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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATON

INFORMATION SURVEY

FOR A STUDY OF THE PRESENT AND FUTURE ENERGY SITUATION IN AFRICA AND ITS IMPLICATION FOR THE INDUSTRIAL DEVELOPMENT

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CONVERSION FACTORS

(Terajoules/1,000 metric tons)

Hard coal	29.3076	Motor gasoline	43.9614
Lignite	11.2834	Natural gasoline	44.8992
Coke-oven coke	26.3768	Jet fuel	43.1994
Gas coke	26.3768	Kerosene	43.1994
Brown coal coke	19.6361	Naphta	44.1289
Patent fuel (hard coal briquettes)	29.3076	White/industrial spirit	43.2078
Lignite briquettes	19.6361	Gas-diesel oil	42.4960
Peat	9.5250	Residual fuel oil	41.4996
Fuelwood (10^3 m^3)	9.7680	Lubricants	42.1401
Charcoal	28.8888	Feedstocks	43.9405
Bagasse	7.7221	Plant condensate	44.3131
Animal wastes	8.4000	Bitumen (asphalt)	41.8000
Vegetal wastes	12.5000	Petroleum wax	43.3334
Other non-commercial energy sources	8.4000	Petroleum coke	36.4000
Crude petroleum	42.6133	Other petroleum products	42.4960
Natural gas liquids	45.1923	Liquefied petroleum gas	45.5440
Alcohol	40.0000	Natural gas (10^6 m^3)	37.2600
Aviation gasoline	43.9614	Electricity (Million kWh)	3.6048

Kilo	- 1 000	$= 10^3$
Mega	- 1 000 000	$= 10^6$
Giga	- 1 000 000 000	$= 10^9$
Tera	- 1 000 000 000 000	$= 10^{12}$
Peta	- 1 000 000 000 000 000	$= 10^{15}$
Exa	- 1 000 000 000 000 000 000	$= 10^{18}$

Standard conversion factors for liquid fuels are determined on the basis of the net heating value using average specific gravities for each product.

The conversion of fuelwood (solid volume, 0.333 TCE/m^3) is based on an average 20-30 per cent moisture content. Production data include the volumetric equivalent of charcoal using a factor of 6 to convert from a weight basis.

The methodology used for estimating fuel bagasse production is derived from the work done by the Economic Commission for Latin America. The methodology selected assumes a yield of 3.26 tons of fuel bagasse of 50 per cent humidity per ton of cane sugar produced. In most cases, sugar production data were extracted from the Sugar Yearbook of the International Sugar Organization (London).

For users wishing to convert the data from terajoules (TJ) to other common units: one thousand tons of coal equivalent (1,000 TCE) has traditionally been defined as comprising 29.3076 TJ, and one thousand tons of oil equivalent (1,000 TOE) as 42.6216 TJ. One calorie corresponds to 4.1868 joules and is the amount of energy which will raise the temperature of one gramme of water by one degree Celsius.

1. Introduction

Inspite of its vast natural resources, Africa remained the least developed continent in the world in terms of all significant economic indicators. In accordance to their level of industrialization, an important index for development, the majority of the African countries, especially those of the sub-Saharan region, must be classified as "least industrialized countries".

A few statistical data should underline this assumption.

In 1980 the industrial sector in Africa accounted for only 9,8 % of the region's GDP and for only 0,9 % of the world manufacturing output as compared to 2,7 % and 6,0 % for South and East Asia and Latin America respectively. The sector is characterized by an inflexible structure based on the production and export of mainly agricultural and mineral products. Despite the abundant reserves of phosphates, limestone, iron, bauxite, etc., the region is importing large amounts of fertilizers, cement, iron, steel, aluminium, etc. Even more striking is the fact that the agricultural output per capita has continued to decline, resulting in a 20% decrease in sub-Saharan region between 1961 and 1978 whereas cereal imports are raising rapidly from 3.8 million tons in 1965 to more than 20 million tons in 1980. Between 1982 and 1984 the situation became even worse and the shortfall in cereals beyond the year 2000 may reach 200 million tons a year which will lead to even more severe political and social repercussion for the world as a whole.

The general socio-economic situation is illustrated by the fact that the balance between population, resources and development has increasingly deteriorated. At present out of the 36 countries classified by the United Nations as least developed, 26 are in Africa and 21 out of the 34 countries classified by the World Bank as "low income" developing countries are located in the region. All these countries belong to the sub-Saharan region which has a per capita income of only US$ 240, that is one third of independent Africa's average.

The World Bank Development Report 1984 projects that, even with some fundamental improvements in domestic economic management, per capita income in sub-Saharan Africa will continue to fall during 1985-1995. In the same period of time GDP is expected to grow at 2,8 % per year and population at 3,5 % resulting in an annual reduction in per capita GDP of 0,7 %. On this assumption, sub-Saharan Africa income in 1995 might be so low that between 65% and 80 % of the population will be living below the poverty line, compared with roughly 60 % today.

An analysis of the present industrial situation in Africa shows that the "forced" import substitution strategy implemented shortly after the independence and financed largely from the earnings of the agricultural and mineral exports did not fulfill the anticipated results to create an industrial structure and the per capita income declined between 1970 and 1983 by around 4%. The reasons are manifold and largely influenced by the past and present global economic situation. First of all, the export of agricultural and mining processed goods proved difficult due to commercial interferences by multinational companies as well as tariff and non-tariff barriers set up by the major importing countries. In addition, the present balance of payment shows levels of consumer goods imports which are inferior to those of the intermediate commodity inputs necessary for the new local industry. Presently only less than half of the production capacity is fully utilized not only due to the limited demand mainly concentrated on the high income urban population accounting for less than 25 % of the total, but also due to infrastructure deficiencies and shortage of foreign currency needed for the purchase of spare parts and intermediate inputs. In many countries the most important enterprises work at a loss and survive only thanks to national subsidies. Consequently the level of development of the required capabilities, infrastructure and other factor inputs for economic development have remained at a rudimentary stage.

To overcome the crisis in the short term, sound African enterprises must resolve to higher capacity utilization and companies which could become productive must be supported by the Government. Even more important is the increase of the production level and income of the rural population,accounting for 75% of the total, which would largely stimulate and expand the domestic market. In the long term, the agricultural and exporting activities must become better balanced which requires a clearly designed policy for its implementation.

First of all African Governments must commit themselves to their natural, human and financial resources, to implement the designed plans. At the same time they have to encourage the mobilization of external bilateral and multilateral assistance by providing experts, material and funds for the implementation of Africa's priority development programmes.

In recognition of this situation and determined to undertake measures for the restructuring of the economic basis of the continent, several international and regional organizations are advocating integrated approaches to African economic development. This approach is based primarily on the strategy of collective self-reliant and self-sustained development in the interest of the people of the region and considering an increased local utilization of African natural and human resources towards the attainment of self-sufficiency in food production of the continent by the year 2000.

Second to the aspiration for self-sufficiency in food production, in recognition of the critical role which industry plays in economic development, accelerated industrialization in Africa was given special importance, emphasized by the proclamation of the 1980's as the Industrial Development Decade for Africa (IDDA).

The programme of IDDA lays down the broad objectives for the formulation and implementation of related programmes and activities at the international level. Emphasis is placed by IDDA inter alia on human, natural, financial and energy resources.

Taking into account that energy is one of the major factor inputs to industrialization this survey aims to provide a better understanding of the present status and future trends of the energy situation in Africa and its implication for industrial development resulting in a well defined study within the programme of IDDA of the energy requirements for industrial development which should furnish the basis for more detailed technical assistance projects related to:

- the collection of the socio-economic and energy input data for a better assessment of the relation between energy and industrial development;

- the provision of methodologies for developing and implementing long-term industrial energy policies;

- the execution of well defined case studies in individual countries to formulate and implement coherent energy policies and to develop master plans relevant for other countries of the sub-region in co-operation with national, regional and international organizations.

2. The specific energy situation in Africa and its role for industrial development

Among the resources required for socio-economic and in particular for industrial development energy plays a central role. No potential resource, be it material, human or financial, can become useful without the contribution of energy. Its indispensability as input to all kinds of industrial activities is emphasized by the strong interdependence between the structure of the energy system and the structure of the production system in all industrialized countries.

The specific problems of the relation energy - industry in sub-Saharan Africa, is underlined in Table 1, presenting the share of commercial and total energy used by industry in some selected sub-Saharan countries compared to that of the Fed.Rep.of Germany and Egypt, as well as the contribution of the industrial sector to the Gross National Product (GNP). The presented factors of energy intensity in industry, although being a rough measure, are a reflection of the industrial structure, the relative efficiency of energy consumption but also indicate the substantial share of traditional energy used. A high level of industrial energy intensity normally means an early stage of industrial development or a concentration on the production of energy intensive commodities. The high energy intensities for Gabon, Tanzania, Togo, Zaire and Zambia are an indication of an early stage of industrialization mainly concentrated on basic products, e.g. metals, building materials, etc., and the development of the infrastructure. The examples of the Federal Republic of Germany but also Egypt show that in more balanced economies, the share of commercial energy consumed by the industry is nearly equal to the contribution of industry to the GDP.

For a more detailed energy-industry analysis it is necessary to distinguish between three categories of industrial activities, related to different energy-, labour- and capital intensities:

1. Large and medium sized industries, e.g. petro-chemical, steel, cement, paper, etc., which are often government controled enterprises or subsidary companies of multinational organisations and large energy consumers.

2. Small-scale industries are relatively labour-intensive and the production is related to the local consumer markets, e.g. drying and canning of food, breweries, forges, etc..

3. Informal sector- activities include: artisan activities and craftmanships, repair shops, etc., and are highly labour-intensive. Their energy consumption is very small and dispersed.

The development of categories 2 and 3 is of specific importance for sub-Saharan Africa and their production process presently relies mainly on human and traditional energy. The introduction of mechanized technologies in both categories is the most important step towards increased productivity. Hence industrialization and infrastructure development, e.g. transport and distribution systems, largely depends on a rational energy policy to satisfy commercial energy demand in forms of final energy, especially electricity.

The importance of commercial energy for economic development is demonstrated in Figure 1 presenting absolute values of GNP, commercial and traditional energy consumption for 22 sub-Saharan countries. The presentation clearly indicates the positive correlation between commercial energy consumption and economic development (GNP), but also the independence or possibly negative influence of traditional energy consumption to economic development.

The above mentioned trends mentioned demonstrate the required structural changes in energy demand for industrial development.

This structural transformation, induced by the industrial development and the rising commercial energy consumption, makes the development process particularly vulnerable to energy availabitity and costs. Therefore any analysis of the relationship between the present and future energy demand situation and the industrial development objectives must be seen in the context of countries' socio-economic framework as well as of the regional and world wide energy situation.

The present low energy consumption per capita of sub-Saharan Africa and the progections for the year 2000 in comparison to the other world regions are shown in Table 2. The level is comparable to that of the Asian region which, however, represents more than 50 % of the world population. Based on present projections, energy production and therefore industrialization might not substantially increase within the next 15 years. Even more striking is that the consumption of electricity per capita, the most important energy input for industsrialization, is with a factor of 35 to 75 times lower compared to industrialized countries. The average of sub-Saharan Africa electricity consumption is 132 kWh/cap (see Table 3) compared to Italy with around 3300 kwh/cap., Japan with more than 4900 kwh/cap. and in the Fed.Rep.of Germany of around 6000 kwh/cap. In addition Table 3 shows the substantial differences in electricity production levels existing among the sub-Saharan countries. This very low level of electrification is one of the major inhibitors of the industrialization process in sub-Saharan Africa.

From the supply side independent Africa has, however, a large unutilized potential of energy resources (Fig. 2) totalling 2250 Exa Joules, compared to the proven recoverable resources of 965 Exa Joules. Natural gas and crude oil represent 77.6 percent of the potentially recoverable resources and the solid fuels 9.3 percent. At the 1982 level of extraction (11.14 ExaJ./year), the potentially recoverable resources could sustain the production for another 200 years, not taking into account possible new discoveries. If only African commercial energy consumption in 1982 is considered (3.25 ExaJ./year), energy supply is assured for 700 years. In addition, Africa has a vast conventional hydro electricity potential amounting up to 200.000 MW(el) from which at present less than 3 % are utilized. The small and non-conventional hydro potential, which is influenced by geographical and climatic factors, can be estimated as additonal 10 to 20 MW(el).

The presently proven recoverable energy resources of 965 Exa Joules, are however not evenly distributed among subregions and countries. Oil and gas deposits, are mainly concentrated in North and West Africa, representing 54 percent of the total, coal deposits in the Southern and Southeastern regions of the continent (23 percent) and uranium in the Southwestern region. Hydro energy resources are concentrated in Central Africa, e.g. Zaire has 32 % of the total explorable hydro energy resources of the continent, and finally the geothermal potential along the Rift Valley in East Africa.

Only 40 % of the proven energy resources (Figure 3), are located in sub-Saharan Africa with coal, as the largest potential energy source (Ref. 81), amounting to 172 Exa Joule, oil with 121 Exa Joule and natural gas with 53 Exa Joule. The substantional oil deposits are concentrated in only four countries and most of the oil produced is exported. The coal and gas deposits are, at present, either underdeveloped or unutilized, e.g. most of the natural gas in Nigeria is still being flared. The development of the potentially recoverable energy resources of the region will require highly capital intensive exploration and infrastructure developments which goes beyond the possibilities of individual countries and requires extensive international co-operative and investment programmes.

The only energy resource that is overutilized at present is fuelwood, accounting for about 80 % of the total energy consumption in sub-Saharan Africa. It is being used to meet the growing needs of households and small enterprises, in rural areas, since other forms of energy are not available or costs are too high related to the income. This trend has very serious implications on the forest resources and agricultural activities of some sub-Saharan countries and the "fuelwood crisis" may become more serious than the "oil crisis" in many countries. As seen in Table 4, fuelwood consumption is and will remain higher compared with the annual increment of tree stocks in selected sub-Saharan countries. Even for the countries with present surplus (e.g. Senegal) the relation between de- and aforestation will be negativ in the year 2000.

The relation between energy demand and supply is, however, not equal in different sub-Saharan countries. The small number of oil exporting countries, e.g. Nigeria, Congo, Gabon, Angola, and Cameroon are faced with the large number of countries with limited energy resources forced to import most of the oil with all its severe economic consequences of a negative balance of payment and rising indebtness. There are other classification criteria but the energy resource potential and the development of indigenous energy sources could be a basis for a grouping of countries. Therefore, based on the known economically explorable commercial energy resources in relation to the energy needs, sub-Saharan countries should be classified into three groups as shown in Figure 4 (for the list of countries included in each group see Appendix 5).

Countries in the first group have limited energy resources and future energy independence would require the development of new and renewable sources of energy (NRSE). The 15 countries in the first group represent 19 % of the region's population, their average energy consumption is 15.2 GJ/cap (1.1 GJ/cap commercial energy), and 8 % share of manufacturing in GDP. Their GNP is below US$ 230 less than one third of Africa's average, and are classified in the group of the least developed countries in the world.

23 countries and 53 % of sub-Saharan population belong to the group with moderate energy resources. It has the highest contribution of manufacturing to the GDP (12.9 %), and 16.8 GJ/cap total energy consumption (2.6 GJ/cap commercial energy). Some countries of this group have ambitious and successful economic development programmes.

In this context it is interesting to note that availability of physical resources alone is not a sufficient criterion for industrial development. Zaire, for example, has substantial hydropower but also its oil, gas and coal deposits largely exceed the country's present needs; however, its present commercial energy consumption per capita is only 1.81 GJ, and the share of manufacturing in GDP 6.2%. Mainly because of this low level of development and the low energy demand the available hydropower (Inger dam) cannot be economically used. Only additional investments for the establishment of a regional grid for the export of electricity to the neighbouring countries or for the development of energy intensive industries in accordance with the market situation would positively influence the situation of the country and the region.

The example of Zaire clearly shows that countries of the moderate group find themselves between two extremes. In some (e.g. Sudan and Tanzania) energy resources have only recently been found and are still being assessed, with production to start in the near future. Other countries (e.g. Kenya and Ivory Coast) with small domestic energy resources, are in the process of substituting oil with coal, electricity and increasingly with new and renewable sources of energy. These different options, jointly with energy needs generated by the most dynamic economies among sub-Saharan countries, have given an impetus to different regional cooperation schemes for electrical grids interconnection and for joint development of hydro potential and coal deposits (e.g. ECOWAS and SADCC energy programmes, Volta River Authority, Senegal and Gambia River utilization schemes, etc.)

The oil exporting sub-Saharan countries, grouped as countries with substantial energy resources, represent 27.5 % of the population, they have a relatively high GNP of US $ 860, a total energy consumption of 15.5 GJ/cap (3.52 GJ/ cap commercial energy) and 8.2 % contribution of manufacturing to the GDP. As a group, they are subject to different constraints and options compared to those of the first two, dominated by distribution and utilization problems, e.g. the paucity of distribution networks limiting the access of commercial energy to the remote regions, or the lack of the infrastructure to use natural gas presently flared, etc..

A starting point for a possible development strategy could be the two extreme scenarios for the whole of Africa (Ref. 41) developed by the UN Economic Comission for Africa (ECA):

The elaborated "low" scenario is an extrapolation of the existing historical trends and their unfavourable implications up to the year 2008 are as follows:

- the region as a whole would require increased food imports (or aid);
- over 90 percent or all capital goods required for development have to be imported;
- large amounts of energy intensive products like fertilizers, cement, iron and steel, and textiles, must be imported (the projected figures are presented in Table 5).

The "high" or normative ECA scenario outlines a possible alternative for self-sustaining growth, self-reliance and fuller utilization of African resources. The "high" scenario does not take into account the present and foreseeable future constraints.

Even with the "high" scenario the region as a whole has to import needed machinery and transport equipment as well as iron and steel, but it may reach self sufficiency in the production of fertilizers and cement (Table 5). The "high" scenario clearly emphasizes an acceleration of the industrialization process in the next decade especially in sub-Saharan Africa. However, as shown in Table 6, in both scenarios energy demand will largely increase. Crude oil consumption increases by more than 8 times of the present level, gas consumption 8 to 11 times and electricity production for the "low" scenarion more than 8 times and more than 14 times for the "high" scenario in absolute terms, whereas the increase of electricity generation per capita is 4.3 times or 6.4 times respectively, reaching the value of 1000 kwh/cap., compared to today's avarage of 150 kwh/cap.. In both scenarios the required substantial increase in electricity generation can only be achieved by a better availability of the present capacity and by a rapid build-up of hydro electric power plants. The assumption that required increase of electricity generation can be achieved without active involvment of the substantial coal potential of the region seams unconsistent. In 2008, hydropower should represent 75 percent of total installed capacity for the "low" scenario and up to 85 % for the "high".

The already mentioned present low level of electricity generation, as shown in Table 3 is one of the major constraints for industrial development and the financing of the capital investment needed for the development of power sector will remain the most difficult problem. If only hydro power is considered the capital requirements will be, for the "low" scenario about $ 85 billion and for the "high" $ 130 billion. Even if it is assumed that 60 % of the total cost could be covered by local contribution, e.g. machinery, equipment, civil works, etc., the foreign currency needs for import are $ 34 billion for the "low" and $ 54 billion for the "high" scenario.

The above stated requirements raise a variety of questions, e.g. the timing, magnitude and composition of the investment, the competition with other capital intensive industrial development needs, the overreliance on a single source for electricity production, etc.

The required increase of natural gas consumption is calling not only for a substantial investment in the resources development, the infrastructure for utilization, transport and distribution but also for elaboration of long-term development strategy for the use of gas for power generation or as feedstock for the fertilizer and petrochemicaly industry.

The capital investment requirements for the development of natural gas resources are also considerable. To illustrate the order of magnitude, the cost for exploration, development and transmission of natural gas supply, as estimated by the World Bank in 1983, is 514.9 million US $ for Cameroon (63 $/1000 m3), 1889.5 million US $ for Nigeria (39 $/1000 m3) and 184.7 million US $ for Tanzania (37 $/1000 m3).

The utilization of the local coal resources, mainly located in Southern African countries, is also bound to rise significantly in both scenarios. The resource development can be economically justified only if regional or international markets can be accessed, which requires the build up of adequate land transport infrastructure and port facilities including those situated in the neighbouring countries. Consequently the elaboration of a coherent regional coal policy is an important prerequisite for the economic use of coal. In this respect the ongoing assesment of African coal resources, production and trade (Ref 81) co-sponsored by ECA could serve as bases for comparison of the existing options.

The required speed of energy development as well as of the corresponding infrastructure clearly lead to the conclusion that the development programme and its timely implementation have to be carefully planned. In this sense energy and industrial planning, must be seen as an integral part of a rational and coherent long-term development policy.

Analysis and planning activities can be divided into two parts:

1. descriptive assessment and 2. analysis and planning. The first group consists of the most basic initial information gathering and descriptive activities; the second consist of more focussed analysis, usually treated in greater depth and complexity, with greater attention to specific technologies and sectors.

The basic information gathering and descriptive assessment activities are exemplified by the energy assessments carried out in the Joint UNDP/World Bank Energy Assessment Program (Ref. 4 - 29). which are playing a major role in establishing the fundamental information base in many countries, especially the least developed and/or smaller countries .

In order to undertake a comparative analysis of the energy situation in individual countries and to initiate Integrated Energy/Industrial Planning activities it is essential that specific energy and non-energy data e.g. macro-economic data, industry specific data, etc. are available. The data should cover the energy system itself and its interaction with the other determinants of the national development. These data are either actually or potentially available and, in order to ease their collection, they should be grouped into homogeneous sets. Three main data sets are perceived relevant to our study:

- Socio-economic information, e.g. population , GDP and its structure, etc.
- Energy balance sheet data covering primary, intermediate and final energy flows;
- Industry specific data covering production activities in the energy intensive sectors jointly with some energy specific industrial indicators.

The above defined sets elaborated in a detailed form are given in Table 7.

On those principles, we have developed a specific data base which should facilitate and support the analysis of our study.

An example of the in depth decision oriented planning is the development of a diversified energy policy in Kenya (Ref. 34, 56) and the Kenyan approach to energy management and industrial development could be used as a case study for the other African countries in the area of joint energy-industry planning.

3. Assessment of the available information for sub-Saharan African countries

An assessment of the availability of data needed for the comparative analysis of the countries' industrial energy efficiency and for establishing a basis for an integrated Energy/Industry planning, is done with the data sets defined in Table 7

The assessment is based on available surveys of :

a. the computerised data bases of UNIDO and IAEA;
b. the World Bank/UNDP Energy Sector Assessment Reports;
c. other relevant publications, as listed in the Reference section.

A part of the relevant data quoted below has been organized in a separate basic computerized data base, serving the specific needs of the study. The sources of data of specific interest for the study, are summarized below.

3.1. Population characteristics

The total population of the sub-Saharan region was estimated in 1980 as 411.3 million and in 1983 as 450.6 million. Most of the people leave in the rural areas, but the trend towards urbanisation is accelerating recently.

Population estimates are available from the "UN World Population Prospects as Assessed in 1983", from the most recent issues of the UN "Population and vital statistics" report, from the Demographic statistics (Eurostat 1984) and from national censuses.

Population projections for 1990 and 2000 are available from the World Bank and from the above quoted UN World Population Prospects.

Estimates of labor force and its sectoral distribution, e.g. agriculture, industry, and services, are available from the International Labor Organisation (ILO) publication, "Labor force estimates and projections, 1950-2000", and from the World Bank. Data on urban population, represented as percentage of total population is available from the UN "Estimates and projections of urban, rural, and city population 1950-2025", and can be supplemented by data from the World Bank and from various issues of the UN Demographic Yearbook.

3.2. Economic information from National Accounts

The economic information from National Accounts, e.g. GNP in constant prices, GNP originating in mining,manufacturing, construction, utilities, and services, is available in UNIDO's data base (UDB) for all sub-Saharan countries.

3.3. Information on Output per sector, Value Added and Production Indexes

The available, but largely uncoplete, information on output per sector, value added and production indexes for up to 28 industrial branches in the manufacturing sector of 40 Sub-Saharan countries is presented in UNIDO data base (Ref. 52). The branches included in the manufacturing sector and their correspondent International Standard Classification (ISIC) codes are shown in Table 1 Appendix III. Some country's samples are also attached in Appendix III for illustrative purpose while the full discription of available information can be found in the Reference 52.

The country's page is divided into six panels, each showing the availability of statistics concerning employment, wages and salaries, gross output, value added, gross fixed capital formation and the production indexes for the manufacturing branch or the 3-digit level of the International Standard Classification (ISIC) code .

From the 40 sub-Saharan countries present in the data base, information on Output per sector, Value Added and Production indexes is available in most of the cases in fairly uncoplete form for 29 countries, namely: Burkina Faso, Cameroon, Central African Republic, Congo, Ethiopia, Gabon, Gambia, Ghana, Ivory Coast, Kenya, Lesotho, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Tanzania, Rwanda, Senegal, Saychelles, Somalia, Sudan, Swaziland, Togo, Uganda, Zaire, Zambia and Zimbabwe.

The above data can be used for:

a. evaluation of the energy consumption of the branch (if energy balance data are not available)

or

b. determination of the energy intensity of that branch, based on final energy consumption data (from the energy balance) for the branch.

3.4. The Energy Balances

The present constraints to obtain the data needed for national energy balances for sub-Saharan countries can be summarized as follows:

a. Information on the National Energy Balance from UN sources is available only for a few countries with a time delay of 3 to 4 years;

b. Data on Energy Balance from other sources exists for most of the countries, however:

(1) balances are compiled and published by various institutions, in most cases not national;

(2) methodologies used are based on a diversity of conventions, thus making direct data comparison impossible;

(3) data collection is not based on systematic monitoring, but rather on ad-hoc references;

(4) information on consumption of traditional energy is derived from extrapolations of limited regional surveys;

(5) the energy consumption in the Industrial Sector is disaggregated (if at all) to a few branches, thus not revealing the energy utilization patterns in industry.

The aim of the proposed study is to systematize needed data, to assess their suitability for energy balance building and to compile industry oriented energy balances, based on a common methodology, for several countries. The methodology used together with a short description of UNIDO and IAEA data bases is summarized in Appendix I.

For the data collection and assessment of the available information relevant to energy balances, three major sources will be looked into, namely the UN sources, the UNDP/WB Energy Sector Assessment Reports, and the CEC study on energy for development done by the established "network of energy institutes".

3.4.1. The UN sources:

1.The UN Statistical Office (UN SO) is supplying UNIDO and IAEA every year with an Energy Tape containing Energy Balances and Electricity Profiles starting from 1950 and the latest year available is presently 1982 (Ref.42).

The information is presented as flows of primary, intermediate and final energy to the main consuming sectors:

- households
- transportation
- industry and construction, subdivided into:
  - iron and steel industry
  - chemical industry
  - other industry and construction

Industry and construction is, however, represented by only three sectors, namely the aggregated iron and steel industry, the broadly defined chemical industries, and others (or industries not specified elsewhere), including manufacturing of non-ferrous metals, glass, cement, textiles, food processing, etc. In response to this broad definition, the most reporting African countries (see Table 8) are supplying information on the aggregated energy consumption of the whole manufacturing sector under other industries only. As a result the data of category other normally includes the whole industry. Information on liquid fuel consumption has only recently been included in the statictics.

Statistics on electricity consumption in industry are available for most of the countries (Table 8). On this basis, a review of the primary energy inputs to electricity production, the estimated electricity production efficiency and the electricity consumption per capita for 26 sub-Saharan countries is presented in Appendix IV. Country data on electricity consumption in industry is available in the computerised data base to be developed as a basis for the proposed study.

Although the traditional energy is satisfying 80 percent of the total energy demand of the subregion and there is evidence that some of it is used by the small scale industry, the countries' replies reflect mostly the statistics on bagasse, subproduct of the sugar industies, undoubtedly the one of the most developed industrial sectors in Africa.

A general observation for most African countries is that the figures reported in their industrial energy consumption to the UN sources are lower than those from other studies, e.g. countries statistics, UNDP/WB ESAP, etc. (Ref. 56 p.210).

From the available information, the UN Statistical Office (UNSO) was able to construct national energy balances for 8 (out of 44) sub-Saharan countries, namely for Gabon, Ivory Coast, Kenya, Malawi, Niger, Nigeria, Zambia, and Zimbabwe. Based on the energy balances, Figures 5 to 12 show the share of industrial energy consumption and its composition , e.g. oil products, coal, traditional energy sources, etc. As shown in the graphs, the share of industrial energy consumption varies from 34 percent in Zimbabwe, down to 8 percent in Ivory Coast and 6.9 for Kenya.

3.4.2. The UNDP/ World Bank Energy Sector Assesment Programme (ESAP)

As of the end of August 1985, 26 Energy Assesment Studies for the sub-Saharan African countries are available in UNIDO (Ref. 4-29).

One of the emphasis of the Assesments, as stated in the Annual Report of the Programme (Ref. 60) was that the "Analysis of energy economy interaction is based on the use of energy balances as a check on the consistency of macro-economic and energy sector plans. These balances trace the flow of energy through the economy, accounting not only for the sources and uses of each energy form, but also for losses in the process of energy transformation and, when possible, estimates of the end-use efficiency of energy".

This intention was fulfilled with mixed success. Although in most of the reports one or several energy balances are presented, their quality largely depends on the quality of the team responsibel for a particular country's assessment. Some of the balances (e.g. Togo, Benin, Kenya, Mauritania, Tansania, etc.) are built in a consistent way, for others (e.g. Ethiopia) the accepted concepts are presented in such a way which makes it impossible to compare them with other energy balances.

The industrial energy consumption, specifically that of the manufacturing sector, is analyzed with a varying degree of comprehension in only ten of the countries' reports.

Based on the information from the UN sources and Energy Sector Assessment Programmes (ESAP), the Energy Balances for the following countries were compiled and are presented in Appendix II : Bennin (1982), Kenya (1982), Namibia (1980), Niger (1982), Mauritania (1983), Tanzania (1981), Togo (1982, 1988, 1998), Ivory Coast (1982), and Zambia (1982).

Due to the problems mentioned above, the industrial sector is represented with a varying degree of detailization, depending on the information available. Thus, only in some cases, e.g. Kenya (see Table 9), a detailed study on energy consumption in industry is available (Ref.34), and the energy balance contains data on all main manufacturing branches.

A major task of the proposed study must be the compilatior of additional information in order to complete the energy balances for all countries.

3.4.3. Energy and development - a study done by the CEC and the "network of energy institutes"

The "network of energy institutes" is composed of ten energy related institutions, situated in Argentina, Brasil, China, Chile, France, India, Kuwait, Mexico, and Thailand, but only one institute in Africa (Senegal).

The study, sponsored and co-ordinated by the Commission of European Communities (CEC), was carried out between 1981 and 1984 and had a total budget of 4.6 million ECU, (out of the total 2,7 mio, ECU were contributed by CEC (Ref. 61).

From the total budget only 8.5 percent were devoted to Africa, mainly due to the fact that only one African institution, the Institute for Environment and Development of the Third World (ENDA), participated in the study.

The study was oriented towards the following research topics:

1. Gathering of national data for a certain number of countries and presentation of the energy balance sheets based on common methodology;
2. Undertaking of a number of case studies, aimed at contributing to a more detailed appreciation of the energy system, than the one obtained from national sources;
3. Elaboration of a methodology for the analysis and forecasting of the energy requirements and provisions in the developing countries.

For the African region, the following studies were carried out by ENDA (see also Ref. 62 - 74):

1. Compilation of the energy balances for Senegal, Mali, Burkina Faso and Guinea-Bissau;
2. Case studies on the energy situation of Senegal, Mali and the fuelwood situation of the Sahel countries;
3. Compilation of a directory of research centers and information sources on "Energy in Africa".

Recently ENDA have set up a team of energy experts which is active in the following directions: field case studies, research, training, seminars, publications and increase of the South-South cooperation.

Agencies and representative officies of ENDA have been set up in Zimbabwe, Cameroon, Morocco and Mauritius and a sister institution is to be espablished in the Republic of Tanzania.

3.4. Energy resources

The estimates of the energy resources of the largely unexploited African continent, are naturally a subject of frequent revisions. New discoveries of natural gas and off shore oil can be expected in several prospective areas.

A thorough review of the known African energy resources was done by OAU/ECA in 1980 (Ref.76), supplemented by the ongoing work on assessment of the coal resources (Ref.81).

The latest estimates of the national energy reserves of the sub-Saharan African countries, based on data of the IAEA's energy and data bank and on other suitable sources (Ref.77) are presented in Table 10.

3.5. Industry related information

The assessment of available information on industrial energy consumption in the sub-Saharan countries is complicated by two major factors:

a. Energy consumption of the small scale industries and of the informal sector only recently became an subject of investigation and it is not clear whether even the conceptual framework for survey conduction is acceptable for the recipients, e.g. local artisants, smiths, etc. (Ref. 48, 80). The information needed must therefore be collected in co-operation with the relevant national energy authorities based on a clearly defined approach.

b. As seen from Table 11, the share of sub-Saharan Africa in the world production of energy intensive basic materials is low, and even diminishing, wich clearly indicates the problem of the region in meeting its development goal.

International assistance to improve the situation requires more adequate and reliable information. Improved reporting practice on all aspects of the industrial sector must therefore become a priority area for all countries concerned.

The annual statistics of industrial commodities production are available from the Yearbook of Industrial Statistics Volume II-Commodity Production Data (Ref. 54) or, alternatively, from the magnetic tape distributed by the UN SO. At the commodity level this information supplements the data on industry presented in section 3.3 above and provides more specific information about the nature and importance of the industrial activities undertaken in each country.

The unsatisfactory reporting practices of those countries that have a record in the Commodity Production data book are summarized in Table 12. While data on the cement production is available for practically all producing countries, information on the other products are very fragmented. To underline the present situation, even for a highly common commodity like soap as many as 29 countries do not report their production figures.

Again improvements of the quality and the quantity of the information needed can only be achieved by direct contacts with national statistical offices and authorities responsible for the industrial sector.

Finally the energy consumption in Industry is very sensitive to the type of technology used. A survey of the energy consuming installations and their energy input should be an important part of the proposed study. An example of such a survey, specifically of the rotary kilns in service of the cement industry in Africa and their energy input is presented in Table 13. A similar survey table for the other energy intensive products should become an important part of the study to provide a better understanding of the energy consumption in industry.

Again it requires direct contacts with the national organizations and individual companies conducting energy audits, e.g. TIRDO on Tanzania.

4. Methodologies for national industrial energy planning

Some African countries are already engaged in extensive energy planning activities for the:

- preparation of a capital investment programme for the development of a long-term energy programme;
- development of government policies relating to the regulation and control of the energy system, and
- provision for the development of capital goods industry for the supply of the energy equipments.

Specific planning objectives for an industrial energy policy are:

-development of a diversified energy supply system with reduced dependence on imported fuel;
-optimization of the use of indigenous energy sources;
-energy requirements for industrial development;
-reduction of non-commercial fuel use and resulting aforestation;
-development of the necessary manpower and infrastructure ;
-development of cost-optimized energy supply systems;
-use of locally produced equipment and other inputs for energy programme development.

For selecting appropriate ways of achieving the above goals two distinct types of information are used in national industrial energy planning:

1. Detailed technical information required by energy planners including engineers, geologists, economists, etc. to analyse and evaluate the technical and economical viability of alternatives;

2. Less technically oriented information required by the policy-makers, including:

- Energy requirements for economic and industrial development;
- Resources required to conduct and operate the perceived energy systems (local and foreign currency, labour, machinery and equipment, etc.,) energy alternatives and their impacts to the economy.

In order to answer this set of questions different types of formal and mental models should be used .

Basically, formal mathematical models are used in energy planning for energy demand forecasting, optimization of the energy supply system and other complex analyses, ie the testing and assessment of the effects of various measures and policies on the energy system itself or on the physical, social, industrial and general economic environment.

Independently of which category a formal model belongs to, there are a few simple conditions which should not be overlooked when selecting and using a model. They can be briefly summarized as follows:

- In general a model can only answer the questions for which it was originally designed.

- The results of any modeling efforts are no better than the quality of the input information.

- The model is nothing more than a tool, a set of calculations.

- No single model can provide all necessary answers; a set of analytical tools is necessary.

- The skill of the interpreter is the most significant item in the use of any model.

The current models used for long term energy demand forecasting are based on the assumption that :

-the energy demand growth, in the long term, can not be considered as deterministic but rather as flexible and can be influenced by energy policy tools.Thus, energy demand management became an important component in energy planning.

-the complexity of the relationships between economic development and energy demand evolution cannot be hidden in aggregated formalized relations used by some econometric models; a very detailed analysis of the mechanisms of formation and evaluation of energy demand is required before trying to formalize in any model the evolution of this demand

Based on the above provisions, the family of MEDEE models (Model for Energy Demand Evaluation) e.g. MEDEE2, MEDEE3, MEDEE-S , etc., use two methodological setups: (1) systems analysis applied to the socio-economic system driving energy demands and (2) the scenario approach used for the description of the possible evolutions of this system. Three major steps are carried out in the model construction:

1) Disagregation of the major determinants of the energy demand in a set of "modules" which are homogeneous regarding :

-the social need or the economic activity from which energy demand evolves,

-the economic function and the behaviour of the end-users of energy,

-the physical and technological context.

2) Analysis of the mechanisms of evolution of energy demand within each module, i.e. identification of the factors which explain the evolution of the three groups of variables determining the energy demand (needs or activities, technological characterisitcs, equipment) and identification of the relationships linking these factors.

3) Construction of a simulation model by formalization of the relationships identified for each module and by the linkage of the modules on the base of the structure identified in the first step.

As seen from the above, the approach allows for considerable freedom in chosing the determinants of the energy demand eg number of modules, level of disagregation of energy demands, and indicators used for the determinants eg. value added, physical output, etc..

In the African context it seems that this freedom should be used in constructing a model that is taking into account the regional and national, specifics, e.g. different consumption patterns of the rural and urban population, energy requirements of the modern industrial sector, the specific regional consumption habits of the artisants and rural enterprises, the predominance of fuelwood and charcoal in the countries' energy balances, etc. Another constraint to the use of the existing MEDEE models is the paucity of data in some African countries.

1) As a result MEDEE-S, or MEDEE 3 cannot di[illegible] be applied to most African countries and the adapted model should be [illegible]oped in a way suitable for the use of small computer.

2) The elaboration of standardized reference energy balances for accounting the energy flows through the industrial and other sectors is a pre-condition for demand projections.

Another methodology for energy demand analysis , based on the end-use approach, is the LEAP model developed by the Beijer Institute in Sweeden (Ref. 82). This model and the assosiated with it energy flows bata base is being implemented at present in several sub-Saharan countries.

Energy demand projections have to be checked with the constraints of the existing energy system and the rest of the national economy to find the best options for meeting the adequate supply. From the large number of models available for supply analysis, a few are briefly commented on, the selection criterion being their applicability for African countries.

The MARKAL energy supply model (MARKAL: an acronym for market allocation), is a multi-period linear programming model which has been developed and applied by 15 OECD countries for the purpose of energy technology research and development planning.

MARKAL is written in a flexible form which allows for the representation of very different energy systems. When the model features available in the cureent version are adjudged to be insufficient for an appropriate description of the system analysed, the model can easilly be enlarged by new model features. Thus, the current structure of the model is a product of an initial systematic approach enriched by experience gained in a number of projects in industrialized as well as in developing countries.

The basic input data are structured in a series of classes and tables which contain quantitative information about energy carriers and technologies. For each technology and energy carrier one table is used to describe their technical, economic, environmental and time parameters.

The ESPM (Energy Supply Planning Model) provides a systematic means of calculating, for any candidate energy development strategy, the total direct resources (capital, labor, materials, local and imported equipment, land, water and energy) required to build and operate the energy-related supply facilities needed for the strategy. The results of the model can be used to analyse the economic and other related impacts of energy strategies. By virtue of the extend of details in its results, the ESPM can help identify labour, materials, and equipment categories for which shortages may occur unless remedial actions are taken. These results can be used to investigate their impacts on specific sectors of the economy in order to determine manufacturing capacity and labour force expansion needs.

The WASP (Wien Automatic System Planning) model is an example of a supply model constructed for the purposes of the electricity system expansion planning. The WASP is using dynamic programming techniques for economic optimization of the expansion planning. It is structured in a flexible, modular system which can deal with the following interconnected parameters in an evaluation: load forecast characteristics (electric energy forecast, power generation system development); power plant operating and fuel costs; power plants capital costs; power plant technical parameters; power supply reliability criteria; and power system generating practices.

5. Conclusions and recommendations

The information survey was intended to identify the directions of a more detailed study aimed at developing:

- priority areas for UNIDO's technical assistance programme on energy and industrialization within the framework of IDDA;
- specific guidance to African Governments to establish a long-term energy-industry development policy, and
- possible areas of a closer co-operation between UNIDO and international, regional and national organizations.

The information collected in the survey for a proposed study of the present and future energy situation in Africa and its implications for the industrial development have identified the following general conclusions for the proposed study :

1.There is a clear difference between the energy-related industrial situation of the sub-Saharan region and the rest of Africa. The specific constraints and difficult socio-economic situation of sub-Saharan Africa justify the concentration of the present study on this region.

2.Real improvements in the stringent socio-economic, industrial and energy situation of this region can only be achieved by comprehensive actions of the countries concerned and by well co-ordinated assistance of all relevant regional and international organizations and industrialized countries.

3.The present problems cannot be solved by individual actions or isolated assistance programmes only. An integrated long-term strategy for socio-economic and industrial development is required in order to activate the enormous demand on human, phisical and financial requirements.

4.Specific emphasis must be given to the development of the rural areas, representing 75 % of the population, as the starting point for development.

5.The development of the small-scale and rural industries is of specific importance for sub-Saharan Africa. Their production process presently rely mainly on human and traditional energy. The introduction of mechanized technologies, being an importante step towards increased productivity, requires commercial forms of final energy especially electricity.

6.The low level of electrification is one of the major inhibitors of the industrialization process.

7. Any proposed development strategy for the industry and energy sector must be consistent with the global development trends..

The directions of the proposed study should be in accordance with UNIDO IV, underlining inter alia "the need to strengthen the methodologies for developing and implementing energy-industry policies in developing countries and to develop mechanisms for sharing experience of development, industrial and energy policies." It should take into account the recommendations of the Seventh Meeting of African Ministers of Industry in Addis Ababa in 1984 stressing that "UNIDO should provide assistance in the preparation of a detailed study of the energy requirements for the industrial projects proposed in the programme for the IDDA". Finally, it should contribute to the Lagos Plan of Action for the Economic Development which identified as a main item related to the energy problem "the lack of a national energy policy in most African countries and of short-, medium- and long-term energy development programmes".

Consequently the survey identified the clear need for long-term integrated industry and energy policies, not only at the national but also sub-regional level in accordance with the socio-economic development goals and strategies.

The major problem for the development of long-term policies is the lack of reliable and accurate statistical data of the energy-related industrial sector including traditional energy. The data presented in the present survey therefore can only provide the general trends and directions of a more detailed study, as the statistical data collected and disseminated by international and national organizations not only differ by an order of magnitude but also partly disregard the industrial sector.

A more detailed study should mainly rely on direct contacts with national and regional organizations to assure the provision of reliable input data especially of the industrial sector.

More comprehensive input data are also required for the development of a common methodological framework including normalized energy balances, modelling tools, etc.. At present most of the available methodologies and tools are not or are only partly applicable to the specific situation of the sub-Saharan region. The reasons are that they have been developed for industrialized countries and their high development stage and they are not able to take into account the predominance of traditional energy, mainly firewood, representing around 80 % of the energy balance in the sub-Saharan region.

The final step should include a number of case studies in selected countries with different development stages. Such case studies should not only verify the data sets and the adapted methodologies but should help to initiate indepth decision oriented planning activities at the national level.

The training of the national team, actively contributing to the study, must be an integral part of the co-operative programme.

Case studies should identify in particular the necessary parameters and requirements for a long-term energy-industry policy, e.g.:

- measures to be taken for improved utilization of indigenous energy resources, including new and renewable;
- analysis of a possible diversification of energy supply;
- optimization of electricity supply systems for rural and urban areas;

- institutional measures for a harmonization of national and regional grids;
- identification of a programme for improved energy management and energy conservation in industrial sub-sectors and processes;
- development of the local manufacturing of energy equipment;
- a policy for concrete investment actions for a long-term development programme.

In summary based on the results of the survey presented the following proragmme is recommended:

1. Compilaton, review and presentation of statistical data indicating the socio-economic, industrial and energy-related status of the sub-Saharan countries, which should include the following main steps:

- development and distribution of a questionnaire for the collection of industry-related energy data;
- direct collection of data jointly with African national and regional organizations and authorities responsible for energy and industrial development;
- co-operation with international and regional organizations engaged in energy assessments and studies in Africa (ECA; UNDP-World Bank Energy Sector Management Assistance Programme; CEC programme on energy for development and other relevant institutions in industrialized countries);

- review of data and development of a normative energy balance with specific emphasis of the industrial sector (UNIDO in co-operation with other international, regional and national organizations).

2. The development of methodologies and tools for energy demand and supply analysis and projections with special attention to the industrial sector. Adaptation of existing models and methodologies would be preferred to new developments (possible partners for co-operation IIASA, national organization experienced in energy modelling, e.g. from Switzerland, Sweden, Fed. Rep. of Germany, Denmark, U.S.A., Canada, etc.).

3. A report on the present and future energy situation in Africa and its implication for industrial development.

4. Case studies in selected sub-Saharan countries with the purpose to verify data sets, methodologies and models, to develop long-term energy-industry policies and to identify priority areas for technical assistance projects. Such studies should be carried out in co-operation with organizations in industrialized countries, and should be financed by UNDP, IDDA and participating organizations.

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Table 1. Relation between energy, industry and economy in selected sub-Saharan countries (1981)

Country	Share of Industry (1) in total* energy consumption %	(2) in commercial energy consumption %	(3) in GNP %	Energy Intensity in Industry (4) Total* (1/3)	(5) Commercial (2/3)
Gabon	23.	39.	12.67	1.81	3.07
Ivory Coast	7.9	30.8	28.2	0.28	1.09
Kenya	6.9	19.2	25.75	0.27	0.74
Sudan	3.8	17.	13.	0.3	1.31
Tanzania	16.4	22.	13.	1.26	1.69
Togo	18.6	79.	15.5	1.2	5.1
Zaire	20.5	55.	11.2	1.83	4.9
Zambia	30.	60.	32.5	0.92	1.85
Zimbabwe	34.4	54.	47.06	0.73	1.15
Fed. Rep. of Germany		34.	36.		0.944
Egypt		35.	35.		1.0

Ref.: 1. UN SO, "Energy Balances and Electricty profiles 1982",(1985) issue
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* Total energy is the sum of commercial and traditional energy.

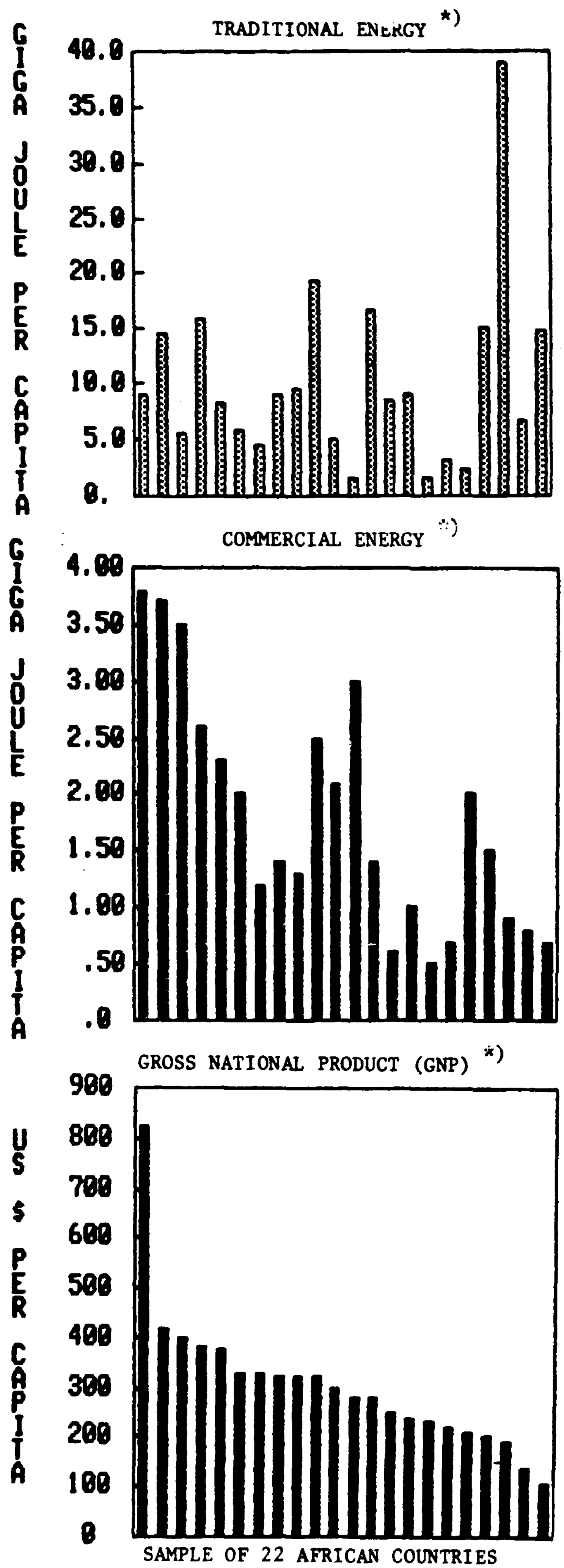


Figure 1. Relation between traditional and commercial energy consumption and economic development.

*) The three bar-charts are presenting individual countries in the same order.

Table 2. Estimates of total energy and electricity consumption per capita [units: energy(GJ) electricity (MW.h)]

Country group	1984 Energy	1984 Electric.	2000 Energy	2000 Electricity
North America	297.0	10.70	358.0 -389.0	14.90 -16.80
Western Europe	121.0	4.40	145.0 -160.0	6.00 - 6.70
Eastern Europe	179.0	4.70	229.0 -255.0	7.40 - 8.30
Industrialized Pasific	125.0	5.00	165.0 -185.0	7.70 - 8.20
Asia	19.0	0.30	22.0 - 28.0	0.60 - 0.80
Latin America	51.0	1.20	65.0 - 82.0	2.20 - 2.60
Africa and Middle East	30.0	0.60	35.0 - 43.0	0.90 - 1.10
Sub-Saharan Africa *)	16.4	0.14	20.0 - 25.0	0.50 - 0.90

Source: 1. IAEA, "Energy, electricity and nuclear power estimates for the period up to 2000", (1985 eddition)

*) our estimates

Table 3. Electricity production of sub-Saharan and selected industrialized countries in 1982

Country	Production of electric energy TWh(e)	Electricity production per capita kWh(e)	Share of industry in electricity consumption (%)
1 Zambia	10.1	1648.9	84.6
2 Nigeria	8.3	100.7	32
3 Ghana	4.7	377.4	13.5
4 Zaire	4.4	145.9	86
5 Zimbabwe	4.1	529.7	67
6 Ivory Coast	1.9	225.9	30.3
7 Cameroon	1.9	213.5	60.3
8 Kenya	1.8	101.1	53.1
9 Angola	1.7	223.0	..
10 Liberia	1.1	523.8	..
11 Sudan	1.0	51.8	56.4
12 Ethiopia	0.8	22.9	39.3
13 Tanzania	0.8	39.3	..
14 Uganda	0.7	47.1	..
15 Mozambique	0.6	57.4	..
16 Senegal	0.6	102.7	16
17 Gabon	0.5	1060.0	54.7
18 Botswana	0.5	547.8	6.7
19 Guinea	0.5	92.5	..
20 Malawi	0.4	70.5	66.9
21 Madagascar	0.4	46.7	47.4
22 Mauritius	0.4	466.7	32
23 Swaziland	0.3	853.0	72
24 Sierra Leone	0.2	62.2	..
25 Niger	0.2	32.7	48
26 Congo	0.2	111.0	..
27 Rwanda	0.2	30.8	61
28 Mali	0.1	15.1	36
29 Burkina Faso	0.1	15.3	..
30 Mauritania	0.1	58.8..	..
Subtotal	48.5		
All 43 countries	49.0	132.2	
1. Italy		33[illegible]6.	
2. France		4[illegible]0.	
3. Japan		4916.	
4. Austria		5144.	
5. F.R.Germany		6082.	

Sources:
1. UN SO "Energy Balances and Electricity Profiles 1982, New York 1985
2. OECD/IEA "Energy Balances of Developing Countries 1971/1982", Paris 1984

Figure 2. ENERGY RESOURCES OF INDEPENDENT AFRICA

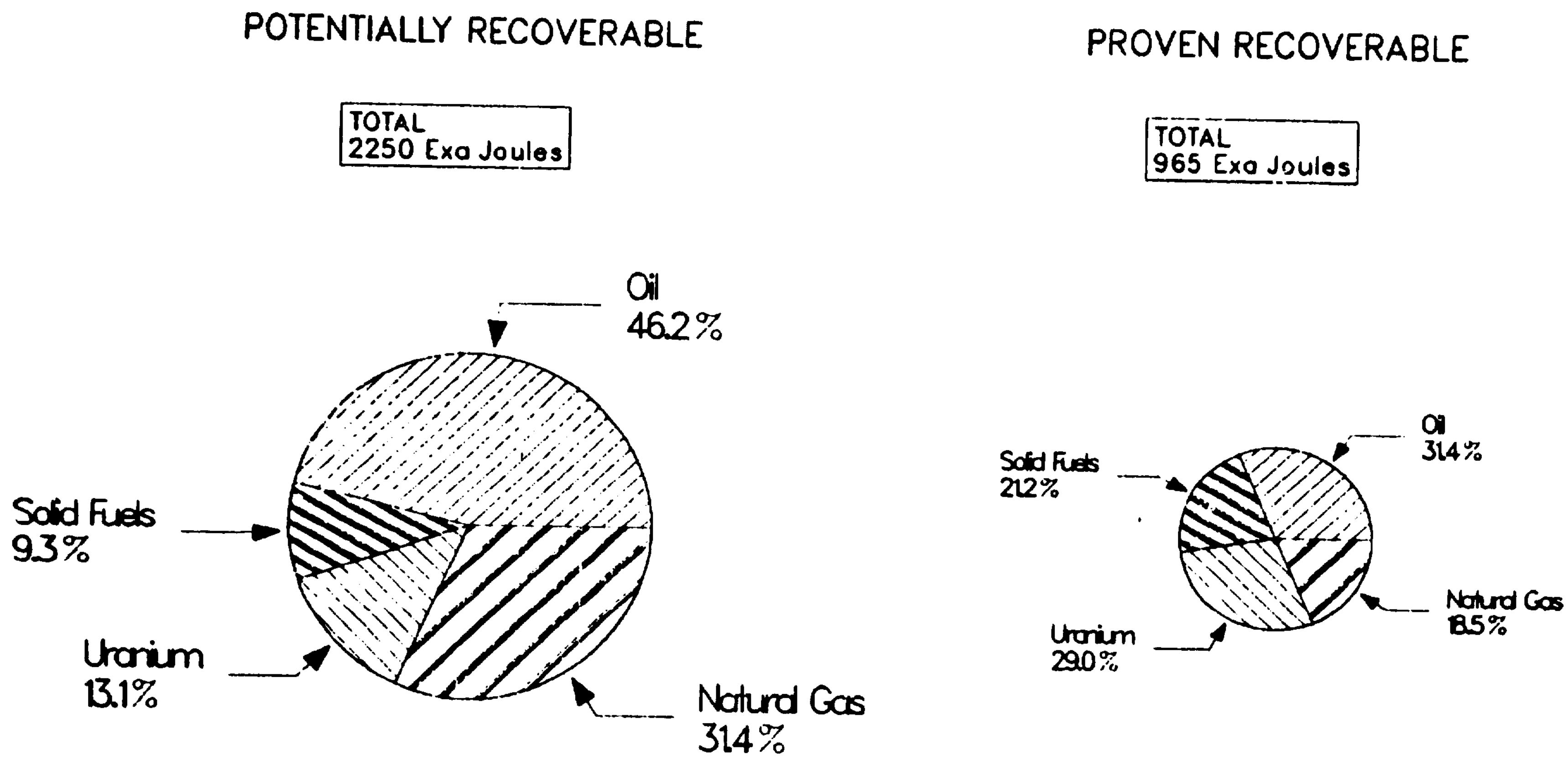


Figure 3. PROVEN RECOVERABLE ENERGY RESOURCES IN INDEPENDENT AFRICA

TOTAL 965 EXA JOULES

Black shaded slices refer to Sub-Saharan Africa
White slices refer to rest of independent Africa

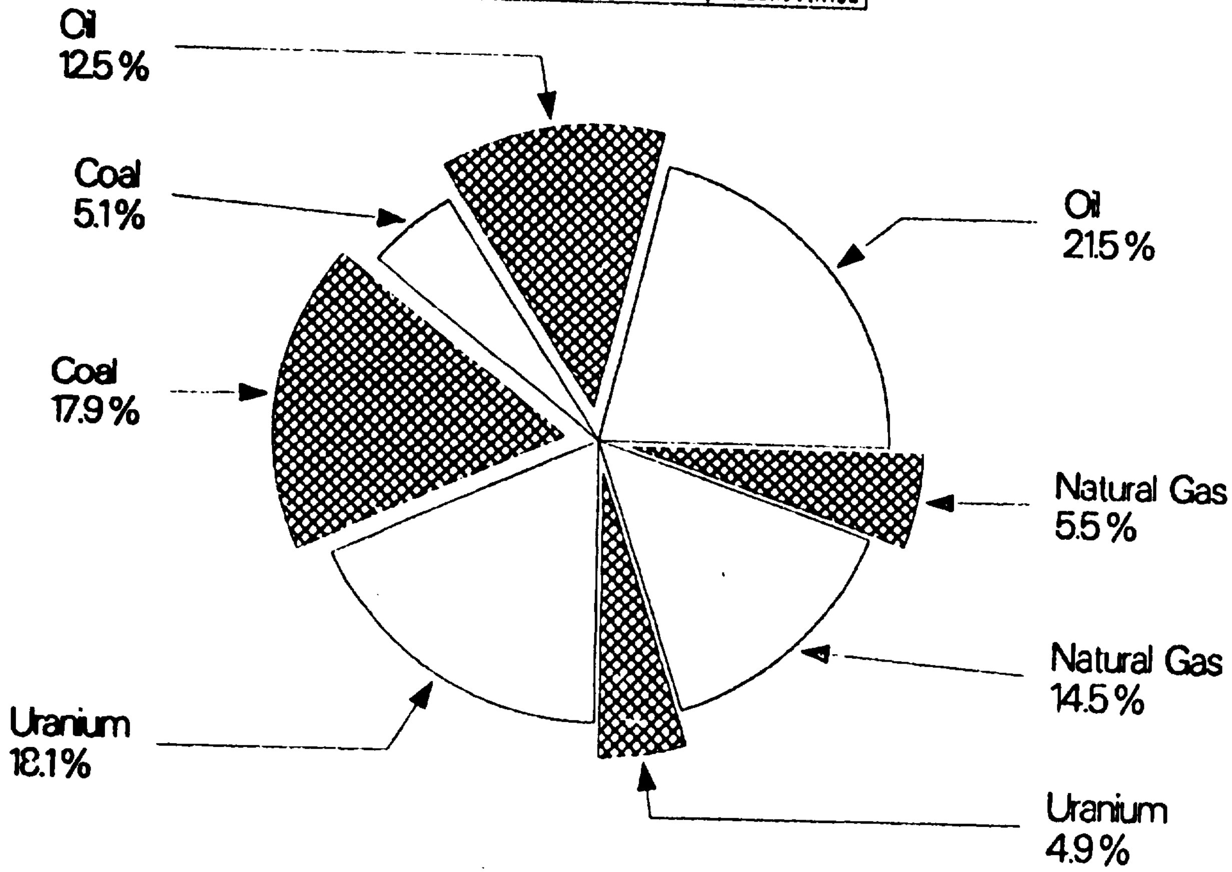


Table 4. Fuelwood Consumption Compared with the Mean Annual Increment of Tree Stocks in Selected Sub-Saharan Countries (1000 m3/year)

	Mean Annual[1] Increment of Tree Stock	Fuelwood[2] Consumption	Excess of Consumption Over New Supply	
Mauritania	97	963	866	893 %
Senegal - 1981	7,200	4,600	- 2,600 [3]	-36 %
- 2001	6,300	7,200	900	14 %
Niger - 1980	1,400	4,100	2,700	193 %
- 2000	1,000	7,200	6,200	620 %
Sahel - 1980	17,000	22,000	5,000	30 %
- 2000	15,000	34,000	19,000	127 %
N. Nigeria 1980	13,500	23,300	9,800	73 %
Ethiopia -1982	13,600	34,000	20,400	150 %
Sudan - 1980	44,400	75,800	31,400	71 %

Source: Energy Assessment Studies in the respective countries, and the seminar notes of Jean Gorse of the Sahel, attached to a memorandum dates May 16, 1983.

Notes:

[1] Projections based on current trends.

[2] Included wood used for charcoal production (except Nigeria).

[3] A surplus

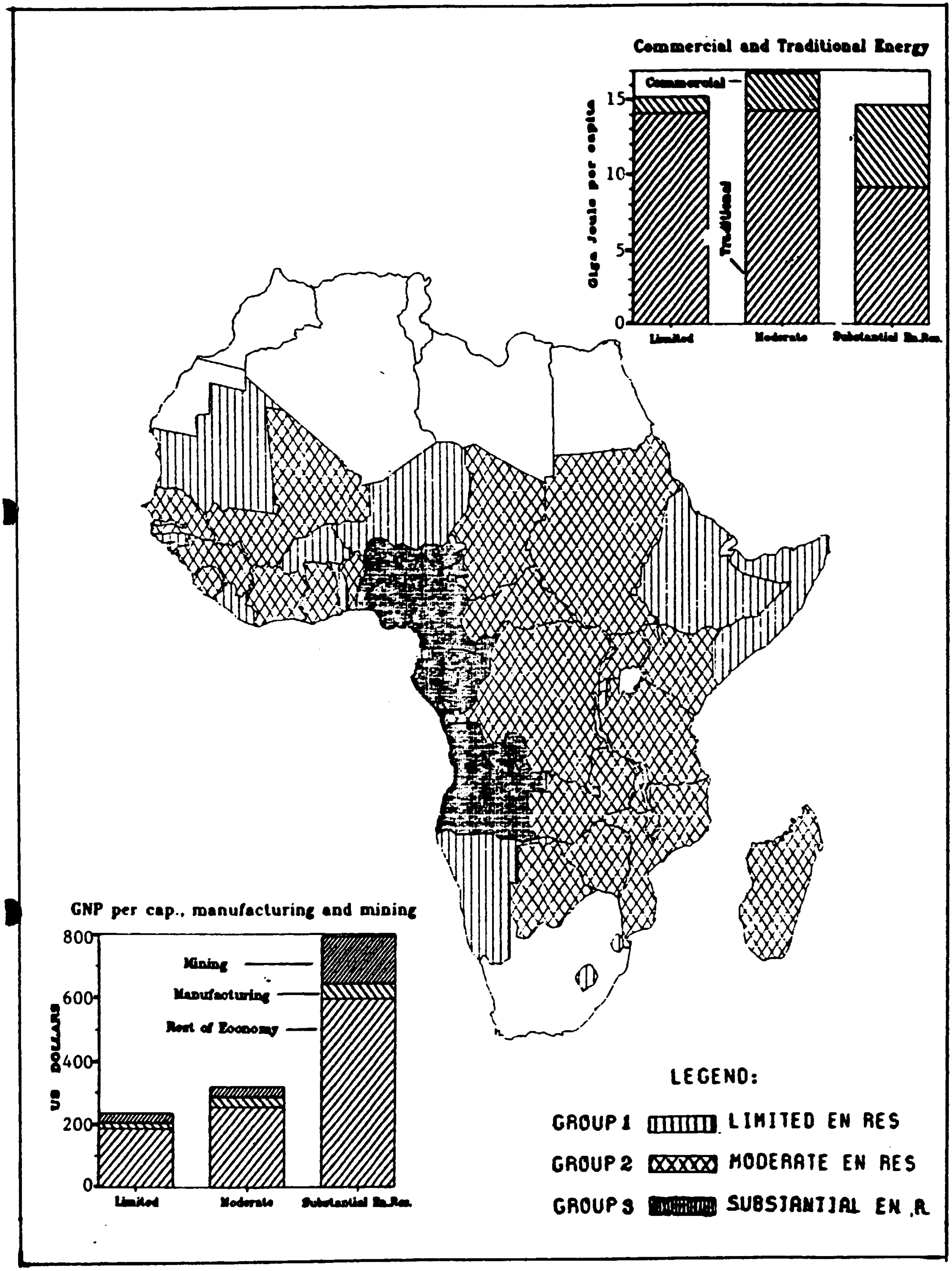


Figure 4. Grouping of Sub-Saharan Countries in Accordance with their Energy Resource Endowment

Table 5. Projections for selected energy intensive products up to 2008 under the "Low" and "High" scenario of UN ECA

	1978	"Low" Scenario	"High" Scenario
		2008	2008
A. Fertilizers (thousand tons)			
Total consumption	2,278.0	7,880.0	21,490.0
Total production	1,422.0	4,980.0	21,490.0
Imports	856.0	2,900.0	0.0
B. Cement (million tons)			
Total consumption	28.0	130.0	264.0
Total production	23.0	114.0	264.0
Imports	n.a.	16.0	0.0
C. Iron and Steel (million tons)			
Total consumption	13.4	97.0	195.0
Total production	6.5	39.8	61.0
Imports	n.a.	57.2	134.0
D. Textiles (million tons)			
Total consumption	0.8	3.4	5.1
Total production	0.3	2.5	4.1
Imports	n.a.	0.9	1.0

Source: ECA and Africa's development 1983-2008
A preliminary perspective study, April 1983

Table 6. Projection for selected energy types in Africa up to 2008 under the "Low" and "High" scenario of UN ECA

	Africa 1978	sub Saharan Africa 1982	"Low" scenario 2008	"High" scenario 2008	Economically Recoverable Reserves
A. Crude oil (million tons)					
Total production	289.7	116.5	508.7	751.6	7,700.0
Exports (including stocks)	279.1		254.3	254.3	
Imports	50.1	92.8	282.3		
Domestic consumption	59.8	23.7	536.7	497.3	
B. Coal (million tons)					
Total consumption	6.8	4.5	10.1	24.2	
Total production	4.8	6.3	10.2	27.8	62,000.0
Net imports (exports)	2.0	(1.8)	(1.0)	(3.7)	
C. Natural gas (bill.cub.meters)					
Total consumption	6.4	1.2	40.7	67.3	
Total production	20.0	1.2	101.8	150.2	72,450.0
Net imports (exports)	(13.6)		(61.1)	(82.9)	
D. Electricity					
Installed cpacity (MWel)	19,121.0	15,140.0	128,000.0	169,941.0	
Thermal	8,298.0	5,105.0	32,300.0	25,491.0	
Hydroelectric	10,823.0	10,035.0	95,700.0	144,450.0	297,000.0
Total production (GWh)	69,985.0	48,900.0	604,104.0	1,019,639.0	
E. Traditional energy for sub-Saharan Africa [kilograms per capita]		1,430.0	1,430.0	1,100.0	
E. Per capita demand level					
Crude oil (kg/person)	131.6	64.8	537.9	498.6	
Electricity (kwh/person)	159.0	133.5	687.2	1,022.0	

Source: ECA and Africa's development 1983-2008
A preliminary perspective study , April 1983

Table 7

BASIC INFORMATION
REQUIRED FOR ENERGY-INDUSTRY STUDIES

I. Population

1. National statistics for the last decade
   a. Population, distribution in rural and urban areas
   b. Official population projections up to 2000
   c. Total labor force
   d. Labor force in industry
2. Regional distribution and population density

II. Economic Information from National Accounts

1. Gross Domestic Product (GDP) in constant prices;
2. GDP originating in Agriculture
3. GDP originating in Mining and Quarrying
4. GDP originating in Manufacturing
5. GDP originating in Construction
6. GDP originating in Electricity and Gas (Utilities);
7. GDP originating in Services
8. Exchange rates

III. Energy balance data

1. Househould energy consumption
2. Transport Energy consumption
3. Agriculture Energy consumption
4. Production of commercial and traditional energy
5. Energy import and exports
6. Efficiences of the energy transformation centers, e.g. refineries, conventional power plants, charcoal plants, losses, etc.

IV. Energy resources.

(Table 7 continues on next page)

(Table 7 continuation)

V. <u>Industry related information</u>

A. Basic data

1. Output of:

   a) Energy intensive products (compatible with 6 digits ISIC based code) in tones per year and/or value added, e.g.:

      - steel (steel ignots ISIC 371016, 371017);
      - non-ferrous metals (primary copper ISIC 3720041, primary aluminium ISIC 3720221, primary zink ISIC 3720431);
      - non-metalic mineral products (quicklime ISIC 369201, cement ISIC 369204)
      - pulp and paper products (pulp sulfite ISIC 341110, pulp sulfate ISIC 341113);
      - chemicals (amonia ISIC 351158, caustic soda ISIC 351159, calcium carbide ISIC 351173, methanol ISIC 351121, acetylene ISIC 351105, nitrogenous fertilizers ISIC 351201)
      - textiles;
      - food-processing;
      - others.

2. Growth rate indexes for the sectors and commodities as of above.
3. Sectorial consumption of final energy forms, e.g. coal, natural gas, residual oil, electricity, bagasse, etc. based on national statistics or surveys.

B. Additional indicators

1. Energy intensities of the produced commodities,expressed either as ratio of the total energy per ton of output (value added) or as ratio of liquid fuels, electricity, and solid fuels per ton output (value added).
3. Types of technologies used in the production of energy intensive commodities, e.g. iron, cement, etc.
4. Specific plans for new capacities in each industrial sector .
5. Structure of production and estimated output of the small and rural enterprises, their geographical distribution and the energy inputs used.

End of Table 7.

Table 8. Energy Consumption in Industry for Sub-Saharan Countries *

cc	Country	Bagasse	Electr.	NG	LPG	Light D	Heavy D	Coal	Other Energy Forms
24	Angola	4 (70)							
72	Botswana		4 (80)					4 (70)	
167	Congo	4 (70)							
120	Cameroon	4 (70)	4 (70)						
108	Burundi		4 (75)						
132	Cape Verde		4 (70)			4 (75)	4 (75)		
140	Centr.African Rep.		4 (80)						
148	Chad	4 (80)	4 (80)						
180	Zaire	4 (70)							
204	Benin		4 (70)				4 (80)		
226	Guinea					4 (80)			
230	Ethiopia	4 (70)							
266	Gabon	4 (80)	4 (80)	4 (80)	4 (80)		4 (80)		
288	Ghana	4 (75)	4 (80)			4 (75)	4 (80)		
324	Guinea	4 (80)	4 (80)						
384	Ivory Coast	4 (75)	1,3,4 (80)				4 (80)		
404	Kenya	4 (70)	4 (70)		4 (70)	4 (80)	4 (70)	4 (80)	4 Charcoal (82)
430	Liberia	4 (82)							
450	Madagascar	4 (70)	3,4 (70)						
454	Malawi	4 (70)	4 (70)				4 (80)	4 (70)	4 Fuel Wood (80)
466	Mali	4 (70)	4 (75)						
480	Mauritius	4 (75)	4 (75)		4 (80)				
508	Mozambique	4 (71)							
562	Niger		4 (80)			4 (80)	4 (80)		
624	Guinea Bissau		4 (80)						
646	Rwanda	4 (75)	4 (80)						
686	Senegal	4 (80)	4 (70)		4 (70)	4 (70)	4 (70)		
690	Seychelles		4 (70)			4 (70)			
694	Sierra Leone	4 (82)							
706	Somalia	4 (70)							
716	Zimbabwe	4 (70)	4 (70)			4 (80)	4 (80)	1,4(80)	1 Coke (80)
736	Sudan	4 (70)	4 (80)						
748	Swaziland	4 (70)	4 (80)					4 (80)	
768	Togo		4 (80)						
800	Uganda	4 (70)	4 (70)				4 (80)		
834	Tanzania	4 (70)							
894	Zambia	4 (70)	4 (80)		4 (80)	4 (80)		4 (80)	4 Coke (80)

Industrial sectors: 1 - Iron and Steel Industry
3 - Chemical Industry
4 - Industries not specified elsewhere

* Time series based on the UNSO "Energy Tape"; first digit in the column is the industry sector, in brackets the first year of available data.

Figure 5.

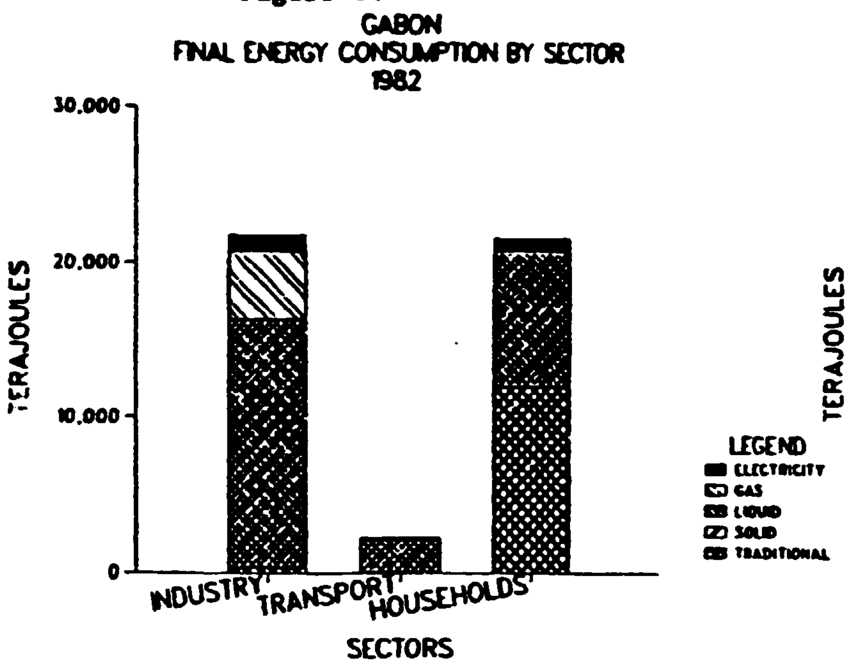


Figure 6.

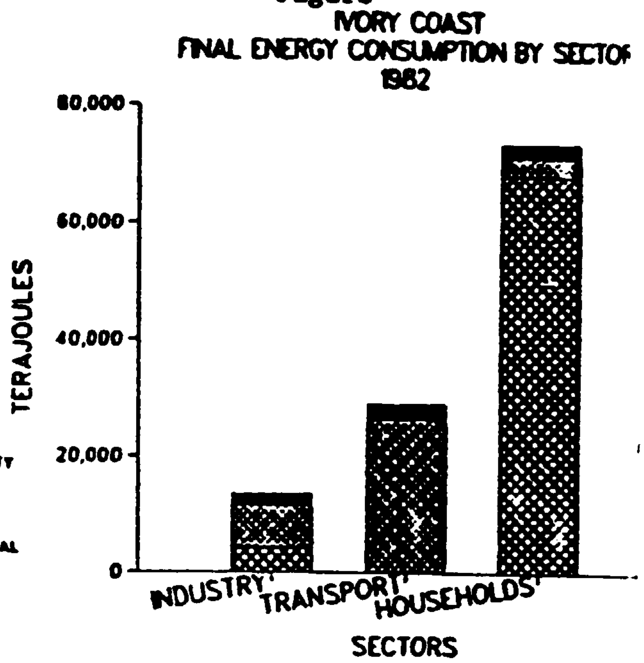


Figure 7.

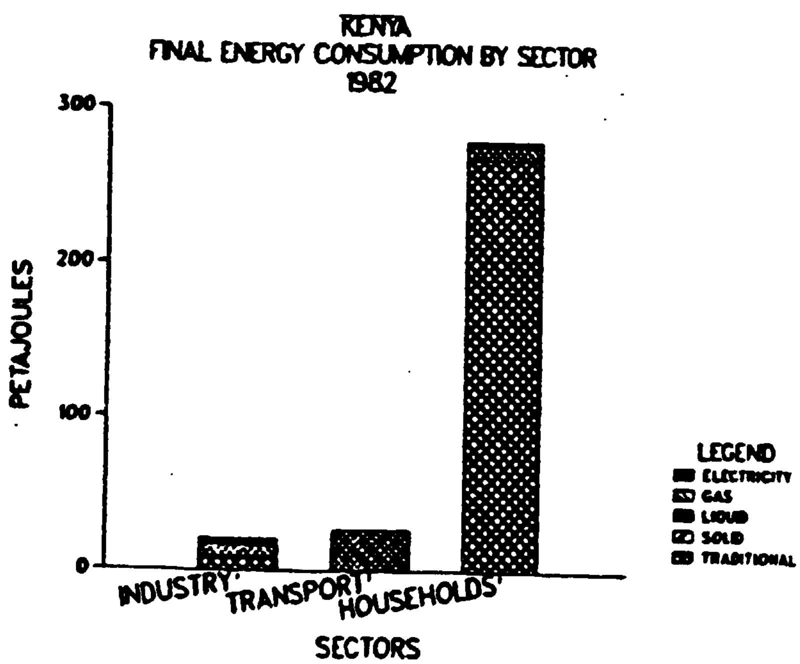


Figure 8.

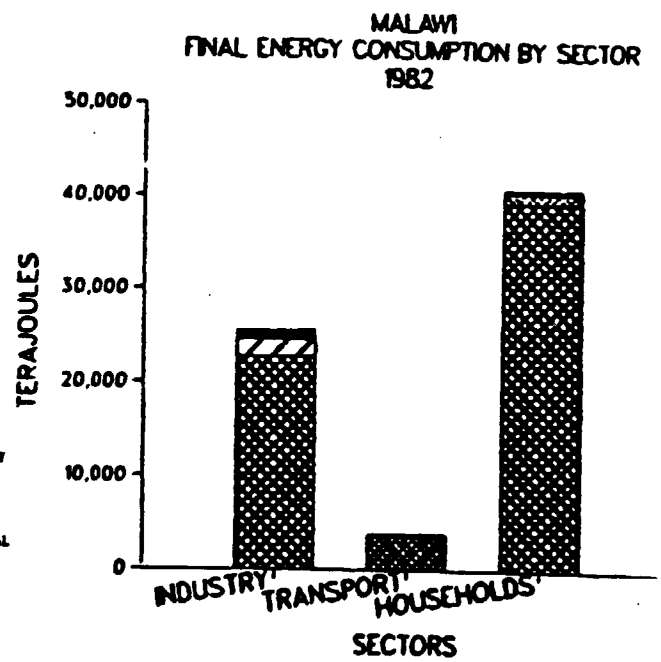


Figure 9.

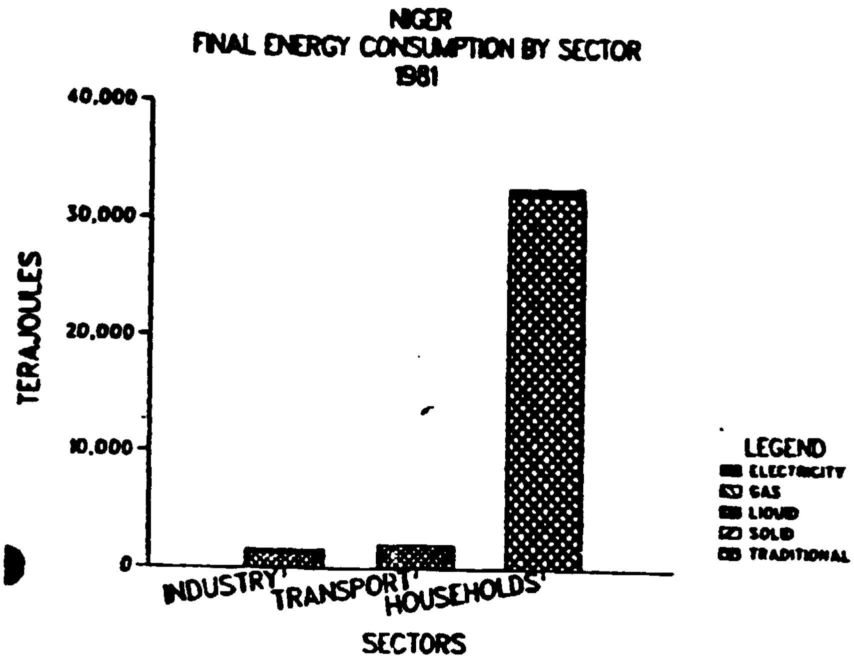


Figure 10.

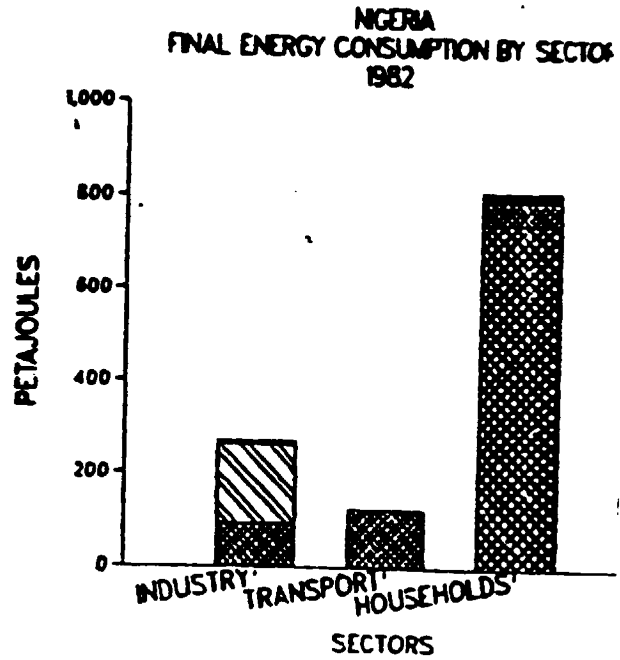


Figure 11.

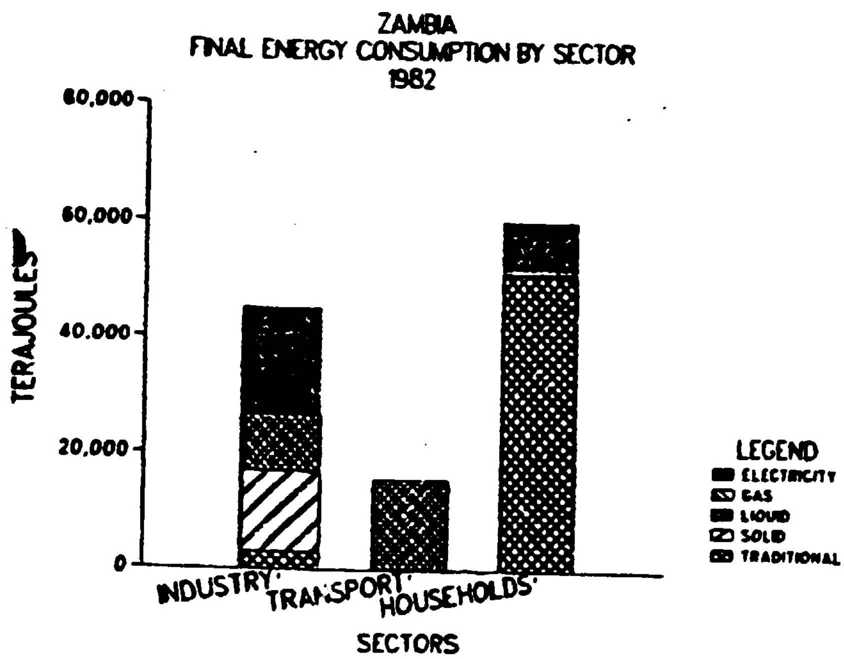
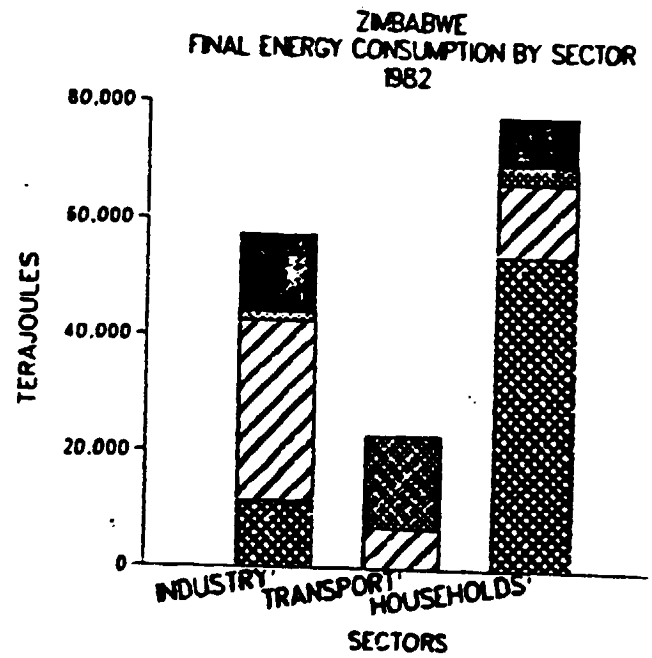


Figure 12.



ENERGY BALANCE SHEET

unit: terajoules — Country: Kenya — YEAR: 1982

Energy Flows	PRIMARY ENERGY: Petroleum	Coal	Hydro and Geotherm	FIREWOOD	TOTAL PRIMARY ENERGY	INTERMEDIATE ENERGY FORMS: Light Petrol. Products	Heavy Petrol. Products	LPG	Feedstok & Other Petr. Pr.	Briquets and cokes	ELECTRICITY	CHARCOAL	BAGASSE	TOTAL INTERMED. AND FINAL ENERGY
Production			17,938	301,000	318,938									0
Imports	92,173	938			93,111	1,970	12,074		1,056	26	764			15,890
Variations of stock					0	(5,486)	(5,925)							(11,411)
TOTAL SUPPLY	92,173	938	17,938	301,000	412,049	(3,516)	6,149	0	1,056	26	764	0	0	4,479
Exports					0	(11,512)	(25,371)	(46)	(675)					(37,604)
Non-utilized					0									0
DOMESTIC SUPPLY	92,173	938	17,938	301,000	412,049	(15,028)	(19,222)	(46)	381	26	764	0	0	(33,125)
TOTAL Transformations	(88,593)	0	(17,938)	(31,600)	(138,131)	30,485	45,552	911	2,062	0	6,844	6,300	8,208	100,362
Petroleum Refineries	(88,593)				(88,593)	30,485	50,220	911	2,062					83,678
NGL processing plants					0									0
Gasification Plants					0									0
Coking Plants					0									0
Hydro Power Plants			(17,938)		(17,938)						5,382			5,382
Thermal Power Plants					0		(4,668)				1,462			(3,206)
Charcoal Plants				(31,600)	(31,600)							6,300		6,300
Other Transformations					0								8,208	8,208
Losses					0						(1,388)			(1,388)
Adjustments					0	4	0	0	0	0	(6)	(3)	0	(5)
Final Consumption	3,580	938	0	269,400	273,918	15,457	26,330	865	2,443	26	6,220	6,300	8,208	339,767
Energy Sector	3,580				3,580									3,580
Household, Com, Publ				269,400	269,400	3,038	2,625	729			2,437	4,474		282,703
Agriculture					0	440	2,105							2,545
Transportation		293			293	11,410	11,751							23,454
Industrial Total		645			645	565	9,849	136	2,443	26	3,789	1,829	8,208	27,490
Cement & Build.Mat.					0	41	5,872				510			6,423
Pulp & Paper					0	83	2,344				67			2,494
Chemiacls&Petrochem					0	195	730a		2,443		152			3,520
Textiles					0									0
Food-Processing					0	50	435				223			708
Sugar					0		62				36			98
Other Industries		645			645	196	406	136		26	2,801	1,829	8,208	14,247

SOURCES: 1.Energy Balances and Electricity Profiles 1982, UN, NY, 1985
2. Kenya: Issues and Options in the Energy Sector , UNDP/WB En
3.Industrial Energy Use and Prospects for Conservation and
FUel Substitution in Kenya,H.Mike Jones, Nayrobi, 1984

Table 9. Energy balance for Kenya in 1982

Table 10. SUB-SAHARAN AFRICA - ESTIMATED ENERGY RESERVES

COUNTRY	LIQUID PetaJ.	GAS PetaJ.	SOLID PROVED PetaJ.	URANIUM < $130/kg PetaJ.	TOTAL CONVENT PetaJ.	HYDRO THEORET. MW(e)
Angola	8420.0	1900.0	230.0		10550.0	10000.0
Botswana			102550.0		102550.0	
Burundi			4500.0		4500.0	18.0
Cameroon	2790.0	5110.0			7900.0	36000.0
Centr.Afr.Rep.				2600.0	2600.0	500.0
Congo	7550.0	2180.0			9730.0	
Ethiopia					0.0	59000.0
Gabon	2790.0	2310.0		2800.0	7900.0	
Ghana	12.6				12.6	
Ivory Coast	1800.0				1800.0	68000.0
Madagascar			2600.0		2600.0	
Malawi			350.0		350.0	2500.0
Mozambique			11000.0		11000.0	50000.0
Namibia				16900.0	16900.0	3000.0
Niger			250.0	23000.0	23250.0	
Nigeria	95890.0	40920.0	18700.0		155510.0	2230.0
Rwanda					0.0	360.0
Somalia				924.0	924.0	
Sudan	1160.0	90.0			1250.0	4626.0
Swaziland			53000.0		53000.0	53000.0
Tanzania		40.0	5860.0		5900.0	
Uganda					0.0	2000.0
Zaire	840.0	50.0	29300.0	263.0	30453.0	
Zambia			2700.0		2700.0	58000.0
Zimbabve			121500.0		121500.0	
TOTAL	121253	52600	352540	46487	572880	349234
natural units	Giga t.o.e.	Tera m3	Giga t.c.e.			
TOTAL	2846.3	1411.7	12032.1			

Table 11. Share of sub-Saharan Africa in the World production of selected energy intensive basic materials (%)

	1970	1973	1978	1980	1981
Zink, unwrought	2.5	2.77	1.68	1.44	1.71
Aluminum unwrought	1.75	1.68	1.11	1.56	1.64
Copper refined	13.4	[illegible]	10.98	10.77	10.19
Cement	0.81	0.[illegible]	0.99	0.77	0.74
Nitrogenous fertilizers	0.09	0.2	0.15	0.18	0.18
Quicklime	0.18	0.31	0.4	0.32	0.37
Acethylene	0.07	0.09	0.13	0.18	0.24

COUNTRY — Commodity / ISIC code	Cotton yarn 321109	Cotton fabric 321120	Acetilene 351105	Nitrogenous fertiliser 351201	Super phosphates 351204	Building bricks 369101	Cement 369204	Soap 352301	Crude steel ignots 371019
Angola							yes		yes
Benin							part.		
Burundi							yes	yes	
Cameroon			part.	part	part.		yes	yes	
Cape Verde							yes		
Centr.Afr.Rep.		yes							
Chad		yes							
Congo			yes				yes	yes	
Eq.Guinea									
Ethiopia	yes	yes			yes		yes	yes	
Gabon			part.				yes	yes	
Gambia							yes		
Ghana		yes						yes	
Guinea									
Guinea Bissau									
Ivory Coast	part.	part.	part.	yes	yes	part	yes	part	
Kenya	yes	yes				yes	yes	yes	
Liberia							yes	part.	
Madagascar		yes	part.				yes	yes	
Malawi							yes		
Mali							yes	part.	
Mauritius				yes					
Mozambique			part.	yes	yes		yes	part.	
Namibia									
Niger		yes				yes	yes	yes	
Nigeria	part.	part.			yes		yes	part.	yes
Rwanda								part.	
Senegal	yes	yes	yes	yes	yes		yes	yes	
Seychelles								part.	
Sierra Leone									
Sudan							yes	part.	
Swaziland		part.							
Tanzania		yes		yes			yes	part	
Togo		part.				yes	yes		
Uganda		yes			yes		yes	yes	yes
Upper Volta	yes					yes		yes	
Zaire		yes	part.				yes	part.	
Zambia		yes	yes	yes			yes	yes	
Zimbabwe				yes	yes	yes	yes		yes

Source: UN Yearbook of Industrial Statistics 1981 Edition

Table 12. UN-Reporting practice for the energy intensive products
yes - uninterrupted time series
part.- interrupted time series

Table 13. Rotary kilns in service in African countries at end 1978

Country	Process	Fuels			Process	Fuels			Process	Fuels			Note
	Dry	Oil	Coal	Gas	Semi-dry	Oil	Coal	Gas	Wet	Oil	Coal	Gas	
Algeria	10			x	-				5			x	2 DPK[a/] burning gas were planned for 1983 and 1984
Angola	-				-				4	x			
Benin	-				-				-*				* One DPK was under construction
Cameroon	1	x			-				-				One DPK was planned to be added
Congo	1	x			-				-				
Egypt	-				3	x			18	x		x	(a) Some of the wet kilns were planned to be converted to dry process; (b) two DPK were under construction
Ethiopia	2	x			1	x			-				
Gabon	-				-				1				No information regarding fuel use
Kenya	2	x			-				2	x			6 vertical kilns using coal were in operation
Libya	9	x			-				-				One dry process kiln in 1983
Madagascar	-				-				1		x		It has been decided to build two vertical kilns in 1979 to be increased by a third kiln
Malawi	1		x		1		x		-				
Mali	-				1				-				(a) No information regarding fuel use; (b) one DPK was planned for construction for 1983

a/ DPK = Dry process kiln.

Table 13. Rotary kilns in service in African countries at end 1978 (cont'd)

Country	Process	Fuels			Process	Fuels			Process	Fuels			Note
	Dry	Oil	Coal	Gas	Semi-dry	Oil	Coal	Gas	Wet	Oil	Coal	Gas	
Morocco	1	x			4	x			8	x			5 DPK were planned to be constructed during 1979/83
Mozambique	1		x		1		x		1		x		
Niger	1	x			-				-				
Nigeria	4	x			-				8	x	x		(a) Two rotary semi-wet kilns were in operation; (b) four DPK were under construction
Senegal	3	x			-				-				
Sudan	3	x			-				-				One DPK was under construction
Tanzania	2	x			-								Four DPK were under construction
Togo	2*	x			-								* Refers to 1979
Tunisia	4	x		x	-				3	x			One DPK was under construction
Uganda	4	x			-				-				
Zaire	3	x			1	x			3	x	x		
Zambia	2		x		-				3		x		
Zimbabwe	1		x		3		x		-				