gabès and Gafsa — coefficient of 1.25.
5. Isolated networks supplied by local diesel plant — coefficient of 1.30.

The tariff for each region is thus obtained by multiplying the basic tariff by the appropriate coefficient.

It would appear that the tariffs in force are not entirely adapted to the conditions of economic and industrial development of the country and could be modified. A first study has been carried out by an Expert Commission under a consulting engineer. A detailed study is also being made in collaboration with the appropriate services of Electricité de France.

# ANNEX V

# SHORT SUMMARY OF PROSPECTS AND SCHEMES FOR ELECTRIC POWER DEVELOPMENT (SELECTED COUNTRIES)

## CAMEROON

The future rate of annual increase in over-all demand has been estimated at 12 per cent. Of the installed capacity of the hydro plant at Edéa 20 MW has been reserved to meet the general demand of Douala and Edéa. Another 30 MW from this plant is available for the needs of new consumers (15 MW guaranteed).

For the production of aluminium 105 MW of the Edéa plant have been reserved for that particular purpose. While electricity requirements were increasing rapidly up to 1959 for aluminium processing they have been somewhat more stabilized since 1960. The increase in requirements of the Youandé region, which are estimated at a similar rate to those for Cameroon as a whole, will have to be satisfied by continuing to instal new diesel groups, as it will not be possible to build hydro plants or to connect the region to other networks with a sufficient capacity.

## CENTRAL AFRICAN REPUBLIC

No economically exploitable mineral deposits have so far been discovered, although diamonds occur in some of the river beds. The only industrial plant is the textile mill at **Icot** near the **Boali Falls**, although there is also the **Mocaf** brewery in **Bangui**.

Most of the inhabitants cannot afford to use electricity and those that do restrict their consumption to a few electric light bulbs and possibly one radio. The rate of increase (19.4% in 1961) has, however, been very rapid. In view of the fact that local markets are too small to justify industrial plants and non-industrial demand so far is low, any scheme for over-all electrification seems premature at the moment and demand it therefore continuing to be met by isolated power plants.

## DAHOMEY

It is not considered probable that energy requirements will increase rapidly over the next 10 years or so. Dahomey relies entirely on the import of oil for the production of electricity and it is not considered that in the foreseeable future, generation requirements will exceed 10 MW. The only important non-domestic demand is that of the port installations of **Cotonou.** Two new diesel plants (900 kVa each) will be installed to meet these requirements.

Although there is no plan to exploit fuel or hydro-electric resources it is intended to study the possibilities of building a barrage on the **Mono** for the double purpose of irrigation and electricity production.

## ETHIOPIA

Development of iron ore deposits might contribute considerably to the consumption of electric energy. Investigations are being carried out for other mineral resources but their impact on electricity consumption cannot be forecast.

A rate of increase in consumption of at least 22 per cent is forecast by the Ethiopian Electric Light and Power Authority up to about 1967. To meet this rate of increase the Authority expects to put into service at least 95 MVA of hydro capacity and at least 5 MVA of thermal capacity. The grid system, operating at 132 kV, will be increased by at least 130 km. If any major industry were to be developed earlier than anticipated this would alter the situation completely.

In **Asmara,** SEDAO has under construction 10 MVA of steam capacity to meet the growing load. The corresponding network it at 50 kV.

The standardization and electrification of neighbouring countries can probably benefit from the abundance of hydro power in Ethiopia, in which case the financing of any projects would require international co-operation. There is much scope for investigations in connexion with mineral resources as potential users of electric power.

## FRENCH SOMALILAND

The rate of increase of production at **Djibouti** has been 18.8 per cent between 1960 and 1961. The installation in 1963 of a new diesel group of 2.4 MW at the **Djibouti** plant is envisaged.

## GABON

With regard to the town of **Libreville** the forecast rate of increase in consumption is of the order of 30 per cent annually on the average. For the towns of **Port Gentil** and **Lambaréné** the annual increase is estimated as of the order of 7 per cent, corresponding to the normal increase of demand by consumers. This estimate is independent of special industrial development mentioned below. Studies for the development of paper pulp and cellulose industries are not yet complete. The same applies to projects for an oil refinery, a cement works and other new industries. There is also a possibility for development at **Haut Ogooué** for the direct reduction of iron ore in the Massif of Boka-Boka. This might necessitate international co-operation.

There is a project for the hydro-electric development of **Kinguélé.** A transmission network of around 100 km is also envisaged at 90 kV.

At **Port Gentil** and **Lambaréné** there is a project for an increased capacity of 3 MW, either by gas turbine or by three generating units using gas.

## GAMBIA

No definite development plan yet exists and no special energy-intensive mineral or other resources are known. In respect of projects requiring international co-operation the import of electric power from Senegal to neighbouring villages up-river might be envisaged.

## GHANA

The main mineral resources include bauxite, manganese, gold and diamonds, of which the processing of bauxite in the proposed smelter at **Tema** will be by far the most important, a maximum demand of 310.8 MW, at a load factor of around 99 per cent, being likely when the smelter is completed.

The Volta River Authority will also be involved in future development. From the present composition of the industrial and domestic load the expected rate of increase amounts to 15 — 20 per cent per year, the load being expected to rise to a gross total of 102.6 MW by 1966, before the smelter begins operation. The corresponding figure by 1970, including the smelter, is estimated to be 372.7 MW and by 1980 682.5 MW.

To meet this increase the **Akosombo** dam and power station, with a capacity of 768 MW — to which can be added, if necessary, 200 MW from **Bui** on the **Black Volta** and various smaller stations in the western region — is being developed.

The smelter project is already the result of international co-operation but the Ministry of Industries may have further plans of this type.

## KENYA

There are no known mineral resources of special importance such as bauxite.

From past and recent trends, and bearing in mind experience in Nigeria and Tanganyika after independence with due weight for local conditions, the estimated rates of increase in net consumption are as follows:

| | |
|---|---|
| 1963: | 7 per cent |
| 1964: | 10 " " |
| 1965: | 10 " " |
| 1966 to 1968: | 15 " " |

To meet this demand it is intended to install additional oil-fired steam plant at **Kipevu** on the coast. It is expected to draw another 15 MW of hydro power from Uganda Electricity Board for the main areas of the highlands, afterwards developing the major **Seven Forks** scheme on the **Tana** river (240 MW), filling any gaps with peaklopping thermal plants using oil and based on **Nairobi.** At the same time minor towns, newly electrified in areas remote from present transmission lines, will be equipped with small diesel plants until their development justifies their connexion to a grid system. The only major grid in use is the double-circuit **Tororo-Nairobi** 132 kV line, but 33 kV and 11 kV transmission is used extensively to link minor centres with main transmission centres. Any major grid linking the main supply areas of **Kenya,** and also linking **Uganda** and **Tanganyika** with **Kenya,** will need to be of the order of 275 or 330 kV. Considerable local load development is needed before such a grid could be economically justified.

**Kenya** imports bulk supplies from Uganda Electricity Board at **Jinja** under a 50-year agreement. Further co-operation has been considered.

## MADAGASCAR

Mineral reserves likely to require an important consumption of electric power include:

**Chromite:** deposits of Ranomena (reserves of 100,000 tons at surface and 150,000 tons subsurface). Also deposits of Ambodiriana and Andriamena.

**Nickel:** deposits of Valogora, giving 70,000 tons of nickel.

**Bitumin:** deposits of Bemolanga, giving one milliard tons of bitumin.

The principle adopted for future growth of consumption assumes a doubling every 10 years (7.2 per cent per annum).

The plan for **Madagascar** is in course of preparation and numerous preliminary plans have been studied. The present programme, as follows, has a limited objective:

- hydro-electric plant of **Beantsv,** installed capacity 525 kW, giving 4 million kWh per year, with lines of 35 kV linking the plant to the town of **Tuléar** (Cost: 128 million CFA);
- power line **Tananarive-Antsirabe** (60 kV), with a link of 135 km and costing 400 million CFA;
- hydro plant of the **Little Namorona,** with an installed capacity of 1.8 MW and giving 14 million kWh. There will be a 50 km line at 35 kV costing 300 million CFA.

Any of the projects relating to the exploitation of chromite, nikel and bitumin already referred to would be likely to require international assistance. Such assistance would also be desirable in the study of sites on the rivers **Ikopa** (5 developments) and the **Betsiboka** (2 developments).

## MALI

Rich bauxite deposits are known in the regions of **Satadougou** and **Kita** (800 million tons with an $Al_2O_3$ content of between 40 and 45 per cent and silica content below 4 per cent).

It is therefore the intention to study conditions for establishing an electro-metallurgical complex in relation with hydro-electric development. Near to **Kayes** on the **Senegal** the two adjoining sites of **Gouina** and **Galougo** appear interesting in this connexion since the cost of hydro power appears to be competitive for industrial purposes if part of the investment could be allocated to agriculture and navigation. A further possibility for a medium size dam on the **Bakoy** has also been emphasized.

Independently of these important possibilities the forecast rate of increase for total electric power consumption in the immediate future is considered to be of the order of 15 per cent per year.

## NIGERIA

In 1965/66 the energy generated by the Electricity Corporation of Nigeria will rise to 1112 GWh, implying a mean rate of consumption growth of around 20 per cent from the figure of 448 GWh in 1960/61 (figures refer to the year beginning 1 April).

However, the rate of development after 1965 will be influenced considerably by:

(a) the availability of loan capital;

(b) the rate of industrial development together with the possible establishment of an integrated iron and steel works and an aluminium smelter.

Among industrial fields of special importance for energy consumption about 50 per cent of the excavating for tin and columbite production is undertaken by mechanical means using electricity, the power being produced at hydro-electric stations. By March 1961 the average daily load was between 13 and 15 MW.

The Embel Tin Smelter at Jos in Northern Nigeria uses electric furnaces for smelting tin. At present only two furnaces can be used owing to shortage of electric power but the number may be increased to 8 as soon as possible.

The reserves of tin and columbite are estimated at 137,000 tons and 68,000 tons of ore respectively. At present these reserves would last for some eleven years, but the estimates are probably incomplete and the probable life of mining is considerably greater.

The requirements supplied by the Electricity Corporation of Nigeria are expected to develop from 182.76 MW of thermal capacity and 1.72 MW of hydro capacity as at 1961 (the latter located in Cameroon), of which 13 per cent was interconnected, this total of 184.48 MW rising to 223 MW (maximum demand generated) in 1966 (83 per cent interconnected).

By 1965 it is planned to extend the transmission network under 100kV from 420 miles circuit length to 700 miles; that between 100 and 200 kV from 130 to 430 circuit miles; and above 200 kV 350 miles (plus 480 miles under conctruction) will be installed.

By 1967 the Afam 80 MW gas turbine plant should be brought into service; also the Ughelli gas turbine plant (60-80 MW). The Niger Dams Hydro scheme (initially 320 MW) should also be completed by 1967/68.

## MOROCCO

Among the factors leading to a notable increase in consumption of electricity is the prospect for the development of a superphosphate chemical complex at Safi, together with a steel-producing installation foreseen in Nador and an electro-chemical project also foreseen at Meknes, as well as the extension of existing phosphate mines.

Total consumption in 1962 corresponds to a production of 1,088 GWh. Since production possibilities are due to be increased to 1,388 GWh the immediate consumption requirements can be provided for by the existing plants.

## REUNION

There are no known mineral resources which would constitute an important source of electric power consumption.

During the last decade public consumption has increased at an average annual rate of 17.5 per cent. It is probable that this rate will be maintained for some years although it is thought that it might decline a little later on.

Detailed studies for the Takamaka scheme on the Marsuran river, which would give 16.5 MW and 78 million kWh annually, would allow future needs to be met over the next ten years. However, this plant cannot be brought into service before the beginning of 1967 and existing means of production are likely to be insufficient after 1964. A new diesel group of 3.3 MW is, however, in course of installation at the St. Denis plant.

## SIERRA LEONE

Mineral reserves of importance for electric power development include reserves of bauxite (10 million tons probable, with an indicated reserve of 25 million tons). There is a ten-year plan of economic and social development which includes provision for electricity.

## TOGO

No mineral or other resources are known which would constitute an important source of electric power consumption.

Development of the river Mono has been the subject of an application (Togo-Dahomey) to the UN Special Fund and is being investigated. Development of the basin of the Oti is also possible but has not yet been envisaged.

## FEDERATION OF RHODESIA & NYASALAND

(Northern Rhodesia, Nyasaland and Southern Rhodesia)

The hydro power of the Zambezi allows increased production of copper, zinc and lead to be envisaged in Rhodesia.

In Northern Rhodesia increased production of electricity would be particularly developed for meeting mining requirements. In the three territories the four main sources of demand to be met may be summarized as:

- the local needs, which are growing, of the most important urban areas;
- the encouragement of industrial growth;
- the increase in production and modernization of agricultural output; and
- the need to give favourable conditions for the development of surface transport facilities.

## SENEGAL

The **Bel-Air** thermal plant at **Dakar** (12.8 MW) is expected to be able to satisfy the increase in demands for power until 1965-1966. It is expected that there will be an 80 per cent increase in consumption in the 5-year period ending 1964. Most of the increased requirements will be needed for setting up industries requiring large amounts of power, including the phosphates installation of Taiba and a textile industry, as well as for the extension of cement production.

Most of the increased requirements are likely to occur in the region of **Thiès.** In order to improve the security of power supply it would be useful to extend the high voltage interconnexion network to the areas of **Fatick, Kolack** and **Bambey.**

## SOMALIA

Substantial deposits of iron ore have been confirmed in the southern area of the country and some prospecting for oil has of late been in progress. Transport facilities are not plentiful and the demand for electric power seems likely for the present to continue to be met by small scale scattered generating units requiring relatively small quantities of fuel, which is costly to transport.

## SUDAN

There appears to be no long-term plan so far for the development of consumption requirements. A petroleum refinery is envisaged at **Port Sudan** and other factories, including a sugar refinery, are planned. The rapidly growing demand for electric power appears to be covered until 1964. There are in all some nine projects for developing hydro power in conjunction with irrigation, but apparently large-scale development in this field is not so far envisaged for the immediate future. Large-scale projects of 100 MW or more appear to be possible.

In conjunction with deposits of copper ore, small quantities of uranium have been found in the region of **Darfur** and **Bahr-el-Ghazal.** A considerable amount of electricity production appears to be possible from sugar cane and cotton wastes.

## TANGANYIKA

There are some 250 million tons of coal reserves in the **Southern Highlands** but at present no known reserves of liquid or gaseous fuels.

Low-cost energy is available from the hydro-electric project of **Hale,** near **Tanga,** which should be available by 1964 to supply two main industrial centres of **Tanga** and **Dar-es-Salaam.** This scheme would give 21 MW and 95 million kWh per year. From 1967 the rising demand in these areas is expected to absorb the capacity of the **Pangani Falls** and of **Hale,** and a further source of supply will have to be developed. Other schemes which would be available include the **Moshi** No. 2 project (13.5 MW), giving 55 million kWh per year, and a further hydro potential giving up to 8 MW, or around 33 million kWh per year, would allow supplies to meet the industrial requirements of **Arusha** and **Moshi** and to further irrigation.

In the more distant future a development of the **Roufiji** river could give 500 MW. On the river **Malagarasi,** at 160 km from **Mpanda,** a hydro-electric scheme may be necessary to supply the exploitation of lead in the area.

In the industrial region south of **Lake Victoria** and the **Southern Highlands** where, in addition to coal and iron, diamonds exist and cotton production and a paper factory could be set up, the cost of energy is at present higher than elsewhere owing to transport charges.

## UGANDA

Although it has been estimated that demand might increase at 10 per cent per year, requirements can be covered for a certain time by the output from the**Owens Falls** plant, which in case of necessity could be extended to 150 MW. There is a possibility for the construction of a 180 MW scheme downstream from **Owen Falls** and other possibilities exist on the **Victoria Nile** and other rivers. The transport system is well developed and low-cost energy is available within the country.

The present interconnected supply system serves the main towns in the areas around **Lake Victoria,** the **Nile,** the **Elgon** and **Mbarara regions,** including the cities of **Kampala, Entebbe** and the industrial centre of **Jinja.** It is planned to extend the transmission system in order to further electrification and to increase the total market for power. Although at the moment there is a temporary excess of supply, the power sold under a 50-year contract to the Kenya Power Company is the only export at present. The neighbouring countries of Congo (Leopoldville), Rwanda, Burundi, Tanganyika and the Sudan are not so far supplied with energy from Uganda's hydro-electric resources.

# ANNEX VI

# SHORT SUMMARY OF ORGANIZATION OF ELECTRIC POWER SERVICES (SELECTED COUNTRIES)

## ALGERIA

Electric power questions fall under the **Ministry for Industry and Energy,** in which there is a Depart ment for Energy and Fuels.

The organ responsible for electricity supply is the EGA **(Electricité et Gaz d'Algérie)** with headquarters in Algiers.

## CAMEROON

The **Régie d'électricité et d'eau,** which falls under the Ministry of Public Works, is responsible for production, transmission and sale of electricity in the three towns of **Yaoundé, Nkongsamba** and **Maroua,** all with diesel production. All investments are made through the Government.

**L'Energie électrique du Cameroun** (Enelcam) a private company, supplies electricity to Edéa Douala, and the aluminium plant of the **Compagnie camerounaise de l'aluminium** (Alucam) through the hydro plant on the **Sanaga,** and from diesel plants.

Other towns (except **Dschang,** which possesses a small hydro plant) are supplied by small diesel plants utilized for the most part by the appropriate municipal authorities.

## DAHOMEY

The production and distribution of electric power for the regions of **Cotonou, Porto-novo** and **Ouidah** are assured by the **Compagnie coloniale de distribution d'énergie électrique** (CCDEE), a private company operating under government concession.

## ETHIOPIA

(a) The Ethiopian Electric Light and Power Authority at Addis Ababa is a government-owned corporation created by Imperial Charter in 1956. The Authority is responsible for generating, transmitting and distributing electrical energy in Ethiopia. At present its activity extends over most of the important provincial towns.

(b) SEDAO is the biggest privately-owned shareholders' company, located at Asmara, Ethiopia; its main activity centres on Asmara and Massawa. The Company is responsible for the generation, transmission and distribution of electrical energy.

(c) There are a number of privately-owned enterprises generating their own electricity for industrial purposes.

In 1961 the Ethiopian Electric Light and Power Authority produced 59% of the total output 24% was produced mainly by SEDAO and the remaining 17% was produced by private industrial enterprises.

(d) The Awash Valley Authority is responsible for multi-purpose development of the Awash river basin.

## UAR (Egypt)

The **Ministry of Public Works** is responsible for electric power development. There is also an Electricity **Commission for the UAR.**

This Commission has set up a **Technical Bureau for the Study and Execution of UAR Electrification Projects,** with headquarters in Cairo. This body undertakes planning, design and implementation of Egypt's interconnected power system.

Another separate body is the hydro-electric administration, which is in charge of the existing Aswan hydro-electric plant and other hydro schemes.

The largest organization for electric power production, which is a government enterprise, is the **Cairo Electricity and Gas Administration.**

## FRENCH SOMALILAND

Ministry Responsible **Ministry of Public Works, Mines Services.**

Company responsible for production, transport and distribution is **Electricité de Djibouti,** the public supply undertaking responsible for production and distribution in **Djibouti** and **Arta.**

## GABON Libreville

### LIBREVILLE

Ministry responsible: **Ministry of Public Works.**
Company responsible for production, transport and distribution: **Compagnie Centrale de Distribution d'Energie Electrique.**

### Port Gentil & Lambaréné

Competent ministerial department: **Ministry of Public Works.**

Companies responsible for production, transmission and distribution:

**Société d'Energie de Port Gentil.** Limited company dealing with:

— production and distribution of electricity and water at:

| | |
|---|---|
| Port Gentil | |
| Lambaréné | since 1962 |
| Moanda | since 1963 |
| Oyem | since 1963 |

— production and distribution of electricity at:

| | |
|---|---|
| Bitam | since 1963 |
| Mouila | since 1963 |

Public body responsible for certain special development **projects for multi-purpose** water use:

**Société d'Energie de Port Gentil** i.e. for the:
— hydro-electric plant at **Kinguélé**
— development of **Haut Ogooué**
— development of the **Nyanga.**

## GAMBIA

The competent Ministry is:

**Ministry of Works and Services, Electricity Department, Bathurst.**

There are no corporations responsible for production, transmission and distribution and no public bodies responsible for multi-purpose river basin development.

## GHANA

Electricity generation for public supply is carried out by the Electricity Division, which forms a branch of the Ministry of Communications and Works. Separate generation is carried out by the mines to a considerable extent, and by private users such as hospitals, certain factories etc. on a very small scale, but there are no details of the amounts generated or the potential load of these smaller plants.

The Electricity Division is responsible for production, transmission and distribution throughout Ghana and has its Head Office in Accra.

## KENYA

The competent Ministry and government department is the **Ministry of Commerce and Industry, Nairobi.**

Corporations responsible for production, transmission and distribution: the **East African Power Co. Ltd. (EAP), and the Kenya Power Co. Ltd**

## LIBERIA

Most of the electricity supply in Liberia is from organizations under government control, the controlling authority being the **Monrovia Power Authority.** In addition, private generating plants are operated by the **Liberian Mining Company** (iron ore mines) and a hydro-electric plant is operated by the **Firestone Rubber Co.**

## MADAGASCAR

The responsible services are:

1. **Ministère d'Etat Chargé de l'Economie Nationale.**
2. **Direction des Mines e[illegible] l'Energie.**
3. **Service Autonome d[illegible]**

Companies for product[illegible] [illegible]ibution:

**Société d'Electricité et [illegible]** [illegible] **Paris.**

**La Société d'[illegible]** [illegible]**.M.), Tananarive.**

The c[illegible] [illegible] for over-all questions

**M[illegible]** [illegible] **des Télécommu-** [illegible] **abitat et des Res-**

[illegible] under concession for [illegible]stribution throughout the co[illegible]

**Ene[illegible]** [illegible] **ociété Nationale d'Economie Mixte).**

Various special projects for the multi-purpose development of watercourses with particular reference to electricity production, have been set up by technical missions and by the local hydraulic services.

## MOROCCO

Competent Ministry: **Ministry of Public Works**
Companies charged with the production and transport of electric energy:

— **Energie Electrique du Maroc (E.E.M.)** **(Paris).**

Principal companies responsible for the distribution of electric power and to which **l'Energie Electrique du Maroc** sells a part of the energy produced:

— S.M.D. : **Société Marocaine de distribution** — distributes electricity in the towns of Rabat, Sale and Meknes.

— R.A.D. : **Régie Autonome de distribution Régie Municipale de Casablanca** — distribution in all parts of Casablanca.

— S.E.K. : **Société d'électricité de Kénitra** — Company charged with distribution in the sector of Kénitra.

— **Compagnie FASI d'électricité** — Company charged with distribution in the sectors of FES and SEFROU.

— **Société d'électricité d'El Jadida** — French Company charged with distribution for El Jadida.

— **Société d'électricité de Safi** — French Company for distribution in SAFI.

— E.E.B.M. : Electric enterprise in the region of Marrakech - (Moroccan Company charged with the distribution in the surrounding area).

— E.E.Z.M. : Electric enterprise of **Zénatas Mohammédia** (Moroccan Company charged with distribution in the sectors of Zénatas and Mohammédia).

— S.C.E. : **Société Chérifienne d'Energie** (Moroccan Company).

— R.E.I. : **Régie des Exploitations Industrielles.**

The last two organizations provide more particularly for the small centres of the interior.

The organization dealing particularly with hydraulic questions is **l'Office National des Irrigations.**

## NIGERIA

Information for Nigeria relates to the Electricity Corporation of Nigeria, which began operation for public supply in 1951, following Government legislation in 1950. The Corporation's year begins on 1 April and ends on 31 March of the following calendar year.

## REUNION

Competent Ministry:

**Ministère française de l'Industrie (Direction de l'électricité)**

Companies responsible for production, transmission and distribution of electricity are:

**Société Anonyme d'Energie Electrique** at St. Denis, which has authority for the public supply of electricity throughout the island and for the public distribution of electric energy in all communes except that of St. Denis. At St. Denis the public supply distribution is undertaken by the private company Bourbon-Lumière.

## SENEGAL

The **"Compagnie des Eaux et electricité de l'Ouest Africain"**
(Private Company founded in 1950), is responsible for the production and distribution of electric energy in the western region of **Senegal.**

## SIERRA LEONE

The competent Ministry and department are:

— the Electricity Division of the Ministry of Works. Undertakings include the S.L.S.T., S.L.D.C. and SIEROMCO mining companies, operating at Yengema, Marampa and Gbanbatok respectively.

## SUDAN

There is a **Ministry of Irrigation and Hydro-electric Power** which has its headquarters in the **Gezira** region.

**The Central Electricity and Water Administration** in Khartoum is the responsible body and supplies electricity in the Khartoum area and as far south as **Sennar.** This body was set up in 1959 to replace the **Sudan Light and Power Ltd.,** and the **Wad Medani Light & Power Co. Ltd.**

## TANGANYIKA

The **"Tanganyika Electric Supply Co. Ltd."** (TANESCO), a private company, is solely authorized by the government for the production, distribution and sale of electric energy.

## TOGO

The responsible Ministries are:

**The Ministry of Public Works, Mines, Transport, Posts and Telecommunications.**

Companies responsible for production, transmission and distribution of electric energy are:

— **Union Electrique d'Outre-mer** (UNELCO which covers production and distribution in the urban areas of **Lomé** and **Anécho.**

— **Energie Electrique du Togo,** a company for the production and transmission of energy at **Kpimé.**

## FEDERATION OF RHODESIA & NYASALAND

(Northern Rhodesia, Nyasaland and Southern Rhodesia).

The Electricity Act, 1956, as amended, provides the legal framework of the electricity supply industry in the Federation and is administered by the Federal Ministry of Power.

Electricity undertakings in the Federation comprise the following:

(a) The Federal Power Board
(b) private undertakings
(c) licensees, and
(d) local authorities.

All undertakings, except the Federal Power Board, private undertakings and local authorities which supply electric power within the area under their jurisdiction only, require a licence to supply electricity.

The Federal Power Board is a statutory body established in terms of the Electricity Act.[a] Its first function was to construct the Kariba hydro-electric project in order to supply power in bulk to other undertakings. The Board also has the duty of investigating further facilities for bulk supplies of power in the Federation. Power is transmitted from Kariba over a 330 kV system to Lusaka, Kitwe (serving the Northern Rhodesia Copperbelt and Ndola), Norton (serving the Salisbury area), Sherwood (serving the area supplied by the Southern Rhodesia Electricity Supply Commission), and to Bulawayo. The Act empowers the Board to interconnect its main transmission lines with the generating stations of any licensee or local authority. The Board controls the output of such stations and meets the cost of generating electricity at these stations. At present the interconnected generating stations are Salisbury, Umniati, Bulawayo and Lusaka.

Private undertakings do not require to be licensed in terms of the Electricity Act, though the consent of the Minister of Power must be obtained before power can be supplied to other persons. They have to be constructed and maintained in accordance with regulations and private undertakings must comply with any requirements of the Minister for the purpose of facilitating co-ordination with existing or future undertakings. Private undertakings may be divided into two categories:

(a) an undertaking for the generation or supply of electricity for use solely or mainly on the owner's premises or for the purposes of his business, being a business other than a business for the supply of electricity;

(b) an undertaking or undertakings for the generation or supply of electricity operated solely or mainly in the interests of a group of associated companies for the purposes of the businesses of these companies.

[a] Under an agreement concluded in November 1963 (Northern Rhodesia Government Gazette, Vol. LIII, No. 63). The main function of the Board will subsequently be vested in a body to be known as the Central African Power Corporation (see also note in Chapter V).

The Electricity Art also provides for the establishment of an Electricity Supply Commission in each of the three territories of the Federation. The functions and duties of Electricity Supply Commissions are to generate, acquire or supply electricity within their territories and in consultation with the Federal Power Board to investigate new and additional facilities for the supply of electricity and for the co-ordination of existing undertakings.

The Southern Rhodesia Electricity Supply Commission owns power stations at Umniati, Shabani, Gwanda and Umtali, and a small diesel station at Chipinga. It owns over 7,000 miles of transmission and distribution lines which supply power to a very large area including most of the smaller local authorities in Southern Rhodesia. Larger municipalities such as Fort Victoria, Gatooma, Gwelo, Que Que and Umtali purchase the whole of their requirements in bulk from the Commission and carry out distribution within their respective areas of supply. The Commission also supplies a larger number of mines, farms and domestic consumers.

The Nyasaland Electricity Supply Commission is the successor of the Nyasaland Government Department of Electrical Services. The Federal Government provides the capital requirements for the Commission's undertakings in the Southern Province and at Lilongwe, Fort Johnston and Mzuzu.

An Electricity Supply Commission was not established in Northern Rhodesia and there has, therefore, been no need to re-allocate financial responsibility between the Federal and Territorial Governments for development of electricity distribution there.

As stated above a local authority does not require a licence to supply electricity within the area under its jurisdiction, and no undertaking may supply electricity within the area under the jurisdiction of a local authority without its prior consent. If, however, a local authority supplies electricity outside the area of its jurisdiction it does require a licence. The Territorial Governments of Northern and Southern Rhodesia are responsible for making capital available to local authorities to meet their requirements for electricity development.

The Electricity Act provides for the establishment of an Electricity Council in each territory. The functions of these Councils are to advise the Minister of Power on matters relating to the issue and amendment of licences and on tariffs to be charged by licensees.

## TUNISIA

(a) **Le Secrétariat d'Etat au Plan et aux Finances** is responsible for electric power and controls its production and distribution.
Production and distribution for the whole of Tunisia is undertaken by the **Sociéte Tunisien-**

**ne de l'Electricité et du Gaz,** with headquarters at Tunis.

(b) This is a national organization set up by the State and is exclusively responsible for the development of electric energy in Tunisia.

(c) **Le Secrétariat d'Etat à l'Agriculture** is responsible for development of watercourse for purposes of irrigation. It is responsible for baggage construction and additionally, in cases where it is economic, for associated electric power installations.

### UGANDA

The public organ responsible for the production and distribution of electricity is the **"Uganda Electricity Board"** (UEB) which is situated in Kampala.

# ANNEX VII

## SUMMARY OF ANNUAL CAPITAL INVESTMENT FOR ELECTRIC POWER SUPPLY BETWEEN 1955 AND 1961 (SELECTED COUNTRIES)

### ETHIOPIA

The total figures below exclude expenditures of self-producers. The expenditures — for the Ethiopian Electric Light & Power Authority — are in Ethiopian dollars:

| | |
|---|---|
| $ 1,538,000 | for 1958 |
| $ 1,408,000 | " 1959 |
| $ 35,939,000 | " 1960 |
| $ 2,106,000 | " 1961 |

### GABON

Refers to the system of **Port Gentil-Lambaréné.** Investment for thermal plants amounted to 92 million Frs. This figure refers to plant investment only through the **Société d'Energie de Port-Gentil.**

### GHANA

Including the **Tema** development project average capital expenditure per year between 1955 and 1961 was £G 782,000. This figure represents the amounts available from development funds, annual votes and covers thermal power plants, transmission and distribution.

### KENYA

The fixed assets and annual investment for **The East African Power and Lighting Company Limited** and **The Kenya Power Company Limited,** from 1955-1961, are set out in Table A and B below.

### MALAGASY REPUBLIC

The annual investment between 1950 and 1960 of the various electric power undertakings was as follows:

| **Companies** | **Million of Francs CFA** |
|---|---|
| Electricité et Eaux de Madagascar | 2,457 |
| Société d'Energie de Madagascar | 1,889 |
| Electricité de la France Australe | 80 |
| Others | 28 |
| TOTAL: | 4,454 |

**TABLE A.**

**The East African Power and Lighting Company Limited**

| Year | | Thermal Plant | Hydro Plant | Transmission Lines | Distribution Lines | Total |
|---|---|---|---|---|---|---|
| 1955 | Opening Balances | 2,475,674 | 2,768,425 | 391,820 | 2,840,622 | 8,476,541 |
| | Additions/Deletions | 741,503 | —2,641,288 | 303,131 | —440,978 | —2,037,632 |
| | | 3,217,177 | 127,137 | 694,951 | 2,399,644 | 6,438,909 |
| 1956 | Additions/Deletions | 789,316 | 1,819 | 2,659 | 378,106 | 1,166,582 |
| | | 4,006,493 | 128,956 | 692,292 | 2,777,750 | 7,605,491 |
| 1957 | Additions | 88,498 | 1,148 | 34,017 | 371,702 | 495,365 |
| | | 4,094,991 | 130,104 | 726,309 | 3,149,452 | 8,100,856 |
| 1958 | Additions/Deletions | —182,049 | Nil | 69,190 | 422,097 | 309,238 |
| | | 3,912,942 | 130,104 | 795,499 | 3,571,549 | 8,410,094 |
| 1959 | Additions/Deletions | —254,290 | 98 | 380,474 | 179,736 | 306,018 |
| | | 3,658,652 | 130,202 | 1,175,973 | 3,751,285 | 8,716,112 |
| 1960 | Additions/Deletions | 166,274 | 112,041 | 673,898 | —350,933 | 601,280 |
| | | 3,824,926 | 242,243 | 1,849,871 | 3,400,352 | 9,317,392 |
| 1961 | Additions | 468,386 | 942 | 135,663 | 211,956 | 816,947 |
| | Closing Balance: | £ 4,293,312 | 234,185 | 1,985,534 | 3,612,308 | 10,134,339 |

TABLE B.

The Kenya Power Company Limited

| Year | | | Hydro | Main Transmission | Total |
|---|---|---|---|---|---|
| 1955 | Assets Acquired and Additions | | 2,800,216 | 697,220 | 3,497,436 |
| 1956 | Additions/Deletions | | — 22,557 | 2,068,418 | 2,045,861 |
| | | | 2,777,659 | 2,765,638 | 5,543,297 |
| 1957 | Additions/Deletions | | — 11,691 | 1,167,814 | 1,156,123 |
| | | | 2,765,968 | 3,933,452 | 6,699,420 |
| 1958 | Additions/Deletions | | — 9,605 | 4,609 | — 4,996 |
| | | | 2,756,363 | 3,938,061 | 6,694,424 |
| 1959 | Additions/Deletions | | 7,587 | — 5,201 | 2,386 |
| | | | 2,765,950 | 3,932,860 | 6,696,810 |
| 1960 | Additions/Deletions | | 687 | 254,561 | 255,248 |
| | | | 2,764,637 | 4,187,421 | 6,952,058 |
| 1961 | Additions/Deletions | | — 871 | — 6,784 | — 7,655 |
| | Closing Balance: | £ | 2,763,766 | 4,180,637 | 6,944,403 |

## MALI

Gross annual investment for electric power over the period 1955-1961 was as follows:

| | |
|---|---|
| Thermal plants | 35 million Frs. Mal. |
| Hydro plants | — |
| Transmission | — |
| Distribution | 15 million Frs. Mal. |

## MOROCCO

The total annual investment (gross) has been: 111 million dirhams.

## NIGERIA

Average annual capital expenditure (1956-1961) was:

| | |
|---|---|
| Plants (thermal & hydro): | £ 1,034,000 |
| Transmission & Distribution | £ 931,000 |

## FEDERATION OF RHODESIA & NYASALAND

The gross expenditure for the period 1953-1961 in the electricity supply industry (generation, transmission and distribution) was approximately £ 133,000,000 (Rhodesian).

## REUNION

Over the period 1955-1961 investments for public supply production and distribution of electricity have been:

| | |
|---|---|
| Diesel plants | 59 million Frs. CFA |
| Hydro-electric plants: | 702 million Frs. CFA |
| Transmission lines (at 63 kV): | 115 million Frs. CFA |
| Distribution network: | 405 million Frs. CFA |

## SIERRA LEONE

Annual investment expenditure on supply equipment has been as follows:

| | Thermal Power Plants | Hydro Power Plants | Trans-mission | Distri-bution |
|---|---|---|---|---|
| 1960 | £ 49,596 | — | £ 3,350 | £ 22,041 |
| 1961 | £ 353,450 | — | £ 153,350 | £ 34,860 |
| 1962 | £ 98,600 | — | £ 43,600 | £ 9,340 |
| 1963 | £ 546,000 | £ 15,000 | £ 68,850 | £ 66,050 |

## TOGO

Annual gross investment over the period was:

| | |
|---|---|
| Diesel plants: | 220 million Frs. CFA (1955-1961) |
| Hydro-electric plants: | 310 million Frs. CFA (Kpimé) |
| Transmission: | 170 million Frs. CFA (1955-1961) |
| Distribution: | 134 million Frs. CFA |

## ANNEX VIII

### CHARACTERISTICS OF SOME IMPORTANT INDIVIDUAL THERMAL GENERATING PLANTS (SELECTED COUNTRIES)

| Country | Name of Plant | No. of units and unit capacity (MW) | Year of entry into service | Steam conditions: Pressure in kg/cm$^2$ (or lb/in$^2$) | Steam conditions: Temperature in °C (or°F) | Maximum load supplied (MW) |
|---|---|---|---|---|---|---|
| ALGERIA | Alger Port | 120 (2 x 60) | ... | 89 | 540 | ... |
| ETHIOPIA | Addis Ababa | 1 x 6.25 MVA | 1957 | 29 | 425 | 5 |
| GABON | Port Gentil | 3 (8 MVA) | 1950-58 | 32 | 400 | 2.85 |
| GHANA | — | — | — | — | — | — |
| KENYA | Kipevu | 3 x 5 | 1956-61 | 450 (lb/in$^2$) | 750 (°F) | 12 |
| MOROCCO | Roches Noires Sud | 2 x 16 | 1952 | 50 | 460 | 204 (production in $10^6$ kWh) |
| REUNION a) | Le Gol | 1.55 (MVA) | 1958 | — | — | 2.04 |
| | Ravine Creaze | 1.50 (MVA) | 1954 | — | — | 2.84 |
| | La Mare | 5.28 (MVA) | ... | — | — | 6.20 |
| FED. RHODESIA & NYASALAND | | | | | | |
| S. RHODESIA | Bulawayo No. 1 | 10-30 (MVA) | 1939-45 | 200 (lb/in$^2$) | 600 (°F) | ... |
| | Bulawayo No. 2 | 20-37 (MVA) 148.5 | 1948-55 | 600 (lb/in$^2$) | 850 (°F) | ... |
| | Salisbury No. 1 | 4-10 (MVA) | 1934-42 | 200 (lb/in$^2$) | 640 (°F) | ... |
| | Salisbury No. 2 | 9.35-25 (MVA) 153 | 1946-55 | 375 (lb/in$^2$) | 775 (°F) | ... |
| | Salisbury No. 3 | 37.5 (MVA) | 1957 | 600 (lb/in$^2$) | 865 (°F) | ... |
| | Umniati | 120 | 1947-55 | 400 (lb/in$^2$) | 800 (°F) | ... |
| N. RHODESIA | Nchanga | 93 | 1938-55 | 350-650 (lb/in$^2$) | 750-850 (°F) | ... |
| TUNISIA | Goulette I | 70.3 (6-6.4-17.5) | 1928-48 | 12-28 | 325-400 | 42 |
| UAR (EGYPT) | Cairo South b) | 147 (2x66-2 x 7.5) | 1957 | 84 | 500 | 104 (1961) |

(a) Selection from 13 back-pressure plants operated by six sugar refining companies.
(b) Block type, with 2 boilers per turbine and oil fired.

## ANNEX IX

### BASIC CHARACTERISTICS OF SOME MAIN HYDRO-ELECTRIC PLANTS (SELECTED COUNTRIES)

| Country | Name of plant and river | Gross head (m or ft.) | Installed capacity (MW) and number of individual units | Year of entry into service | Mean annual producibility (yearly production under average conditions) (GWh) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| ETHIOPIA | Koka (Awash) | 32-40 | 43 | 1960 | 110 |
| | Aba Samuel (Akaki) | 45 | 7 | 1939 | 23 |
| KENYA | Tana (Maragua | 248(ft.) | 14.42x2 MW & | 1933 | |
| | (Tana | 186(ft.) | (2x4+1x2.4 MW) | 1955 | 73 |
| | Wanjii (Maragua | 231(ft.) | (1x1 MW | 1954 | |
| | (Mathioya | 345(ft.) | 7.4(1x1 + 2x2.7 MW) | 1953 | 53 |
| MALI | Felou (Senegal) | 14 | 650 (kVa) | 1927 | 3.5 |
| MOROCCO | El Oidane (El Abid) | 105.5 | 120.6 (45 MVA units) | 1953-55 | 160 |
| | Fourer | 235 | 94.5 (52 MVA units) | 1953-55 | 390 |
| REUNION | Langevin (Langevin) | 130 | 3.5 | 1961 | 17 |
| | St. Denis (St. Denis) | 43 | 0.25 | 1933-59 | ... |
| | Ravine-Greuse | ... | 0.67 (MVA) | 1933-59 | 0.21 |
| FED. RHODESIA & NYASALAND | Kariba (Zambezi) | 101 | 575 (112.5 MVA units) | 1959-61 | 4400 |
| | Broken Hill (Mulangushi) | 358 | 18 (2.5 — 7.0 MVA units) | 1925 | 143 |
| | (Lunsemfwa) | 118 | 16 (5.5 — 6.6 MVA units) | 1945 | 149 |
| TOGO | Kpimé (Aka) | 250 | 1.6 (2 x 0.8) | 1963 | 5.5 |
| TUNISIA | Fernana Amont (O. El Lil) | 170 | 7.8 (1 x 7.8) | 1958 | 18 |
| | Fernana Aval (O. El Lil) | 34 | 1.5 (1 x 1.5) | 1962 | 3.6 |
| | Nabeur (Mellegue) | 60 | 13.6 (2 x 6.6) | 1956 | 15 |
| | El Aroussia (Medjerda) | 12 | 4.6 (1 x 4.6) | 1955 | 8 |
| TANGANYIKA | Pangani Falls | ... | 17.5 | ... | 80 |
| UGANDA | Owen Falls | ... | 120 | 1958 | 430 |

## ANNEX X

### SPECIFICATIONS OF DIESEL PLANTS IN SELECTED COUNTRIES

| country and name of installation | Capacity and number of units | Year of entry into service | Maximum load (kW) |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| MADAGASCAR a) | | | |
| Arsenal Diégo-Saurez | 2,400 kVA | ... | 3,200 |
| Société Rochefortaise | 465 kVA | ... | 855 |
| Société Sucrière Mahavavy Ambilobe | 8,168 kVA | ... | 10,954 |
| C.A.S.N.B., Nossi-Be | 2,702 kVA | ... | 1,660 |
| Cimenterie d'Amboanio | 3,900 kVA | ... | 2,379 |
| Société Filature Tissage Madagascar | 1,160 kVA | ... | 1,613 |
| Sucrerie Marseillaise Madagascar | 4,440 kVA | ... | 3,491 |
| Sucrerie Côte Est Maromary | 650 kVA | ... | 835 |
| Usine Sarpa, Tuléar | 740 kVA | ... | 850 |
| De Heaulme à Berenty | 1,290 kVA | ... | 600 |
| Domaine Pechpeyron Bevala Amboasary | 1,162 kVA | ... | 613 |
| MALI | | | |
| Bamako | (3 x 1,000 kVA | 1953 | 3,260 |
| | (2 x 2,500 kVA | | |
| Segou | (2 x 475 kVA | 1929 | 450 |
| | (1 x 575 kVA | | |
| Kayes | (2 x 350 kVA | 1954 | 300 |
| Gao | (2 x 80 kVA | 1953 | 160 |
| | (1 x 135 kVA | | |
| | (1 x 210 kVA | | |
| REUNION | | | |
| St. Denis | (1 x 1,000 kW | 1951 | 1,900 |
| | (1 x 600 kW | | |
| | (1 x 300 kW | | |
| Le Port | (2 x 255 kW | 1951 | 1,710 |
| | (1 x 1,200 kW | | |
| St. Pierre | (1 x 600 kW | 1951 | 1,030 |
| | (1 x 300 kW | | |
| | (1 x 130 kW | | |
| TOGO | | | |
| Lomé | (2 x 80 kW | 1936 | |
| | ( 450 kW | 1951 | 1870 |
| | ( 550 kW | 1958 | in |
| | ( 425 kW | 1960 | 1962 |
| | ( 550 kW | 1961 | |
| Kpimé | 4 x 1,500 kW | 1961 | — |
| CAMEROON | | | |
| Yaoundé | 440 kW | ... | ... |
| Nkongsamba | 900 kW | 1962 | ... |
| Maroua | 460 kW | ... | ... |
| Bassa | 2,600 kW | ... | ... |
| Garoua | 428 kW | ... | ... |
| GHANA | | | |
| Tema (not including mining companies) | 35.2 MW | ... | ... |
| Accra | 13.0 MW | ... | ... |
| Takoradi | 7.2 MW | ... | ... |
| Kumasi | 6.8 MW | ... | ... |

a) Figures in column 4 refer to production (kWh)