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ENERGY RESOURCES IN AFRICA

I. Introduction

1. Among natural resources, energy resources play a fundamental role in the economic and social development of human societies. Any progress is reflected in a regular and often substantial increase in energy consumption.

2. In Western civilizations and elsewhere, energy is increasingly related to power and is considered a dynamic determinant of economic growth. Nowadays it is energy that dictates the rate of growth and economic development because it almost always determines the rate of development of all the other sectors of the economy.

3. In many international statistics, national revenue indicators and energy consumption indicators are correlated. It would of course be wrong to think that energy consumption engenders national income, but there is some relationship between the two. This relationship becomes stronger among all the productive activities in a country as of the time when agriculture ceases to be based exclusively on food crops and crops are export-oriented requiring processing, even at the industrial level, and when local industries begin at least partially to serve domestic markets, trade expands and adequate administrative machinery is built up.

4. It should however be stressed that to increase national revenue, many inputs and their accessories are required and they all consume energy: power facilities, raw materials for transformation, industrial products, transport and other facilities of all kinds as well as luxury items.

5. Frequently, defects in the production and supply systems and the simple lack of adequate energy considerably impede or even paralyse the operations of the productive machinery of a country. Energy is thus essential in public life and the reason for its being a State monopoly can be found in the often disproportionate burden caused by the shortage of resources or irregularity of supply.

6. Without being the only factor in economic and social development, energy is an indispensable element because, by taking advantage of available energy resources, a country can strive effectively towards the creation of an economic climate conducive to industrial development.

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7. There is no question that Africa has immense energy resources which could provide a support for its development for a fairly long time to come. It has combustible solids, hydrocarbons, hydro-electricity, non-conventional forms of energy such as fissile minerals, solar energy, geothermal energy, marine thermal energy, wind power, vegetable fuels, etc. In the following pages an attempt will be made to evaluate the magnitude, distribution and use made of them at present. It would appear in the light of available data that the continent's primary energy resources are fairly great but badly distributed and hardly used.

8. It is the development and rational exploitation of such resources rather than their abundance, which marks the level of development of a country, a region or a continent. Economic development consists above all in the capacity to consume energy productively, not in possessing or producing it even in large quantities.

9. After taking an inventory of local energy resources and determining future requirements, the next problem is to meet those needs in the best possible way. Therefore an optimal capital equipment plan has to be drawn up for phased implementation. For countries which have few exploitable energy resources, sound co-operation with better endowed neighbouring countries offers the best hope.

10. Without prejudging the difficulties African countries will face in establishing all the infrastructure needed to develop their resources, attention should be devoted as a matter or priority to the fact that, in the field of energy as moreover in many other sectors of the economy, the initial quantitative approach of production at any price is out of date nowadays. Africa has come to the economic stage of choosing among the various sources of energy that compete at the international and intercontinental levels.

11. It should also be pointed out that, whereas Africa's energy potential is immense, if improperly known, and its development offers considerable possibilities, development requires major investments. Development will therefore be heavily penalized in a period of almost galloping world inflation characterized by monetary instability, recession and a constant increase in interest rates.

12. If it is to cope with the world energy crisis which could provoke an international economic crisis with unpredictable consequences, Africa must mobilize its known energy resources for development. It will still need considerable capital, highly-skilled manpower and, above all, regional agreements and effective co-operation among its member States.

II. Commercial sources of primary energy in Africa

13. Active steps are being taken to compile an inventory of primary energy resources on the African continent. Prospecting is on the rise even in areas which were hitherto considered of no economic or strategic interest. In its initial phases, the search was facilitated by profound structural changes in the world energy industry which called for the diversification of sources of supply together with lower costs and greater output to cope with the ever growing consumption of the developed countries. More recent activities seem to be geared rather to a desire for more advanced planning because, whatever its timespan and modalities, to plan long-term energy needs and how to meet them is one of the basic preoccupations of developing African countries whose permanent sovereignty over their natural resources and economic activities has just been recognized.

14. Although the inventory is not yet complete, the most pessimistic estimates would indicate that Africa contains a relative large share of the world's energy sources which come onto the international market and a more than negligeable amount of the so called non-traditional forms of energy. Apart from Africa's solid fuels, hydrocarbons, fissile metals and hydroelectricity, there are also important deposits of bituminous schists, sands and limestone as well as good possibilities for solar energy, wind power and geothermal energy, marine thermal energy and ligneous fuel.

15. An analysis reveals that, although some of the possibilities are still ill known or inadequately evaluated, the African continent has a relatively good supply of primary sources of energy and that its future development can be based on those resources, be they coal, crude, natural gas, uranium and thorium, and above all on its hydroelectric potential. These resources have not yet been adequately exploited. It is not however beyond the bounds of possibility that the world energy crisis which started in October 1973 will speed up their use both for the economic development of the countries of the continent and for meeting the needs of other parts of the world which are energy hungry.

16. The resources should also be viewed in the light of world energy reserves and production and Africa's share therein should be assessed together with its share in production and consumption and what may reasonably be considered the prospects for the African economy and the role it should play in international co-operation in the field of energy.

17. A brief analysis reveals that Africa produced 34 million tons of coal equivalent in 1950, 65 million in 1960, 497 million in 1970 and 516 million in 1973. In terms of world energy production, these figures represent 1.28 per cent, 1.45 per cent, 6.72 and 6.08 per cent respectively of all the primary energy produced throughout the world. The growth rate was relatively high until 1970 but the drop in 1973 seems to be the result of the fall off in crude production in the Libyan Arab Republic and the low growth rate of coal production in southern Africa.

18. The following figures show the relative share of each form of primary energy in the total amount produced on the continent. In 1950 coal accounted for almost 88 per cent and crude for 12 per cent; in 1960 the figure for coal was 66 per cent, that for crude 12 per cent and that for hydroelectric power and natural gas around 3 per cent. In 1970, coal accounted for 12 per cent, crude for 86.5 per cent, natural gas for 0.9 per cent hydroelectricity for 0.6 per cent. In 1973, the figures were 13 per cent for coal, 82 per cent for crude, 4 per cent for natural gas and about 1 per cent for water-based energy.

19. On the other hand, the consumption of primary energy in Africa in 1973 was 140 million tons of coal equivalent or only 27 per cent of the total produced in Africa and 5.6 per cent of total world production. <u>Per capita</u> consumption was only 19 per cent of the world average. Coal accounted for some 48 per cent of the total amount of energy consumed in Africa in 1973, crude for 40 per cent, natural gas 10 per cent and hydroelectricity 2 per cent.

20. These figures show that all in all Africa exports 80 per cent of the energy it produces and, despite its relative wealth, still imports 13 per cent of what it needs. This anomaly will be analysed in the sections following the inventory of the continent's energy resources.

Coal and lignites

21. Africa's coal reserves are now estimated at 88.5 billion recoverable tons. The main coal deposits are located, in the north of the continent, in the Sahara basins and the northern edge of the African platform and, in the south and south-east, in the Karrao deposits which easily take first place with reserves estimated at 72 billion tons in the Republic of South Africa alone and almost 7 billion tons in Southern Rhodesia, or 95 per cent of Africa's known evaluated coal reserves.

22. Coal production in African countries rose from 43 million tons in 1960 to 54 million in 1965, 60 million in 1970 and 68 million in 1973, representing an average annual growth rate of 1.7 per cent over 14 years compared to an average rate for the world as a whole of some 0.7 per cent where production increased from 2,191 million tons to 2.440 million tons between 1960 and 1973. During the last five years referred to, African production increased by 3.6 per cent per year while the growth rate for world production hardly reached 0.95 per cent. The world coal production growth rate seems to reflect a fairly long period of stagnation resulting from competition from petroleum products.

23. Although coal was the force behind economic and industrial development in the world in the last century, it has been losing ground regularly as a fuel over the last 50 years to hydrocarbons. From 76 per cent of the energy produced in the world in 1929, its share fell to around 70 per cent in 1937, 58 per cent in 1950, 55 per cent in 1955, 51 per cent in 1960, 43 per cent in 1965, 32 per cent in 1970 and less than 29 per cent in 1973. In terms of the total amount of energy produced in Africa coal accounted for around 93 per cent in 1955, 66 per cent in 1960, 25 per cent in 1965, 12 per cent in 1970 and 13 per cent in 1973.

24. Based on the 1973 production rates, Africa's coal reserves may be exploited for 1,301 years. African coal reserves are 172 times larger than Africa's total energy production, estimated at 516 million tons of coal equivalent. They represent 36 times world production and 37 times world consumption of coal in 1973 and almost 10 times the production and 11 times the consumption of energy in all the countries of the world during that year.

25. Compared to world coal production, Africa's share has increased regularly, rising from 1.03 per cent in 1929 to 1.22 per cent in 1937, 1.87 per cent in 1950, 1.96 per cent in 1960, 2.34 per cent in 1965, 2.5 per cent in 1970 and 2.79 per cent in 1973.

26. It is more difficult to establish Africa's share of world coal reserves. Estimates of world coal resources have varied considerably in the last 50 years because of conflicting evaluations. As an indication, various evaluations are given below:

(in billion tons)

1913 = Geological Congress of Toronto	7,400
1937 = Moscow Congress	5,200
1948 = World Energy Conference	6,000 - 6,500
1958 = Lardinois study (based on recoverable coal only)	2.400
1972 = United States Geological Survey	7,600
sum total of recoverable reserves by country, according to official statistics	2,900

Source: Industries et Travaux d'Outremer, No. 253, December 1974.

27. Taking the highest figure of 7,600 billion tons, Africa would have only 1.16 per cent of the world's reserves of coal. On the basis of the lowest estimate, (2,900 billion tons), Africa's share would be 3.05 per cent.

28. Coal was produced in the following African countries in 1973.

(in thousand tons)

South Africa 1/	=	62,352
Southern Rhodesia	=	3,060
Zambia	=	940
Morocco	=	565
Mozambique	=	394
Nigeria	=	327
Zaire	=	115
Algeria	=	15
United Republic of Tanzania	=	3
Total	=	67,771
In round figures	=	68,000

Source: United Nations, World Energy Supplies, Series J, No. 18 (1970-1973).

1/ Customs Union of Swaziland, Botswana, Lesotho and South Africa (including Namibia).

29. It is not inconceivable that, with the effects of the international energy crisis and the increase in the price of petroleum products, African countries will take a greater interest in their coal potential and rapidly increase their production. It is equally conceivable that in the future scientific and technological developments will make it possible to handle new sources of energy and industry may consider it a waste to burn coal instead of distilling it. Moreover, coal may again become the motive force of industrial development if it can be guaranteed to be competitive with other sources of energy. In view of the ever rising price of petroleum products, this hypothesis is becoming increasingly probable. The prospect of the world's resources of petroleum and natural gas being exhausted in 50 years or so also makes it a probability unless the exploitation of nuclear and solar energy becomes more economical.

30. The largest producer of coal on the African continent, the Republic of South Africa, is already turning towards carbo-chemical uses of some of its coal reserves whilst continuing to explore for other deposits. Several African countries have again embarked on exploratory activities and intend to intensify them.

31. In North Africa, the Abadla basin was being exploited only at one point: Kenedsa-Ksiksou, a soft bituminous coal deposit. Recent data have established that this deposit, in view of its magnitude, no doubt contains the major portion of the coal reserves of North Africa, with more than one billion tons. Another basin, the Mezarif basin, seems to be very interesting but only outcrops have been seen. In Egypt,

although no mention was made of any coal being produced in 1973, the Ayoun Moussa and Jebel Marega deposits discovered in the Sinai peninsula before the Israeli occupation, appear interesting. The anthracite reserves at Jerada in Morocco are now being worked to produce electricity at a power plant installed at the mine-head.

32. In West Africa, the Nigerian coal deposits are being worked again. They extend into the territory of the People's Republic of Benin but the conditions would not seem favourable. Coal deposits have also been revealed along the Air in the Niger some 30 kilometres north of Agadez. They will soon be exploited to supply electricity to the uranium mining installations in the area.

33. In Central Africa two groups of coal bearing basins have been identified in the Shaba province in Zaire: in the north, the Lukugu and Tanganyika basins and in the south the Luena and High Lualaba basins. Definite reserves in these basins are estimated at 180 million tons and probable reserves at 1 billion tons. The Luena coal can be made into coke but is apparently difficult to work because of a tendency to spontaneous combustion. Several possibilities are now being considered to increase the production of the deposits.

34. In East Africa, Zambia, which formerly received its supplies from the Wankie deposits in Southern Rhodesia, intensified the search for coal on its own territory after the latter's unilateral declaration of independence. It has discovered deposits at Ekandabwe and Senkindoba, the latter being of better quality. Production reached 940,000 tons in 1973. In Malawi, the reserves in the Liwingtonia, North Rukuru, Sumbu-Mkonbedzi and Chiromo basins have not yet been estimated but seem interesting.

35. In the southern part of Africa exploration is being conducted actively particularly in Namibia where rich deposits have been discovered in the Etosha Basin; in Mozambique where soundings have revealed two important layers of coal at Maotige a total of 13 metres thick with reserves of 100 million tons; in Swaziland where, after detailed exploration of the Mpaka, Mtendekwa and Maloma regions, production has increased appreciably; in South Africa, where new deposits have been discovered in the region of Aberden but little is known about the extent of the coal-bearing formations buried under deposits of upper Karrao which occupy the centre of the basin; in Lesotho and in Botswana where it is intended that a coal mine should be set up near the Southern Rhodesian railroad; and in Madagascar where the Sakoa deposit seems to be of some interest.

36. African reserves of lignite are estimated at a 100 million tons of which 75 million are in West Africa, mainly in Nigeria, and 35 million in East Africa, mainly in Madagascar. The presence of lignite and peat has been noted in many other African countries but the value of the deposits has not been estimated. Lignite production in Africa is still negligible. The peat reserves are not well known yet except in Rwanda where they are estimated at 2,226 million tons.

37. Bituminous schist deposits are located in the Zaire basin, in the northern part of the Republic of South Africa and in the Majunga region of Madagascar. Reserves are estimated at 15,023 million tons of oil content particularly in the north east part of the Zaire basin between the Lualaba and the Lomami. In that area the oil schist deposits are found in beds of some 10 metres thick which are almost horizontal. The potential of the area is estimated at 15 billion tons of oil.

Crude oil

38. Proven African reserves of petroleum were estimated in 1973 at 10,086 million tons or 11.2 per cent of the world's reserves which are estimated at 90,378 million tons. 1/ They represented 13,112 million tons of coal equivalent or 25.4 times the total amount of energy produced on the African continent and 1.5 times the amount produced in the world in 1973 which was estimated at 8,485 million tons of coal equivalent.

39. The deposits in the Sahara in North Africa are by far the most important with reserves estimated at 4,343 million tons in the Libyan Arab Republic and 1.6 billion in Algeria. Among the deposits in the Gulf of Benin those of Nigeria are the largest with 2,850 million tons. Other African deposits in Egypt, Tunisia, Morocco, Gabon, the Congo, Zaïre, Cabinda and Angola are provisionally estimated at 1,293 million tons.

40. The latest evaluation of world crude oil reserves submitted to the World Petroleum Congress in May 1975 by Mr. M.J.D. Moody of Mobil Oil gives the following:

(in million barrels)

	World	Africa	Percentage Africa
Total production up to 1973	297	16	5.4
Recuperable reserves (proven and potential) as of 1 January 1974	740	61	8.24
Undiscovered potential:			
On land	585	40	6.84
Off shore	378	46	12.17
Total definitive reserves	2 000	163	8.15
Reserves in billion tons	279.9	22.2	8.13

Source: The Petroleum Economist, June 1975, Vol. XLII, No. 6.

41. It may be deduced from these indications that there are still some 1,703 billion barrels to be exploited in the world as a whole or some 232.3 billion tons and 147 billion barrels in Africa or 20 billion tons, representing 8.63 per cent of the final figures. Although the estimates come from authoritative sources, they seem somewhat pessimistic as far as Africa is concerned compared to those of the secretariat of the Commission which indicate potential recuperable reserves of 31.6 billion tons or 11.6 per cent of total world reserves.

42. Petroleum production in Africa increased extremely rapidly during the 1960s. From some 13.8 million tons in 1960, it reached 107 million tons in 1965 and 292 million tons in 1970. For political and economic reasons production has declined slightly since then to around 286 million tons in 1973. The average annual growth rate of African crude production was 24.2 per cent over a 14 year period whereas the world rate during the same period was 8.1 per cent. In view of the remarkable growth in world production during this lengthy period the increase in Africa reveals the magnitude of the continent's take off in the field of petroleum.

1/ Europe Outremer, No. 526 - November 1973 (Reserves as of 1 January 1973).

43. The share of African petroleum in total world energy production is increasing from year to year. From 14.8 per cent of the total amount of energy produced in the world 1929, the crude petroleum produced in Africa reached 18.9 per cent in 1937, 25.3 per cent in 1950, 34.4 per cent in 1955, 35.9 per cent in 1960, 41.2 per cent in 1965, 46.7 per cent in 1970 and 49.7 per cent in 1973. Its share in the total amount of energy produced in Africa was 11.8 per cent in 1950, 30.8 per cent in 1960, 73 per cent in 1965, 86.7 per cent in 1970 and 82 per cent in 1973.

44. The most important event in the last 15 years was without doubt the discovery of plentiful petroleum reserves in Africa which was facilitated by several politico-economic factors. Indeed, it was in response for the nationalization of Iranian petroleum and to cope with the demands of the Middle East producing countries that the West, and in particular Europe, turned its attention to the African continent were geologists had estimated that there was at least 8 million km^2 of sedimentary basins which were likely to contain hydroearbons. Ever since, the diversification of sources of supply became a constant feature of the developed world's energy policy which was basically to reduce as far as possible the price of imported energy and to ensure that supplies were guaranteed.

45. Whereas in 1950 Egypt was the only important producer in the continent, since then Africa has become one of the most important centres of geophysical activity. One by one the major deposits in the Sahara have been discovered starting in 1956 with Algeria and then with the Libyan Arab Republic. Later came less important discoveries in Tunisia, Angola, Gabon, the Congo, the Gulf of Suez and El Alamine in Egypt following the major deposit in Nigeria. Names like Hassi-Messaoud, Edjeleh, Zaraitine, Ghanet and El-Gassi in Algeria, Zelten, Dahra, Sidra, Amal and Naforaz in the Libyan Arab Republic, Kokori, Afam, Ebutu, Oloibiri, Obagi and Ughelli in Nigeria, El Borna in Tunisia, Tobias in Angola, Pointe Clairette, Cap Lopez, Tchengué, Anguille and Gamba in Gabon, Pointe Indienne and Emeraude in the Congo, are hallmarks of the petroleum breakthrough in Africa.

46. Exploitation is continuing with greater intensity in the Mauritanian, Malian, Nigerian and Chad parts of the Sahel as well as along the Atlantic costline in the Gulf of Guinea in particular, in Zaire, South Africa and in East Africa, particularly Somalia and Ethiopia. Hopes are rising in Senegal were the maritime basin of Casamance contains reserves estimated at 100 million tons, in the Ivory Coast, in Ghana, in Benin, in the United Republic of Cameroon and in Zaïre which became a producer in 1975.

47. In 1973 the following countries accounted for Africa's crude production:

	(in millions of tons of crude)	
- Libyan Arab Republic	104 756	
- Nigeria	101 765	
- Algeria	49 632	
- Egypt	8 479	
- Angola	8 175	
- Gabon	7 598	
- Tunisia	3 878	
- The Congo	2 054	
- Morocco	42	
Total	286 379	- arounded up to 286 000

Source: United Nations "World Energy Supplies", Series, J. No. 18 (1970-1973).

48. The list shows that 58.2 per cent of the petroleum produced in Africa in 1973 came from the North African countries, 35.6 per cent from Nigeria and West Africa and 6.2 per cent from Central Africa. The countries of East and southern African have not yet started to produce. The threesome, the Libyan Arab Republic, Nigeria and Algeria, accounted for 89.4 per cent of total production and the first two of them for 72 per cent of production in 1973.

49. In 1973 African petroleum accounted for 10.3 per cent of the total produced in the world as against 0.1 per cent in 1937, 0.4 per cent in 1950, 1.31 per cent in 1960, 7.1 per cent in 1965 and 12.86 per cent in 1970. There was a slight drop in production between 1970 and 1973.

50. Taking 1973 production figures, world crude reserves will last for 32.5 years and African reserves for 35.2 years. If account is taken of the global proven and potential resources which still have to be exploited, the maximum duration of reserves is estimated at 84 years for the world as a whole and 70 years for Africa (110 years according to ECA estimates). On the same basis, Libyan reserves will last for 41 years, Nigerian reserves for 28 years and Algerian reserves for 32 years.

Natural gas

51. African reserves of natural gas were estimated at 5,500 billion m^3 at the beginning of 1973 2/ or 7,315 million tons of coal equivalent which represents 14 times the amount of energy produced in the continent and 0.86 per cent of world energy production in 1973. These reserves represented 10.3 per cent of world reserves estimated at 53,286 billion m3 in the same year.

52. Natural gas depostis are located in North Africa, primarily in Algeria, the Libyan Arab Republic, Egypt and Tunisia, in Nigeria in West Africa and in Gabon in Central Africa. Algeria had reserves estimated at 3,000 billion m^3 in 1973, Nigeria 1,132 billion m^3, the Libyan Arab Republic 778 billion m^3 and the other African countries taken together just 590 million m^3. Mention should also be made of the existence of methane gas in Lac Kivu with reserves estimated at 57 billion m^3. The Hassi R'Mel deposit in the Algerian Sahara is thought to contain more than one third of the current known reserves of natural gas in Africa. After North America, USSR and the Middle East, Africa has the fourth largest total reserves of natural gas in the world.

53. Despite the size of some of the natural gas reserves, production is still low in Africa. It was around 174 million m^3 in 1960, 1,967 million m^3 in 1965, 377 million m^3 in 1970 and 15,682 million m^3 in 1973. Also in 1973 Africa's share in the total amount of natural gas produced in the world was approximately 1.27 per cent approximately.

54. In 1973 the following were the main products of natural gas in Africa:

		(in million m^3)
- The Libyan Arab Republic	=	10 454
- Algeria	=	4 745
- Nigeria	=	190
- Tunisia	=	114

2/ Commité professionnel du pétrole, "Petrole 1973".

(in million m^3) (cont'd)

- Morocco	=	65
- Egypt	=	57
- Gabon	=	40
- The Congo	=	16
- Rwanda	=	1
Total	=	15 682

<u>Source</u>: <u>United Nations "World Energy Supplies"</u> Series J. No. 18 (1970-1973).

55. The average growth rate in the production of natural gas in Africa was 17 per cent per year between 1960 and 1973. In the same period, the annual world growth rate was around 7.1 per cent. The growth rate was thus relatively high.

56. The production of natural gas in Africa has been retarded above all by the lack of outlets. Until the Arzew liquefaction plant came into service in Algeria the gas associated with petroleum was flared at the mine head unless it could be used immediately locally. A small amount was used in the production of electricity in Algeria and in Nigeria in particular: 0.4 per cent of the amount produced in 1960, 0.9 per cent in 1961, 1.1 per cent in 1962 and 1963, 1.5 per cent in 1964, 2.9 per cent in 1965, 6.7 per cent in 1970, almost 13 per cent in 1971 and 22 per cent in 1972. The percentage seems to have been considerably greater since 1973.

57. There are at present excellent prospects for African natural gas, which could lead in the years to come to a substantial increase in production, especially in Algeria, the Libyan Arab Republic and Nigeria. In Gabon, natural gas has been used for several years, in small quantities, to supply the thermal station at Port-Gentil and in the terminal installations of Cap Lopez. The Congo previously planned to use its unexploited reserves of natural gas to produce the electricity required to operate the potash exploitation plant at Holle and to supply light industry in the Pointe-Noire area.

58. Natural gas liquefaction plants have expanded spectacularly in Algeria. Apart from the Arzew plant, which came on stream in 1964 and now has an annual capacity of 3 billion cubic metres, the new prospects offered by large-scale marketing of liquefied natural gas led to the construction of a second liquefaction plant at Skikda, which will be able to process 6 billion cubic metres of natural gas per year initially and, eventually, 12 billion. Similarly, a second natural gas liquefaction plant is planned at Arzew with a capacity of 10 billion cubic metres a year. A third plant with annual capacity of 10 billion cubic metres is planned in the medium term. All these installations are or will be supplied from the giant Hassi R'Mel deposit through a network of large-capacity gas pipelines.

59. In 1973 the Libyan Arab Republic was Africa's main producer of natural gas, with output of 10,454 million cubic metres, representing about 67 per cent of total natural gas production in the Continent. Accordingly, it plans large natural gas liquefaction plants, the first of which has been constructed at Brega. The Government's plans are for the largest liquefied gas installation in the world. No details are available concerning its present annual capacity or future extensions.

60. It appears that talks have recently been concluded for the supply of Nigerian natural gas to the United Kingdom. To date the principal users of natural gas in Nigeria have been the thermal stations, the oil refinery in the Port Harcourt area and a few industries located in the production areas of Afam and Apara, in the east of the country, and Ughelli in the west central areas. Important studies have been prepared on the use of Nigerian natural gas, and a liquefaction plant is located at Bonny.

61. On the subject of the availability of natural gas in Africa and throughout the world, it would seem useful to mention, for the record, a paper presented to the World Petroleum Congress, which was held in Tokyo in May 1975, by two specialists from the oil company BP, T.D. Adams and M.A. Kirkby. They estimated established reserves of natural gas at 2,296 trillion cubic feet for the countries of the world, excluding the communist countries of southern Asia and the Far East, and 175.1 trillion cubic feet for Africa. These estimates roughly correspond to 81,082 billion cubic metres for world reserves and 6,184 billion cubic metres for African reserves. Africa's share represents 7.6 per cent of the world total.

62. Several serious estimates have been made during the past decade, to the effect that confirmed world natural gas reserves are of the order of at least 10,000 trillion cubic feet, or about 353,144 billion cubic metres; but such suggestions imply an undiscovered potential of more than twice the total discoveries to date, and Adams and Kirkby found no evidence to support that assumption.

63. Estimated confirmed world natural gas reserves and their location may be illustrated as follows (in trillions of cubic feet): 3/

	Reserves	Percentage of total
United States	270.0	11.6
Canada	68.0	3.1
Western Europe	181.4	7.9
Middle East	728.3	31.7
Africa	175.1	7.6
Southern Asia, Far East a/	91.9	4.0
Australia	36.9	1.6
Latin America	58.2	2.6
USSR	632.0	27.5
Eastern Europe	24.2	1.1
China	30.0	1.3
World total	2 296.0	100.0

a/ Excluding communist countries.

64. The major part of the exploitable gas is to be found in areas such as the Middle East and the USSR, which are characterized by basins containing giant deposits and a considerable potential for accumulation. It is thought that the share of these areas will increase in the future, as efforts so far to develop the gas have focused, for

3/ T.D. Adams and M.A. Kirkby, B.P.

obvious economic reasons, on the areas closest to centres of consumption. North America, in particular, is an exploration area in decline, and the North Sea reserves will make only a slight contribution to total world reserves. 4/ Africa remains the great unknown, as barely 20 per cent of possible areas have been prospected, while it contains 7 or 8 million square kilometres of sedimentary basins. Africa's share in natural gas reserves so far unexploited, and even unestimated, might be much larger than is generally thought.

Uranium and thorium

65. African countries' uranium reserves in 1973 were reported to be 271,800 metric tons, or a third of the potential of the Western world exploitable in the short term. Some additional explanations should be provided to justify this assessment.

66. According to the magazine Europe-Outremer in January 1974 (issue 528), a recent report - the fifth of the type since 1965 - entitled "Uranium: ressources production et demande" drawn up jointly by the Agence pour l'énergie nucléaire (AEN), the Organisation for Economic Co-operation and Development (OECD) and the International Atomic Energy Agency (IAEA), supplies all the details required on the world scale. It should be noted that the world in question does not include the USSR, Eastern Europe or China, which did not provide any data, and that the report, published in August 1973, was not able to take account of the new prospects in the energy market following the oil crisis which arose from the Israeli-Arab war in October 1973.

67. The international rates refer to the price of an English pound of uranium oxide (U_3O_8) expressed in dollars. As the price of uranium in 1973 was of the order of $6 per pound of U_3O_8, the resources were classified in two categories: the group above $10 per pound and the group at $10-15 per pound. Each of the two groups was subdivided into reasonably assured resources and estimated additional resources. The report does not cover resources exploitable at more than $15 per pound, considering that they were unlikely to be exploited in the short term.

68. Let us take the first group (price below $10 per pound). Estimates of world uranium resources (excluding the USSR, Eastern Europe and China), according to data available in January 1973, are summarized in the table below (in thousands of metric tons of uranium):

Country	Reasonably assured resources	Estimated additional resources
Argentina	9.2	14.0
Australia	71.0	78.5
Brazil	-	2.5 c/
Canada	185.0	190.0
Central African Republic	8.0	8.0
Denmark (Greenland)	5.6	10.0
France	36.6	24.3
Gabon	20.0	5.0
Italy	1.2	-
Japan	2.8	-

4/ "The Petroleum Economist", June 1974

Country	Reasonably assured resources	Estimated additional resources
Mexico	1.0	-
Niger	40.0	20.0
Portugal	6.4	5.9
South Africa	202.0	8.0
Spain	8.5	-
Turkey	2.2	-
United States	259.0	538.0 b/
Yugoslavia	6.0	10.0
Zaïre	1.8	1.7
Total (rounded)	866.0	916.0

Source: "Uranium", report drawn up jointly by AEN, OECD and IAEA, in August 1973 c.f., Europe-Outremer mentioned above.

a/ In addition, 70,000 tons which may be obtained as by-products of phosphates.

b/ In addition, 70,000 tons which may be obtained as by-products of phosphates and copper.

69. These data may be briefly summed up as follows (in thousands of metric tons of uranium).

	Reasonably assured reserves	Estimated additional reserves
World total	866.0	916.0
Africa total	271.8	42.7
Central African Republic	8.0	8.0
Gabon	20.0	5.0
Niger	40.0	20.0
South Africa	202.0	8.0
Zaire	1.8	1.7

70. These two tables show that five African countries (the Central African Republic, Gabon, the Niger, South Africa and Zaïre) totalled in the first group, in reasonably assured resources, 271,800 tons of uranium, or more than 31 per cent of the reserves of the Western world, especially because of South Africa, which alone contributes 202,000 tons, or more than 23 per cent of the world total, which places it in second position after the United States. The Niger has 40,000 tons, or almost 5 per cent, Gabon 2 per cent, the Central African Republic and Zaïre less than 1 per cent.

71. In estimated additional resources, these five African countries total 42,700 tons of uranium, or less than 5 per cent of world estimates, which appears over-pessimistic because of the limited and still imperfect knowledge of other African possibilities.

72. The estimates in the second group (from 10 to 15 dollars per pound of U_3O_8) may be summarized as follows (in thousands of metric tons of uranium) with the reserves indicated above: 5/

Country	Reasonably assured resources	Estimated additional resources
World total	680.0	632.0
Africa total	72.0	54.0
Angola	-	13.0
Central African Republic	-	-
Gabon	-	5.0
Niger	10.0	10.0
South Africa	62.0	26.0
Zaire	-	-

73. This table shows that the Western world's reasonably assured resources appear to be 680,000 tons of uranium and estimated additional resources 632,000 tons. Africa's position in this second group would be of the order of 10 per cent of world reserves.

74. Although they are authorities in this field, the bodies which drew up the report did not demonstrate their objectivity. A number of serious gaps are to be deplored, and some important omissions should be indicated. In addition to the considerations below, it should be noted that Algeria has reserves of 12,000 tons of uranium in its southern Sahara and that important discoveries have been announced in Somalia since 1972. Moreover, the Niger's resources are apparently underestimated. The Bangui anomaly, recently recorded by American (sic) satellites, may in future considerably change the picture of the distribution of uranium resources in the world, undoubtedly, to Africa's benefit.

75. According to the source already mentioned, total estimated world uranium resources are as follows, by extrapolation (in thousands of metric tons of uranium metal):

World total	=	3 094.0
Africa total	=	440.5
Angola	=	13.0
Central African Republic	=	16.0
Gabon	=	30.0
Niger	=	80.0
South Africa	=	298.0
Zaire	=	3.5

76. For as yet unassessed reserves of uranium, apart from deposits which have been located and are known, mention may be made of the reserves contained in the phosphate deposits of North Africa (Morocco in particular and Egypt), Senegal and Togo and the granite deposits of Morocco, the Ivory Coast, Ghana, Nigeria, Southern Rhodesia and Namibia, the United Republic of Tanzania, Mozambique, South Africa and Madagascar.

5/ "Uranium", report mentioned subject to the same reservations - table summarized by the ECA secretariat.

77. In general, all granites contain an average of 1 to 3 grammes of uranium per ton and the earth's crust contains from 4 to 12 grammes of thorium per ton. This could mean that, for Africa, more substantial quantities of uranium and thorium should be discoverable in the future.

78. In present circumstances, it may be noted that uranium reserves discovered so far are substantial, despite still very incomplete prospecting. It is significant in that connexion that the highest values relate to the lowest cost prices: the reserves have basically been concentrated around the most favourable indications and those which are as close as possible to centres of consumption.

79. African uranium production evolved as follows from 1971 to 1973 (in metric tons):

Year	Production of preconcentrates	Production of uranium metal
1971	1 272	545
1972	522 a/	208 a/
1973	1 403	642

Source: "Europe Outremer", No. 531, April 1974.

a/ Discovery of a fossil atomic pile in the Oklo quarry which disturbed exploitation.

80. Despite the fall in production recorded in 1972, African production of uranium reached 4,160 tons of U_3O_8 concentrates, or 20 per cent of World production (19,660 tons). That performance was basically due to South Africa, third largest world producer, with 3,076 tons, behind the United States (9,900 tons) and Canada (4,000 tons). The Niger and Gabon respectively supplied 870 and 210 tons.

81. Previous production of uranium oxide was: 5,689 tons in 1960, 5,067 tons in 1962, 4,584 tons in 1964 and 3,351 tons in 1965. Madagascar's production of uranothorite progressed markedly from 1960 to 1965. Zaire has ceased production, which had reached 1,822 and 1,789 tons of uranium oxide in 1958 and 1959. Zambia has also ceased production, which in 1958 and 1959 was of the order of 101 and 77 tons respectively.

82. Since 1954, important discoveries of uranium deposits have been made in Africa by the French Commissariat à l'énergie atomique, especially in some French-speaking countries such as Madagascar, Gabon, the Central African Republic and the Niger. The Soviet Union contributed to the discovery of uranium deposits in Somalia and southern Algeria.

83. Exploitation of a uranothorianite deposit discovered in 1954 was begun the same year. However, economically exploitable reserves were very limited, and exploitation had to cease in 1968, after 14 years. A total of 5,900 tons of concentrates had been produced, containing 1,030 tons of uranium and 3,200 tons of thorium. It seems unlikely that other deposits will be discovered in the immediate future in that country, where still exploitable reserves are assessed at 1,000 tons of U_3O_8 and 2,000 tons of thorium.

84. The Mouana uranium deposit in Gabon was discovered in 1956. The deposit is basically uranium- and vanadium-bearing. Nevertheless, its exploitation began only in 1961, by Comuf

(the Compagnie des mines d'uranium de Franceville). The processing plant concentrates ore containing 4 per cent uranium in the form of magnesium uranate with about 40 per cent uranium. It has a capacity of about 13?,000 tons of ore per year, producing some 1,500 tons of concentrates and about 600 tons of uranium after processing. The capacity is capable of being increased by up to 100 per cent as soon as market conditions permit.

85. Also in Gabon, in the immediate extension of the Mounana deposit, a second deposit has been discovered at Boyindzi, but exploitation has not yet begun. A third deposit, at Oklo, has been exploited since 1971. It is only two kilometres from the previous deposit. In the Oklo quarry in 1972 a fossil atomic pile was discovered, which apparently functioned 1,700 million years ago. This is certainly a most important scientific discovery, the first case so far in Africa. But the reactor caused a marked diminution in the isotope 235 content of the ore, though over a small area. For that reason Gabon's uranium production was reduced to 582 tons of concentrates, or about 200 tons of uranium, in 1972. Other interesting possibilities appear to exist in Gabon for uranium exploitation.

86. In the Central African Republic, the M'Patou uranium site was discovered in 1965, in the Bakouma area. After a few years of hesitation, the Compagnie des mines d'uranium de Bakouma (Urba) was set up in 1969. However, on the basis of laboratory analyses, the M'Patou ore, which is phosphatic, seems unsusceptible to conventional concentration techniques. A new, special process has to be used, and its high cost led to a deferment of exploitation until the world prices of uranium collapsed in 1970.

87. As the market for uranium began to recover significantly with the oil crisis, the Urba company was planning to develop the Bakouma mining project in 1974, when the Government of the Central African Republic concluded an agreement in January 1974 with the Swiss firm Alusuisse for exploitation of the country's mineral resources in general and the study of the Bakouma uranium deposit in particular.

88. However, the Central African Republic's prospects in the field of uranium have improved as a result of the recent discovery of what is known as the "Bangui anomaly". American natural resources research and inventory satellites have detected a substantial belt of uranium-bearing indications in a vast area around the town of Bangui. Adequate information is not yet available, but it already seems clear that the ECA region has a confirmed role to play in terms of uranium, a role which will be specified shortly when the results of analyses and interpretation of serial surveys are available.

89. Until the beginning of 1966 the uranium reserves discovered in the Niger, in the Azelik and Madouela deposits, could not be regarded as exploitable, both because of their actual characteristics and because of their geographical position. During the first few months of 1966 the Commissariat à l'énergie atomique (CEA) discovered, in the Tin Mersol basin, close to Arlit, about 250 kilometres North of Agadès, economically exploitable concentrations of uranium. After the establishment of the Société des mines de l'Air (Somair) in 1968, exploitation began in 1971. The capacity of the processing plant was initially set at 750 tons of uranium per year, in view of economic conditions. The tonnage was to be obtained in concentrates of sodium uranate with about 70 per cent uranium.

90. In 1972 production was 1,250 tons of concentrates, or about 867 tons of uranium. It was decided in June 1973 to raise the capacity of the plant to 1,800 tons of uranium on 1 July 1977.

91. CEA has concluded international association agreements for the prospecting and possible exploitation of the new deposits discovered in the Niger. The first agreement, signed on 1 June 1970, between the Niger, CEA and a Japanese consortium made up of about 20 firms, the Overseas Uranium Resources Development Company (Ourd), for work on the Akouta deposit, about 10 kilometres south of Arlit. On 1 January 1974, the association announced the setting up of the Compagnie minière d'Akouta (Cominak), with the purpose of extracting 600,000 tons of ore per year from 1979, producing about 2,000 tons of uranium contained in commercial concentrates.

92. In contrast with the Arlit deposit, which is exploited by Somair in the open air, the Akouta deposit, which is deeper but richer, will require highly mechanized underground exploitation. Construction of a mining and industrial complex close to that of Somair began in 1974, and should produce 2,000 tons of uranium before the end of the decade.

93. The second tripartite agreement was signed on 12 December 1973 between the Niger, CEA and the German (sic) company Urangesellschaft, with a view to the establishment of a joint company to prospect and exploit the uranium deposits on the Djado plateau, which covers no less than 100,000 square kilometres in the north-east of the Niger.

94. A third agreement was signed on 3 April 1974, between the Niger, CEA and the American (sic) company Continental Oil Company (Conoco), for prospecting in the Imouranen area, about 100 kilometres north of Agadès and 80 kilometres north of Arlit. In particular, it provides for machinery for joint development and marketing of uranium, whereby each of the partners is able to dispose of its own share of the production. Research is financed by CEA and Conoco. On 14 May 1974 in Niamey the Société de mines du Djado was set up, with its central administration and Headquarters at Niamey. The three partners mentioned above will shortly be joined by the Japanese body Power Nuclear Fuel Development Corporation (PNC).

95. The purpose of the company will be as follows:

(a) In the first phase, to verify the uranium indications set out by ECA in 1970, in a 100,000 square kilometre area in the Djado region;

(b) In the second development phase, if genuine uranium indications have been proved, to specify the size and value of the deposit or deposits found and study the possibility of exploiting it or them economically.

The expenses payable by the Niger under this project will be financed by the Federal Republic of Germany, within the framework of a recently concluded technical assistance agreement.

96. After a period of stagnation in which the market was choked, production curbed and prevailing prices inadequate to encourage prospecting, especially in areas where the development of new deposits did not appear viable, the energy crisis and the prospects for the nuclear industry are substantially altering market conditions. Currently, 199

atomic stations are in service, under construction or on order in the United States. In France, 32, not counting two others shared with Belgium and one with Spain; the Westinghouse Company plans to build about 100 stations a year on average, half of them in the United States. These figures would probably be doubled if the economy became completely electrified.

97. Demand for uranium is expected to rise by 816 per cent in 20 years, and to meet these requirements some $3 billion will have to be invested in prospecting. If account is taken of the delay of about 8 years between the discovery of a deposit and its exploitation, it is clear that such prospecting must be urgently expedited.

98. The development of the nuclear industry should lead to a rise in demand for uranium, a marked increase in prices of uranium and fair remuneration for producers, which is indeed essential for research activities. But even there it should be made clear that more than 90 per cent of world uranium consumption will be met, up to 1978, through the application of sales contracts concluded a few years ago, at very low prices. Consequently, the highest prices in coming years will apply only to additional demand arising from improvements in equipment (stations), and will involve only minor quantities at the start.

99. Consequently, the producing countries must now look beyond the forthcoming shortage to the 1980s, during which over-supply may well upset market prices. Those who have been wise enough to keep a spirit of moderation will then be rewarded, both by investors they have not discouraged and by the assurance of genuine and stable outlets, each of these conditions essential for a long-term mining-based economy. 6/

100. Thorium deposits have been discovered in a number of African countries, including Egypt, Nigeria, Malawi and Madagascar. As yet unassessed indications are to be found in Ghana. Uranium deposits have also been reported, though of secondary importance, in Sierra Leone and Mali. Important reserves appear to exist in Algeria, in the Tibesti region of Chad, in Somalia and the United Republic of Tanzania, but adequate information concerning their size and location is so far unavailable. Uranium reserves are reported to amount to 12,000 tons in Algeria and more than 8,000 tons in Somalia, but these figures need to be checked and perhaps modified.

101. In general, it may be concluded that African reserves of uranium are particularly abundant. They are to be found first and foremost in South Africa, location of the biggest deposits in the world after those of Blind River (Canada) and Eliot Lake (United States) (1 billion tons of ore containing 280,000 tons of uranium oxide U_3O_8 in South Africa compared with 1,190,000 tons of uranium oxide at Blind River). Uranium was first discovered in southern Africa in gold mine waste heaps, but it is also contained in sedimentary rock in Witwatersrand, between Pretoria and Johannesburg, where the formation becomes very thick, and also in the Orange Free State.

102. The other African reserves are the recognized deposits in the Tibesti region in Chad, in the Niger (Arlit being exploited, Akouta and Djado), in Algeria in Hoggar, in the Central African Republic, in Gabon (in the Haut Ogooué, near Mounana and Oklo being exploited, as well as Boyindzi in reserve), in Zaire where the first stratum of the

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6/ This article draws broadly on the data supplied by the magazine "Europe-Outremer", in issues 528 of January 1974 and 531 of April the same year.

Shinkolobwé deposit, grand-daddy of world uranium mines, is now exhausted (the second stratum, deeper and more difficult to exploit, offers possibilities which are not negligible, but which the state of the world market has prevented from being assessed), in Madagascar near Antsirabé, in the aluminous phosphates of Taiba, near Thiès, in Senegal, the Van Rhynsdorf/thorium deposits in South Africa and uranothorianite deposits of Port-Dauphin in Madagascar.

103. A third series of uranium reserves which have not yet been accurately assessed are the deposits in Somalia, the reserves contained in the phosphate and granite deposits in the Maghreb, Egypt and Togo and in the granites of West Africa (Ivory Coast, Ghana, Nigeria), Eastern Africa (Southern Rhodesia, Zambia, the United Republic of Tanzania, Mozambique), South Africa and Madagascar.

104. African production of uranium has remained above 20 per cent of world production since 1960. The above table, produced from secretariat assessments, is not far removed from the indications supplied by certain international statistics which we have considered incomplete. It indicates total African production and the production of the Western world (in tons of uranium oxide), as well as Africa's share in world production:

Year	Africa	Western world a/	African share
1960	5 686	21 200	26.82
1965	3 351	15 100	22.12
1969	3 580	17 600	20.34
1970	3 567	18 322	19.46
1971	4 190	18 789	22.38
1972	4 154	19 927	20.85
1973	4 028	19 706	20.44

Sources: "Nuclear Energy Agency (NEA) of IAEA and OECD".

a/ Excluding the USSR, Eastern Europe and China.

105. The supplying of the nuclear industry is essentially based on uranium, the only currently usable natural element. Another element, thorium, is in theory usable in the atomic industry, but thorium-based techniques are still far too unreliable.

106. But uranium is economically exploitable only when the ore content is at least 1 per mille (or 0.1 per cent), the average being between 0.2 and 0.3 per cent. African uranium has a content often close to 0.4 per cent, which, together with its relatively low price, gives it considerable advantages on the international market, at a time when the rise in the price of oil and its derivatives is prompting the industrialized countries increasingly to master nuclear technology.

107. An indication of the development of nuclear energy for the production of electricity is given in the following table, which outlines the development of the provision of

nuclear thermal plant in power stations throughout the world and in certain countries regarded as most advanced in this field (in MW):

Year	World nuclear production	United States	United Kingdom	France	USSR	Federal Republic of Germany	Canada
1963	3 270	749	1 138	146	966	15	20
1964	4 160	906	1 503	166	966	15	20
1965	6 440	926	3 387	416	1 016	15	20
1966	8 480	1 942	3 881	416	1 016	322	20
1967	10 810	2 887	4 168	1 025	1 216	338	240
1968	12 210	2 817	4 648	1 271	1 226	808	240
1969	15 390	3 980	4 647	1 771	1 591	933	240
1970	18 920	6 493	4 813	1 771	1 591	958	240
1971	25 020	8 687	5 607	2 301	2 031	962	1 570
1972	36 680	15 301	5 614	2 709	2 621	2 307	2 126
1973	46 200	21 070	5 814	2 942	3 509	2 414	2 666

Sources: United Nations, "Statistical Yearbook", 1973 and 1974.

108. Although Africa's share in world uranium production is large, the Continent does not yet possess any nuclear stations. Some powerful reactors used in small experimental installations (in Zaire, for example), are designed for research and development of certain peaceful uses of atomic energy. Some projects for the construction of nuclear stations have been prepared by Egypt and the Libyan Arab Republic, on the one hand, and South Africa on the other. In the latter country the first atomic station, now being constructed, will enter into operation in 1981. The reader will observe the importance attached to uranium and nuclear energy in this study, which is due to the prospects the developed countries allow these elements as a form of energy which can serve as a replacement beyond 1980.

Hydroelectricity

109. Although hydroelectric energy was the subject of a detailed section in the report on "Electric energy in Africa: development and prospects" (E/CN.14/NRSTD/E/3), it is important to stress certain data relating to that form of primary energy, on which will depend, in part, the economic and social development of several countries of the Continent following the oil crisis.

110. As has often been written and said, Africa's technically exploitable hydroelectric potential would appear to be about 1,630 billion kWh per year, or more than a third of the exploitable hydroelectric potential of the submerged land of the globe. This annual average production capacity represents almost 15 times the total electricity production of African countries in 1973 and 52 times the Continent's total hydroelectric production. Compared with world production, it represented in 1973 41.5 per cent of total electricity production and 123 per cent of total hydroelectric energy production.

111. Depending on the conversion factors selected, the annual average production capacity of Africa would vary between 204 million tons of coal equivalent (for 1,000 kWh = 0.125 t.c.e.), and 815 million t.c.e. (for 1,000 kWh = 0.5 t.c.e.). In the most

favourable circumstances, those selected by the Commission secretariat, Africa's hydroelectric potential would correspond to 1.58 times the Continent's total production of primary energy and less than 10 per cent (9.6 per cent) of total world energy production in 1973.

112. This potential represents capacity of the order of 200 million kilowatts, or almost 35.4 per cent of the hydroelectric capacity yet to be harnessed in the world (565 million kW). This African potential has hardly been tapped, if it is remembered that total installed hydroelectric capacity in Africa in 1973 was only 8,726,000 kilowatts, or about 4.36 per cent of the technically exploitable capacity of the Continent. The table below shows the evolution of African hydroelectric production (compared with total production of electricity) and installed hydroelectric capacity (compared with total capacity) from 1963 to 1973:

Year	African hydroelectric production (in GWh)	Share in total African electric production	Installed hydroelectric capacity (in MW)	Share in total African installed capacity
1963	11 257	22.9	2 853	22.4
1964	12 349	23.0	3 110	23.5
1965	13 552	23.3	3 663	26.4
1966	14 172	23.0	4 185	28.9
1967	15 870	23.7	4 209	24.3
1968	19 014	25.7	4 924	25.9
1969	22 295	28.0	6 108	27.7
1970	24 773	28.3	6 830	29.2
1971	26 382	28.0	7 300	28.9
1972	29 834	29.3	8 140	30.1
1973	31 372	28.1	8 726	30.2

Source: ECA secretariat.

113. The average growth rate of African hydroelectric production was 9.8 per cent per year from 1964 to 1973. The advance was continuous and regular compared with the growth of world hydroelectric production, which had an annual average rate close to 4.6 per cent during the same period. Hydroelectric plant increased faster, with an annual average rate of increase from 1964 to 1973 of about 10.9 per cent for Africa as a whole.

114. However, African hydroelectric potential is very unevenly distributed. The Central African subregion alone has a minimum potential of 744 billion kWh per year, or about 46 per cent of the continent's total hydroelectric potential, while North Africa has only 5 per cent, West Africa about 10 per cent, Eastern Africa 22 per cent and southern Africa about 17 per cent. It is unquestionably tropical and equatorial Africa's hydroelectric potential which constitutes the Continent's major and decisive asset for its future energy development.

115. The subregional distribution of hydroelectric resources provides indications of relative size. It conceals a large disparity both between countries and between the watercourses that flow through them. For example, Zaire has an exploitable potential of 530 billion kWh, with the Inga site, reputed to be the biggest in the world, which can accommodate 30 million kilowatt plant capable of producing 200 billion kWh a year.

Zaire is followed by Angola (230 billion kWh per year), Madagascar (114 billion kWh per year), the United Republic of Cameroon (about 100 billion kWh per year) and the United Republic of Tanzania (75 billion kWh per year).

116. As these examples demonstrate, Africa's hydroelectric potential is almost entirely concentrated in the high-rainfall equatorial region and its immediate surroundings. But since these resources have been only partially prospected, they are still poorly known. That is no doubt due to the lengthiness of the research the prospecting requires. As R. Braquaval 7/ indicates, the studies carried out had a specific purpose in almost every case: supply to urban centres, mining or industrial installations; the characteristics of the demand to be met and the place of consumption limited the research in terms both of the capacity to be installed and of the geographical area to be prospected.

117. The same author stresses, pertinently, that hydroelectric developments are complex wholes and are essentially different one from another, which makes them difficult to classify. One can imagine that the geological, hydrological and topographical factors which vary greatly from one site to another give each installation a special nature, and that consequently standardization of equipment between plants is practically impossible. As a result, each case must be made to measure. The studies which precede the implementation of such schemes are of necessity long, delicate and costly. In particular, they include a large share of the preparatory field work (cartography, topography, geology, geophysics, reconnaissance using trenches or borings, by mechanical samplings and, in some cases, by drivage). It is known that the capacity that can be used from a given waterfall is proportional to the volume of flow and the height. Accordingly, accurate knowledge of those two factors is essential.

118. If measuring the height does not present any special difficulties, the same is not true for measuring volume of flow in terms of its changes over time. The flow of a watercourse varies considerably from one season to another, but it also varies markedly from one year to another.

119. This applies to African watercourses such as the Senegal, the Niger, the Konkouré, the Cavally, the Bandama, the Comoe, the Volta rivers, the Sanaga, the Nyong, the Ogooué, the Zaire and its tributaries, the Cuanza, the Cunene, the Zambezi, the Pangani, the Shire, the Ruziz, the Limpopo, the Orange, the Nile, the Wabe Shebelle and the rivers of Madagascar. It should be noted, however, that the basins of the Zaire, the Nile, the Zambezi and the Orange loom very large in that distribution.

120. Taking no account of the development of international watercourses which cross several countries or form a border between them, the African countries least well endowed with exploitable hydroelectric resources are: Mauritania, the Libyan Arab Republic, the Niger, Tunisia, Somalia, Rwanda and Burundi, which contain a potential of less than 2 billion kWh per year.

121. Although the final picture is still incomplete and not accurate, Africa's specific hydroelectric potential is very favourable compared with other continents. Per capita, it represents more than 3 times the world average and, in terms of area, more than 1.5 times the average per square kilometre for the countries of the world as a whole.

7/ R. Braquaval, Chief Engineer of Electricité de France (Daféco) in "Les diverses sources d'énergie: leurs applications aux pays en voie de développement", Industries et Travaux d'Outremer, No. 253, décembre 1974, special issue 4th edition.

122. It should be mentioned that, in general, hydroelectric equipment is characterized by very high investment costs. On average, for every dollar invested in the construction of a hydroelectric station, $1.50 is invested in the transport and distribution network and about $5 in purchases of machinery to use the energy. It is therefore essential to measure the investment capacity of countries introducing such schemes in terms of their national income, and to plan fairly accurately so that the electricity produced can be absorbed immediately by the consumers.

123. A recent study estimates that, as a first approximation, for completed plants, the installed kilowatt costs two to three times more from hydroelectricity than from a conventional thermal plant. It should be noted, in that regard, that the cost includes expenditure relating to the transport of energy, as the sites are often far from the place where the energy is used. On the other hand, in contrast to the situation with thermal stations, operating costs are low. The price of a kWh is influenced little by economic conditions, and at all events is independent of variations in the cost of fuel; moreover, when the investment has been paid off after a period of several decades, the scheme continues in existence and goes on producing a kilowatt-hour very cheaply.

III. Non-conventional energy sources in Africa

124. It is usual to classify various sources of energy into primary energy and secondary energy, or conventional and non-conventional sources. Some speak of commercial or non-commercial sources of energy. These classifications may be acceptable for convenience, but they have no strict scientific acceptation, and in most cases the meanings attached to them differ widely.

125. Primary energy is the form in which nature supplies that resources, while secondary energy is the form in which man consumes it. While some forms of primary energy, such as coal, are also secondary forms when consumed as they are, electric energy is solely secondary, whether thermal, hydroelectric or nuclear, in other words it is always the product of the transformation of primary energy, in conditions which may be more or less favourable.

126. In his article mentioned above, Braquaval notes that the various forms of primary energy are as follows:

Solar energy;

Geothermal energy and its counterpart, thermal energy from the sea;

Wind energy;

Mineral fuels:

- Lignite,
- Oil shales,
- Coal,
- Petroleum and natural gas,
- Uranium and thorium;

Other fuels:

- Wood,
- Agricultural wastes etc...;

Hydroelectric energy and its variant, tidal energy.

127. For clarity of exposition, solid fuels, hydrocarbons, radio-active ores and hydroelectric energy are dealt with in the second section of this document. In the non-conventional sources of energy, we will deal with solar energy, wind energy, geothermal techniques, thermal energy from the sea and other fuels.

Solar energy

128. The international energy crisis, partly caused by the rise in the prices of petroleum products, rekindled interest in the use of solar energy, which is abundant over the surface of the globe. It is recognized that in periods of insolation, in countries with clear skies, the energy received is of the order of 1 kW per square metre. This form of energy is characterized by the fact that the "fuel" is free, abundant and harms neither man, nor livestock, nor plant life. It is not thermal in nature, but of electromagnetic origin; in theory it is 100 per cent transformable into mechanical energy.

129. Solar energy is still in the realm of expectations in industrial terms, but serious studies are being undertaken throughout the world with a view to deriving maximum benefit from it. Prospects for solar energy are in fact limitless. Over the 15 million square kilometres of tropical or subtropical deserts (in Africa, the Arab countries and Australia) where this non-polluting form of energy can be mobilized, there is a theoretical potential of several quadrillion kWh.

130. With minimum efficiency of 1 per cent, an amount of electricity would be obtained corresponding to thermal production of more than 100 billion tons of crude petroleum, or more than 15 times the world's total production of primary energy in 1973 and more than 16 times total world energy consumption. The potential would represent almost 172 times world electricity production in 1973.

131. The important aspect of these considerations is that more than half the world's solar energy prospects are to be found in Africa, with its Sahara, Nubian and Kalahari deserts. From that point of view, Africa is very well endowed.

132. Of course, in technical terms it is too early to envisage massive mobilization of electricity in the vast desert areas of the Continent. We do not yet know how to harness this extraordinary scattered potential in order to focus it on powerful stations, nor - most important - to do so economically. The practical task of converting solar energy into electricity has not yet been solved satisfactorily. Heat losses increase to such an extent when attempts are made to raise the yield that the over-all efficiency of present schemes is still of the order of 5 per cent, and mechanical capacity is about 0.05 kW per square metre. A 5 kW plant would require a collector receiving a beam with a cross-section of 100 square metres.

133. For fixed flat collectors, the simplest and least costly, efficiency barely exceeds 2 per cent, and in optimum insolation conditions a receiving surface of 50 square metres develops maximum power of 1 kW and collects 5 to 7 kWh per day. Large installations able to produce substantial power levels are thus out of the question at the present stage of solar technology development. It should be added that power is available only

if the sun shines, and that it can be used only intermittently. Continuous use would require an accumulation of energy which would be too expensive, whether it was carried out in thermal or chemical form.

134. Accordingly the applications of solar energy for the solar engine are limited to occasional use, without energy storage, in high-insolation areas which are isolated in energy terms, for example for pumping out water or for pumping for purposes of irrigation in arid areas.

135. As a result of studies and research carried over the past 15 years by various national or international institutions, it is clear that the Sudano-Sahelian region, and especially its Sahelian component (crossing Africa from West to East, from Mauritania) is among the most favoured regions of the world in terms of the annual duration of the intensity of solar radiation. Accurate data exist concerning the results of measurements of average monthly and yearly insolation taken at several locations, and relate to measurements carried out in about 60 stations covering almost all West and Central African countries as far as Luanda. The average annual duration of continuous insolation (annual total relative to the various values of the duration of continuous insolation) was measured in about 20 centres, and the intensity of total solar radiation (direct + dispersed) over a horizontal surface (average monthly values in kilocalories per square metre per hour) was noted in about 15 centres.

136. The value of that region, which has been dramatically affected by a long period of drought, is that it is still at present very poorly endowed in terms of the existence of conventional sources of energy. Even if current prospecting reveals particularly valuable riches in the subsoil, or if technological progress was to make possible widespread and economic harnessing of watercourses, as hydroelectric potential, it is to be feared that the conditions imposed by distance, climate, the low degree of industrialization, the fact that the population is scattered and the other characteristics peculiar to the Saharan, Sahelian and Sudanian zones, will make it a delicate and expensive operation extensively to produce and distribute electricity in most of that large arid and semi-arid area.

137. In addition, production of electricity of thermal origin at whatever scale has now been made prohibitive by the four-fold, if not five-fold increase in the price of crude petroleum and its derivatives, for all land-locked countries which do not produce liquid fuels.

138. It has thus become increasingly clear that solar energy in particular could make an appreciable contribution to the implementation of major programmes for the economic and social development of certain zones, for the benefit of many population groups which have been particularly hard hit and underprivileged.

139. It is for that reason that the Governments of the countries concerned have initiated major programmes of scientific work and practical applications oriented towards the search for economic solutions. The basic guidelines followed in that initiative relate to the high-priority sectors such as the development and testing of the following:

Low-powered solar thermal engines for pumping out water and various skilled operations in rural areas;

Solar thermopiles and photoelectric cells for pumping water, for telecommunications, education (radio or televised) and the production of electricity;

Solar water heaters, distilling condensers, drying apparatuses and sterlizers for hospitals, clinics, maternity services, school canteens and other school services;

Solar cookers (for family, school, community use);

Solar refigerators and air-conditioning units;

Solar ovens and kilns for firing bricks and manufacturing building materials etc.

140. Since 1960 the solar energy research experimentation centres of Dakar, Bamako, Niamey, Ouagadougou and several specialized units in African Universities have made substantial progress both in the field of measures and applied research and in the development and popularization of prototypes of equipment using solar energy. Their efforts and goodwill have often been held back by the shortage of financial and human resources and the absence of adequate equipment to facilitate their research and the development of their discoveries.

141. Elsewhere, outside Africa, mention should be made of an area where solar energy has obtained remarkable results, that of high temperatures in an inert atmosphere, at Mont-Louis in the eastern Pyrenees, where the work is at the forefront of technical progress. In addition, in 1969, at Odeillo-Via, near Font-Romeu, the most powerful solar kiln in the world was put into operation. With a capacity of 100 kW it can produce temperatures of 3,000 to 3,500 degrees C in an inert or controlled atmosphere.

142. Photoelectric generators are widely used in space technology. At present their cost is excessively high compared with that of the conventional methods of electricity production. What is involved is more a market problem than a problem of technological development. Spectacular progress is expected from this technique, which has already given rise to great hopes for the future. Some believe that this type of generator might become competitive shortly.

143. What should be noted is that in the field of autonomous sources, photoelectric generators are already competitive, and for that reason have already begun to appear on the market. There is no doubt that a fall in manufacturing costs is essential before use of this new source can become widespread. However, there is nothing to prevent such a fall, and competitiveness for large-scale use may be envisaged for the start of the next decade.

144. Adequate competitiveness may already be observed with primary batteries. It is there, in the field of autonomous sources, that the present market for photoelectric cells is to be found. The following fields may be mentioned in particular:

Supplying school television sets in sites without electricity supply;

Rechargers of batteries of sailing boats;

Boring platforms;

Navigational aids, point-setting for railways, roadside emergency posts;

Portable apparatus such as digital watches, radio receivers, cine cameras, portable tape-recorders etc.

In all cases the solar panel is linked to a battery, most often made of lead, which is fed in sunlit hours and ensures permanent supplies.

Wind energy

145. Wind energy is best used in windy and isolated areas which lack major hydroelectric resources and where the cost of supplying fuel is very high. In such cases windmills linked with conventional units may be envisaged in order to economize on fuel.

146. This form of energy is characterized by very substantial irregularity according to time and place. It requires perfect knowledge of the wind system and maximum speeds. The generator must be able to provide its nominal capacity for as low a speed as possible and to resist violent winds which may reach or exceed 150 km per hour. In desert or Sahelian areas, the blades must be able to resist sandstorms.

147. Wind energy is used in some African regions for water pumping and irrigation (Morocco, Mauritania, Mali, the Upper Volta, the Niger, Chad etc.). For countryside which is arid, far from the coast and lacking conventional sources of energy, the use of windmills may, in the future and if conditions are right, become of greater interest and more economic.

148. Unfortunately, the search for sites and the measures carried out in the equatorial and tropical zones have almost always been disappointing. Outside the Sahara, the Sahel and the Kalahari, Africa seem in general very unfavourable compared with the temperate countries and polar regions where there are powerful and regular winds. As a result, wind energy does not appear to have a great future in Africa.

149. Nevertheless, numerous experiments are continuing on the African continent, with fairly satisfactory results. In Senegal, for example, the physics unit at the Thiès Ecole polytechnique is working on the use of wind energy with generators with a nominal capacity varying between 0.5 and 3 HP. Studies of the viability and reliability of low-power windmills are being carried out for water pumping and recharging of accumulators. It is true that the main object of this work is to identify and solve problems with the adaptation in Senegal of various types of machines already developed, rather than to effect aerodynamic studies of windmills or endeavour to produce entirely new prototypes, as for example at Ouagadougou, where the search for the economic optimum encourages innovation and the use of local materials.

150. The results obtained in Morocco, Algeria and Mauritania (perhaps also in the Libyan Arab Republic) can no doubt be improved by the innovations of a French firm which, in addition to the phenomenon of jamming due to sandstorms, has succeeded in solving other problems, notably through an arrangement for variable adjustment of the blades, which enables the machines to supply their entire nominal capacity, as soon as the wind reaches a fairly low speed (from 5 to 7 m/s) and resist violent winds. The firm makes air-driven generators with capacity of up to 4 kilowatts for a blade length of 4.60 metres which, linked with auxiliary emergency generators, can be used on marine beacons.

151. Construction is currently planned of an air-driven generator with a blade length of 22½ metres and a capacity of 100 to 400 kW, depending on the normal wind speed (7 to 11 m/s). The operation seems to be technically possible, but the economic conditions are not known.

152. Since the 1930s and more recently in the 1950s, the United States has used wind energy to turn large electricity generators. In the 1940s, in particular, a windmill/generator unit was built in Vermont which was able to supply a total of 1.25 MW over a

four-year period to a public electricity network. Since then, public electricity distribution networks have been supplied in that manner in Denmark, France, Germany (sic), by large windmills driving generators of several kilowatts. That seems possible in certain high-latitude African countries.

153. The world energy crisis created a strong tide in favour of wind energy. Several American universities and NASA are involved in the problem. The latter is starting construction of an experimental 100-kW generator in Ohio. It appears that, provided that they are well sited, some windmills have been able, in the United States, to compete in terms of the price of a kilowatt-hour with conventional-type generators operating on the same site. In the period of cheap petrol, it was impossible to justify such installations economically.

154. Since then, progress in aerospace research has brought better machines, and modern windmills with blades that can be feathered supply up to 6,000 HP (about 4,500 kW). In addition, the price of fuel oil has rocketed. According to current estimates, the use of air-driven generators with a wind of 25 per cent of its possible capacity, in excellent technical conditions, would be a viable operation in Great Britain. 8/

Geothermal energy

155. Geothermal energy is one of the resources on which the developed countries are largely counting to ensure a new world energy balance during the forthcoming decades. At all events, it is one of the hopes on which Africa may count in order to assure the future of its electricity production, especially in the east, where there are still many active or extinct volcanoes and hot springs, all connected with the tectonics of the Rift Valley. Numerous geothermal anomalies exist between the Red Sea and Lake Malawi (or Nyasa), crossing the lakes region.

156. In purely theoretical terms, harnessing a geothermal site presents no special problems: the steam or hot water is used to drive a turbo-alternator unit. However, in practical terms deposits and corrosion are important factors which often necessitate the use of heat exchangers to protect the active elements of the turbines from attack by the various salts contained in the steam or caused by the hot water. Another difficulty arises in planning extensions to the deposits without highly advanced borings.

157. Accordingly, at the present state of knowledge, geothermal energy seems to be a endowment whose use is limited to a few favourable areas of the world. The regions in the African Continent which might be prospected cover a substantial area. Apart from the large strip along and beside the Rift Valley, multiple borings or phenomena observed over the past few years indicate huge areas of interest: the French Territory of the Afars and Issas, Ethiopia, Kenya, Uganda, Rwanda, the United Republic of Tanzania, Malawi, the United Republic of Cameroon (on Mount Cameroon and in the Adamawa), the Tibesti region (Chad), the area between the Volta basin and the Senegal, the Lac Faguibine region in Mali, the area from the Canaries to Libya through Morocco, Algeria and Tunisia.

158. According to the latest indications, the most favourable areas are in Ethiopia, the French Territory of the Afars and the Issas, Kenya and the United Republic of Cameroon, but it seems that those countries have not yet taken any decision to begin commercial exploitation.

8/ M. Arthur Bruckner, of City University, London: article in the "New Scientist".

159. Despite the importance of these prospects, only one small geothermal station as yet exists in Africa, at Kuabukwa, in Shaba province, Zaire, with a capacity of 220 kW. The steam generator of the station uses water from a hot spring to produce, in a vacuum, low-pressure steam which drives a turbo-alternator unit. The station consumes 40 litres of water per second at 91°C. The electricity produced is currently supplying a tin mine about 10 kilometres away.

160. Italy, the United States, New Zealand, Japan, Mexico, Iceland and the Soviet Union already possess geothermal stations. No information is available concerning the installed geothermal capacity in the USSR or in the Federal Republic of Germany. In Iceland half of the population is heated with hot water and steam from geothermal sources. In countries using geothermal energy, installed capacity grew as follows (in MW) from 1963 to 1973:

Year	Italy	United States	New Zealand	Japan	Mexico	Iceland	Total
1963	331	27	192	-	-	-	550
1964	331	27	192	-	-	-	550
1965	339	27	192	-	-	-	558
1966	342	27	192	-	-	-	561
1967	372	55	192	31	-	-	650
1968	372	84	192	31	-	-	679
1969	395	84	192	31	-	2	704
1970	402	84	192	31	4	2	715
1971	402	203	192	31	4	2	834
1972	391	322	192	31	3	2	941
1973	406	332	192	31	78	2	1 041

Sources: United Nations "Statistical Yearbook", 1973 and 1974.

161. In a work entitled "Geothermal Energy, Resources, Production, Stimulation", James B. Koenig, of the California Division of Mines and Geology, stated that it had been demonstrated in Hungary, Iceland, New Zealand and the Soviet Union that the direct use of geothermal energy in industry, agriculture and the heating of buildings was markedly less costly than the use of heavy fuel oil, petrol or domestic fuel oil for the same purposes... In electricity production, hydroelectric sources alone had been recognized as cheaper, and then only in certain circumstances.

Heat energy from the sea

162. In exploitation of heat energy from the sea, the process consists of using the temperature difference between very deep waters (of the order of 4 to 5 degrees) and surface waters (from 25 to 30 degrees) in equatorial and tropical regions.

163. The French engineer Georges Claude carried out an experiment in the waters off Abidjan for the production of electricity, but without success. The first experimental station to use the process was to be located at Abidjan, on the west coast of Africa, in the Gulf of Guinea. In the first stage the equipment was to include a 3,500 kW unit. Commercial implementation studies were prepared, from 1951 to 1956, in Abidjan and Paris, by the company Société thermique des mers in co-operation with Electricité de France. The test was abandoned, although confirmation trials had been begun to prove its success. All that can be said is that the process was applicable in principle.

164. Georges Claude's successive failures seem to have been due in essence to the difficulty of transporting the cold water from the deep waters by pipe. Georges Claude twice lost the pipe in the delicate laying operation. Nevertheless, he succeeded at his third attempt, but the pipe, which was very badly damaged, permitted only a few tests of the turbine at reduced power, because of the inadequate flow of cold water.

165. The problem which had led to the failures was solved through many studies and experiments carried out over the past 15 years or so. At present gas pipelines cross the seas to supply Europe with natural gas. The technical and objective conditions have now been met to renew the experiments and move to the construction of electric stations of this type, disregarding the limitation on power. It would appear that the viability of such a plant would be guaranteed only in arid countries, where electricity and fresh water would be used at the same time. It was noted that for equipment of 7 to 10 MW (without fresh water production), the estimated cost price was markedly higher than for a conventional diesel station. This handicap has now been removed as a result of the prohibitive cost of petroleum products.

166. The waters off Abidjan are still among the most favourable points for the success of such an experiment. On the one hand, the existence of the "Bottomless Pit" is an undoubted advantage. On the other, thermal energy from the sea is in fact limited to an area between the isotherms of 25 degrees at the surface, which roughly follow the lines of the tropics. The process requires warm surface water throughout the year, and depends on the shape of the coast permitting the transport of water from the deep through a pipe of a reasonable length. At Abidjan the region is very shallow, and it is the submarine trench known as the "Bottomless Pit" which makes it possible to reach a depth of 430 metres by means of a pipe only 5 kilometres long.

167. The initial installation cost of the project at Abidjan, the only one to have produced a complete study, was of the same order of magnitude as that of a waterfall producing a regular supply of energy, and that fact emphasizes the value of reviving the studies and, if necessary, commercially implementing such a project, if considerations of ecological balance do not preclude it.

Other fuels

168. It is not without value to note that production and consumption of firewood and wastes from plant products is still very important in the African country-side and, in general, in the under-developed world. They are developing principally in countries or regions where the population's purchasing power is still low. It so happens that it is in the countries regarded as the poorest in the world, most of which are in Africa, that firewood and charcoal are most used. In the semi-arid or arid countries and in the Sudano-Sahelian countries, this small-scale activity leads to the destruction of the scanty vegetation and encourages the encroachment of the desert. Deforestation and bush fires are anti-econcaio and anti-social activities, since they destroy an ecological balance which is already precarious.

169. The absence of official statistics, in most countries, hinders the assessment of consumption of other fuels. These forms of energy are made up of important quantities of wood cut and used in farms, firewood and charcoal, used for household needs, branches from forests and rods, groundnut, coconut and almond shells, bales of paddy or cotton, cotton seeds, bagasse, straw, grass or other plant and animal waste etc...

170. However, it is estimated that African production and consumption of the other fuels, regarded as non-commercial sources of energy, have reached the following approximate amounts, expressed in thousands of tons of coal equivalent:

1949	=	46
1955	=	77
1960	=	84
1965	=	92

171. As early as 1949 the distribution of world production of non-commercial energy was as follows (in millions of tons of coal equivalent):

Region	Production	Share in total (per cent)
North America	68.7	10.7
Europe	60.3	9.4
Oceania	4.9	0.8
USSR and other socialist countries	72.0	19.0
Africa	45.7	7.1
Latin America	55.9	8.7
Asia	284.8	44.3
World total	592.3	100.0

Source: "Ressources mondiales en énergie" during certain years of the period 1929-1950

172. The amounts indicated for Africa (year 1965) represented about 45 per cent of the total production of commercial energy production in the continent for that year. In certain economic subregions, such as West Africa and Central Africa, consumption of non-commercial energy was still higher than that of conventional forms of energy. These examples show how much African countries must already have been concerned to study possibilities for the sound exploitation of these forms of energy, which were still widely used in many parts of the world, and to remedy such destruction of vegetation.

173. For the period 1960-1965, the shares of the various forms of non-commercial energy, compared with world production of commercial forms of primary energy, was estimated as follows:

Country		Per cent
North America	=	4.00
Western Europe	=	6.00
Eastern Europe	=	12.00
Latin America	=	14.00
Asia and the Far East	=	52.00
Oceania	=	2.00
Africa	=	10.00
Total	=	100.00

174. If, by extrapolation, it is considered that Africa's share in 1970 represented only 12 per cent of world energy consumption, the Continent's consumption of non-commercial energy would represent almost 82 million tons of coal equivalent, or more than 17 per cent of its total commercial energy production and almost 76 per cent of its total consumption of commercial energy in 1970. If the same data are kept for 1973, we arrive at almost 16

per cent of production and a little less than 59 per cent of total consumption of commercial energy for the same year. These figures seem excessive, but the drought which for several years hit the Sahelian zone of Africa, together with the increasingly unsound exploitation of forests, may well give grounds for pessimism which will not be allayed by the progressive advance of the deserts.

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