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DEVELOPMENT OF PETROLEUM REFINERIES IN AFRICA
Present Status and Future Prospects

Prepared by the secretariat of the
United Nations Industrial Development Organization
(UNIDO)

Rennert

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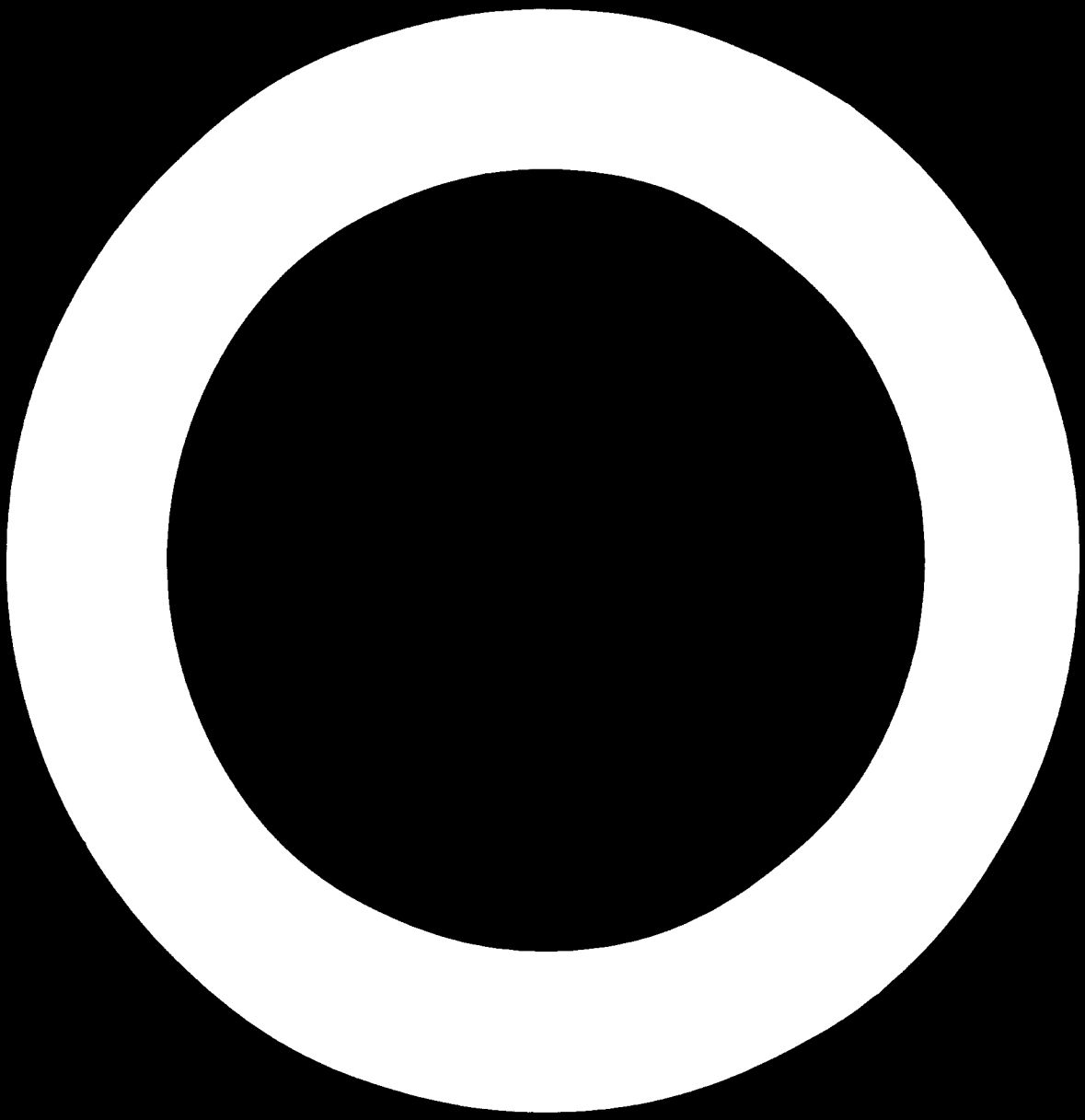

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1. INTRODUCTION

Action at the world level

1. During the last few years considerable attention has been accorded at the global level to general and specific matters related to the world energy situation. The sixth special session of the United Nations General Assembly on raw materials and development, the Fourth Summit Conference of Non-aligned Countries which took place in Algeria in September 1973 as well as the Conference of Developing Countries on Raw Materials which took place in Senegal in February 1975 are among the international conferences which have stressed the need for consolidated and co-ordinated world-wide action, particularly among the developing countries, on raw materials development, with special emphasis on energy resources. The Senegal Conference invited international and intergovernmental organisations to prepare an action programme for raw materials, particularly in the field of energy. The Lima Declaration and Plan of Action on Industrial Development and Co-operation which was adopted by the Second General Conference of UNIDO, held at Lima, Peru, in March 1975, stressed the need for developing countries to have effective control over natural resources and the harmonisation of policies for their exploitation, conservation, transformation and marketing; to ensure the intensive use of national resources, infrastructural development and internal regional development, placing particular emphasis on employment policies, as well as full and intensive utilisation and on-the-spot processing of raw materials; and to place a premium on self-reliance in the development effort for the realisation of their full potential in terms of both human and natural resources and, to that end, to adopt meaningful and concerted policies and pursue action directed towards greater technical and economic co-operation among themselves.

Action by African countries

2. In Africa, concerted efforts have also been initiated. The first and second Conferences of African Ministers of Industry, held at Addis Ababa in May 1971 and at Cairo in December 1973, emphasized the need to foster the effective co-ordination of policies and programmes in respect of the exploitation and use of mineral resources and to formulate and pursue policies and programmes aimed at the greatest domestic processing of Africa's renewable and non-renewable natural resources before export.

3. The need for African countries to consolidate their position and to undertake co-operative efforts for the development and use of their energy resources has been expressed in several forums. At the African Regional Conference on Human Settlements, which was organised in Cairo in June 1975 by ECA, the role of energy in the development of human settlements in Africa was extensively considered. It was recognised that there was an urgent need for innovation, not only in the search for more economical and efficient uses of existing energy resources, but also in the search for alternative sources and for other appropriate uses of energy, as well as a need to stimulate innovation to achieve the best possible planning methodologies and operational procedures so as to ensure that the demand for various sources of energy for a variety of uses was met, subject to physical, operational and any other relevant constraints. It was also recognised that,

while Africa [illegible] quarter of energy, the great majority of African countries [illegible] barriers of commercial energy, particularly petroleum products.

4. The recent energy crisis has emphasized even more strongly the need for African countries to strengthen their co-operation in the field of energy resources. To this effect, the first Regional Conference on the Petroleum Industry, which took place at Tripoli in February 1974, recommended effective co-operation between African Governments in exploration and training and the distribution of information pertaining to petroleum and natural gas resources. In August 1974, ECA organised a meeting at Addis Ababa of the Association of African Central Banks to consider the impact of the energy crisis on trade and development of African countries. That meeting concluded that it was the moment when the imagination of the Governments of the oil producing and the non-oil producing African countries could rise to the challenge and effect the African dream of economic co-operation.

Second African Meeting on Energy

5. In the light of the above, ECA decided to organize the second African Meeting on Energy [illegible], Ghana, in March 1976 to:

(a) Appraise the current and future energy situation and prospects on the continent;

(b) Analyse trends in energy resources supplies and marketing, and the development of indigenous sources of energy at all levels;

(c) Consider the possibilities and feasibility of co-operation among member States in the field of energy,

(d) Exchange information on the latest advances and research in the field of energy;

(e) Consider the possibilities of training the technical personnel needed in the energy field; and

(f) Formulate and co-ordinate energy policies of member States.

6. At the invitation of ECA, UNIDO is contributing towards the work of the meeting by submitting the present paper. In preparing this paper, UNIDO has limited itself to petroleum refineries, while taking cognisance of other types of refineriesfor energy purposes. While also recognising the fact that petroleum is only one of several sources of energy, this paper was restricted to petroleum refineries since a review of the topics to be discussed at the meeting indicates that other sources of energy will be accorded special attention.

7. The purpose of the paper is therefore to review the present status of the petroleum industry in Africa. This includes present petroleum reserves, production and refining capacities, as well as the level of consumption in Africa. A brief comparison with other sources of energy is presented. The paper further forecasts

future trends and prospects with regard to petroleum production, refining and consumption. Suggestions are made, for the consideration of the meeting and African Governments, about ways and means to promote greater co-operation among the member countries through, for example, the exchange of information on the latest advances and research and the training of technical personnel in petroleum refining and utilization. Suggestions are also made for possible co-operation between international organizations, particularly UNIDO, and the African countries in helping to meet the targets for the consumption of petroleum products.

II. APPRAISAL OF THE PETROLEUM REFINING INDUSTRY IN AFRICA

General considerations on production and consumption of petroleum in Africa

8. Africa, which contains about 10.7 per cent of the world's crude oil reserves and about 9.6 per cent of the world's natural gas reserves, has good potential for the development of petroleum refining industry and of the industrial branches based on these two valuable raw materials for the generation of energy and the production of fuels and petrochemicals. In the area of crude oil reserves, in particular, Africa ranks third after the Middle East and the Socialist countries, with a total reserve estimated on 1 January 1974 at 9,219 million tons of crude (see annex). In 1973 Africa produced 291.3 million tons of crude oil which represented more than 10 per cent of the world's output and placed the continent on the fourth position among the other geographical regions (see annex). Notwithstanding these favourable conditions, the total installed capacity for petroleum refining in Africa, as estimated in 1974, amounted to only 18 per cent of the total crude produced on the continent. This clearly indicates that the major portion of the crude oil produced in Africa is exported to countries outside the African continent.

9. The production of crude oil in 1972 represented (see annex) about 81.4 per cent of the overall primary energy produced in Africa. Coal and lignite contributed 14.52 per cent, natural gas 3.4 per cent and hydro- and nuclear energy only 0.9 per cent. The total primary energy output in the same year, which amounted to 441 million metric tons of coal equivalent, represented 5.82 per cent of the world output and about 19 per cent of the average production in developing countries. The total production of primary energy per capita in Africa (see annex) which in 1972 was 363 kg coal equivalent, represented only 18 per cent of the world average and about 5.84 per cent of average figure for the developed countries of 6,211 kg coal equivalent.

10. In the same year, the total per capita output in primary energy of the African continent was on a level with the average figure of developing countries (about 362 kg coal equivalent). In the same context, the consumption of liquid fuels in Africa represented in 1972 over 41 per cent of all types of energy consumed, second only to solid fuels (over 47 per cent). This fuel consumption pattern is different, as reflected in annex 3, from that of the developing countries where liquid fuels account for 61.49 per cent and that of the industrialised countries where the liquid fuels contribute about 49.78 per cent to overall primary energy consumption. It should be noted that the above figures are averages for the entire African continent where considerable differences and disparities exist between the levels of energy consumption and rates of growth among the individual countries.

11. These last figures clearly show that, although operated still on a relative small scale, the crude oil refining industry in Africa has and continues to have an important role in the overall development on the national economies of African countries.

12. The production of crude oil, particularly from the eight major producers in Africa (Algeria, Angola, the Congo, Egypt, Gabon, the Libyan Arab Republic, Nigeria and Tunisia)has made a significant contribution towards the economic development of the continent. The drilling and extraction of crude oil, although started more than 25 years ago, did not become really developed until the majority of African nations were independent. During the last ten years, in particular, average production increased by some 167 per cent.

13. Out of 291 million metric tons produced in 1973 by the African continent, the Libyan Arab Republic led the African countries in the production of crude oil in 1973 (see annex IV). Thirty-seven per cent of total crude oil output was produced by that country (107.9 million metric tons), over 34 per cent by Nigeria (101.3 million metric tons) and 18 per cent by Algeria (52.8 million metric tons). Substantial petroleum reserves are also to be found in Angola, the Congo, Egypt, Gabon, Morocco and Tunisia. In addition, encouraging discoveries have recently been made in the United Republic of Cameroon, Dahomey, Ghana, Senegal and Zaire, particularly offshore. In addition to petroleum, there are natural gas reserves in Algeria, the Congo, Egypt, Gabon, the Libyan Arab Republic, Morocco, Nigeria, Rwanda and Tunisia.

14. There are good prospects of further oil discoveries in basins with existing reserves such as the North African Atlas area in Tunisia, the North African Platform stretching from Morocco to Egypt; the Gulf of Suez and the Red Sea basins; the Nigerian and West African coastal basins; and the Niger delta and Congolese basins. There are also good prospects of discoveries in the coastal basins of East and southern Africa and other basins in the interior of the continent; potential reserves are predicted along the other coasts and in deeper waters. In line with the production of crude oil, the consumption of petroleum has made a steady increase in Africa reaching in 1973 a total of 48.6 million metric tons (see annex V). During the period from 1970 to 1974 the consumption of petroleum products increased by over 39 per cent. In 1973, Egypt led the developing countries of Africa in the consumption of petroleum products with about 7.8 million metric tons. It was followed by Algeria with 2.9 million metric tons and Nigeria with 2.5 million metric tons. In addition to these three countries, other African nations such as the United Republic of Tanzania and Zaire increased the rate of their consumption during the period 1970 and 1974 by about 100 per cent. The per capita consumption of petroleum in Africa was in 1974 only 1.7 per cent of the world average. Although Africa as a whole is a net exporter of energy, the great majority of developing countries in Africa have remained net importers of commercial energy, principally petroleum. In 1972, the energy deficit developing countries of Africa imported nearly 15 million metric tons of refined petroleum products and 26.33 million metric tons of crude petroleum. About 23.98 million metric tons of the total crude oil (see annex XI) imported by African countries in 1972 (some 91 per cent of total requirements) were obtained from other African countries (11 per cent) and the Middle East (80 per cent). It is estimated that imports of crude petroleum and refined products rose substantially in the last years. The burden and pressure on the balance of

trade and balance of payments caused by the quadrupled prices of petroleum and petroleum refined products in the last few years has been excessive for the developing countries of Africa and has, in many cases, resulted in a slackening of economic activity. 1/

15. Apart from liquid petroleum, oil shale deposits have been reported in many developing countries of Africa including Egypt, Gabon, Madagascar, Mali, Morocco, Niger, Somalia, Uganda and Zaire. Other African developing countries like Ghana, Nigeria, Ivory Coast and Madagascar are known for their deposits of tar sands which are also potential raw materials for crude petroleum and petroleum products.

Present situation of petroleum refining industry in Africa

16. In 1974, more than thirty petroleum refineries were in production in African developing countries, the majority being operated on crude oil produced locally and others on imported raw material. Out of a total installed capacity of 93.8 million metric tons in 1974, about 68 per cent belonged to developing African countries (see annex VI). An important consideration for the establishment of crude petroleum refineries was primarily the local demand which in 1960 amounted, for refined products, to about 18.6 million tons with the largest consumers being Egypt and Algeria. In 1970 the demand for the same products was about 37 million tons which led to a per capita increase of refined products from 60 kg to 85 kg. The total crude oil consumption in Africa in 1960 was about 6.8 million metric tons, a figure which was close to Africa's refining capacity during the same year. In 1970, the consumption of crude oil in Africa amounted to about 42 million metric tons, a figure which showed an increase of about 500 per cent compared to that of 1960, but one which was approximately equal to Africa's refining capacity in that year. In 1960 African countries imported 2.65 million metric tons of crude oil and 15.2 million metric tons of refined products. In 1970 their imports increased to about 21 million metric tons of crude oil and decreased to some 13.7 million metric tons of refined products.

17. The considerations in chapter II strongly indicate the need to strengthen and expand the petroleum refining industry in Africa. An additional consideration for increasing the remaining capacity of Africa is the demand of the industrial sector including the electricity generating subsector and transportation. Although no

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1/ As stated in the report of the "Regional Conference in Petroleum Industry and Manpower Requirements in the Field of Hydrocarbons", held at Tripoli from 2 to 12 February 1974, "the African countries at the present time fall into four categories. The first group consists of countries which produced substantial quantities of petroleum for export and the second group meets of their national requirements from their own production and export some portion of the production. A third category of countries are without crude petroleum production but have their own refineries and the fourth category concerns those countries which have no crude oil production nor petroleum refineries and have to import all their requirements of finished products. Approximately half of the countries of Africa fall within the fourth category and the list includes most of the land-locked, least developed of the developing countries of Africa. It also includes five of six countries of the Sahel Zone."

detailed [illegible] available the share of refined petroleum consumption in the industrial sector, [illegible] indicates a sharp increase. The same situation is true for [illegible] although thermal generation still predominates in spite of the [illegible] Africa's great hydro-electric potential, although not evenly distributed among the African countries. With regard to transportation, about 3.1 million passenger cars and 1.1 million trucks and buses were registered in Africa in [illegible] a total of 7.6 million metric tons of gasoline consumption (see annex V). In spite of the increase in the number of private cars in practically all African countries, the level of mass transportation continues to be relatively higher in these countries.

18. An extensive programme of refinery construction was carried out during the last decade and while there were only seven refineries operating in Africa in 1960 with a total capacity of about [illegible] million tons, in 1973 the number has risen to about 31 refineries in the developing countries with a total capacity of about 40 million tons.

19. Initially, the main refineries in Africa were built in the crude oil producing countries, mainly in North Africa, and with rather small capacities limited to 1 million metric tons per year.

20. In the past, the crude oil processing capacities varied in the developing countries of Africa from 150,000 tons per year in the Libyan Arab Republic to about 3.5 million metric tons per year in Egypt. At present more than half of all refineries belonging to these countries have capacities between 500,000 to over 1 million metric tons per year. About 59 per cent of the total capacities installed in developing countries and 36 per cent in Africa are located in the North African countries. Among the rest of the countries Nigeria has the highest capacity with about 3 million metric tons per year in one refinery.

21. The production of all refineries in the region was steadily increased from 21.4 million metric tons processed crude oil in 1965 to about 53.8 million metric tons in 1974, an increase of about 150 per cent. Based on the information published in 1972 when a survey concerning the operation of 16 refineries was prepared, 2/ the majority of the refineries in Africa are operating close to 100 per cent installed capacity. The same survey indicated that some refineries, such as those in Morocco, Mozambique and in Tunisia are operated at 110 and 135 per cent of the nominal capacity following some technical improvements.

22. Most of the refineries in the developing countries of Africa undertake standard operations such as atmospheric and vacuum distillation, catalytic reforming of naphta and catalytic cracking of middle and heavy distillates. The pattern of fuel production corresponds accordingly to the production of LPG, gasolene, naphtha, kerosene, jet fuel, gas oil and residual fuel oil (see annex VIII). Non-fuel products such as lubricating oils, bitumens paraffin wax and petroleum coke are also produced in rather large quantities. In accordance with the latest statistics (see annex VII), in 1973, all the refineries produced, 520,000 tons of LPG, 780,000 tons of naphtha, 7.78 million tons of motor spirit (gasolene), 2.94 million tons of kerosene, 1.66 million tons of jet fuel, 10.69 distillate fuel oil and 16 million tons of residual fuel oil. As in other developing countries, the bulk of production during

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2/ Petroleum Times, 28 January 1972.

the last years, is oriented towards middle and heavy distillates in view of the various needs for commercial energy and possible feed stocks for the petrochemical industry. From the analysis of the process structure of the main existing petroleum refining facilities which are presented in annex I, it appears that they are mainly oriented towards the conversion of crude oil mostly into the middle and heavy distillates and less into gasoline. From this point of view, the processing is more similar to the European type of scheme than that applied in North American refineries (about 35 per cent of a barrel of crude oil converted into gasoline versus 45 per cent in North America). It is also to be noted that the majority of refineries in Africa do not at present use to a great extent such processes as hydrocracking, alkylation, pentane isomerization, separation and purification of BTX, isomerisation of xylenes and recovery of sulphur which are closely related to the build-up of petrochemical feed stocks. It has also been observed that little has been done on pollution control in the refineries.

23. In general, all existing refineries are located close to the oil fields and the consumption and distribution areas are connected with pipe lines to transport crude oil and finished products. The majority of refineries are government owned or contracted through larger participation within the national companies including participation of foreign companies. In some subregions such as in the Central African countries, an arrangement at the political level, among the States members of UDEAC has led to an agreement on the location of two refineries in the United Republic of Cameroon and the Congo.

Future prospects and requirements of the petroleum refining industry in Africa after 1980

24. The main developments of crude oil refining capacities in Africa, summarized in annex 12 reveal that a substantial increase in capacity will take place before 1980. On the basis of the expansion capacities and new refineries under construction in 1975 and 1976 a net increase of about 276.33 b/day (about 14 million tons per year) of petroleum refining capacity will be developed by 1980. This figure represents around a 22 per cent increase over the existing installed capacity in 1975 of 61.7 million metric tons (see annex IX).

25. On the basis of the trend in the increase of consumption in Africa in 1980 of about 57,000 tons 1/ the effective consumption increase in 1980 would be about 19 per cent. This figure, together with the increase in refining capacity, correctly reflects the future trend in Africa. From the new investments planned and under construction in Africa, it is anticipated that the expected capacity of 75 million metric tons forecast for 1980 will reach about 150 million metric tons between 1985 and 1990, an increase of about 145 per cent over the 1975 installed capacity. A significant trend for the future concerns the sizes of the capacities of new refineries which in certain North African countries such as Algeria and the Libyan Arab Republic will reach about 20 million metric tons per year, as well as the variety of refining processes involved. It is expected that, in the crude oil producing countries in particular, substantial development will also be directed towards the establishment and diversification of the petrochemical industry.

1/ ECA secretariat, Regional Meeting on Petroleum Industry, Tripoli, 2-12 February 1974.

26. In the light of the above, the development of refineries in Africa for the purpose of meeting future requirements must take into account the limited resources of crude oil and the limited demand for petroleum products, forecast for the years after 1980. The African countries dependent on imports of crude oil would need to take the necessary steps to optimize the production of fuels and petrochemical products. In this respect important efforts should be also made in oil producing countries to make use of associated gases which are now still burned off as well as to integrate natural gas recovery with the production of first generation petrochemicals. In view of the large possibilities existing in the African crude-oil producing countries, as well as the interest of African crude-oil importing countries in maximizing their profits from the processed crude oil, appropriate consideration should be given in the future to the establishments of petrochemical refineries. This is particularly important since mere conversion of crude oil to petrochemicals through a combination of well established refinery and petrochemical processes is technically feasible but, under normal circumstances existing in developing countries, hardly economic. The most economic facility would generally, therefore, be to produce a combination of petrochemicals and petroleum products.

27. Under any circumstance, the key aspects which any investor must define and investigate include the desired spectrum of petroleum and petrochemical products; crude oil sources; optimal degree of crude conversion to petrochemicals; and optimal configuration and individual unit capacities of the petrochemical refinery.

28. As an illustration basis for further discussions as described in the technical literature, 4/ six possible configurations of petrochemical refineries are considered on a nominal capacity of 1.5 million metric tons per year, which is close to that of future average African refinery. The relevant investment and processing costs, based on United States Gulf Coast figures from December 1974, cover all charges but do not cover the cost of crude oil.

29. Figure 1 is typical of existing facilities.

30. Crude is fractionated in an atmospheric distillation unit into naphtha and lighter material as feedstock for a pyrolysis unit, middle distillates and heavy fuel oil (atmospheric residuum) which are desulfurized.

31. The aromatics contained in the pyrogasoline are extracted and separated and the raffinate is recycled to the pyrolysis unit. The small amount of relatively high octane heavy gasoline produced can be marketed or consumed internally.

32. The hydrogen generated internally through steam reforming makes the facility self-sufficient. The configuration requires the lowest investment cost but produces the lowest yield of petrochemicals. Under the conditions existing in developing countries, the olefin unit with a capacity of just over 200,000 tons per year of ethylene is of economic size and can successfully provide the basis for a second generation petrochemical industry. Similar considerations can be made on the production of aromatics which can be easily sold on the international market and/or enable the country gradually to develop its own facilities for synthetic fibres and plasticisers.

4/ Hydrocarbon Processing, 11 November 1974.

ATMOSPHERIC DISTILLATION AND PYROLYSIS OF NAPHTHA FOR FUELS AND PETROCHEMICALS

(DISTILLATION ATMOSPHERIQUE ET PYROLYSE DES NAPHTAS POUR LES FUELS ET LES PRODUITS PETROCHIMIQUES)

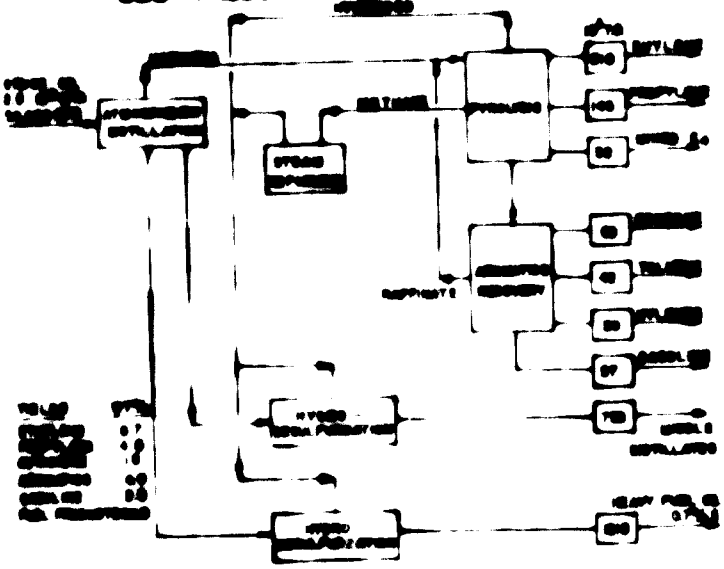


Figure 1

(DISTILLATION ATMOSPHERIQUE ET PYROLYSE DE TOUS LES DISTILLATS ATMOSPHERIQUES POUR LES FUELS ET LES PRODUITS PETROCHIMIQUES)

ATMOSPHERIC DISTILLATION AND PYROLYSIS OF ALL ATMOSPHERIC DISTILLATES FOR FUELS AND PETROCHEMICALS

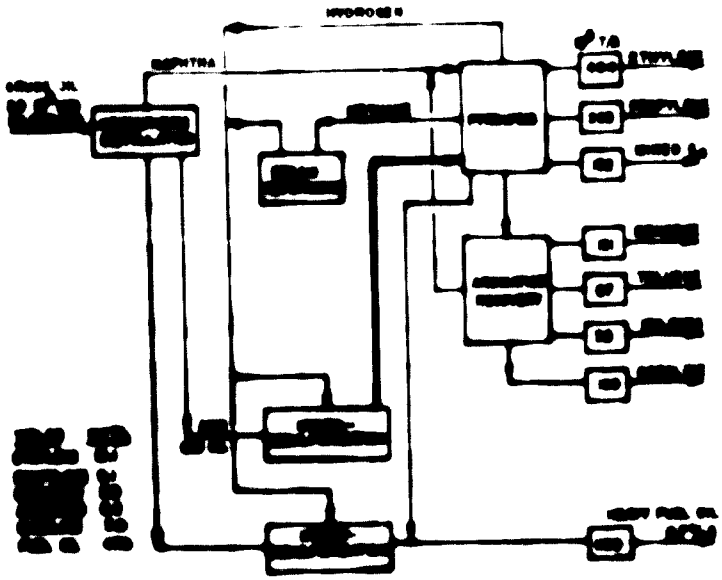


Figure 2

33. Figure 4 is similar to Figure 3 except that the middle distillates are sent to the pyrolysis unit. In countries where this configuration may be used when jet fuel, diesel oil and/or home heating oil are not to be marketed but the demand for petrochemicals can justify such an arrangement.

34. The total yield of petrochemicals increases substantially. A total of 900,000 tons per year of petrochemicals can be produced from 4.5 million tons per year of crude oil. The hydrogen produced in the pyrolysis balances the requirements of the desulfurization units.

35. Since the investment cost increases with the capacity of the pyrolysis unit this should be properly designed in order to achieve the needed flexibility for processing naphtha and gas oil in any ratio.

36. Figure 5 adds only a vacuum distillation unit to produce addition feedstock for the pyrolysis unit which increases the yield in petrochemicals to about 42 per cent.

37. The yield of petrochemicals from vacuum gas oil is low as a consequence of the lower hydrogen content of raw material. As a result of using the direct oil quench system, less high pressure steam will be generated and the utility cost will be slightly increased.

38. A substantial portion of the pyrolysis feedstock (25 to 40 per cent of the feed) will be degraded to pyrolysis gas oil and heavy pyrolysis fuel oil. The pyrolysis gas oil (10 to 15 per cent on feed) can be further processed into a marketable product.

39. The heavy pyrolysis fuel oil (15 to 25 per cent on feed), with special precautions, can be used as plant fuel in boilers and fired heaters. However, it is uncertain to what extent it can be blended with vacuum tower bottoms and marketed as heavy fuel oil without further processing.

40. On the other hand, it can be an economically attractive source of naphthalene, premium coke, petroleum pitch and carbon black. Commercial processes similar to the hydrocracking process for the production of benzene from pyro-gasoline can be applied and readily yield high purity naphthalene.

41. Heavy pyrolysis fuel oil has been processed successfully for the production of premium electrode coke and petroleum pitch.

42. The configurations discussed so far provided for the separation of crude oil into suitable fractions but do not, with the exception of the desulfurization units, contain any real conversion units which would change the yield of crude oil fractions.

43. Two conversion processes may be of interest in this context:

- A hydrocracking unit can convert heavy fractions into saturated light material which forms a very good feedstock for the production of olefin.

- Although it will not produce significant quantities of pyrolysis feed stock, catalytic cracking will be a substantial source of propylene and aromatics.

44. Figure 4 contains a fluid catalytic cracking unit for the vacuum gas oil.

45. In order to saturate the highly olefinic gasoline product, a hydrotreater must be added. This will provide an additional source for the aromatics recovery unit and the aliphatic components resulting after separation will be sent to a pyrolysis unit. The total petrochemical yield is now about 50 per cent. Investment and operating cost savings can be achieved in configuration 4, if environmental regulations do not impose desulfurisation of the feedstock to the catalytic cracking unit.

46. Figure 5 contains a hydrocracking unit which replaces the catalytic cracker and, therefore, leads to higher investment costs bearing in mind the associated hydrogen plant. A complex of this configuration would produce the greatest yield of ethylene (22 per cent) and a 51 per cent yield of total petrochemicals.

47. The hydrocracker is supposed to crack the vacuum gas oil, under moderate severity and with low hydrogen consumption, into atmospheric gas oil with a distillation end point of 376°C. It can be designed however, to crack both atmospheric and vacuum gas oil to naphtha, in which case the total yield of petrochemicals would increase substantially.

48. The hydrocracking scheme represents the only viable route for heavy high sulphur crudes, which will in any case require fuel oil desulfurization and, without further conversion, give a rather low yield of distillates.

49. Figure 6 yields the maximum amount of petrochemicals from crude oil and a minimum of fuel products. The vacuum tower bottoms are severely hydrotreated to achieve maximum conversion to distillates.

50. Upto 70 per cent conversion of vacuum bottoms to distillates has been achieved commercially in residuum conversion units. The virgin and hydrocracked vacuum gas oil is further cracked by conventional hydrocracking to saturate the pyrolysis feed with hydrogen. The resultant pyrolysis feed then consists of virgin and hydrocracked atmospheric gas oil. Hydrocracked materials, owing to their high hydrogen contents, constitute good pyrolysis feedstocks.

51. Configuration 6 gives the highest yields of desirable petrochemicals, 59 per cent.

52. All six configurations offer ample flexibility for any refinery in African countries which is dependent on crude oil imports and has a limited market for fuels but good prospects for developing a chemical industry for either internal or export demand.

53. It should also be mentioned that for certain African countries the extraction and processing of oil from oil-shale and tar sands could in the future be of great importance. With the current improvements in tar-sands and oil-shale extraction technology and with the level of present prices for petroleum and petroleum products, it is obvious that countries like Egypt, Ghana, Mali, Madagascar, Uganda and Zaire should evaluate their deposits of oil shale and tar sands in the light of recent technology and comparative costs of production.

ATMOSPHERIC AND VACUUM DISTILLATION AND PYROLYSIS FOR FUELS AND PETROCHEMICAL

(DISTILLATION ATMOSPHERIQUE ET SOUS VIDE ET PYROLYSE POUR LES FUELS ET LES PRODUITS PETROCHEMIQUES)

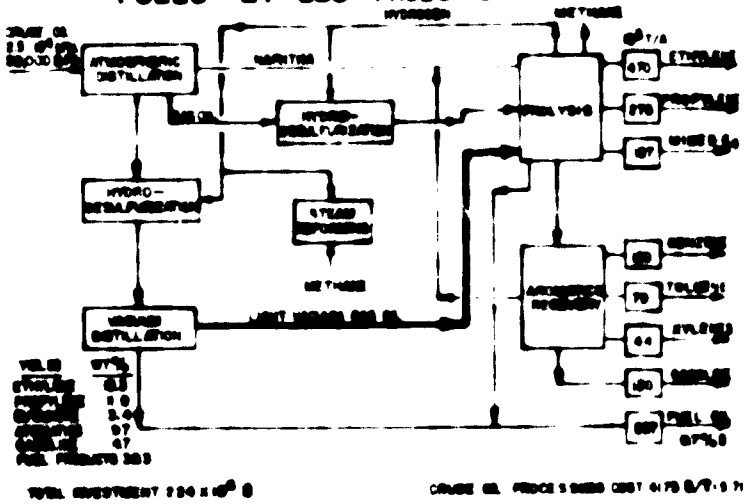


Figure 3

(DISTILLATION ATMOSPHERIQUE ET SOUS VIDE, CRACKAGE ET PYROLYSE POUR FUEL ET PRODUITS PETROCHEMIQUES)

ATMOSPHERIC AND VACUUM DISTILLATION, CAT CRACKING AND PYROLYSIS FOR FUELS AND PETROCHEMICALS

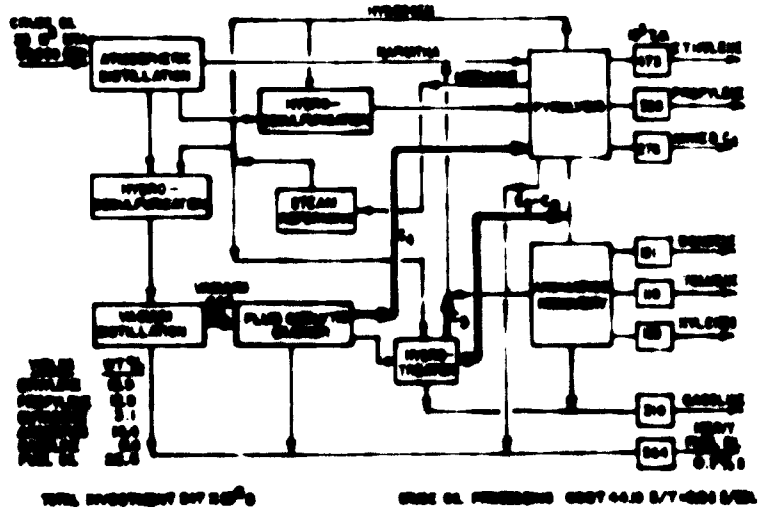


Figure 4

ATMOSPHERIC AND VACUUM DISTILLATION, HYDROCRACKING AND PYROLYSIS FOR FUELS AND PETROCHEMICALS

(DISTILLATION ATMOSPHERIQUE ET SOUS VIDE, HYDROCRACKING ET PYROLYSE POUR FUEL ET PRODUITS PETROCHEMIQUES)

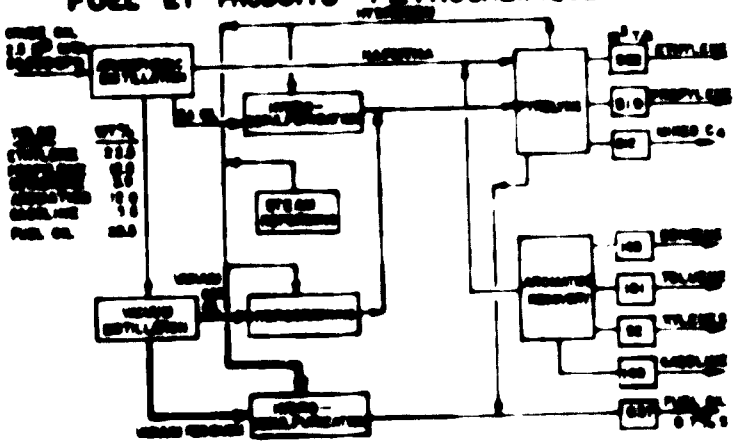


Figure 5

(DISTILLATION ATMOSPHERIQUE ET SOUS VIDE, TRANSFORMATION DES RESIDUS, HYDROCRACKING ET PYROLYSE POUR FUEL ET PRODUITS PETROCHEMIQUES)

ATMOSPHERIC AND VACUUM DISTILLATION, RESID CONVERSION, HYDROCRACKING AND PYROLYSIS FOR FUELS AND PETROCHEMICALS

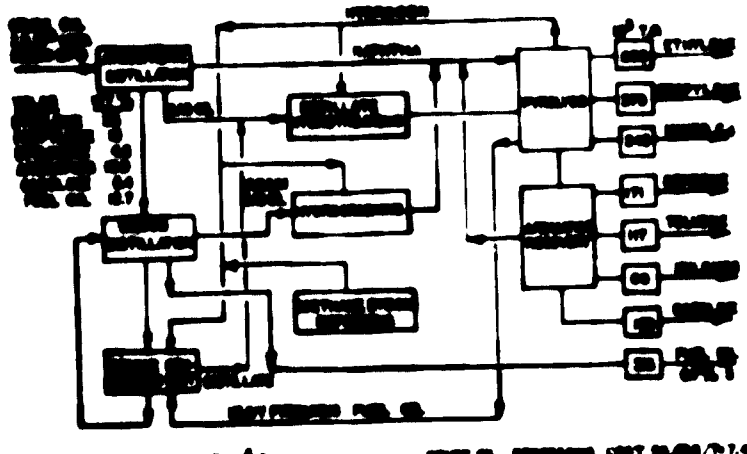


Figure 6

III. ESTABLISHMENT OF REFINERIES AT THE NATIONAL LEVEL AND POSSIBLE CO-OPERATION AMONG AFRICAN COUNTRIES IN THE ESTABLISHMENT OF PETROLEUM REFINERIES

General

54. The Lima Declaration and Plan of Action on Industrial Development and Co-operation recognised that the developing countries generate less than 7 per cent of industrial production, that the gap between the developed and developing countries has been widened owing to the persistence of obstacles in the way of the establishment of a new international economic order based on equity and justice. Therefore, recalling General Assembly resolution 3306(XXIX) of 14 December 1974 and taking into account the policy guidelines and qualitative recommendations made during the Second General Conference of UNIDO held at Lima from 12 to 26 March 1975, it was recommended that the share of developing countries should be increased to the maximum possible extent and as far as possible to at least 25 per cent of total world industrial production by the year 2,000.

55. This recommendation has a significant importance for the developing African countries with petroleum and related industries which make an important contribution to the overall development of national economies.

56. On the other hand, such a development is hardly conceivable without ensuring an adequate role for the State in the direction of industrial development in general and the strengthening of the public sector in the expansion of petroleum industries in particular. Of great importance in achieving this goal is the formulation of policies and the application of specific measures in the field of legislation, the location of future petroleum refineries, their capacities and range of products, man-power development, acquisition of appropriate technology and know-how, financing, development of infrastructure, marketing and distribution.

57. The petroleum refining industry can offer wide scope for co-operation among developing African nations themselves since already good experience has been accumulated in this field in several countries. Co-operation on a bilateral or multilateral basis can be extended to all relevant aspects related to the establishment or expansion of existing refineries including the evaluation and selection of technologies, maintenance and repair, development of infrastructure, training of the personnel, as well as the establishment of joint companies and research facilities. Similar co-operation can be also envisaged with the developed countries and international organizations such as UNIDO.

Legislative measures

58. It is necessary to adopt certain legislative measures in order to harmonise the petroleum refining industry with economic and social development policies and ensure consistency with other national legislation in accordance with the country's development plan and priorities. The legislative measures should cover every possible sector and subsector of the petroleum refining industry including planning and implementation. First of all, they should cover investment and the participation of public and private capital including regulations for re-investment of profits, depreciation, taxation and repatriation of foreign capital. Investment incentives would logically form part of this legislative sector, as well as the laws and regulations governing import and export duties for raw materials,

auxiliary chemicals and utilities, semi-finished and finished products, and last but not least the group of capital goods required for the construction of the refinery. Investment in infrastructure in the widest sense and balanced territorial development should also receive due consideration.

59. The second group of legislative measures should deal with the important area of the transfer of technology and know-how. They should be concerned with regulating the acquisition of foreign technology and proprietory know-how, patented or not patented, as well as with the purchase of capital goods and services. As far as possible specimen contracts with due safeguards for the purchaser and appropriate provisions for arbitration should be adopted.

60. Legislative measures should include national standards for construction materials and equipment as they relate to the problem of safety of operation and the prevention of hazards to life and property. The basic relevant legal requirements can be grouped under the following three headings: the law of negligence, the law relating to strict liability and statute law.

61. While the details of factory and similar legislation are too cumbersome to be discussed in detail in this paper, safety statutes consist of technical, administrative and retributive requirements. The technical requirements, added to other relevant national regulations, tend to form the bulk of the legislation. Administrative arrangements are important and the retributive sections setting out the various penalties simply function as a reminder that the matter is one of criminal law.

62. Another important area to be covered in the legislative measures for the petroleum refining industry concerns the protection of the environment. This is often erroneously minimized in several developing countries. Owing to specific climatic conditions, the provision of clean water to the cities and the countryside as well as for industry pose certain problems in African countries. Due consideration should, therefore, be given to providing legislation for the protection of the environment at a relatively early stage when planning the establishment of refineries.

63. The set of legislative measures elaborated by other groups of developing countries such as the Andean Group may well provide some interesting leads for the African nations. Areas where co-operation should be initiated are joint agreements on technology, particularly on the benefits of economy of scale, exchange of experience in the implementation of common technologies and the drafting of standard contracts for the purchase of technology, equipment and engineering services. Due consideration should be given to the harmonization of the pertinent legislation with the ultimate objective of adopting a joint position in international forums.

Selection of location, range of products and production capacity

64. In the world as a whole and in developing countries in particular, crude oil refineries face extraordinary challenges today because they have to: (a) obtain the adequate crude oil at reasonable prices; (b) find suitable sites for the expension of present capacities and/or establishment of new "grass root" refineries; (c) choose flexible technologies and a suitable range of products adapted to meet local and

international market fluctuations (d) operate more efficiently in order to overcome competition and (e) find sufficient investment capital to accomplish these objectives. Taking into consideration that Africa's petroleum products consumption represents less than 3 per cent of the world's and the output of its refineries is only about 2 per cent thereof, it is particularly important for the region to accord special consideration to all these factors. This situation is even more complex in the case of the African countries with no crude oil resources and with a growing demand for petroleum products, for any potential investor could be caught between the market requirements and insufficient crude oil supply.

65. Many African countries are contemplating a significant expansion of their petroleum refineries during the next few years. The location of these new refining capacities should be given particular attention. The location of a refinery apart from the technical and economic considerations, should be also judged from the point of view of a developing country on social considerations which have paramount importance in raising the standard of living of a certain region. In the case of developing countries with crude oil resources, where oil fields are located in remote areas and crude is easily carried through pipelines, it might be worth considering locating the refineries in consuming areas. This is particularly applicable to non-oil producing countries since crude is imported through harbours located in populated areas. In general, these areas usually possess the most highly developed infrastructural facilities (roads, railways, power and water supply, etc.) in the country which help to reduce total investment costs considerably. Although crude oil refining is not a labour-intensive industry because of the high skills required of its operators, it can also help professional schools in developing personnel for other related industries such as the chemical, petrochemical and fertilizer industries.

66. In view of the present local and export market demand in many African countries the range of products is limited, in general, to the standard refining products including bitumen for road construction and fuels for commercial power generation and motorisation. This does not, however, restrict the possibilities of providing full flexibility for producing some petrochemicals which can meet local and export demand. In this respect, the development of aromatics production including the xylenes together with the production of high octane gasoline may be mentioned as an example.

67. Except in the case of the oil-producing countries, the minimum size future refineries needed by the African developing countries seems to be between 1 million and 2.5 million metric tons per year. This size, although today not fully competitive in the industrialized countries, can be economically operated in developing countries to cover the local demand and to provide inputs for a petrochemical industry. The size of the refinery can, however, be reasonably well defined only after the elaboration of feasibility studies which can assess the various technical and economic factors. Another way of setting up large economic crude oil refineries (5 million metric tons per year and more) worth considering in Africa is through joint ventures between three or four neighbouring countries for the construction of a refinery which could cover their demands based on a joint distribution system.

Manpower development and training of personnel

68. In developing countries the manpower needs in the crude oil refining industry depend to a large extent on the development of the petroleum refining industry itself; the development of industries using the petroleum products either for energy generation or as feedstock for the petrochemical industry and on the overall social economic development of the producing country. Overall economic development, which is generally reflected by per capita income, seems, however, not to be a true index as revealed by the lower standards of living in many oil-rich countries.

69. The secretariat of the Economic Commission for Africa presented some information on manpower in the petroleum industry at the Regional Conference on Petroleum Industry and Manpower Requirements in the Field of Hydrocarbons held in February 1974, at Tripoli, Libyan Arab Republic. From the ECA estimates the future manpower requirements in Africa, based on calculated average rates of production, refining and marketing are summarised in table 1 below.

Table 1: Manpower requirements in Africa

Year and level	Exploration and production	Refining	Marketing and distribution	Total
1979				
High level	2 400	1 350	5 000	8 750
Middle level	4 000	10 975	21 450	36 425
Skilled and lower	25 400	21 700	195 550	242 650
Total	31 800	34 025	222 000	287 825
1980				
High level	7 150	2 200	6 540	15 890
Middle level	12 255	16 500	26 500	55 256
Skilled and lower	55 930	31 000	247 950	280 990
Total	75 335	49 700	280 990	406 025
Add for natural wastage	13 795	10 650	63 615	88 060
Grand total	89 130	60 350	344 605	494 085

70. The above estimates indicate that the additional manpower required up to 1980 for all the three activities of the petroleum industry would be about 206,000, out of which 148,930 (72 per cent) would be needed for refining, marketing and distribution. These trends also indicate that at the national level during the present decade a tremendous effort should be made in order to achieve this goal by all African countries. Special attention should also be given to the development of middle-level and skilled personnel.

71. Historically speaking, the training of local personnel in African oil-producing countries began when foreign companies operating in these countries started to employ local labour and technicians. In non-oil-producing countries, training began with marketing operations and later was extended to the refining of crude oil when refineries were established. The oil companies operated the training centres mostly by themselves not only to maintain efficiency but also to minimise government interference. Occasionally they helped local Governments in developing their own training facilities.

72. The training of university graduates started mainly when local nationals had been appointed to supervisory and middle-management positions. The content and levels of training given by oil companies, therefore, depended to a very great extent on the pattern of employment of local nationals. With the establishment of national oil industries, an important first requirement is the training of trainers and teachers. Higher-level educational and technological institutions have therefore had to grow parallel with vocational training centres and in-plant training. High-level educational training is covered in several African oil-producing and refining countries by a series of institutions such as oil institutes, universities and polytechnic high schools. Such facilities at present exist in Algeria, Egypt, the Libyan Arab Republic, Morocco, Kenya, Nigeria and the United Republic of Tanzania.

73. In addition, those African countries which started crude oil production and refining at an earlier stage have accumulated practical experience based on in-plant and on-the-job training, which can be successfully shared with other countries which have become involved in crude oil refining more recently. This could be accomplished through bilateral arrangements and conducted as an in-plant training programme particularly for middle-level personnel and skilled workers in such fields as the operation of plants and refinery equipment; repair and maintenance of equipment and instruments; and quality control.

74. A good opportunity for training technical personnel is offered to countries which have new investments in the field of petroleum refining. In the contracts relating to the supply of technologies, engineering and equipment concluded with specialised companies, provisions for training of the buyers' personnel in the refineries of developed countries should always be included.

Acquisition of appropriate technology and know-how

75. During the last 30 years over one hundred various technologies have been developed in the crude oil refining industry. Each technology has particular advantages when it is applied for the manufacture of a certain group of products provided that certain conditions are respected concerning the quality of raw materials and the economics of the overall process. As in other industries, the selection of the most suitable technology for a refining process is a difficult choice even in developed countries. Selection of the technology which in many instances includes a great deal of "know-how" (also frequently called trade secrets, unpatentable inventions or technical information), is more difficult since reliable information cannot always be obtained through the published sources or even from proposals of the process owner.

76. In general terms, in the case of a developing country comparing the available process, the following specific questions will need to be answered:

- Is the process technically suitable for existing local conditions?
- Is the process economical for its intended use and its performances proved on a commercial scale?
- Is it suitable for the conditions existing in the particular country and the skill of local personnel?

77. In crude oil refining, a correct evaluation and selection of the processes is also depending on the availability of basic data such as quality and quantity of feedstock, utilities and the selected site. These data and information should be collected and processed earlier in order to be ready for the call of tenders.

78. In many of the African oil producing countries where petroleum refining has already become a tradition, there are good prospects for competence in the selection of appropriate technologies. This is supported by the existence, at the government level, of specialized authorities and bodies which have already acquired enough practical experience. The situation is different in the non-oil producing countries, where the establishment of new refineries is being contemplated and existing facilities are operated on a reduced scale. This activity has recently become more difficult owing to the high price increase of crude oil, which reduces the overall economic benefits of certain processes.

79. On the other hand, with the exception of a few African countries, there is a lack at the government level of specialized agencies, including highly qualified local technical personnel, which can carry out feasibility studies for screening the various technologies. Usually, these types of activities are implemented through consulting firms, without consultation with or advice from other neutral consultants.

80. It is very well known that the cost of know-how and royalities in the case of sophisticated catalytic processes for petroleum refining could represent up to 20 per cent of total investment costs. This puts a heavy burden on the budgets of non-oil producing countries in particular, which have to pay special attention from the beginning to the correct selection of the most suitable processes.

81. Another aspect which is worthwhile mentioning here is the lack of national design and engineering institutes in the majority of the African countries. Such institutes can be established initially with the assistance of the respective Governments and can take over the design and engineering works for standard processes such as atmospheric distillation, storage tanks, off-site facilities, etc., not only for the refining industry but also for chemical and other allied industries. The experience of other developing countries like India has demonstrated that the creation of such institutes could provide important savings in the investment costs, together with the upgrading of local technical personnel.

82. Another means of improving the capacities of African countries in evaluating and selecting appropriate technologies is through regular consultations between the more advanced countries in crude oil refining and those which are beginning to develop. Such consultations, which can be organized with the assistance of international organizations, could provide guidelines and orientations adapted to the specific conditions existing in these countries.

83. One of the areas of co-operation concerns technical expertise and qualified experience in the selection and valuation of technologies which can be transferred from African countries with a longer tradition in crude oil refining to the countries which are beginning to develop in this area. This activity could also involve the exchange of experts and technical personnel who could assist in organizing special departments charged with responsibility for planning and evaluating petroleum refining technologies. Such a programme could be envisaged in stages, for example with the assistance of countries like Egypt and Algeria which could provide the necessary assistance to other developing countries.

84. More assistance can be channelled from the African countries with a longer experience in the field of quality control of the raw materials and end products in organizing laboratories and introducing new test methods in refineries in other countries. A thorough understanding of the specifications of petroleum products and their significance for practical application under the local conditions is of vital importance for the refining industry. Considerable experience has been acquired by other developing countries in this area. For example, the crude oil refineries in India have modified the specifications of some of the products to increase the yields from sour or heavier crudes e.g., the smoke point of kerosene for domestic use has been reduced from 20 mm to 18 mm and the sulphur content in diesel oil has been raised from 1 per cent to 1.2 per cent and heavier ends have been slightly increased. Such adaptation of products to the local need are often recognised even by international standards organizations such as ASTM and aim at obtaining an increase in "production flexibility". Such knowledge can be achieved only through a technical investigation and evaluation of products. This offers another area for possible co-operation among African countries and other developing countries in the establishment of research facilities as well as of pilot plants which can be shared by a number of countries. This co-operation could be arranged at the beginning between specialised research and development institutions from other developing countries like NIOC in Iran and the Indian Petroleum Institute at Dhra Dun in India. This type of co-operation should not concentrate in the beginning on too complex and sophisticated aspects but more on those which are related to the present problems confronting African refineries such as the application of products, studies on crude oil quality, corrosion in refineries, by-product and waste treatment and utilization.

85. The establishment of joint pilot plants could assist each country in knowing the crude oil they use and how they can upgrade its utilization. It is known that many developed countries in Europe, Japan and the United States concentrate on obtaining products of high value whose prices are high compared with the crude oil. One example can be offered by the lube oils, asphalt and coke which have prices twice that of crude oil. In contrast, refineries in major oil-producing countries produce mainly fuels and less high value products. Although not every crude can yield satisfactory lube oil through conventional technology, hydrotreating processes are suitable and enable its production from a variety of crude oils. Such investigations could be carried out jointly by a number of African countries in co-operation with other developing countries.

86. In the field of equipment there are also wide possibilities for co-operation among African countries as well as with other developing countries as in the field of the maintenance and repair of existing refineries by developing countries such as Egypt, India and Brazil, as well as by developed countries. The proper organization and strengthening of workshops in refineries could provide a sound basis for

the continuous operation of plants without unnecessary loss of production. At a later stage, the activities of such well equipped workshops could be expanded to include the manufacture of equipment like storage tanks and heat exchangers.

Financing

87. Before October 1973, the required total investment for a petroleum refinery was between US$ 500 and $1,000 per barrel per stream/day, varying with the complexity and number of processing steps, economy of size and site conditions. These figures have since risen to US$ 1,000 and US$ 1,500 for certain locations requiring a more elaborate off-site system of facilities; thus, the process units proper, they are even higher. Petroleum refineries on the low side of design capacities and consequently on the high side of investment requirements, therefore, generally cost around $ 40 million for the 1 million ton per year range.

88. Once the total investment required for the petroleum refinery project has been computed, on the basis of a feasibility study, the investment schedule should be set up. This investment schedule has a dual purpose: it is an input for the cash flow analysis and serves as the basis for financial planning. Most of the investment costs usually occur during the construction period and the start of operations generally takes place, in most developing countries, in year three or four, depending upon the complexity of the task.

89. Several financial institutions have emerged during the last quarter of a century to provide capital for new industrial projects in the public, joint and private sectors. Practically all developing countries have established some developmental financing institutions under diverse names, such as Industrial Finance Corporation, Industrial Development Bank, and the like. In most countries there is more than one institution available for project financing. Larger countries have established financial institutions at different levels, with special institutions catering for the requirements of smaller industrial projects.

90. Some international institutions provide foreign currency loans. Such sources are the World Bank (IBRD) and the International Finance Corporation (IFC), and some national institutions in industrialized countries, such as the export import banks of the United States and Japan. There are commercial banks also operating on an international or national scale which provide or participate in term financing. Relatively recent newcomers to this host of financing institutions are the Governments or, indirectly, the national oil companies of petroleum producing States.

91. Other financing schemes are deferred credit terms. Many suppliers in industrialized countries sell capital goods and related engineering services on deferred payment terms, with payments being spread over up to 15 years, with five- to ten-year periods being the most popular. Deferred payment terms are available against bank guarantees which help the suppliers to obtain financing facilities from their bankers.

92. The assistance available as institutional finance has grown to a point which makes it possible for the sound projects to be started with as little as 10 per cent of the total investment provided that the own development effort does not absorb a substantial part of the country's oil revenues.

93. The main partners in financing oil production in developing countries are the foreign petroleum corporations (governmental or transnational). The attitude of the developing oil producing countries towards this type of foreign participation varies in accordance with their national policies and the pertinent legislation.

94. However there exists another variant of financial co-operation which so far has not received much attention. This concerns joint ventures by two or more developing countries which, without economy of scale, would not be able to set up a petroleum refining industry with the participation of a company from a developing or industrialised country providing know-how and any technical assistance required for the erection and operation of the refinery. Appropriate legislative measures are absolutely necessary for the functioning of such a financial set up and should spell out precisely the duties and obligations of each partner. The failure of similar ventures has most probably been due to the lack of such legal instruments.

Development of infrastructure

95. The infrastructure for the petroleum refining industry and industrial development as a whole has two components. First is the intellectual capacity and institutional set up which exists in the country in support of the industry and of each of the inputs for industrial development. It can be compared to the "software" of computers. From this angle the sections of this paper dealing with legislative measures, manpower development, acquisition of appropriate technology and know-how, financing, petroleum supply and the marketing and distribution of petroleum products each contain an infrastructure component.

96. The other sphere through which infrastructure exercises its influence is its hardware effect. In the narrow sense, this concerns the immediate physical inputs for the refinery project into this category falls the availability at the petroleum refinery boundary of petroleum, auxiliary chemicals, water, labour force and electric power. Infrastructural hardware in a somewhat wider sense comprises facilities for bringing the petroleum to the refinery, the physical means for taking the products to the consumers, as well as housing and transportation for the labour force and related urban facilities.

97. In a number of developing countries some hardware infrastructure exists, although in most cases it had originally been designed in a way which does not fit into the present day situation and the development plans of the countries concerned.

98. While the evaluation of a petroleum refinery complex will primarily be based on the concept of commercial profitability, making the widest possible use of existing infrastructure, it will be the option of the Government of the developing country concerned to consider, in accordance with its development plans, the alternative locations and infrastructural developments best suited for its goals.

99. In this connexion, the cost/benefit criterion comes into play and the benefits attributable to and expected from the project are analysed against the background of the development policy adopted. There are a number of national and international financing institutions specialised in providing soft loans for infrastructural development.

100. In order to extract and highlight the thought underlying each of the related disciplines and the common philosophy for co-operation among African developing countries some aspects are considered to be particularly worth mentioning in this context. They include

- The exchange of information as appropriate on the transfer of technology and a unified approach;
- Joint preparation, financing and execution of research projects of interest to several countries;
- Exchange of experts, expertise and trainees
- Utilisation by a country of the laboratories and installations of another in order to promote a better use of human and material resources
- Creation of "specialized technology centres".

101. The hardware aspects of infrastructure concern mainly the transport and storage of petroleum and petroleum refining products, electric power transmission, water supply, plants and installations, protection of the environment and the supply of housing and transportation for labour. This subject presents another group of problems which lend themselves to co-operative efforts among the African countries, as well as with other countries, both developing and industrialised. Pipelines and shipping by tankers with related harbour development and long distance electric power transmission may present the first problems to be considered, although such problems would obviously differ according to the region or the country. With the complexity and specific take-off constraints faced by many African countries now, original and unorthodox steps towards industrial development in general and the establishment of a petroleum refining industry in particular may sometimes have to be applied. The utilisation of wasted flare gas in oil fields for large-scale generation of cheap electric power and its transmission to countries and places which are in urgent need of energy for their economic take-off but which are handicapped by the economy of scale is one example. A recent practical example of co-operation among developing countries on infrastructure which can be considered by African countries is the credit granted by Iran for harbour and infrastructure development in Turkey. This move will benefit the exports of Iranian hydrocarbons, while helping Turkey to enhance its shipping facilities.

Marketing and distribution

102. The refining industry requires a careful analysis of the marketing and distribution pattern. When an oil refinery is likely to be the sole supplier of products on the market and the probability of market insulation by Government policies or through tariff or quota protection is high, the entire market demand may be the limit within which the sales target may safely be fixed.

103. A problem arises when other refineries or importers of petroleum products already exist or are likely to enter the market or expand their operations. This problem is of course easily resolved if the total demand is not likely to be exceeded by the existing suppliers taken together. A market analysis in most developing countries follows the techniques of economic development planning and is based on targets relating to capacities established in development plans for different industries and, in particular, for such vital basic industries as petroleum refining.

104. It might be worthwhile enacting legislation or regulations governing industrial development or adopting some form of industrial licensing to ensure that capacities in excess of targets are not created. With a detailed knowledge of total demand, the prevailing price levels and structure and response of the market, it would be possible to envisage a market strategy capable of achieving the target sales. The strategy should include the fixation of product prices; creation of a sales organization; appointment of distributive outlets; fixation of trade discounts and commissions; sales promotion and advertising; trade marks and standards of packaging (e.g., for lubricating oils); distribution system; after-sales service; consumer advisory services; export market system, where required; and consumer contacts, feedback and research. Specifying distribution channels and sales strategy is such an important subject that attention should be devoted to it at the early stages of feasibility studies. Market penetration should also be programmed during the pre-production stage if an economic level of production is to be obtained without much loss of time.

105. In African countries the marketing of petroleum products has been developed recently. As in the other fields, the major contribution came from the foreign companies who introduced their own market and distribution techniques which were transferred to and adopted later by local personnel. However, after independence, the heritage of foreign companies was not always completely in line with the new interests and goals of the African petroleum industry. Therefore, even African countries with a more developed petroleum refining industry are constantly interested in adapting their market strategy to new local and export requirements.

106. In the next five years Africa will need about 59,000 additional trained people for the marketing and distribution of petroleum products. Such a task can be successfully fulfilled only if the necessary steps are taken now through arrangements at the Government level in order to train personnel with the assistance of other African countries, developed countries and specialized international organizations.

107. In this respect, of special interest and utility for the African developing countries are the training programmes organized on a regular basis by companies in developed countries, as well as the fellowships provided by United Nations agencies. An exchange of experience with other developing countries like Iran, India and Venezuela can be also considered when the local conditions and difficulties which should be overcome are practically the same.

IV. POSSIBLE CO-OPERATION BETWEEN THE AFRICAN COUNTRIES AND UNIDO IN CO-OPERATION WITH ECA

Previous activities of UNIDO in petroleum refining

108. The United Nations Industrial Development Organization (UNIDO) was established on 1 January 1967 by the United Nations General Assembly as an autonomous organization within the United Nations system to promote and accelerate the industrialization of the developing countries. The General Assembly also gave UNIDO the central role in co-ordinating all the activities of the United Nations system in the field of industrial development. The headquarters of the organization are at Vienna, Austria.

109. UNIDO carries out its task in two main ways: through operational activities, involving direct assistance to developing countries, and through related supporting activities, which include action-oriented studies, training and research. In addition, it has a third and growing function of promoting direct contact between the financial and business communities in the industrialized world and their counterparts in the developing countries, for the benefit of both.

110. Governments are assisted, on request, at every stage of their industrial growth, from the drawing up of an overall national industrial development plan to the selection of equipment and the training of staff for a single factory. They are helped to manufacture goods making use of their natural resources, raw materials or by-products, to acquire technology and adapt it to their needs, to promote domestic investment and external financing for industry, and to develop products suitable for export. Assistance is also given, on request, to set up or strengthen national organizations serving local industry, or to develop industry on a regional basis.

111. Assistance takes the form of expert or consultant services for periods ranging from a few weeks to several years, equipment and fellowships for nationals of the recipient country to be trained abroad.

112. In an effort to achieve effective co-ordination of industrial projects in developing countries, UNIDO, in agreement with the United Nations Development Programme, has outposted a number of Industrial Development Field Advisers, who are in direct contact with member Governments and the Resident Representatives of UNDP, on specific matters relating to industrial development and the formulation of requests for technical assistance.

113. To increase the effectiveness of its field operations UNIDO conducts expert group meetings, seminars and training programmes and undertakes research. These headquarters-based supporting activities can deal with specific industries and techniques or with basic industrial issues such as planning, management, investment or quality control. The exchange of views on these issues often gives rise to conclusions and recommendations for further action and these are widely disseminated.

114. Acting as a clearing house for industrial information, UNIDO compiles analyses, publishes and disseminates a variety of data, and answers enquiries from Governments, semi-public bodies and industrial enterprises of all kinds. In addition, the Industrial Information Service maintains a register of consultants and developing countries can be advised on available consulting skills and services as well as on the choice of industrial equipment.

115. UNIDO also organizes in-plant training programmes, in which engineers and technicians from developing countries acquire practical experience in factories in the advanced countries.

116. The activities of UNIDO in the field of crude oil refining have been closely co-ordinated with the needs of developing countries for establishing new refineries and/or increasing the output and efficiency of existing ones. Technical assistance has also been provided for the adaptation of existing and new refining facilities in producing feedstocks for the petrochemical industry.

117. Among the highlights of the projects implemented during the last years are:

- Review by a group of experts of a feasibility study for a crude oil refinery in the Gambia with a capacity of 1 million tons per year

- Assistance to the Homs Refinery in the Syrian Arab Republic in the establishment of a testing and quality control laboratory

- Assistance to the Syrian Refinery in Burma in the expansion of its research and quality laboratory;

- Assistance to Indian Oil Corporation (IOC) for strengthening the public sector of the petroleum refining industry through the provision of modern expertise and technical training of IOC staff;

- Assistance in the production of catalysts for the petroleum refining industry in Iran;

- Assistance to the Tanzanian Petroleum Development Corporation in expanding the capacity of the TIPER Refinery to 1.8 million tons per year;

- Assistance in establishing mechanical inspection and preventive maintenance services to the Homs Refinery in the Syrian Arab Republic;

- Assistance to the Syrian Refinery in Burma in the in-plant training of refinery operators through the supply of an expert and process simulation equipment;

- Assistance in the operation and maintenance of the Eastern Oil Refinery (PETROBANGLA) in Bangladesh through the provision of experts, fellowships and simulation equipment for in-plant training.

118. Several petroleum engineers from developing countries are trained each year through the individual UNIDO fellowship programme in developed countries. An in-plant training programme in the petrochemical industry which includes basic training in the operation of petroleum refineries with a duration of 9 weeks is organized on a regular basis each year for an average group of 16 to 20 participants from developing countries.

119. New projects in the same field are in an advanced stage of preparation for implementation in 1976. This group includes the UNIDO/UNESCO large-scale project on assistance to Application of Products Division of the Indian Petroleum Institute, Dehra Dun, and the establishment of a crude oil processing pilot plant in Yugoslavia.

120. Summarising the UNIDO capabilities in the field of technical assistance, independent of any bilateral and/or multilateral negotiations and arrangements the interested country may have for the development and implementation of a certain project, UNIDO can always be considered for a second neutral and competent opinion. Its assistance can be provided from the initial stage of a project to its practical implementation in the form of experts, advisory services, fellowships, equipment for laboratories and pilot plants and feasibility and market studies.

121. Apart from the above-mentioned country programme, urgent projects can be implemented, at the request of the interested governments, from the Special Industrial Services Programme and Funds-in-Trust which are deposited for this purpose by developing countries.

Regional Petroleum Institute

122. UNIDO, as a specialized agency, will be able to provide in the future more technical assistance to petroleum refineries in developing countries in all aspects ranging from management, operation and maintenance of refineries, equipment and feasibility studies to personnel training, storage and distribution of petroleum products. The way in which this technical assistance could be supplied depends to a great extent on the receiving countries and the specific conditions existing in each of them. It is a great advantage of the present long-range planning of technical assistance supplied under the country programming system which enables UNIDO to assist the developing countries over several years.

123. Among the large-scale projects involving UNIDO assistance to the developing countries is the establishment of Regional or Subregional Petroleum Institutes. Such institutes could be set up in any of the four main regions of Africa (North, East, Central and West) for direct assistance to the refineries of the countries in the area. The institutes could consist of a group of highly qualified international and local experts, equipment and instruments for laboratories, pilot plants and training facilities. They could assist in the elaboration of short-term and long-term programmes on the trend of petroleum products consumption in member countries; preparation of feasibility, market and pre-investment studies on the development of refineries; trouble shooting; quality control; training of local personnel and the establishment of related national research, design and engineering institutions.

Manpower development for petroleum refining

124. UNIDO could assist in developing efficient training programmes for various levels of technical personnel involved in petroleum refining by organizing, in co-operation with other international organizations and suitable centres, in-plant training programmes. The programmes, with a duration of about two months, would usually involve 20 to 25 participants and could be arranged each year on a regular basis. UNIDO could also provide basic in-plant training on the operation and maintenance of refineries drawing upon the experience of other countries and could arrange visits to refineries in developed and developing countries. Such programmes could also be arranged for individuals.

Feasibility studies

125. The main objective of a conventional economic feasibility study is to identify and to evaluate the economic outcome of a proposed project so that whatever funds are available are used to the best or at least to good advantage. The feasibility report must provide in readily understandable form all the data needed by top management and executive authorities to reach a sound economic decision regarding the disposition of large sums of money. The feasibility study determines which of several different ways a project should be carried out, or whether the project should be carried out at all. Accordingly the feasibility study should help in predicting the outcome of proposed expenditure in financial terms so that available

funds are put to their most advantageous use. There are several steps involved in a complete engineering-economic analysis. These include: understanding the problem; definition of the project objectives; collection and interpretation of data; advice on alternative solutions; evaluation of the alternatives; identification of the best alternative; and monitoring of the results. The first few considerations make up the usual feasibility study and when they have been completed a feasibility report is generally required so that appropriate management action can be taken to initiate the project. The feasibility report should summarize the important features of the proposed project in a brief but impressive presentation.

126. It should be noted that the term "conventional" has been used to focus attention on commercial profitability. In developing countries new industrial projects are usually evaluated in accordance with the Government's development policy, which sometimes extends the parameters of evaluation to direct and indirect national benefits and cost related cost/benefit analysis. It is of utmost importance that all these factors are known and properly specified before a study is undertaken.

127. UNIDO has been involved in numerous feasibility studies conducted by highly qualified staff members or consultants or consulting firms selected after rigorous screening. In the latter cases detailed specifications were prepared by UNIDO, in consultation with the relevant country in order to provide strict guidelines for the execution of the task, and headquarters monitored the progress in the field and at the home office.

128. UNIDO's services for the execution of feasibility studies, therefore, include the preparation of the specifications (terms of reference) and the monitoring of the study in close contact with the counterpart(s) designated by the Government throughout the whole study.

Advisory services for the transfer of petroleum refining technology

129. In addition to the above, UNIDO could also assist the African countries, upon their request, in the provision of technical advisory services for the transfer of petroleum refining technology.

130. During the initial stages of development, these advisory services could emphasize the evaluation of technologies for petroleum refining by comparing, through a group of consultants, experts and/or UNIDO headquarters staff, the tenders received from foreign companies. It could also assist in drafting terms of reference for more advanced studies involving one or more technologies for the same product(s) as well as in the preparation of tenders. During the negotiation stage for the acquisition of petroleum refining technology, UNIDO could also provide advisory services to the Government to ascertain the technical, legal, financial, and commercial implications of the technologies.

131. Technical assistance may also be supplied during the construction of refineries and their start-up through experts who can co-ordinate and supervise all the activities involving the participation of various foreign and local contractors in the engineering, construction, erection, and commissioning.

Improvement of existing petroleum refineries

132. Due to a variety of reasons petroleum refineries in developing countries may show deficiencies in operation and not perform to the originally designed specifications or never fulfill the guaranteed test run conditions. These shortcomings may be reflected in product mix, product quality, throughput per stream/day and down time. This could be caused by difficulties in the plant operation, erroneous design or improper choice of equipment items or equipment components, fouling of equipment or misinterpretation of construction drawings and might date back to the time when the plant was erected. UNIDO is in a position to assist developing countries in tracing the cause or causes of the troubles and to advise on improving the refinery performance through expert services in petroleum refinery operation, construction and maintenance.

133. In cases where the refinery operation conforms to the design specification, and in general to the conditions of contract, but where the economic result is not satisfactory, UNIDO could assist through economic analyses to pinpoint the problems and, by integrating the assistance with experienced refinery engineers, provide advice on the steps to be taken to make the venture profitable. These steps could consist of minor adjustments to the plant to increase its throughput by the so-called "debottlenecking" operation. This operation consists of determining the equipment items which can be operated at higher throughputs and those that cannot and by replacing the items which constitute the bottlenecks by more appropriate ones. Where more radical changes are required to make the refinery operation more profitable, possibly by increasing the capacity and widening the range of products, UNIDO could also provide advisory assistance on revamping existing process units.

V. CONCLUSIONS

134. There is a large interest among the major part of African countries in developing and expanding their refining capacities as part of their overall development toward a higher standard of living.

135. The steps taken already in this decade by many African countries to expand their crude petroleum refineries including the introduction of new technologies and new products open large prospects for a better co-operation between them and international organizations such as UNIDO. Technical assistance could be provided in particular in the field of the selection and transfer of technology, products, adaptation, establishment of national and multinational research and development facilities, quality control, feasibility and market studies, supply of equipment and training of technical personnel.

136. An important role is to be played in the field of co-operation between African countries and UNIDO by the Economic Commission for Africa and the Organization of African Unity which already in the past, as well as recently during the last United Nations Meeting on Co-operation Among Developing Countries in Petroleum, held at Geneva from 10 to 12 November 1975, proposed a significant number of recommendations which offer a good background for the implementation of this programme.

137. Among the main recommendations which can be also implemented with UNIDO technical assistance are the following:

(a) Periodic meetings [illegible] should be held to exchange information on the petroleum industry and in particular on experience in the field of the provision of advisory services;

(b) Each member State should designate experts to participate in the preparation of feasibility studies and in the formulation of subregional projects making use of assistance from intergovernmental organizations and specialized agencies;

(c) Petroleum products required in Africa should be produced and processed inside the continent and a co-ordinated plan for the establishment of refineries on the African continent should be finalized;

(d) The Governments of member States should assume effective control over all their energy resources and related facilities;

(e) Member States should take action to group together so as to enlarge their markets and to examine the possibility of establishing petrochemical industries to serve subregional markets.

138. Another group of recommendations to the African States could also be considered as a possible area for future co-operation with UNIDO:

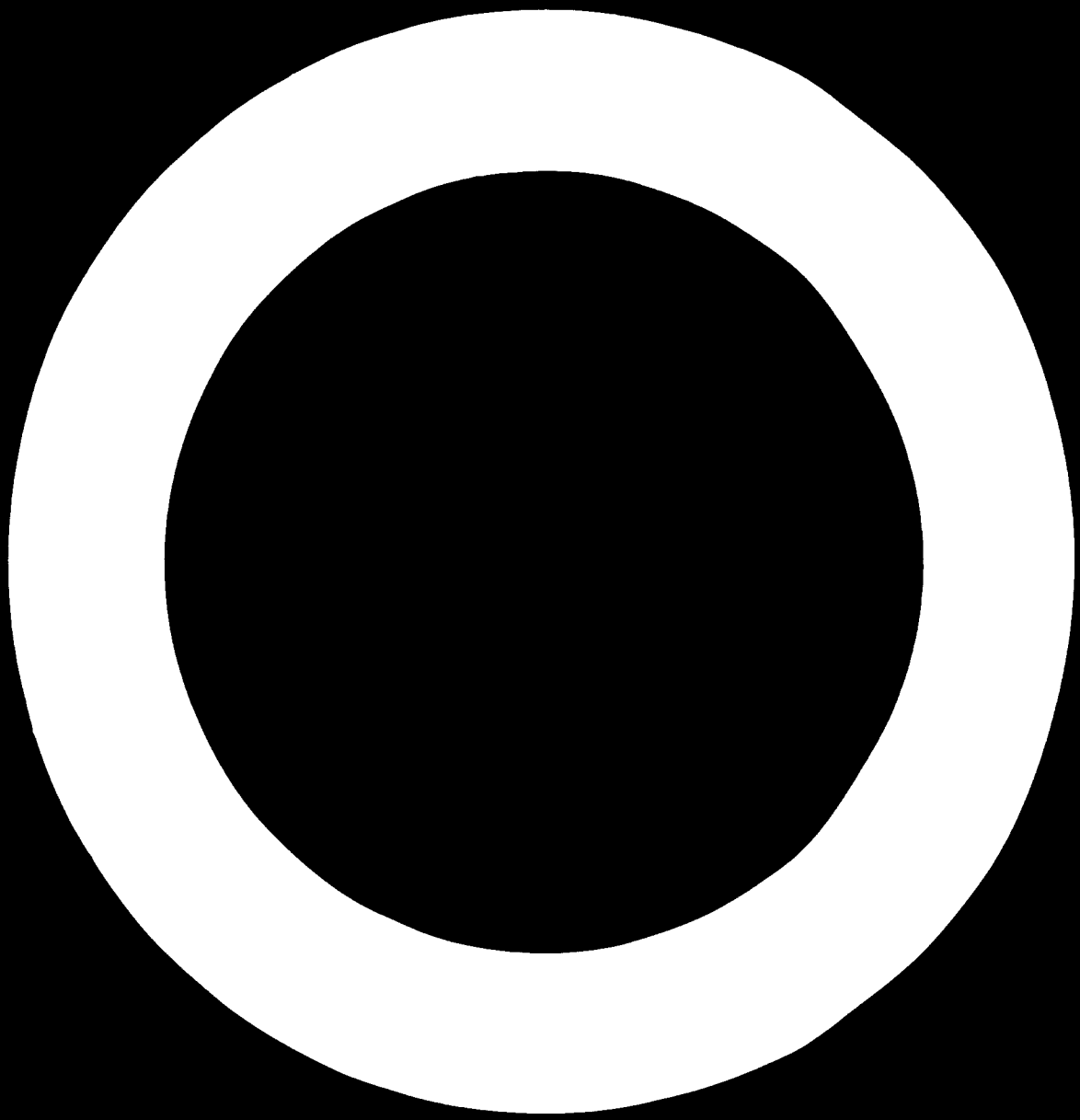
(a) Co-operation in carrying out a survey of all existing training and research facilities and manpower requirements in the field of petroleum and proposals regarding the establishment of new centres or institutions, if required;

(b) Development of a joint plant to reinforce the activities of existing training centres and institutions;

(c) Encouraging the use of existing and future facilities by nationals of African countries;

(d) Promoting the development of research institutes and the establishment of an African Petroleum Institute, an African Petroleum Organization and an African Documentation Centre on Petroleum.

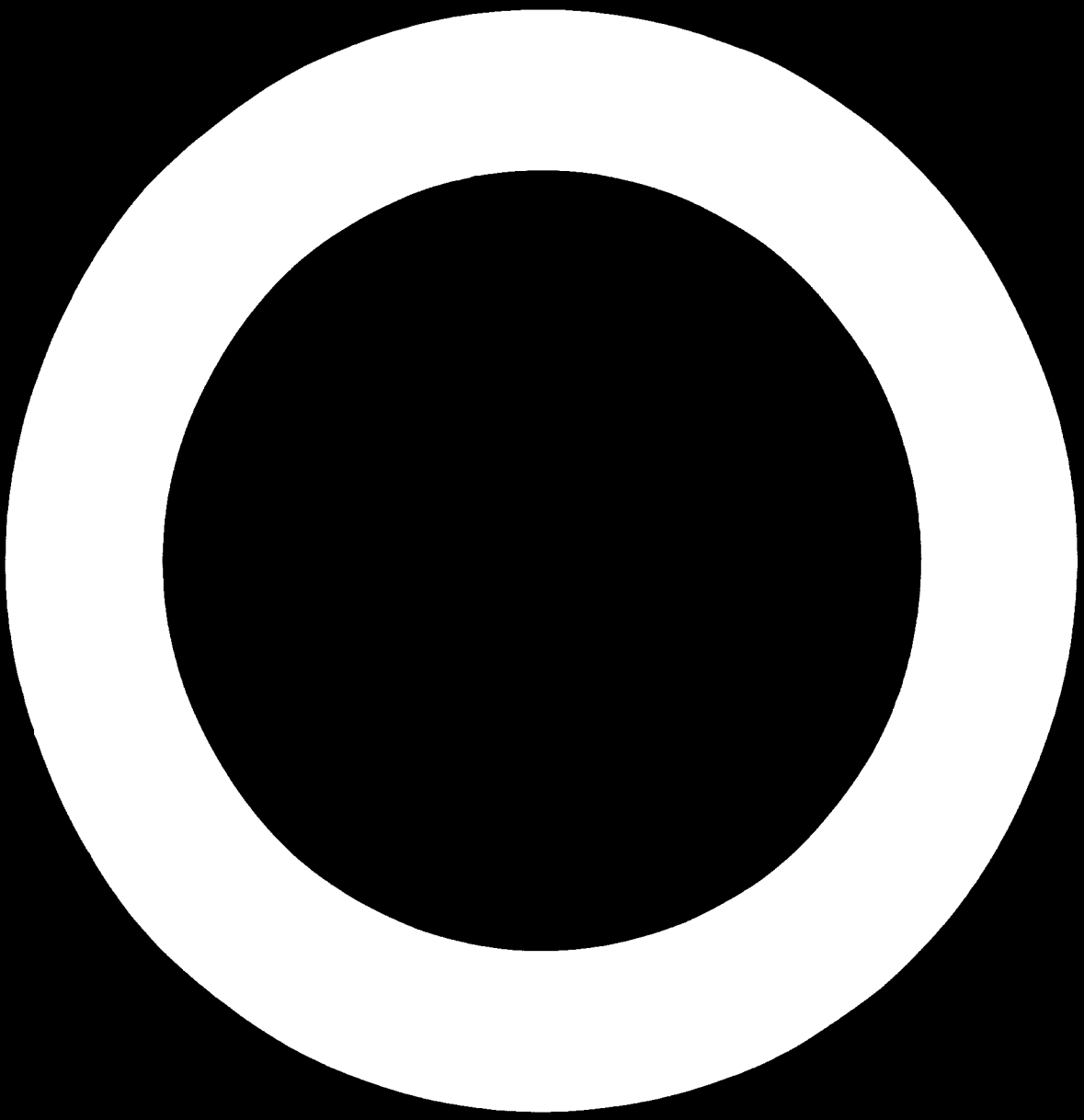
139. It is hoped that through the recent restructuring processes within UNIDO as a direct outcome of the Lima Declaration and Plan of Action on Industrial Development and Co-operation, there will be more capability and flexibility to fulfill these important duties for the benefit of all African nations and increase their share in the world petroleum industry.



WORLD PETROLEUM RESERVES AND PRODUCTION

		Oil reserves (1974) Million metric tons	Gas reserves (1973) Million million c.m.	Crude oil production (1973) Million metric tons	Natural gas production (1973) Million c.m.
1.	Western Europe	2 192	5.5	20.0	251 743
2.	Socialist countries	14 109	20.8	465.0	283 309
3.	North America	6 041	8.4	549.0	738 930
4.	Middle East	47 973	11.7	1 069.0	50 136
5.	Africa	9 219	5.3	251.0	9 509
6.	Far East	2 137	3.2	113.0	17 [illegible]
7.	Latin America	4 329	2.6	257.0	14 831

Source: International Petroleum Encyclopedia, 1974.

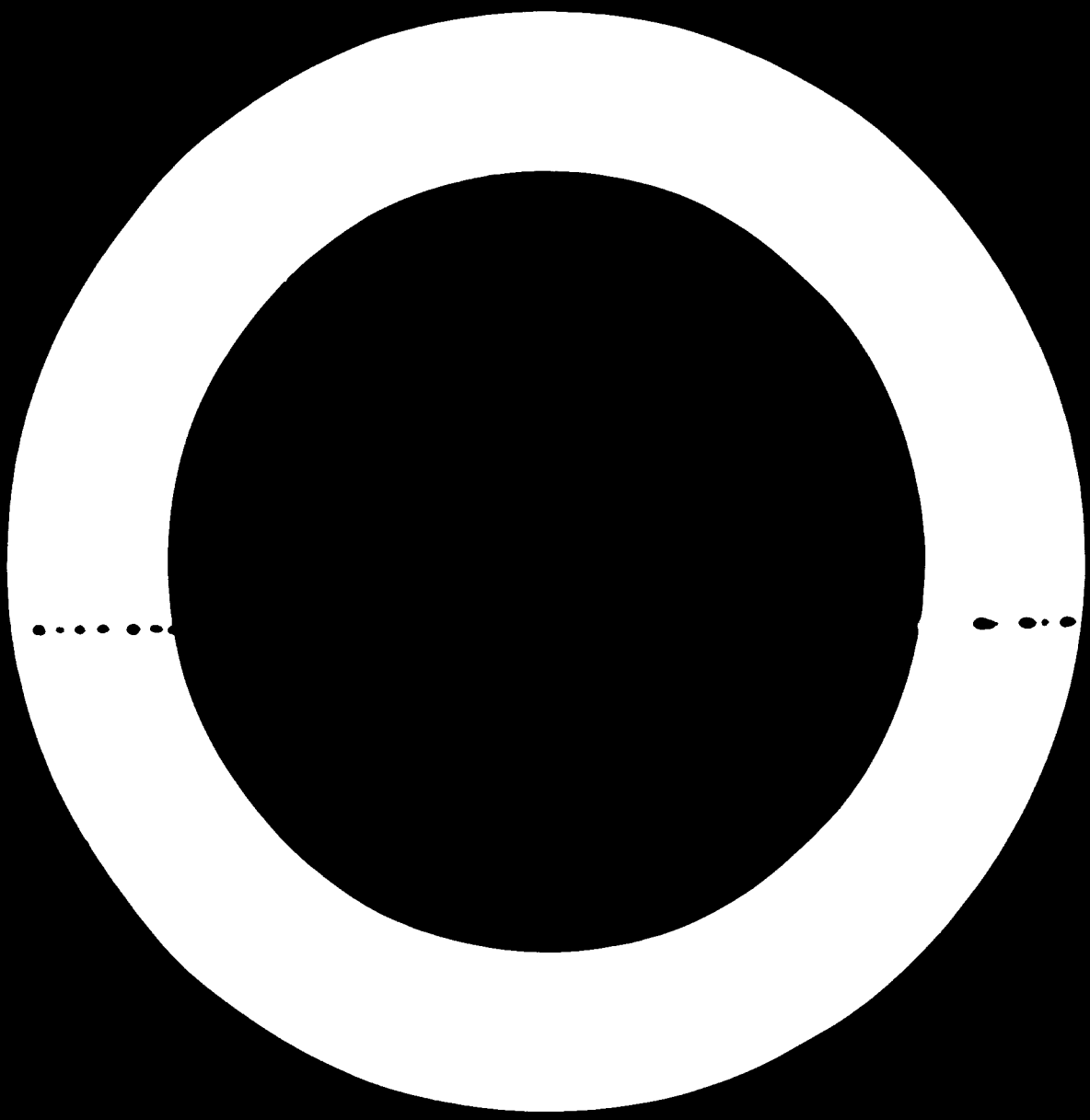


PRODUCTION OF PRIMARY ENERGY

(Quantities in million metric tons of coal equivalent)

		Total primary energy	Coal and lignite	Crude petroleum	Natural gas	Hydro- and nuclear electricity
World	1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1972	[illegible]	2 80	[illegible]	[illegible]	[illegible]
Developed countries	1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1972	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Developing countries	1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1972	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Africa	1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1972	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: United Nations Statistical Papers series "World Energy Supplies" 1969-1972.



PRODUCTION PER CAPITA AND CONSUMPTION OF ENERGY

(Quantities in metric tons of coal equivalent and kilograms per capita)

		Energy production per capita	Solid fuels	Liquid fuels	Natural and imported gas	Hydro, nuclear and imported electricity
World	1970	1 [illegible]	[illegible]	[illegible]	[illegible]	157
	1971	1 [illegible]	[illegible]	[illegible]	[illegible]	167
	1972	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Developed countries	1970	[illegible]	[illegible]	[illegible]	[illegible]	115
	1971	[illegible]	[illegible]	[illegible]	[illegible]	123
	1972	[illegible]	[illegible]	[illegible]	[illegible]	133
Developing countries	1970	3[illegible]	117	551		1[illegible]
	1971	3[illegible]	[illegible]	[illegible]		[illegible]
	1972	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Africa	1970	330	[illegible]	[illegible]	[illegible]	3
	1971	3[illegible]	[illegible]	[illegible]	[illegible]	3
	1972	353	[illegible]	[illegible]	[illegible]	[illegible]

Source: United Nations Statistical Papers series "World Energy Supplies 1950-1972."

PETROLEUM PRODUCTION IN AFRICA

1. '000 b/d
2. million t/yr.

COUNTRIES		1968	1969	1970	1971	1972	1973
ALGERIA	1.	901.7	934.6	1 008.4	775.0	1 004.0	1 070.0
	2.	44.5	46.1	49.7	38.2	52.5	52.8
ANGOLA	1.	19.1	10.0	13.7	115.0	140.0	154.0
	2.	0.9	0.5	0.7	5.7	6.9	7.6
CONGO	1.					7.0	42.0
	2.					0.3	2.1
EGYPT	1.	183.2	245.1	327.3	294.0	212.0	165.0
	2.	9.0	12.1	16.1	14.5	10.5	8.1
GABON	1.	90.1	101.3	108.0	115.0	126.0	147.0
	2.	4.4	5.0	5.3	5.7	6.6	7.2
LIBYAN ARAB REPUBLIC	1.	2 600.2	3 110.7	3 321.4	2 762.0	2 215.0	2 187.0
	2.	128.2	153.4	163.8	136.2	109.2	107.9
NIGERIA	1.	137.8	540.0	1 083.3	1 551.0	1 817.0	2 053.0
	2.	6.8	26.6	53.4	75.5	89.6	101.3
TUNISIA	1.	61.6	78.0	87.7	86.9	83.0	83.0
	2.	3.0	3.9	4.3	4.2	4.1	4.1
OTHERS	1.	2.0		1.5	0.6	1.0	1.0
	2.	0.1		0.1		0.1	0.1
TOTAL	1.	3 977.6	5 019.7	5 951.3	5 678.6	5 665.0	5 [illegible]
	2.	196.9	247.6	293.4	280.0	279.4	281.3

SOURCE: International Petroleum Encyclopedia 1974.

AFRICA - PETROLEUM PRODUCT CONSUMPTION

1. 1 000 b/d
2. million t/yr.

COUNTRIES		1968	1969	1970	1971	1972	1973
[illegible]	1.	38	44	41	47	57	58
	2.	1.7	2.2	2.0	2.3	2.8	2.9
[illegible]	1.	14	12	14	13	19	20
	2.	0.7	0.6	0.7	0.6	0.9	1.0
[illegible]	1.	170	87	113	130	152	158
	2.	8.4	4.3	5.6	6.4	7.5	7.8
[illegible]	1.	10	9	9	13	19	20
	2.	0.5	0.4	0.4	0.6	0.9	1.0
[illegible]	1.	16	14	16	17	19	17
	2.	0.8	0.7	0.8	0.8	0.9	0.8
[illegible]	1.	18	28	30	30	38	39
	2.	0.9	1.4	1.5	1.5	1.9	1.9
[illegible]	1.	5	5	7	11	10	11
	2.	0.3	0.3	0.4	0.5	0.5	0.5
[illegible]	1.	20	26	18	21	28	30
[illegible]	2.	1.0	1.2	0.9	1.0	1.4	1.5
[illegible]	1.	9	7	7	9	10	10
	2.	0.4	0.4	0.4	0.4	0.5	0.5
[illegible]	1.	31	33	34	41	47	49
	2.	1.5	1.6	1.7	2.0	2.3	2.4
[illegible]	1.	10	12	15	14	19	20
	2.	0.5	0.6	0.7	0.7	0.9	1.0
[illegible]	1.	23	27	30	35	40	51
[illegible]	1.	3	6	6	7	9	10
	2.	0.2	0.3	0.3	0.4	0.4	0.5
[illegible]	1.	185	182	202	228	277	287
	2.	9.2	9.0	10.0	11.3	13.7	14.2
[illegible]	1.	18	30	30	17	19	20
	2.	0.9	1.5	1.5	0.8	0.9	1.0
[illegible]	1.	10	11	13	14	18	20
	2.	0.5	0.5	0.6	0.7	0.9	1.0
[illegible]	1.	17	22	20	28	32	35
	2.	0.8	1.1	1.0	1.4	1.6	1.7
[illegible]							
[illegible]							

AFRICA - PETROLEUM PRODUCT CONSUMPTION (Cont'd)

COUNTRIES		1968	1969	1970	1971	1972	1973
ZAIRE	1.	10	10	11	13	19	21
	2.	0.5	0.5	0.5	0.6	0.9	1.0
OTHERS	1.	125	112	88	99	116	120
	2.	5.2	5.5	4.3	4.9	5.7	5.9
TOTAL:	1.	710	675	704	788	950	986
	2.	35.1	33.4	34.8	38.6	46.6	48.8

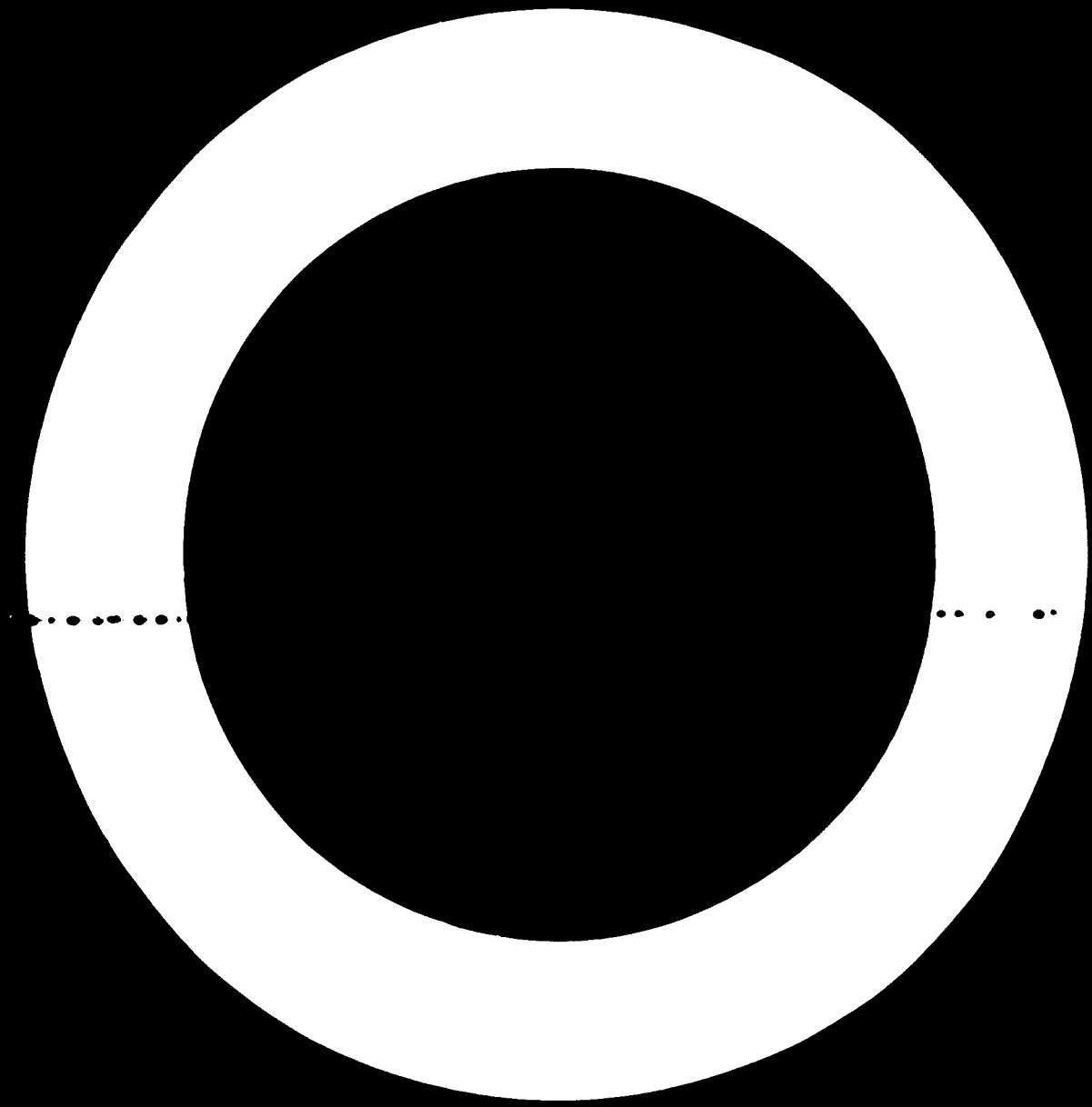
Source: International Petroleum Encyclopedia, 1974.

AFRICA - PETROLEUM REFINING CAPACITY UTILIZATION

1. 1 000 b/day
2. million t/yr

		1968	1969	1970	1971	1972	1973	1974
ALGERIA	1.	47	47	47	48	48	91	115
	2.	2.1	2.3	2.1	2.4	2.4	4.0	5.7
ANGOLA	1.	14	14	20	14	14	16	25
	2.	0.7	0.7	1.0	0.7	0.7	0.8	1.2
EGYPT	1.	169	169	193	179	219	99	180
	2.	8.3	8.3	9.5	8.6	10.4	4.9	8.9
GHANA	1.	29	28	29	28	28	27	25
	2.	1.4	1.4	1.4	1.4	1.4	1.3	1.2
IVORY COAST	1.	19	14	19	21	22	24	44
	2.	0.9	0.7	0.9	0.9	1.1	1.2	2.2
KENYA	1.	44	38	44	50	51	48	48
	2.	2.2	1.9	2.3	2.5	2.5	2.4	2.4
LIBYAN ARAB REP.	1.	9	9	10	9	6	17	16
	2.	0.4	0.4	0.5	0.4	0.3	0.8	0.8
MOROCCO	1.	34	34	35	35	37	56	59
	2.	1.7	1.7	1.8	1.7	1.9	2.9	2.9
MOZAMBIQUE	1.	20	22	20	41	17	17	17
	2.	1.0	1.1	1.0	2.0	0.8	0.8	0.8
NIGERIA	1.	35	38	40	45	55	60	60
	2.	1.7	1.9	2.0	2.3	2.7	3.0	3.0
SOUTHERN RHODESIA	1.	20	20	21	21	20		
	2.	1.0	1.0	1.0	1.0	1.0		
SENEGAL	1.	13	12	13	13	12	12	18
	2.	0.6	0.6	0.6	0.6	0.6	0.6	0.9
SUDAN	1.	20	20	20	21	21	20	22
	2.	1.0	1.0	1.0	1.0	1.0	1.0	1.1
UNITED REP. OF TANZANIA	1.	14	14	14	14	17	17	17
	2.	0.7	0.7	0.7	0.7	0.8	0.8	0.8
TUNISIA	1.	23	23	23	23	25	21	21
	2.	1.1	1.1	1.1	1.1	1.2	1.0	1.0
SOUTH AFRICA	1.	164	179	178	239	251	243	331
	2.	8.1	8.8	8.8	11.8	12.4	12.0	16.3
ZAIRE	1.	49	56	67	59	68	85	94
	2.	2.4	3.3	3.3	2.9	3.4	4.2	4.6
TOTAL	1.	723	768	792	856	902	826	1 092
	2.	35.5	36.9	39.9	42.9	44.5	40.7	53.8

Source: International Petroleum Encyclopedia, 1975.



AFRICA - REFINING CAPACITIES

Country/company, location	Crude b/day	Catalytic cracking b/day	Catalytic reforming
ALGERIA			
Sonatrach			
1. Arzew	7,500	-	15,000
2. El Borma	600	-	-
3. Hassi Messaoud	3 135	-	-
4. Maison Carree	57 000	-	14 500
5. Skikda	177 000	-	-
	292 335		30 500
BENIN			
1. Government - Cotonou	17 000	-	-
UNITED REPUBLIC OF CAMEROON			
1. Société Nationale de raffinage Sonara	40 000	-	-
EGYPT			
1. El Amiriya	26 000	-	-
2. Mex	120 000	-	-
3. Tanta	14 500	-	-
4. Others	19 400	-	-
	180 000		
ETHIOPIA			
1. Ethiopian Petroleum S.C. Assab	14 300	-	1 890
GABON			
1. Société Equatoriale de Raffinage Port Gentil	17 000	-	2 000

AFRICA - REFINING CAPACITIES (Cont'd)

GHANA			
1. Ghanaian-Italian Petroleum Co., Tema	[illegible]	-	9 [illegible]
[illegible]			
1. [illegible] Ivoirienne de [illegible]	[illegible]	-	5 017
KENYA			
1. East African Oil Refinery Mombasa	60 000	-	4 000
LIBERIA			
1. Liberia Refining Co. [illegible]	10 000	-	2 000
LIBYAN ARAB REPUBLIC			
1. American Overseas Petroleum Ltd., Nafoora	1 800	-	-
2. Esso Standard Libya [illegible]	[illegible]	[illegible]	[illegible]
3. Mobil Oil Corp., Amal	1 800	-	-
4. National Oil Co., Intisar	1 800	-	-
5. Zentina	3 000	-	-
6. Libyan National Oil, Zavia	60 000	-	-
	76 400		1 [illegible]
MOROCCO			
1. Société Chérifienne des Pétroles Sidi-Kacem	8 550	3 [illegible]	1 [illegible]
2. Société Am. Marocaine Italienne de Raffinage Mohammedia (Samir)	50 000	-	6 [illegible]
3. Government-Mohammedia	50 000	-	-
	108 550	3 [illegible]	7 [illegible]

AFRICA - REFINING CAPACITIES (Cont'd)

NIGERIA			
1. Niger ia Petroleum Refining Co. Kaduna Alexandria	60 000	-	000
SENEGAL			
1. Societe Africaine de Raffinage, Dakar	1[illegible] 000	-	2 000
SIERRA LEONE			
1. Sierra Leone Petroleum Refining Co., Freetown	10 000	-	-
SUDAN			
1. Shell and BP Sudan Port Sudan	22 000	-	2 000
SOUTH AFRICA			
1. Caltex Oil SA Pty.Ltd. Cape Town	46 000	10 [illegible]	-
2. Mobil Refining Co. Durban	60 000	14 500	[illegible] 500
3. National Petroleum Refineries Sasolburg	50 000	14 000	[illegible] 600
4. Natal Ltd. Boksburg North	3 000	-	-
5. Shell and BP Durban	172 000	17 000	30 000
	331 000	55 900	46 [illegible] 800
SOUTHERN RHODESIA			
1. Central African Petroleum Refineries Ltd. Umtali	20 000 (But in operation, not included in total)		
UNITED REPUBLIC OF TANZANIA			
1. Tanganyika and Italian Petroleum Refining Co. Dar es Salaam	17 000	-	2 690

Annex VII

PINING

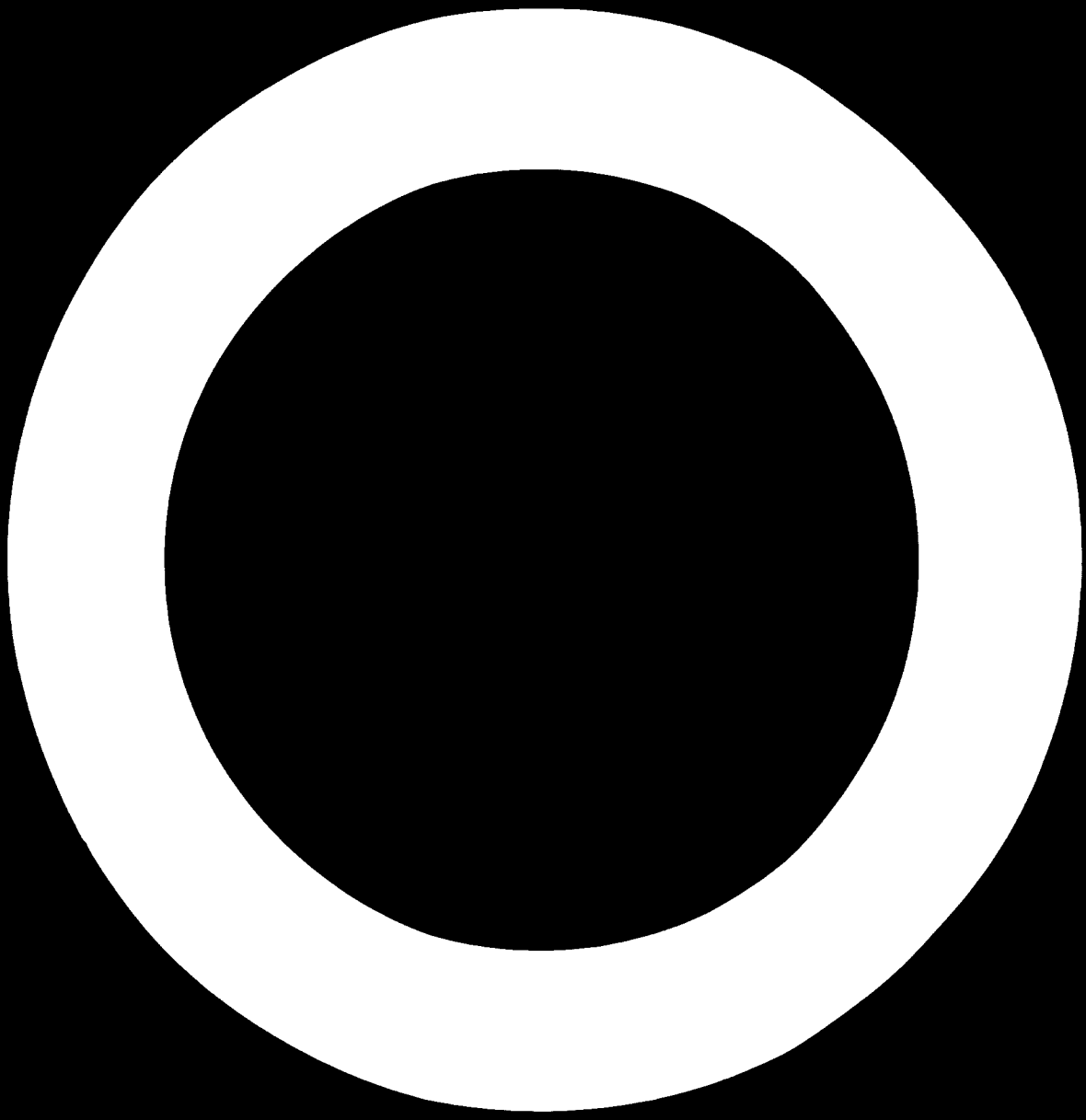
IPE	
	2 900
1.	
	5 600

International

[illegible] OF MAJOR PETROLEUM PRODUCTS IN AFRICA
(in thousand metric tons)

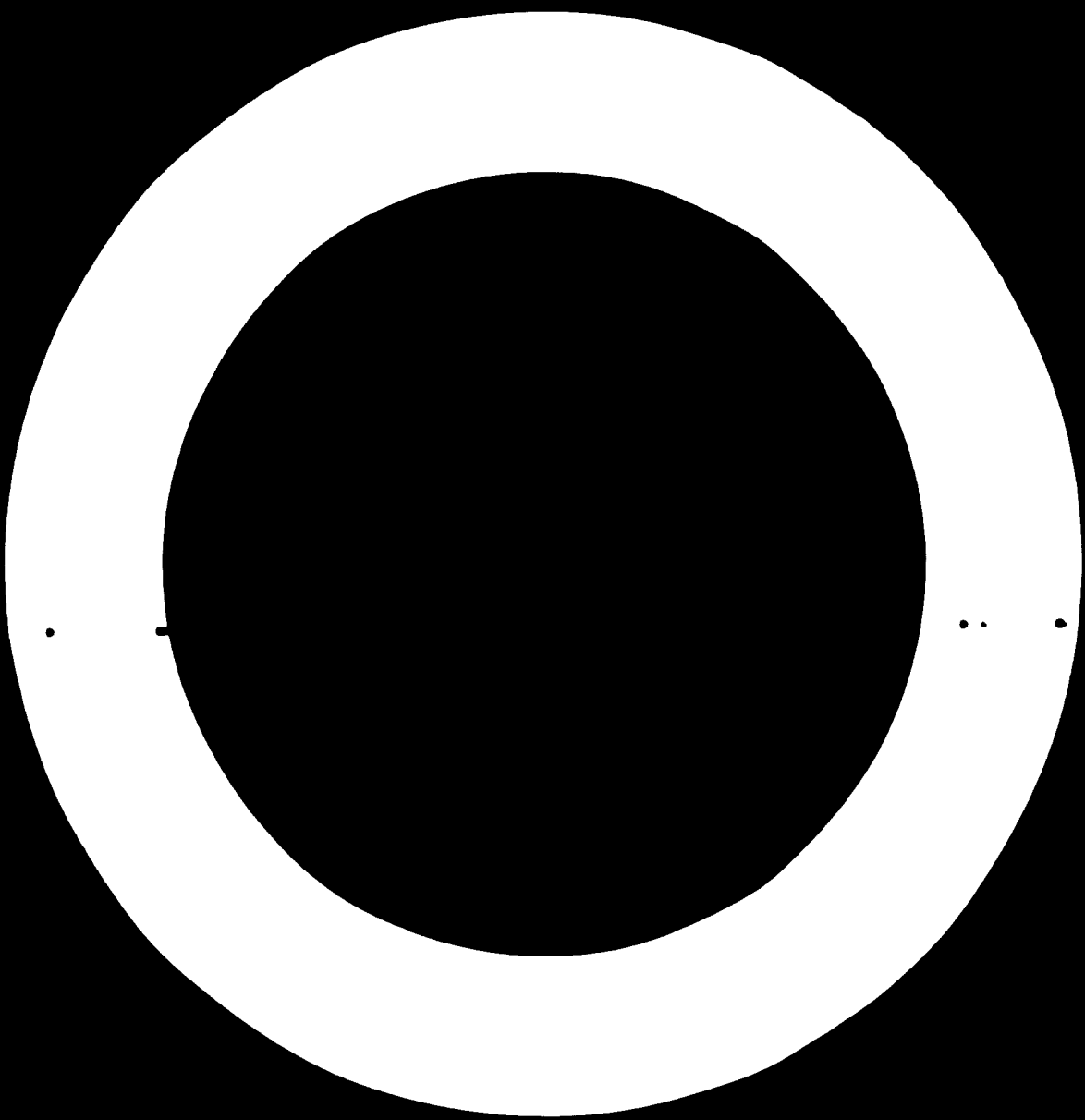
	1970	1971	1972	1973
L.P.G.	310	310	300	525
Naphta (N)	1[illegible]	[illegible]	[illegible]	700
Motor Spirit (M.S.)	5 720	6 [illegible]10	[illegible] 880	7 780
Kerosene (K)	1 [illegible]	[illegible]60	[illegible] 180	1 940
Jet fuel (J.F)	750	1 [illegible]	1 [illegible]	1 [illegible]
Distillate fuel oil (D.F.O.)	7 [illegible]10	[illegible]270	9 550	10 690
Residual fuel oil (R.F.O.)	11 [illegible]	13 940	14 [illegible]	16 030
Lubricating oils (L.O.)	1[illegible]	130	1[illegible]0	240
Bitumen (asphalt) (B)	49[illegible]	5[illegible]0	550	570

Source: United Nations Statistical Yearbook, 1974, page 286.



Region, country	...	...	...	...	...	...	...	...	...	...
1. Europe	...	...	...	...	...	...	...	...	...	...
2. Middle East	...	...	...	...	...	...	...	...	...	...
3. North America	...	...	...	...	...	...	...	...	...	...
4. Asia Pacific	...	...	...	...	...	...	...	...	...	...
5. Latin America	...	...	...	...	...	...	...	...	...	...
6. Socialist countries	...	...	...	...	...	...	...	...	...	...
7. Africa										
Algeria	...	...	...	...	...	...	...	...	...	...
Angola	...	...	...	...	...	...	...	...	...	...
Egypt	...	...	...	...	...	...	...	...	...	...
Ethiopia	...	...	...	...	...	...	...	...	...	...
Gabon	...	...	...	...	...	...	...	...	...	...
Ghana	...	...	...	...	...	...	...	...	...	...
Kenya	...	...	...	...	...	...	...	...	...	...
Liberia	...	...	...	...	...	...	...	...	...	...
Libyan Arab Rep.	...	...	...	...	...	...	...	...	...	...
Malagasy	...	...	...	...	...	...	...	...	...	...
Morocco	...	...	...	...	...	...	...	...	...	...
Mozambique	...	...	...	...	...	...	...	...	...	...
Nigeria	...	...	...	...	...	...	...	...	...	...
Sierra Leone	...	...	...	...	...	...	...	...	...	...
Sudan	...	...	...	...	...	...	...	...	...	...
United Republic of Tanzania	...	...	...	...	...	...	...	...	...	...
Tunisia	...	...	...	...	...	...	...	...	...	...
Zaire	...	...	...	...	...	...	...	...	...	...
Others	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...
World total	...	...	...	...	...	...	...	...	...	...

Source. International Petroleum Encyclopedia ...



CONSUMPTION OF PETROLEUM PRODUCTS, VEHICLE COUNT AND GASOLINE [illegible]

	Total petroleum consumption			Vehicle count				
	1,000 b/d 1973	million t/y	1,000 b/d	million t/y	1.1.1973, 1,000 units			
					Passenger cars	Buses	[illegible]	[illegible]
1a Europe								
14 305	715.3	[illegible]		[illegible]	-			
2a Middle East								
1 692	7[illegible]	[illegible]		[illegible]	[illegible]			
3a North America								
19 060	[illegible]40.3	[illegible]		[illegible]	[illegible]67	[illegible]		
4a Asia pacific								
8 220	405.[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
5a Latin America								
3 [illegible]80	16[illegible].8	[illegible]		[illegible]	-			
6a Socialist countries								
8 775	[illegible]34.40	[illegible]		[illegible]	-			
7a Africa								
Algeria								
3	2[illegible]	[illegible]		[illegible]	-		-	
Angola and Cabinda								
2	[illegible].0	[illegible]		[illegible]	-		-	
Egypt								
15	[illegible]	[illegible]		[illegible]	-		-	
Ethiopia								
20	[illegible]0	[illegible]		[illegible]	-		-	
Gabon								
[illegible]					-		-	
Ghana								
17	[illegible]8	[illegible]		[illegible]	-		-	
Kenya								
30	1.8	[illegible]		1.5	149	[illegible]	[illegible]	-

CONSUMPTION OF PETROLEUM PRODUCTS, REPRESENTATIVE [illegible]

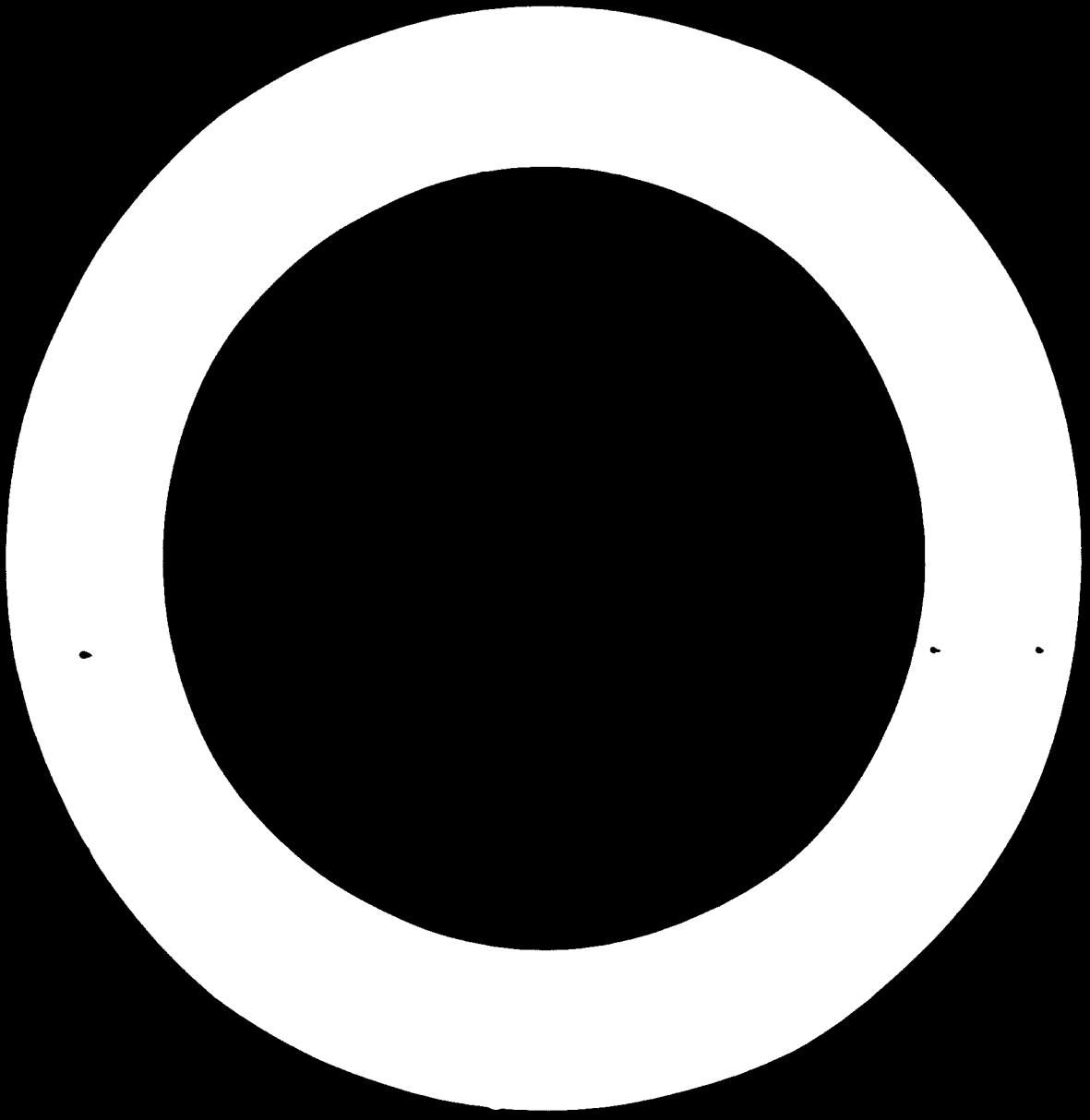
[illegible] 11	0.5	12	0.5	1	[illegible]	[illegible]	[illegible]	1
[illegible] 2	1.4	27	1.3	N.A.	N.A.	[illegible]	[illegible]	[illegible]
[illegible] 19	0.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 15	2.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 29	1.0	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 31	2.5	[illegible]	[illegible]	155	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 10	0.5	[illegible]	[illegible]	N.A.	N.A.	[illegible]	[illegible]	[illegible]
[illegible] 20	1.0	[illegible]	[illegible]	N.A.	N.A.	[illegible]	10[illegible]	[illegible]
United Repo. of [illegible] 30	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 25	1.0	[illegible]	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 21	1.0	20	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 297	19.6	[illegible]	19.6	1 [illegible]	[illegible]			[illegible] 671
[illegible] 73	48.2	985	47.5	3 154	1 527			[illegible]
[illegible] 56 551	2 [illegible]	56 375	2 751.9	221 105	56 [illegible]			

Source: [illegible]

[illegible]

Importers	Year	Total	Imports from African countries	Imports from non-African countries
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Selected African countries				
Morocco				
Tunisia				
Egypt				
Kenya				
Ivory Coast				
United Kingdom of Britain				

Source: United Nations Statistical Papers, World Energy Supplies 1960-1972



NEW PETROLEUM REFINING CAPACITY IN SELECTED AFRICAN COUNTRIES

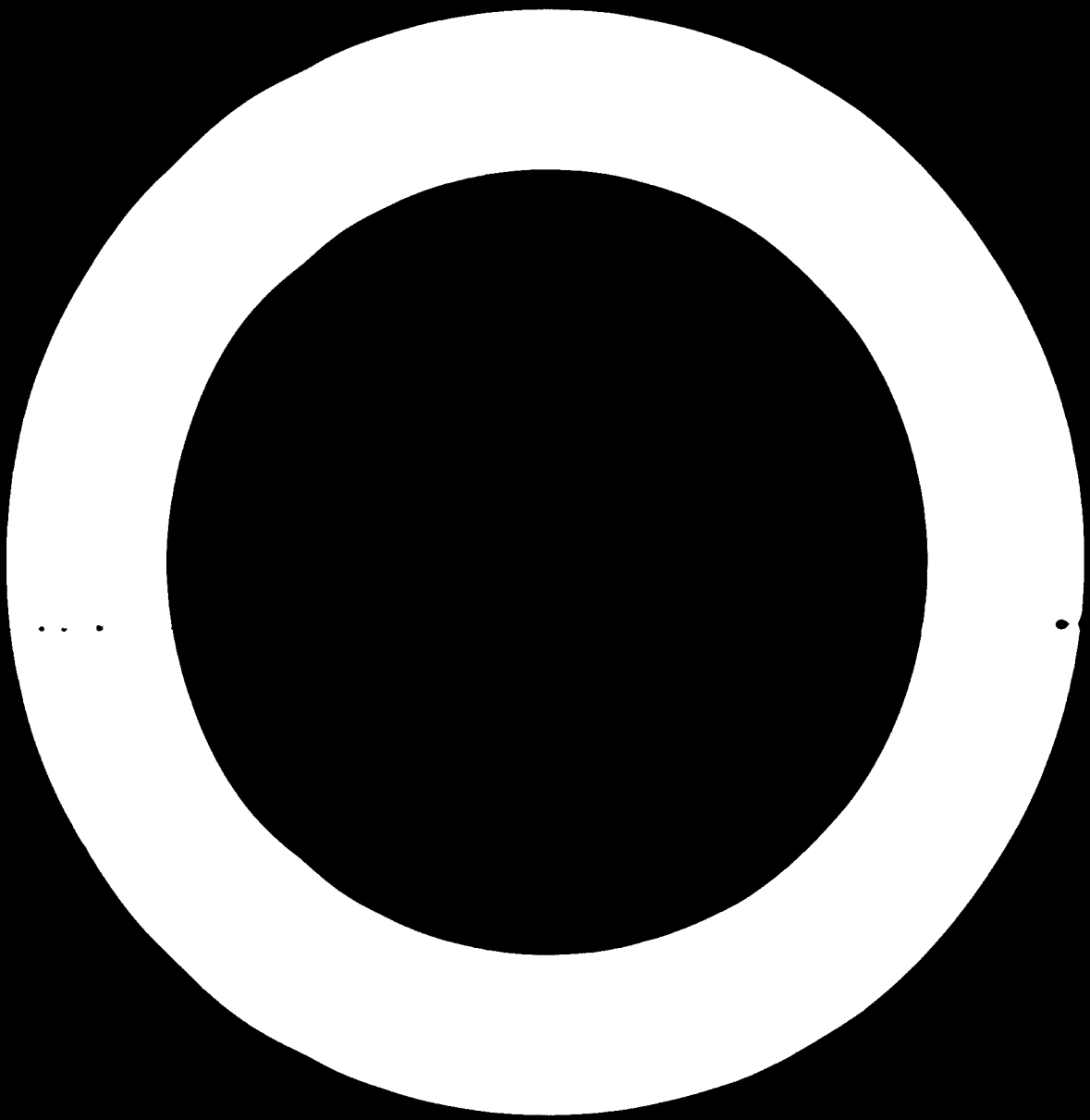
(Planned or under construction)

Country/company and location	Project	New capacity	Remarks and completion date
Algeria			
Sonatrach-Arzew	Expansion vacuum distillates	6,000 b/d	1 , total capacity
	Expansion lube oil	,1 b/	,100 b/d total capacity
	- Asphalt	1, b/	, 00 b/d total capacity
Soc. Ify. Algers	- Atmospheric distillation	4,00 b/d	completed in 197
Sonatrach			
- Bejaia	Crude distillation	175,000 b/d	1 7
	- Cat. reforming	30,000 b/d	1 7
	- Cat. hydrotreating	30,000 b/d	1 7
- Hassi Messaoud	- Crude distillation	6,00 b/	1976; 3 ,0 b/ total capacity
- In-Amenas	- Atmospheric distillation	7, 00 b/d	1 76
- Marsou Carree	- Atmospheric distillation	40, 00 b/d	100, 00 b/d total capacity
	- Vacuum distillates	6,000 b/d	
	- Lube oils	,100 b/d	
	- Asphalt	2, 00 b/d	
- Skikda	- New refinery	360,000 b/d	1977
	- Cat. reformer	30,000 b/d	1977
	- Asphalt	2,500 b/d	1977
	- Aromatic extraction	7,300 b/d	1977
Angola			
Cia. De Petroleos	- Atmospheric distillation	3,230 b/d	41,110 b/d total capacity in 1976
	- Cat. reformer	4,500 b/d	6,300 b/d total capacity in 1976
The Congo			
Government/Pointe	- Refinery	21,500 b/d	completed 1975
	- Electric desalter	56,000 b/d	1977
	- Cat. reformer	2,500 b/d	completed 1975

Egypt			
El Nasr Petr. Co.	- Crude distillation	4[illegible],000 b/d	under construction
	- Kerosine desulfuriser	7,000 b/d	under construction
	Lube oil hydrotreater	1,700 b/d	engineering 1976
	- Gas oil hydrotreater	3,000 b/d	engineering 1976
[illegible]rg. for Ind.	- Copper	1[illegible],000 t/yr.	construction 1976
Nag Hamadi	- Coke calciner	...	construction 1976
Gabon			
Soc. Eq. de Raffinage	- Crude distillation	17,000 b/d	expansion 1976
Port Gentil	- Crude distillation	4,000 b/d	1976
Libyan Arab Republic			
National Oil Corp.	- Desalter	37,000 b/d	completed
Azzawija	- L.P.G.	...	construction 1976
	- Atmospheric distillation	6[illegible],000 b/d	construction 1976
	- Platformer	6,500 b/d	construction 1976
	Kerosine desul.	9,400 b/d	" "
	- Naphta	[illegible],300 b/d	" "
Misarata	- Refinery	200,000 b/d	engineering 1980
Tobruk	- Crude distillation	220,000 b/d	construction 1977
	- Cat. reformer	26,600 b/d	construction 1976
	- Naphta desulf.	26,600 b/d	" "
Zvetina	- Refinery	400,000 b/d	engineering 1979
Mauritania			
Govt./Novadhibow	- Refinery	20,000 b/d	under construction
	- Cat. reformer	6,100 b/d	construction 1976
	- Hydrotreater	12,700 b/d	construction 1976
Morocco			
Samir/Mohamedia	- Refinery	82,000 b/d	engineering 1975
	- Lubricants	100,000 b/d	planning 1977
	- Kerosine hydrotreater	7,000 b/d	engineering 1977
Mozambique			
Soc. Nat. Refinagem Petr.			
Lourenco	- Crude distillation	30,000 b/d	engineering 1975
Marques	- Platformer	6,000 b/d	" "

Mozambique (cont'd)			
	- Unifiner	[illegible] b/d	engineering 1975
	- Merox	3,000 /d	" "
	- Gas recovery	4,000 t/yr.	" "
	- Sulphur	[illegible] t/yr.	"
Nigeria			
Govt./Wavre	- Fluid cat. cracker	6,000 b/d	engineering 1975
	- Cat. reformer	...	" "
Port Harcourt	- Naphta hydrotreater	...	" "
	- Expansion refinery	10,000 b/d	70,000 b/d total capacity
Senegal			
Soc. Afr. Mfg./Dakar	- Desalter	2,800 t/yr.	engineering
Dakar	- New refinery	120,000 b/d	
Sudan			
Govt. and Triad Nat. Co.			
Port Sudan	- New refinery	50,000 b/d	
Togo			
Govt./Lome	- New refinery	20,000 b/d	construction 1976
	- Cat. reformer	3,000 b/d	" "
Tunisia			
Petrole Hellas/Bizerte	- Crude distillation (2 units)	40,000 b/d	completed

Sources: Hydrocarbon Processing - Section 2
World-Wide HPI Construction, Boxscore, February 1975, June 1975
The Oil and Gas Journal 6 October, 1975



1. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Impact [illegible]

[illegible] the role [illegible]

[illegible]

11. Ibid. "Review of the activities and [illegible] developing countries in petroleum co-operation among developing countries regarding petroleum and other matters".

12. Ibid. "Co-operation among developing countries in the sharing of information in the petroleum field".

13. Ibid. "Co-operation among developing countries in petroleum transportation".

14. Ibid. "Promotion of technical and economic co-operation among developing countries in petroleum".

15. Ibid. "Co-operation in the training of technical manpower in petroleum in the developing countries".

16. Ibid. "Co-operation among developing countries in the supply of petroleum equipment and services".

17. Economic Commission for Africa, Regional Conference on Petroleum Industry and Manpower Requirements in the Field of Hydrocarbon, Tripoli, 2-12 February 1974.

18. Ibid. "Report of the Regional Conference on Petroleum Industry and Manpower Requirements in the Field of Hydrocarbons".

[illegible] Among [illegible] Petroleum, [illegible] Vienna, [illegible] organizations [illegible] (later presented by [illegible]).

[illegible] Petroleum [illegible] petrochemicals.

[illegible] [illegible] [illegible] [illegible] market and distribution.

[illegible] [illegible] industries, Canada, [illegible] October 1975, [illegible] with particular reference to petro[illegible], Vienna, Austria.

[illegible] [illegible] "[illegible]" by [illegible]. Mediterranean and [illegible], [illegible], Milan, Italy.

[illegible] "[illegible] from [illegible] by [illegible], [illegible], United States of America.

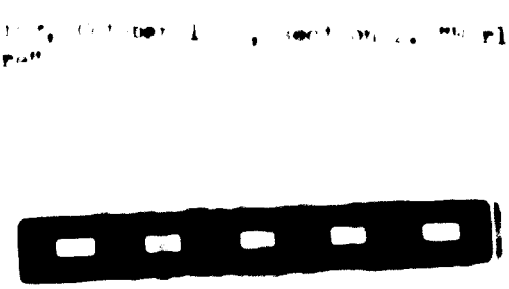
[illegible] "Petroleum [illegible] maximum benefits" by [illegible] and [illegible]. Meier, [illegible], United States of America.

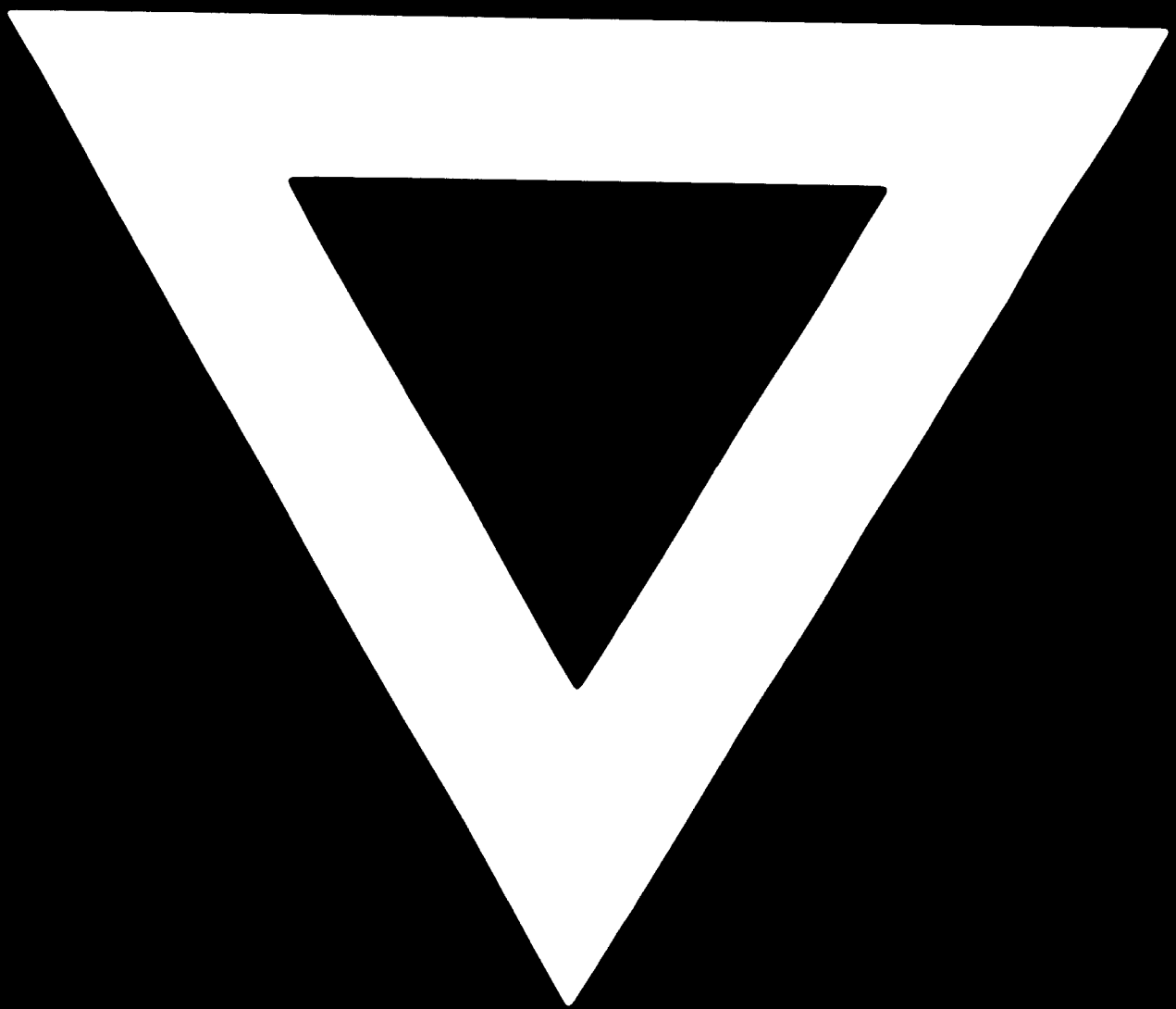
[illegible] [illegible], October 1974, "Oil and Development".

[illegible], [illegible] Statistical Yearbook 1973, part I and II.

Hydrocarbon Processing, November 1974, "More petrochemicals from crude" by [illegible], T.A. Brennan and A. [illegible], The Lummus Co., Bloomfield, N.J., United States of America.

Hydrocarbon [illegible], October 1[illegible], [illegible] "Worldwide to MPI Construction [illegible]"





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