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Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries

Baku, USSR, 21 - 31 October 1969

PET.SYMP.A/2

PROSPECTS FOR THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN AFRICA 1/

Economic Commission for Africa
(ECA)

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23 July 1969

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SUMMARY

PROSPECTS FOR THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN AFRICA 1/

by

Economic Commission for Africa

Introduction

The paper summarised here is wide in terms of product coverage, and it includes a review of situations in some 40 odd countries in Africa. In effect, is a summarised presentation of a good part of the petrochemical industry portaining to Africa. Both this summary and the study itself were prepared by the ECA at the request of UNIDO for the Second Interregional Conference on the Development of the Petrochemical Industries in Developing Countries.

Demand for petrochemicals

Because of the varied assumptions and approaches used in the

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study, it is rather difficult to summarise the section on demand. Under the circumstances presentation of a brief account of the approaches used, together with general analysis of the results obtained, is viewed as necessary in starting. This has been attempted in the following paragraphs.

Some estimates of demand for certain petrochemical end-products were available. For these estimates to serve the purpose of giving a general picture of this important sector, however, two things have had be done in preparing the study in question. The first was to fill in the gaps where possible, e.g., fill in the missing estimates at five year intervals for the 1965-1980 period. Interpolation or extrapolation of available projections were made. The second was to forecast demands for products for which there were no exi ting estimates. The method used was determined by availability of information within the sub-region in question as well as in other sub-regions. Recourse had to be made to per capita consumption, to relationships between one product and another or a group of products calculated from information regarding a group of countries or a sub-region, to derivation of requirements for end-use of product, etc. In the first two cases, data from countries or sub-regions whose conditions were close to those for which the data were applied were used whenever data permitted. Discussion in the study, therefore, relates to the filling in of gaps in existing estimates for some products and to estimating demands for a number of products not hitherto dealt with in other related studies.

Once the end-products have been identified and the prospective demands have been estimated, the next step was to determine the type of feedstock available. In turn, this facilitated determination of the most likely basic and intermediate raw materials and processes for the production of the end-products. Using the backward integration approach, subsequent inputs of intermediates and then basic petrochemical raw materials were calculated.

The projections resulting from the above approach are presented in the annex.

From comparison of 1980 projections with the apparent 1964/65 consumption of the end-products, it is clear that demand can be expected to increase very significantly. Although rates of growth vary from one five year interval to another, and from country to country, the over-all compound rates for the whole period range from 4.4 per cent (n-hexane) to 20.5 per cent (acrylics).

Polyethylene has the highest rate of increase (16.8 percent) among the plastics. Corresponding figures for PVC and polystyrene are 12.2 and 11.8 per cent respectively. In absolute quantity, polyethylene is expected to equal that of PVC around 1980. The principle reason for this is its greater anticipated use in packaging.

As regards synthetic rubbers growth rates are about the same for all types (9.0 per cent).

The greatest difference in increase is evident within the synthetic fibre group. Due to trends toward polyester and other fibres, nylon is expected to grow at about 5.4 per cent while polyester and acrylics at 15.0 and 20.5 per cent respectively. The higher rate for the latter is accounted for, in part, by the small 1964/65 base.

Since the urea-formaldehyde/phenol-formaldehyde relationship was assumed to remain constant throughout the period, the rates do not vary significantly (about 1..0 per cent each). With regard to insecticides, the rate for DDT is slightly higher (12.9 per cent). For carbon black it is 8.9 per cent.

From the preceding figures it may appear that some of the rates are on the high side. That this is not the case may be seen from corresponding past and near future rates for plastics, for instance, in developed countries. If these rates are applicable in such countries it is possible that they could be appropriate in developing countries where the bases for projections are low.

As the projections in the annex are combined values for the four sub-regions, it is not possible to observe directly the relative importance of petrochemicals by sub-regions. Therefore, some reference to this may be in order here. North Africa takes the lead in the share of projected demand for a number of the main products: polyethylene (35%), nylon (68%), dodecylbenzene (45%), and carbon black (36%), while West Africa leads in PVC (33%), polyester (36%), and adhesives (38%). East Africa comes first in DDT (45%). These figures are partial indications of the relative significance and potential of the petrochemical industry in the sub-regions of Africa.

<u>Raw materials</u> (petroleum and natural gas)

A relatively large part of Africa, the coastal areas in particular, is under oil concession to many international oil companies and, in some cases, a combination of national and international groups The search for oil and gas is quite active in certain areas. New discoveries and increased output are frequently in the news. In short, although there remains a lot to be done in prospecting for oil and gas in Africa, the known reserves are good indicators of potential availability of hydrocarbon raw materials.

Total African reserves of crude oil, at the beginning of 1967, were 32,356 million barrels, against 389,050 million for the whole world. Comparison with the 1958 reserves of 4,119 million barrels shows that in nine years African reserve increased eightfold, resulting in an average annual rate of increase of about 26 per cent. In terms of significance in relation to world reserve, the African share increased considerably from 1.5 per cent in 1958 to 4.6 in 1963 and 8.3 in 1967.

The future relative importance of African hydrocarbon reserves may be gauged by prospects in other countries of which the USA is a good example. At the 1967 consumption rate, the USA proven reserves of crude oil and natural gas liquids will last for nine years and natural gas for 16 years. In contrast the African crude oil will be exhausted in over 30 years at the 1967 rate of output.

The development of hydrocarbon exploitation has been as spectacular as that of reserves. Production of crude oil shot up from 23.5 million tons in 1961 to 144 million in 1967, an average annual rate of increase of more than 35 per cent. This development has made Africa a significant contributor to the world output of crude oil (1.3 per cent in 1960, 7.4 in 1965 and 8.3 in 1967).

The situation regarding natural gas is equally impressive. The 1965 African reserves of natural gas have been estimated at 2.2 trillion m^3. This works out to 8.5 per cent of world reserves, a figure slightly higher than the 1967 crude oil share for the continent.

Production is relatively small in comparison with reserves (4,500 million m^3 in 1965). This is also true in relation to world output, as the African share in world production accounted for only 0.3 per cent.

Within the last few years, natural gas has turned out to be a significant export item of the region. Exports in 1965 to OECD countries, for instance, increased by 50 per cent to 800,000 tons in 1966. A similar increase was expected for 1967.

Tar sands and oil shales are other future sources of hydrocarbon materials. Africa possesses a potential of 15,000 million tons of oil from such sources.

The picture just painted is not so rosy when it comes to considering certain areas or sub-regions or individual countries. The Equator roughly divides the region into the well-endowed north and the relatively poor south, with well over 90 per cent of the hydrocarbon resources being in the former. As regards sub-regions, the East African sub-region, with no exploitable resources is the least favoured. The preceding conclusions are reflected in the limited number of producer countries that according to descending order of importance are: Libya, Algeria, Nigeria, the UAR, Angola, Gabon, Tunisia, Congo (B) and Morocco.

Based on geology and on recent finds, it is possible that, within the foreseeable future, some other African countries will join the rank of producers. These may include Cameroon, Dahomey and Congo (Democratic Republic).

Availability of hydrocarbons in crude form is not the end of the raw material question. At the present stage of technological development, appropriate refineries will be the major suppliers of feedstocks for the petrochemical industry.

At the moment there is over capacity in the established refineries in each of the sub-regions. As capacity utilisation may be expected to satisfy increased demand in the early 1970's, no major increases are foreseen in 1970-75. In fact, only a few countries (Algeria, the UAR, Nigeria, Ethiopia and Tanzania) are expected to raise their capacities during this period. In contrast, the 1975-80 period is expected to witness a surge in capacity increase.

The planned construction of additional capacity should be able to meet a large part of the petroleum product requirement for development of the petrochemical industry in the region.

Factors inhibiting petrochemical development

The petrochemical industry, or for that matter any industry, needs certain conditions for its establishment. Availability of raw materials, fuel, power, good transport net-work and market are among such pre-conditions.

The first two have already been dealt with adequately. They have been found to be in favour of petrochemical development in Africa. Brief references are made here to the remaining items.

Although the present electric power situation in parts of Africa may not be satisfactory, the potential for its development is tremendous. Africa possesses over 30 per cent of the world's hydro-electric potential, and roughly 8 per cent of each crude oil and natural gas reserves. Projects already realized and those under construction or being planned may, in general, be expected to play a major role in promoting petrochemical industries in the near future.

Because of historical inheritance there were and still are a number of gaps in transport links between many African countries. Consequently, transport costs figure relatively high in the sales value of goods. Realising this problem, many countries have given priority to the development of transport systems.

Lack of trained manpower is characteristic in Africa. This is especially so in the capital-intensive and experienced manpower oriented industries. A practical but partial solution to this inhibiting factor is the trend toward making the contractor for a new industrial venture responsible for training and otherwise preparing nationals to take over the technical and administrative management of the industry. This, coupled with measures taken by governments and backed by international organization and bilateral aid sources, is expected to alleviate this serious obstacle.

The last but the most crucial obstacle is the limited size of the market in almost all African countries. Present, or for that matter foreseeable, demand for petrochemicals in individual countries does not justify their production on a country basis. Pooling national markets into multinational or sub-regional groupings seems to be the logical answer. The multinational and sub-regional approach has, in fact, been adopted by the ECA for quite some time not only in industry but also in all economic activities of the region. Within the sub-regional framework, economic groupings are emerging. They are expected to serve as nuclei for this approach.

An alternative to larger markets lies in the hands of machinery and equipment manufacturers. With recent and future technological break-throughs, they should surely be in a position to innovate simple economical processes and techniques to manufacture in the small volumes having relevance to local conditions in developing countries.

The development of small-scale units could be supplemented by multi-purpose plants which are capable of producing various products whose proportions can be varied relatively easily and at will according to market conditions. Such plants can and should be competitive with large units designed to produce one or a limited number of products. It is possible that the multi-purpose concept can be extended to apply to a combination of similar processes based on the same or similar raw materials.

Even with all these suggested remedies, some petrochemical plants to be established in Africa may not be in a position to compete with the giant units in industrialised countries. Protection from outside competition may well be required, at least in starting.

Development possibilities

The estimates for some of the end-products represent potential demand, in the sense that they are supposed to meet consumption of petrochemical products appearing in the market as goods entirely made from petrochemicals, as goods incorporating other materials and as parts in machinery, equipment, and vehicles. In developing countries, processing of petrochemicals into end-products is limited to applications of the first two. The extent of production of sophisticated goods varies from country to country. A trend toward diversification is evident in existing establishments in Africa. The plastic industries are, for instance, expanding their output by introducing new products that were hitherto imported. Textile mills are turning out increasingly elaborate, locally woven synthetic fabrics both mixed or pure. More and more tyre and rubber articles' factories are being expanded and established. In short, diversification in the final stage of processing petrochemicals is the trend in Africa.

It should be noted, however, that because of small consumption, special application, complicated processing techniques, product mix, etc., certain final products will necessarily have to be imported. In other words, no matter how fast diversification takes place, there will always be need to import a part of the finished goods demand in African countries.

As is well known, the success of a petrochemical venture lies in the economic upgrading and utilization of co-products of the basic operations: cracking, reforming and pyrolysis. Some attempt has been made to this effect in the study. In view of the need to spread production facilities among member States of each sub-region, however, integration of facilities processing all co- and/or by-products further to the extent desirable is not practical. Because of this and other factors, such as the small or in some cases unknown demand for certain of the products to be derived from the co- or by-products, the extent of integrated development had to be limited.

The feedstocks recommended were dictated by the present and indicated future availability of raw materials and the types and proportions of basic products needed. These, in turn, were used as guides in determining possible processing techniques for the basic operations proposed in the study.

Combined proposed capacities are presented in the annex. Comparison with projected demand shows that, in general, they approximate each other. Full capacity utilization in many of the suggested units will, if practical, be attained some years after the initial operation. Therefore, the likelihood for production to exceed demand, a possibility that may arise due to possible over estimation of demand in some cases, is reduced. It was for this purpose mainly that the capacities were made to correspond roughly to the projected demands.

It is to be noted that proposals for a number of alternative combinations of production facilities are possible in each sub-region. Those presented in the study were based, as much as available information permitted, on a number of factors. These include consumption centres, indicated present and future availability of raw materials, utilities and infrastructures and the need for fair allocation of the production units among member countries.

The proposals in the study are by no means comprehensive. Because of the relatively small demands, even on a sub-regional level, the possibilities for the manufacture of certain products have been ruled out in some or in all sub-regions. Although not considered in the study, an inter-sub-regional approach could possibly render the production of such petrochemicals practical. This approach should be explored.

Fixed investment implications of the proposed units

The capacities and locations of the petrochemical units proposed, as noted earlier, are tentative and, therefore, subject to change in the light of better information and new developments. This relates to developments both within and outside the sub-region. This, coupled with the fact that it is difficult to take into account factors determining investment requirement for so many individual countries in an exercise of this nature, makes it impossible to be definite about the financial implications of the proposed units. What has been done in the study is to indicate rough orders of magnitude.

According to the results arrived at in the study, orders of magnitude of 460 million dollars in 1975 and an additional 500 million dollars in 1980 will have to be invested. It should be noted that these figures are for units oriented toward African market only. In other words, no account has been taken in the study of export possibilities to areas outside the region. In countries such as, Libya and Algeria, which because of their locations have favourable prospects for export, some of the units proposed in the study may have to be revised. It is possible that the additional investment needed for the production of exportable petrochemicals could bring the fixed investment to the level of 1,000 million dollars around 1980.

ANNEX

Estimated potential demands and capacities proposed for petrochemicals in the four sub-regions
(in 1000 tons)

End Products	Potential Demand				Capacity Proposed	
	1964/65	1970	1975	1980	1975	1980
PVC	33	66	117	208	105	205
Polyethylene	16	43	96	193	90	200
Polystyrene	6	12	21	36	-	38
SBR	24	40	66	107	-	80
Butyl rubber	5	8	13	21	-	-
Polybutadiene a/	3	5	8	12	12	12
Nylons	16	20	26	37	25	37
Polyesters	5	11	23	46	23	44
Acrylics	1	4	10	20	5	17
Urea-formaldehyde	7	13	26	36	23	36
Phenol-formaldehyde	3	6	11	15	10	16
Dodecylbenzene	14	24	41	68	35	65
DDT (75%)	6	14	24	42	22	43
BHC (25%)	8	15	29	51	33	54
Perchloroethylene	2	4	6	10	-	6
n-hexane	1	1	1	2	-	-
Carbon black	24	38	60	94	70	95

a/ North Africa only

ANNEX (part two)

Basics and intermediates						
	Potential Demand				Capacity Proposed	
	1964/65	1970	1975	1980	1975	1980
Vinylchloride	36	71	126	225	124	221
Ethylene	41	95	190	366	179	384
Styrene	13	23	39	64	-	55
Butadiene	19	31	50	81	-	63
Caprolactam	15	22	29	41	28	40
Acrylonitrile	1	4	11	21	5	8
p-xylene	4	9	19	38	..	..
DMT	5	12	25	50	19	45
Ethylene glycol	2	4	7	15	-	-
Propylene	20	37	71	123	49	104
Methanol	4	8	16	22	14	22
Formaldehyde	10	18	34	47	30	48
Urea b/	5	9	18	24	15	24
Phenol2	2	4	8	11	-	-
Ammonia b/	32	50	71	101	35	54
Chlorobenzene	6	13	22	38	21	39
Benzene	46	80	132	212	86	142

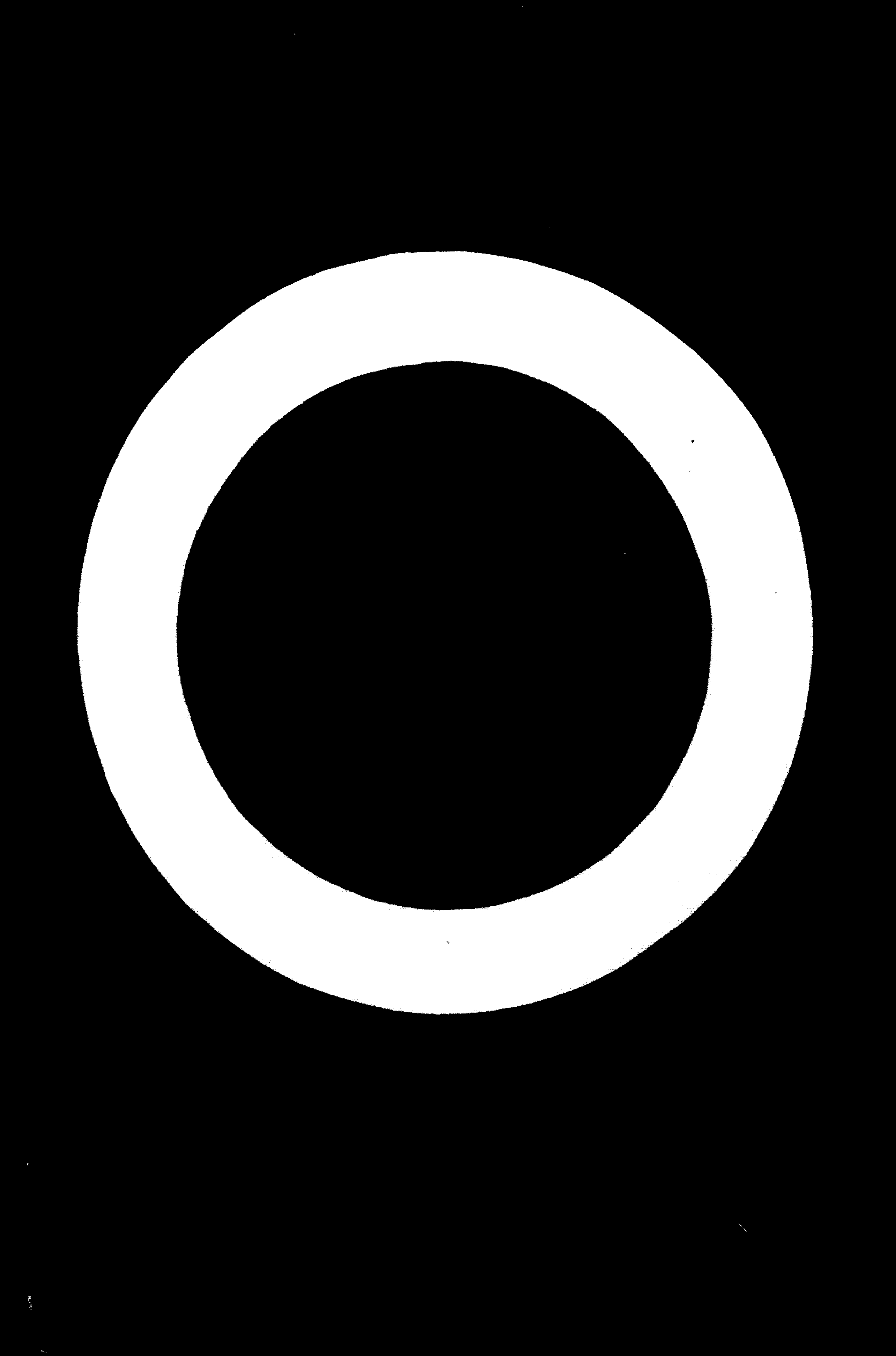
b/ Excludes requirement for fertilizers

INTRODUCTION

This paper has been prepared by the ECA at the request of UNIDO for the Second Inter-regional Conference on the Development of the petrochemical industries in developing countries.

From the outset it should be noted that it is not easy to prepare a study of this nature. Firstly, the petrochemical field is complex and diversified. It offers scope for a number of alternative approaches. The number of final products and the accompanying intermediate and basic organic chemicals, even those within the terms of reference of the study, is extensive. Secondly, there are virtually no existing petrochemical industries in Africa from which to draw practical information. Such information and experience would have been of great assistance in the preparation of this study. Thirdly, the number of countries covered (more than 40) increases the difficulty.

This study is the first of its kind in terms of comprehensive sector and country coverage. Although it is based in part on a number of related studies, the conclusions are tentative and subject to change in the light of additional information and developments, both within and outside the region. The locations proposed, for example, represent only one of several possible alternatives. Despite the effort made to take into account, to the extent available information permitted, all relevant factors in determining locations, the proposals are, as noted, subject to change. The possible need for change will be determined by results of further and more detailed study of the sector. Despite this qualification, if the study has succeeded in identifying opportunities in the petrochemical field in Africa and the problems to be associated with them, it has served its purpose.



DEMAND FOR PETROCHEMICALS

Some estimates of demands for certain petrochemical end-products are available. For these estimates to serve the purpose of giving a general picture of this important sector, however, two things have had to be done. The first was to fill in the gaps where possible, e.g., fill in the missing estimates at five year intervals for the 1965-1980 period. Interpolation or extrapolation of available projections were made. The second was to forecast demand for products for which there were no existing estimates. The method used was determined by availability of information within the subregion in question as well as other subregions. Recourse had to be made to per capita consumptions, to relationships between one product and another or a group of products calculated from information regarding a group of countries or a subregion, to derivation of requirements for end-use of product, etc. In the first two cases data from countries or subregions whose conditions were close to those for which the data were applied were used whenever availability of data permitted. Discussion in this paper, therefore, relates to the filling in of gaps in existing estimates for some products and to estimating demands for a number of products not hitherto dealt with.

Once the end-products have been identified and the prospective demands have been estimated, the next step is to determine the type of feedstock available. In turn, this facilitates determination of the most likely basic and intermediate raw materials and processes for the production of the end-products. Using the backward integration approach, subsequent inputs of intermediates and then basic petrochemical raw materials were calculated. The presentation in this section follows this sequence, starting with end-products such as PVC and ending with basic petrochemicals such as ethylene (see tables 1-7).

End-products

(a) Plastics, synthetic fibres and rubber, detergents

North Africa (Table A1)[1]

In terms of scope and depth of coverage, North Africa leads the other sub-regions in the availability of studies in petrochemicals. Even then, however, certain assumptions had to be made in order to adapt it for use in this study. A case in point is that of synthetic rubbers. According to the source referred to in Table A1, SBR and polybutadiene are supposed to constitute the major part of the synthetic rubber consumption estimates. Assuming that the polybutadiene share in the 1980 total synthetic rubber estimate corresponds to the 12,000 tons capacity envisaged in the UAR complex, the remaining 47,500 tons should represent mostly SBR.

Butyl rubber being the preferred rubber for inner tubes, it should occupy a relatively important position in the synthetic rubber group. In the absence of indications as to its relative importance, the butyl to SBR relationship (0.2), calculated on the basis of the West African situation, was used to estimate butyl requirements. Such relationships resulted in about 8,000 tons butyl rubber and 39,500 tons SBR. Following similar reasoning, the break-up of the total synthetic rubber estimated consumptions were obtained for the remaining years.

West Africa (Table A2)

Among the major plastics there is no estimate for polystyrene. As the significance of this plastic increases with rising standard of living, some rough order of magnitude of future consumption would be in order. This was done on the basis of the polystyrene to PVC + polyethylene relationship derived from North African figures.

Total 1964 fibre consumption was 176,000 tons. Of this, 3.7 per cent (about 6,200 tons) represented synthetics. The latter was expected to increase its share to 5.5 per cent (16,000 tons) in 1980.[2] According to

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1/ The letter "A" forming part of the numbering of a table refers to tables annexed at the end of this study.

2/ Source: The Textile Situation in West Africa: Markets - Industries - Prospects (E/CN.14/INR/129), ECA, 1966.

recent trends, it is likely that this share will double. The estimates presented in this study are, therefore, based on this assumption.

The 1964 synthetic fibre consumption was estimated to consist of 54 per cent nylon, 34 per cent polyester and 12 per cent others. In view of trends toward polyester and other fibres, the 1980 break-up is expected to look like this: 55 per cent polyester, 24 per cent others and 21 per cent nylon. Using these allocations, the 1964 and 1980 estimates were obtained. Demands for 1970 and 1975 were calculated by interpolation.

As regards fibres grouped in "others", it has not been possible to identify the types. It is possible, however, that acrylics should figure significantly in this group. In North African estimates of synthetic fibres, they accounted for 5.5 per cent in 1965, and their share is expected to grow to 10 per cent in 1970, 16 per cent in 1975 and 18 per cent in 1980. In the absence of any indication in West Africa, these figures have been used in estimating demands there for acrylics.

The situation regarding synthetic rubbers is somewhat similar to that of fibres. In some West African countries, the maximum share of synthetic rubbers in total rubber consumption was estimated at about 58 per cent in 1964. This compares favourably with the world figure of 57 per cent in 1967.[1/] According to information extracted from another source,[2/] 1975 and 1980 demands for inner tubes were found to represent about 9 per cent of all types of rubber demand. Assuming inner tubes to be of butyl rubber, the remaining 49 per cent should represent other synthetic fibres. Considering the dominance of tyres and tubes (probably accounting for some 85 per cent of rubber use) in Africa, and the 50 per cent share of synthetics in rubber products in general, it could be assumed that about 45 per cent of the total rubber consumption is in SBR. Using these percentage shares, the butyl and SBR components were calculated from the estimated total rubber demands.

1/ Source: Chemical and Engineering News, December 25, 1967.

2/ Source: The Development of the Rubber Industry in West Africa (E/CN.14/INR/131), ECA, 1966.

Table 1: Estimated potential demand for petrochemical end-products

(in tons)

	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	PVC				Polyethylene			
North Africa	16,750	28,500	44,100	67,100	6,935	17,500	37,700	67,100
West Africa	7,750	17,560	34,480	68,570	4,053	11,950	28,920	64,470
Central Africa	2,587	6,375	12,728	24,431	1,080	3,300	7,600	16,000
East Africa	6,100	13,200	25,500	48,300	3,600	10,700	21,640	45,900
Total	33,177	65,635	116,808	208,401	15,668	43,450	95,860	193,470
	Polystyrene				SBR			
North Africa	2,760	5,100	8,100	11,800	10,600	16,200	26,000	39,500
West Africa	1,360	3,100	6,300	12,200	7,000	12,400	20,000	32,000
Central Africa	430	1,080	2,000	3,700	1,240	1,600	2,100	2,650
East Africa	1,120	2,650	4,660	8,600	5,350	9,900	18,200	33,300
Total	5,670	11,930	21,060	36,300	24,190	40,100	66,300	107,450
	Nylons				Polyesters			
North Africa	7,300	11,000	15,500	25,000	850	3,400	8,000	15,000
West Africa	3,300	4,800	6,100	6,600	2,100	4,400	8,500	16,900
Central Africa	620	820	1,040	1,100	390	760	1,440	2,900
East Africa	2,300	2,900	3,550	4,250	1,400	2,400	5,000	11,000
Total	13,520	19,520	26,190	36,950	4,740	10,960	22,940	45,800
	Acrylics				Urea-formaldehyde			
North Africa	450	1,700	5,000	10,000	1,890	3,100	4,740	7,200
West Africa	340	1,100	2,900	5,600	1,960	3,420	10,300	13,700
Central Africa	60	190	500	950	2,710	4,900	7,130	9,500
East Africa	230	680	1,700	3,600	690	2,050	4,120	5,140
Total	1,080	3,670	10,100	20,150	7,250	13,470	26,290	35,540

Table 1 continued

	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	Phenol-formaldehyde				Dodecylbenzene			
North Africa	810	1,350	2,020	3,100	9,200	14,000	21,800	30,800
West Africa	850	1,480	4,400	5,900	2,600	5,050	10,300	20,600
Central Africa	1,160	2,100	3,070	4,100	290	860	1,360	2,070
East Africa	290	890	1,760	2,210	2,000	3,800	7,600	14,900
Total	3,100	5,830	11,250	15,310	14,090	23,710	41,060	68,370
	DDT(75%)				BHC(25%)			
North Africa	2,684	2,948	5,215	9,270	694	1,849	3,465	6,520
West Africa	1,180	2,860	5,960	10,300	5,454	10,050	18,895	32,370
Central Africa	370	2,830	3,200	3,600	..	..	..	..
East Africa	1,880	5,250	9,980	18,950	1,790	3,480	6,440	12,050
Total	6,114	13,888	24,355	42,120	7,938	15,379	28,800	50,940
	Butyl rubber				Polybutadiene (rubber)			
North Africa	2,200	3,300	5,300	8,000	3,200	4,900	7,800	12,000
West Africa	1,400	2,500	4,000	6,000	..	..	..	..
Central Africa	250	320	410	530	..	..	..	..
East Africa	1,070	2,000	3,630	6,650	..	..	..	..
Total	4,920	8,120	13,340	21,180				
	Perchloroethylene				n-hexane			
North Africa	1,700	2,500	3,600	6,150	..	50-130	..	..
West Africa	330	630	1,000	1,750	400-1000	500-1300	600-1500	670-1700
Central Africa	30	70	120	200				
East Africa	270	420	960	1,500	..	..	..	..
Total	2,330	3,620	5,680	9,600	600-1500	800-2000	900-2250	1000-2550
	Carbon black							
North Africa	12,400	17,000	24,500	34,000				
West Africa	6,200	11,000	17,300	28,000				
Central Africa	1,100	1,400	1,900	2,400				
East Africa	4,700	8,800	16,200	29,500				
Total	24,400	38,200	59,900	93,900				

Central Africa (Table A3)

With the exception of PVC and detergents, there are no demand estimates available for any of the petrochemicals considered in this exercise. As conditions are not very different from those prevailing in West Africa, orders of magnitude of consumption of plastic products (polyethylene and polystyrene) were calculated, using per capita consumption based on estimates for the same products in West Africa.

Total fibre demand, for use in fabrics, is expected to increase from 29,600 tons in 1963 to 47,500 tons in 1975 and 65200 tons in 1980. About 8.5 per cent of the latter (5,250 tons) is expected to be covered by synthetics.[1] As no additional information is available, further assumptions had to be made. Firstly, total fibre demand for intermediate years (1965 and 1970) was obtained by interpolation. Secondly, 3.7 per cent share of synthetics in the West African market in 1964 was assumed to apply in the sub-region in 1965, and on this basis synthetic fibres shares for 1970 and 1975 were obtained by interpolation. Finally, applying the breakdown by types of synthetics assumed for West Africa, approximate demand for nylon, polyester and acrylics were calculated.

As regards synthetic rubber, some incomplete information had to be used as a projection basis. In 1975, annual imports of tyres and inner tubes for cars and trucks to the Congo (Democratic Republic), and excluding import of those mounted on imported vehicles, are estimated to be 200,000 units. The 1955-1959 average consumption of 900,000 units of bicycle tyres and 1.3 million inner tubes are expected to be attained in the 1970-1975 period.[2] The rubber content in all those units will approximate 1,500 tons (1,000 tons for vehicles and 500 tons for bicycles).

In the UDEAC countries, imports of tyres and tubes increased from about 2,300 tons in 1960 to 2,780 tons in 1964. This is equivalent to 1,150 and 1,400 tons of rubber at 50 per cent rubber content and growth at a rate of

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1/ Source: The Textile Situation in Central Africa: Markets-Industries-Prospects, ECA, 1968.

2/ Source: Possibilités d'industrialisation des Etats africains et malgache associés, III, République démocratique du Congo, Vol. I, décembre, 1966.

5 per cent per year. In the absence of adequate information, this rate of growth was used to estimate the order of magnitude of demand for the 1965-1980 period. For the same reason, this rate was applied in extrapolating the 1975 estimate for the Congo (Democratic Republic) referred to above. On the assumption that rubber in tyres and tubes represents 85 per cent of rubber consumption in the sub-region, the following total rubber needs were calculated.

	1965	1970	1975	1980
UDEAC	1,700	2,170	2,800	3,600
Congo (D.R.)	1,050	1,400	1,800	2,300
Sub-region	2,750	3,570	4,600	5,900

Using the 9 and 45 per cent shares for butyl rubber and SBR respectively, orders of magnitude of demand for these two were calculated.

East Africa (Table A4)

The country projections of PVC demands presented in Table A4 were regarded as being on the low side. The sub-regional totals given in the same table were obtained, therefore, by the application of West African per capita consumption estimates to the population projections for the sub-region. Regarding polystyrene, as was the case in West and Central Africa, there was no local indication of past or current consumption which could serve as a base for projection. Under the circumstances, demand for polystyrene had to be estimated on the basis of its relationship to PVC + polyethylene derived from available data on the North African sub-region.

In 1962, synthetic fibres accounted for 4.1 per cent of the total textile market of 993 million yards. This share was expected to increase to 6.0 per cent in 1975 when total fibre demand was estimated at 1,423 million yards.1/ Because of strong indications for an accelerated trend toward synthetics, as evidenced since 1963, this percentage share has been raised to 8.0 and is assumed to increase further to 12.0 in 1980.

1/ Source: The Textile Industries in the East African Sub-region: Present Situation and Growth Prospects (E/CN.14/INR/86), ECA, 1965.

On the basis of 1962-1975 rate of growth (2.8 per cent), 1965 and 1980 total textile markets were estimated at 1,080 and 1,630 million yards respectively. The projections expressed in yards were converted into tonnage taking into consideration the trend towards lighter fabrics. As regards break-up of the synthetic portions, the proportions that were assumed for West Africa were applied for East Africa: nylon share in synthetics to decrease from 54 per cent in 1965 to 21 per cent in 1980, that of polyester to increase from 34 per cent to 55 per cent and that of acrylics from 5.5 to 18 per cent. The results thus obtained are presented in Table A4.

Total rubber consumption in East Africa in 1963 was estimated at 9,300 tons and was expected to increase to 22,000 tons in 1970.[1] Assuming the 1963-1970 rate to apply for the 1963-1980 period, demand may be estimated to have risen to 11,900 tons in 1965 and to increase further to 40,400 tons in 1975 and 74,000 tons in 1980. Following the same reasoning as that applied to West African rubber demand, e.g., using the 9 per cent butyl and 45 per cent SBR shares in the total rubber requirement, estimates for these two synthetic rubbers were calculated.

As regards detergents, the East African sub-region is the only one for which there are no estimated demands or local information adequate for estimating them. Under the circumstances, resort had to be made to the use of per capita consumption in other sub-regions. The West African figures, invariably lying between those of North Africa (high) and Central Africa (low), were assumed to represent the East African condition. The estimates resulting from this approach are presented in Table A4.

(b) Other selected petrochemicals (adhesives, solvents and carbon black)

Because of potential for development, the products in these groups have been selected for inclusion in this study. No demand forecast was available, in starting, and there were no data from which to develop past trends. The approach used here in estimating demand is, therefore, necessarily different. Prospective demand has been derived from the content of the particular petro-

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1/ Source: The Development of Rubber Goods Manufacture in the East African Sub-region (E/CN.14/INR/92), ECA, 1965.

Table 2: Panel production and resin requirement for same

	Panel (1000m³) a/				Urea formaldehyde (tons)				Phenol-formaldehyde (tons)			
	1960-65	1970	1975	1980	1960-65	1970	1975	1980	1960-65	1970	1975	1980
North Africa	55	91	138	210	1,890	3,100	4,740	7,200	810	1,350	2,020	3,100
West Africa	57	100	300	400	1,960	3,420	10,300	13,700	850	1,430	4,400	5,900
Central Africa	79 b/	143	208	377	2,710 c/	4,900	7,130	9,500	1,160 c/	2,100	3,070	4,100
East Africa	20	60	120	150	690	2,050	4,120	5,140	290	890	1,760	2,210
Total	211	394	766	1,037	7,250	13,470	26,290	35,540	3,100	5,830	11,250	5,310

a/ Sources: ECA/FAO Forest Industries Development (1, North Africa (2) Central Africa, 1968.
ECA/FAO Forest Industries Development in West Africa (E/CN.14/INR/108), 1966 (with some change)
ECA/FAO Forest Industries Development in Eastern Africa (E/CN.14/INR/80), 1965 (with some change)
ECA/FAO Forest Industries Development in Central Africa, 1968.

b/ 1968 plywood production in Gabon = 67,000 m³.

c/ 1967 Gabonese import of resin = 3,098 tons.

chemicals in consumer goods or final outlets considered of significance in Africa and inputs in certain industrial establishments.

Adhesives - Under present and foreseeable future African conditions, the wood industry seems to be the major outlet for these resins in the form of adhesives. The requirement for composite panels is viewed as reflecting total demand.

In varying degrees, all sub-regions are producers of panels (plywood, particle board and fibre board). Table 2 presents average production for the 1960-65 period and projections up to 1980. From information obtained in the field, resin content in panels is about 7 per cent by weight. Assuming this to apply to all sub-regions, and converting volume figures to tonnage using average specific gravity of panel equal to 0.7, approximate demand for adhesives was estimated.

Urea- and phenol-formaldehyde resins are the major adhesives used. Again on the basis of field information, 70 per cent is in the form of the former and 30 per cent in the latter. The results obtained using this relationship are shown in the same table.

Moulded goods of various kinds, such as telephone and door and electrical control knobs, are other outlets for phenol-formaldehyde (Bakelite), and domestic appliances are an outlet for urea-formaldehyde. Due to the advent of new plastics, urea-formaldehyde for domestic appliances is of less significance today than it once was. Demand for phenol-formaldehyde could, however, be appreciable. There is no adequate basis for estimating resin requirement for the above end-uses, and no attempt has been made to make such estimates. The above figures regarding phenol-formaldehyde in particular are, therefore, to be regarded as minimum.

Solvents - Dry cleaning, extraction of oil seeds and surface-coatings are among the important activities using solvents in appreciable quantities. An attempt has been made in the following paragraphs to estimate orders of magnitude of consumption for some specific solvents.

Dry-cleaning - The dry cleaning industry has, during a good part of the past three to four decades, seen the advent of new chlorinated solvents. Carbon tetrachloride gave way to trichloroethylene, and this, in turn, is giving way to perchloroethylene. The solvents commonly used nowadays are therefore perchloroethylene, stoddard solvent and petroleum distillates. From past trends, it is expected that perchloroethylene will replace more and more the non-chlorinated hydrocarbons.

In the absence of other information for estimating solvent demand for dry cleaning, an attempt has been based on urban population. Towns of 100,000 and more inhabitants arbitrarily have been assumed to qualify as consumption centres for dry cleaning solvents. From 1960-61 average imports of chlorinated solvents, orders of magnitude of apparent consumption for urban population were estimated for certain countries for which data were available. As shown below, the results range from 0.036 kg per person in Ethiopia to 0.483 in Algeria.

	Kg/person		Kg/person
Ethiopia	0.036	UDE countries	0.250
Morocco	0.158	Zambia	0.386
Madagascar	0.166	Algeria	0.483

Because of climatic conditions, the wearing of apparel normally requiring dry cleaning is not as prevalent in tropical Africa as in the relatively temperate or cool areas in Africa. The latter includes parts of Northern, Eastern and Southern Africa. Some of the above figures do not, however, seem to support this conclusion. Those pertaining to the UDE countries are a case in point. The explanation for the high figure lies in the fact that the quantity of solvent used in estimating consumption per person includes all chlorinated derivatives except DDT. If the Ethiopian case is regarded as an exception, the above figures support the conclusion.

As the standard of living rises, so will consumption of solvents for dry cleaning. Because of fluctuating trends in some of the above-mentioned countries and in the absence of definite pattern of growth, increased consumption per person has not been forecast. Rough future demands are estimated on the assumption of 0.1 kg per person (40 per cent of the UDE countries figure) to apply to tropical areas and 0.3 kg per person (average of the other countries excluding Ethiopia) to the remaining areas. The results are presented in Table 3.

Table 3: Estimated solvent requirement for dry cleaning

	1960		1965		1970		1975		1980	
	Urban population	Solvent (t)	Urban population	Solvent (t)	Urban population	Solvent (t)	Urban population	Solvent (t)	Urban population	Solvent (t)
North Africa	13	3,900	19	5,700	24	7,200	31	9,100	41	12,300
West Africa	7	700	11	1,100	18	1,800	25	2,500	35	3,500
Central Africa	1	100	1	100	2	200	3	300	4	400
East Africa	2	600	3	900	4	1,200	6	2,400	10	3,000
Total	23	5,300	34	7,800	48	10,400	65	14,300	90	19,200

Import statistics indicate that apparent consumption for certain countries, namely UDE, Tunisia, Morocco, Algeria, Zambia, Ethiopia and Madagascar for the 1960-65 period has been around 1,500-2,000 tons annually. Comparison of these with the 1960 and 1965 calculated totals for the sub-regions in Table 3 indicates that the latter will not be very different from the actual consumption.

There is no clue as to the types and quantities of solvents in use. Under the circumstances, a guess based on the trend towards perchloroethylene, referred to above, had to be made. It is, accordingly, expected that the share of perchloroethylene, assumed to be about 30[1] per cent of the 1965 consumption, will increase to 35, 40 and 50 per cent in 1970, 1975 and 1980 respectively. The resulting figures are shownin Table 1.

1/ According to Industrial Chemicals, by Faith, W.L., Keyes, D.B., and Clark, R.L., perchloroethylene accounted for 30 per cent of the dry cleaning solvent in the USA at the beginning of this decade.

<u>Solvent extraction of oilseeds</u> - In developed countries, vegetable oils are mostly solvent extracted. In Western Europe, for instance, over 60 per cent of the 1961 total oil capacity was accounted for by solvent extractors.[1] Solvent extraction can recover up to 98 per cent of the oil. The corresponging efficiency with the conventional expression process is 88. Over 10 per cent of oil content in the latter process is, therefore, left in the oil cake.

A high oil-content cake (more than 8 per cent) is less nourishing and, because of its rancid taste, does not work well as stock feed. Too, this unwanted oil in the cake is a waste to the processor because the price of oil is about three times that of the cake. High oil content is the prevailing state of affairs in almost all oilseed crushing mills in Africa.[2]

According to SEDES[3], 1970 estimated oil production in the whole of Africa is about 3.7 million tons (see Table B2). Using the above relationship and assuming that all the oilseeds produced are crushed in Africa, the oil lost in the cake but recoverable if solvent extracted, is estimated at 400,000 tons. It would not be practical for most existing oil mills to add solvent extraction units. Such units should be centralized in oilseed crushing areas where they could have relatively easy access to cakes of expression mills. As shown in Table B1, West Africa (including Central Africa) accounts for about two-thirds of the African output. This gives a rough idea regarding the areas of possible concentration of available cakes.

At 2-5 kg solvent per ton of oil to be extracted from the cake, solvent requirement for the 1970 is estimated to be 800 to 2,000 tons. Assuming that SEDES estimated rate of increase in oil production up to 1970 will apply to the 1970-1980 period, 1975 and 1980 solvent requirements have been estimated at 900 to 2,250 and 1,000 to 2,550 tons respectively. In the absence of adequate information the distribution of these global projections by sub-regions, the 1954-1962 trend, visible in Table B1, was used to estimate the combined West and Central African share.

1/ Source: <u>Economic Aspects of the Location of Oilseed Crushing (CCP:OF 66/12), FAO, 1966</u>

2/ There appears to be a solvent equipment in Senegal.

3/ Source: <u>Le Marché des Oléanginoux Tropicaux</u>, Rapport Général, SEDES, Paris, Mai, 1964.

With time and industrialisation, and because of the expected shortage of fats and oils in the world, some of the existing expeller mills may have to be converted to solvent extractors. Besides it is to be expected that a good number of new installations will be in this form. As there is no adequate information on which to base the magnitude of production, solvent requirements for such units have obviously not been provided for. Since it is unlikely that all oil seeds will be processed in Africa and since all oil cakes may not be expected to find their way to the solvent extractors, it is likely that the solvent not utilised for cake extraction will be used by the new installations.

Although trichloroethylene is used to some extent, the usual solvents are light petroleum fractions consisting chiefly of n-hexane. It is assumed that the estimated solvent demand will be met entirely by n-hexane.

<u>Surface-coatings</u> - Solvents are among the constituents of surface-coatings. Turpentine used to be the most important. It has long since been replaced by white spirits and SBPs. Aromatic hydrocarbons, alcohols, esters, ketones and others are of particular importance in varnishes and lacquers.

To estimate solvent requirement for surface-coatings it is helpful to have a rough idea of surface-coating demand. Table 4 has been compiled for this purpose and shows local production figures equal to 90 per cent of demand. This implies that the balance (10 per cent), representing special surface-coatings, would be met by imports. Although the requirement of solvents and thinners varies with the type of coating, an average of 10 per cent of total coating has been assumed for the purpose here. Estimates for solvents and thinners as calculated on the basis of this assumption are presented in the same table.

It is not possible to break down the above estimate by types of solvent. All that can be done at this stage is to distinguish roughly between petroleum based solvents and others. The former, by far, command the largest share. On the basis of indications from certain developing countries, a maximum of 10 per cent of the solvent requirement has been assumed to be met by the latter. The resulting quantity, when viewed

Table 4: Solvents and thinners for local paint industry (in tons)

	Surface coatings a/					Solvents and thinners			
	1965	1966	1970	1975	1980	1965/66	1970	1975	1980
North Africa	30,000	..	47,000	69,000	102,000	3,000	4,700	6,900	10,200
West Africa	11,910	..	21,000	37,000	65,000	1,191	2,100	3,700	6,500
Central Africa	4,331	5,600	9,900	13,000	18,000	433	990	1,300	1,800
East Africa	15,000	..	23,500	36,500	57,000	1,500	2,350	3,650	5,700
Total	61,241	..	101,400	155,500	242,000	6,124	10,140	15,550	24,200

a/ **Sources:** North Africa: Dying, Tanning and Colouring Materials and their Future Prospects in the North African Sub-region, ECA, 1968.

Central Africa: Prospects for Some Consumer-oriented Chemicals in the Central African Sub-region, ECA, 1968.

West Africa: Based on Summary Report of Prefeasibility Study of an Expanded Paint Products Industry in West Africa to 1980 (E/CN.14/INR/139), ECA 1966.

East Africa: Own estimate.

against the number of types it represents, suggests no significant volume for any one of them. Because of this, and in view of the difficulty of assessing the magnitude and type of individual solvents, it is assumed here that those establishments which will produce certain chemicals such as benzene, alcohols, etc., could easily produce extra quantity to meet the surface-coatings requirements.

Carbon black - Carbon black is used as a reinforcing agent in rubber manufacture, for tyres in particular. As tyres and tubes account for about 85 per cent of total rubber demand in Africa, as against, say, 60 per cent in the United States of America,[1] the requirement for carbon black should be significantly higher in relation to total rubber consumption.

The carbon black content in manufactured rubber articles varies. In compounding inner tubes and tyres, for instance, 20 and 50 parts of carbon black are needed for 100 parts of rubber respectively. Considering conditions in Africa, it appears that an average of 40 parts per 100 parts may be assumed to represent the proportion applicable to total rubber demand for the period under review. On the basis of this relationship, requirement for carbon black was computed for each sub-region (see Table 1).

As there will necessarily be need to import certain ready-to-use rubber goods, including parts of machinery and vehicles, the carbon black demand estimated may be considered on the high side. It is assumed that the excess will be absorbed by requirements for surface-coatings and inks for which other provision has not been made.

Monomers: Table 5 presents potential monomer requirements for polymerization. They were derived from the estimated demands for polymers shown in Table 1.

Intermediate and basic organic chemicals

The intermediate and basic petrochemical inputs needed to produce the end-products considered in this study are shown in Tables 6, 7 and 8. It should be noted that ethylene requirement as a monomer for polyethylene is given in both tables.

1/ Source: Chemical and Engineering News, December 25, 1967.

Table 5: Monomers requirements for potential demands for polymers (in tons)

	1964/65	1970	1975	1980	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	Vinylchloride for PVC				**Ethylene for polyethylene**							
North Africa	18000	31000	47500	72500	7900	20000	43000	76500				
West Africa	8400	19000	37200	74000	4600	13600	33000	73500				
Central Africa	2800	6900	13700	26400	1230	3800	3650	10200				
East Africa	6600	14200	27500	52200	4100	12200	24700	52000				
Total	35800	71100	125900	225100	17830	49600	109350	220200				
	Styrene for polystyrene				**Styrene for SBR**				**Total styrene**			
North Africa	2900	5300	8400	12200	2100	3200	5200	8000	5000	8500	13600	20200
West Africa	1400	3200	6600	12700	1400	2500	4000	6400	2800	5700	10600	19100
Central Africa	450	1100	2100	3900	2500	3200	4200	5300	2950	4300	6300	9200
East Africa	1160	2300	4000	9000	1100	2000	3600	6700	2260	4800	8400	15700
Total	5910	12400	21900	37300	7100	10900	17000	26400	13010	23300	38900	64200
	Butadiene for SBR				**Butadiene for polybutadiene**				**Total butadiene**			
North Africa	6800	10200	16400	25000	3500	5300	8400	13000	10300	15500	24800	38000
West Africa	4400	7800	12600	20000	..	..	..	..	4400	7800	12600	20000
Central Africa	800	1000	1300	1700	..	..	..	..	800	1000	1300	1700
East Africa	3400	6200	11400	21000	..	..	..	..	3400	6200	11400	21000
Total	15400	25200	41700	67700	..	..	..	..	18900	30500	50100	80700
	Caprolactam for nylon 6				**Acrylonitrile for acrylics**							
North Africa	7700	12100	17000	27500	470	1300	5200	10400				
West Africa	3600	5300	6700	7300	350	1150	3000	5800				
Central Africa	700	900	1100	1200	60	200	520	1000				
East Africa	2500	3200	3900	4700	240	710	1800	3800				
Total	14500	21500	28700	40700	1120	3360	10520	21000				

Table 6 : Potential intermediate and basic organic chemical requirements (other than ethylene and benzene) for petrochemicals considered in this study (in tons)

	1964/65	1970	1975	1960	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	P-xylene for DMT				DMT for polyester				Ethyleneglycol for polyester			
North Africa	700	2800	6700	12400	940	3700	8800	16500	270	1100	2560	4800
West Africa	1760	3650	7000	14000	2300	4800	9400	18600	670	1400	2700	5400
Central Africa	320	630	1200	2400	430	840	1600	3200	130	240	460	930
East Africa	1160	2000	4150	9100	1500	2600	5500	12100	450	770	1600	3500
Total	3940	9080	19050	37900	5170	11940	25300	50400	1520	3510	7320	14630
	Propylene for acrylonitrile				Propylene for dodecylbenzene				Total propylene			
North Africa	770	2900	8500	17000	12000	18200	28500	40000	12770	21100	37000	57000
West Africa	590	1900	5000	9500	3400	6550	13400	26800	3990	8450	18400	36300
Central Africa	100	320	850	1620	380	1100	1770	2700	480	1420	2620	4320
East Africa	400	1160	2900	6200	2600	5000	9900	19400	3000	6160	12800	25600
Total	1860	6280	17250	34320	18380	30850	53570	88900	20240	37130	70820	123220
	Methanol for formaldehyde for urea-formaldehyde				Methanol for formaldehyde for phenol-formaldehyde				Total methanol			
North Africa	890	1460	2230	3400	280	460	690	1060	1170	1920	2920	4460
West Africa	920	1620	4850	6450	290	500	1500	2000	1210	2120	6350	8450
Central Africa	1270	2300	3350	4450	400	720	1060	1400	1670	3020	4410	5850
East Africa	330	960	1920	2400	100	300	600	750	430	1260	2520	3150
Total	3410	6340	12350	16700	1070	1980	3850	5210	4480	8320	16200	21910

Table 6 : Contd.

	1964/65	1970	1975	1980	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	Formaldehyde for urea-formaldehyde				Formaldehyde for phenol-formaldehyde				Total formaldehyde			
North Africa	1900	3000	4700	7200	580	970	1450	2330	2480	3970	6150	9530
West Africa	2000	3400	10300	13700	610	1060	3160	4250	2610	4460	13460	17950
Central Africa	2700	4900	7100	9500	830	1500	2200	2950	3530	6400	9300	12450
East Africa	700	2050	4100	5100	210	640	1260	1590	910	2690	5360	6690
Total	7300	13350	26200	35500	2230	4170	8070	11120	9530	17520	34270	46620
	Urea for urea-formaldehyde				Phenol for phenol-formaldehyde				Chlorobenzene for DDT			
North Africa	1270	2100	3200	4800	610	1000	1500	2320	2420	2650	4700	8330
West Africa	1320	2300	7000	9200	640	1100	3300	4400	1060	2580	5350	9300
Central Africa	1820	3300	4800	6400	870	1580	2300	3100	330	2550	2900	3250
East Africa	460	1380	2770	3450	220	670	1320	1660	1700	4730	9000	17000
Total	4870	9080	17770	23850	2340	4350	8420	11460	5510	12510	21950	37880

Table 7 : Potential benzene requirements for petrochemicals considered in this study (in tons)

	1964/65	1970	1975	1980	1964/65	1970	1975	1980	1964/65	1970	1975	1980
	DDT				**BHC**				**Styrene for polystyrene**			
North Africa	2150	2350	4160	7400	470	1260	2370	4450	2700	5000	7900	11500
West Africa	950	2300	4770	8250	3700	6800	12900	22000	1320	3000	6100	11800
Central Africa	300	2270	2560	2900	..	..	..	..	420	1050	1940	3600
East Africa	1500	4150	8000	15200	1220	2370	4400	8200	1090	2600	4500	8300
Total	4900	11070	19490	33750	5390	10430	19670	34650	5530	11650	20340	35200
	Styrene for SBR				**Caprolactam for nylon 6**				**DDB sulphonate**			
North Africa	2000	3070	5000	7500	9000	13500	19000	30700	4250	6400	10000	14200
West Africa	1330	2350	3800	6050	4100	5900	7500	8100	1200	2320	4730	9450
Central Africa	240	300	400	500	760	1080	1280	1360	130	400	620	950
East Africa	1020	1900	3450	6300	2830	3570	4370	5200	920	1740	3500	6800
Total	4590	7620	12650	20350	16690	23970	32150	45360	6500	10860	18850	31400
	Phenol for phenol-formaldehyde				**Total**							
North Africa	620	1030	1540	2360	21150	32640	49940	78110				
West Africa	650	1120	3350	4500	13250	23790	43150	70150				
Central Africa	880	1600	2330	3100	2730	6620	9130	12410				
East Africa	220	680	1340	1680	8800	17010	29560	51680				
Total	2370	4430	8560	11640	45970	80030	131710	212350				

Table 8 : Potential ethylene requirements for petrochemicals considered in this study (in tons)

	Vinyl chloride				Polyethylene				Styrene for polystyrene			
	1964/65	1970	1975	1980	1964/65	1970	1975	1980	1964/65	1970	1975	1980
North Africa	9200	15700	24300	37000	7900	20000	43000	76500	970	1800	2800	4100
West Africa	4300	9700	19000	37800	4600	13600	33000	73500	480	1080	2200	4300
Central Africa	1420	3500	7000	13400	1230	3800	8650	18200	150	380	700	1300
East Africa	3350	7250	14000	26600	4100	12200	24700	52000	390	930	1620	3000
Total	18270	36150	64300	114800	17830	49600	109350	220200	1990	4190	7320	12700
	Styrene for SBR				**Ethylene glycol for polyster**				**Total**			
North Africa	750	1140	1820	2770	190	750	1760	3300	19010	39390	73680	123660
West Africa	500	870	1200	2250	460	970	1870	3700	10340	26220	57270	121550
Central Africa	90	110	150	190	90	170	320	640	2980	7960	16820	33730
East Africa	380	700	1280	2300	310	530	1100	2400	8530	21610	42700	86300
Total	1720	2820	4450	7510	1050	2420	5050	10040	40860	95180	190470	365610

RAW MATERIALS (Petroleum and natural gas)

A relatively large part of Africa, the coastal areas in particular, is under oil concession to many international oil companies and, in some cases, a combination of national and international groups. The search for oil and gas is quite active in certain areas. New discoveries and increased output are frequently in the news. In short, although there remains a lot to be done in prospecting for oil and gas in Africa, the known reserves are good indicators of potential availability of hydrocarbon raw materials.

Total African reserves of crude oil, at the beginning of 1967, were 32,356 million barrels, against 389,050 million for the whole world.[1] Comparison with the 1958 reserves of 4,119 million barrels shows that in nine years African reserves increased eightfold resulting in an average annual rate of increase of about 26 per cent. In terms of significance in relation to world reserves, the African share increased considerably from 1.5 per cent in 1958 to 4.6 per cent in 1963 and 8.3 in 1967.

The future relative importance of African hydrocarbon reserves might be gauged by prodpects in other countries of which the USA is a good example. At the 1967 consumption rate, the USA proven reserves of crude oil and natural gas liquids will last for nine years and natural gas for 16 years.[2] In contrast the African crude oil will be exhausted in over 30 years at the 1967 rate of output.

The development of hydrocarbon exploitation has been as spectacular as that of reserves. Production of crude oil shot up from 23.5 million tons in 1961 to 144 million in 1967, an average annual rate of increase of more than 35 per cent. This development has made Africa a significant contributor to the world output of crude oil (1.3 per cent in 1960, 7.4 in 1965 and 8.3 in 1967).

The situations regarding natural gas is equally impressive.[3] The 1965 African reserves of natural gas have been estimated at 2,200,000 million m^3. This works out to 8.5 per cent of world reserves, a figure slightly higher than the 1967 crude oil share for the continent.

1/ Source: Europe - France Outremer, No. 456, janvier 1968.
2/ Source: Chemical and Engineering News, April 15, 1968.
3/ Source: World Petroleum Report, 1967.

Production is relatively small in comparison with reserves (4,500 million m^3 in 1965). This is also true in relation to world output, as the African share in world production accounted for only 0.3 per cent.[1/]

Within the last few years, natural gas has turned out to be a significant export item of the region. Exports to OECD countries, for instance, increased by 50 per cent to 800,000 tons in 1966 over 1965. A similar increase was expected for 1967.

Tar sands and oil shales are other future sources of hydrocarbon materials. Africa possesses 15,000 million tons of oil from such sources.

The picture just painted, however, is not so rosy when it comes to considering individual countries. Present availability of hydrocarbons is limited to a few countries, notably, according to descending order of importance: Libya, Algeria, Nigeria, the UAR, Angola, Gabon, Tunisia, Congo (Brazzaville) and Morocco. These countries and others are dealt with in the remaining part of this section.

Libya

Libyan oil reserves increased fourfold to 2,305.5 million m^3 in 1966 as compared to 556.5 in 1961. As regards natural gas, reserves have been estimated to 420,000 million m^3 in 1967. About 68 per cent of this is associated gas.

Production of oil started in 1961 and rose to over 100 million m^3 in 1967, ranking Libya as the fifth exporter of petroleum in the world.[2/] If this fantastic rate could be sustained for some time, Libya, with the tendency for production cost to be low there, will definitely pull itself to a higher rank among the top oil exporting countries in the world.

Except for a small quantity needed for the 8,000 b/d refinery, the crude oil produced is exported. In 1967, export of oil accounted for 98 per cent of all Libyan exports. In terms of volume this was 95 million m^3 and was 114 times that of 1961. According to descending order of importance the Federal

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1/ Source: Electric Energy Survey for Africa (E/CN.14/EP/36), ECA, 1968.

2/ Source: Marchés Tropicaux et Méditerranéens, No. 1198, 26 Octobre 1968

Republic of Germany, the U.K., Italy, the Netherlands and France are the major importers of Libyan crude, each importing over 50 million barrels or 8 million m^3 in 1966.

The significance of oil to the economy of a country like Libya is evident. In 1967/68 oil contributed $476 million to the national income or about $280 per capita as compared to $64 million or $42 per capita in 1963/64.

The future outlook of hydrocarbon resources in Libya seems to be bright. Indications are that reserves may reach 3,200 million m^3 crude oil and 620,000 million m^3 national gas by 1975. The corresponding production figures are expected to be 180 and 15,000 million m^3 per year.1/ Unlike at present, however, a good part of the gas may be expected to be commercialised. In fact according to Chemical and Engineering News of March 25, 68, when completed the liquified natural gas plant under construction at Marsa el Brega is expected to double world capacity.

Compared to the above reserve potentials and possible output, demand for domestic consumption of petroleum products, estimated at about 1.35 million tons in 1980 (see Table 10), is relatively insignificant. In other words, Libya has at its disposal abundant raw materials for local use and export in both crude and processed condition. Income (from crude oil alone), which is expected to reach $855 million per year in 1975, is a factor that may be expected to play a decisive role in the latter, that is, partial and/or total local processing of part of the crude oil and natural gas into intermediates and finished products for export.

Algeria

The known Algerian crude oil reserve of over 1,200 million m^3 is second to that of Libya. As regards natural gas, the situation is reversed with Algerian gas reserve of 2,300,000 million m^3 2/ compared to that of Libya's 420,000 million m^3. It is in fact among the largest reserves in the world.

1/ Information of this nature for the North African countries was drawn mainly from Evolution des Industries pétrolière et chimique dans la sous-région Afrique du nord, CEA, 1963.

2/ 3,000,000 million m^3 according to World Petroleum, Vol. 39, No.2, Feb.1968.

Crude oil production in Algeria started at a rate of 10,000 tons per year in 1957. Until 1963, when it was overtaken by Libya, Algeria used to be the leading producer in Africa. Its output in 1967, of about 45 million m^3, was 45 per cent of that of Libya. As regards natural gas, however, Algeria leads in the production of commercial gas (810 million m^3 in 1964 and 2,200 million m^3 in 1967).

Figures for 1967 exports are not available, but 1966 figures of 33.4 million m^3 crude oil and 1.8 million liquified gas do indicate the magnitude of exports. France and the U.K. are the major importers. It is expected that export requirements will increase from 1,850 million m^3 in 1971/1972 to 4,200 in 1975/1976.1/

As may be expected, income from hydrocarbons and its contribution to national income is not as highly significant as in Libya. Including the benefits accruing to Sonatrach, the state company, 1967 income ammounted to approximately "220 million.

The future of hydrocarbons in Algeria, as in any country, is dependent on future discoveries. From present indications crude oil and natural gas reserves are expected to reach 1,300 and 2,500,000 million m^3 respectively. Algeria, in spite of its lead in natural gas reserves, is expected to have output substantially lower than either the UAR or Libya.

A major part of this output is expected to find its outlet through the liquefaction unit reaching a capacity of 4,500 million m^3 per year in 1975. The plant which will be located at Skikda will be built unit by unit.

In comparison to production, domestic production of refined products is small and is expected to increase from about 3 per cent in 1965 to 4.5 per cent in 1975. This, in other words, means export of over 95 per cent of the crude oil output. From plans under study, a small part of this is expected to be processed into basic and intermediate petrochemicals, mainly for export.

1/ Source: World Petroleum, June 1968.

Nigeria

Nigeria possesses significant proved reserves of hydrocarbons: 200 million m^3 of crude oil and 280,000 million m^3 of natural gas.

Crude oil production started in 1957 in Nigeria. Because of situations in the country, 1967 output of oil has been drastically reduced. About 65 per cent of the crude output being from east of the Niger River was under secessionist "Biafran" territory and no export has been effected for quite some time since July 7, 1967. Previous years production figures of 13.5 million tons in 1965 and 20.7 million tons in 1966, that is an increase of 54 per cent, give indications of what could have happened in 1967 had it not been for the crisis in the country. From production trends observed so far, it is expected that 1969 output will exceed prewar levels. According to Petroleum Times[1], Nigeria crude output is expected to hit the one million b/d mark approximately 60 million m^3 per year in 1970.

As regards export, Nigeria is already the world's tenth largest crude oil exporter. Its 1966 exports amounted to 19 million tons. Countries of destination were: the U.K. (39%), Federal Republic of Germany (15%), France (10%), Canada (9%) and Argentina (7%). If it had not been for the crisis, oil revenue from royalties would have amounted to $56 million in 1967. In 1965, oil's contribution to total exports was 25 per cent. This increased to 33 per cent in 1966, thereby indicating the growing importance of oil to Nigeria.

Domestic requirement for crude is relatively small. Of the 20.7 million tons produced in 1967 only about 1 million tons were used as feed for the local refinery.

UAR

The UAR, until recently, had not been considered an important oil producing country. Because of recent discoveries, its future outlook is bright. Crude oil reserves are expected to increase from 95 million m^3 in 1965 to about 700 million m^3 in 1980. The corresponding figures for natural gas are 14,150 and 400,000 million m^3.

1/ Source: Petroleum Times, 21 July 1967.

The importance of the above reserves is to be reflected in the corresponding increases in production over 1967: a fourfold increase to 40 million m^3 crude oil in 1973[1/], tenfold to 20,000 million m^3 gas in 1980. Unlike in the other countries dealt with so far, both reserves and production of hydrocarbons are expected to increase steadily up to 1980.

From import/export statistics of the first half of this decade it appears that the UAR has been a net importer of crude oil to the tune of 1 to 2 million tons per year. With the new discoveries and exploitation of some, that is, sharp increase in production to 12 million tons in 1968[1/] and the estimated 15 million tons in 1969[2/] the situation must have reversed as early as 1968, making the UAR a net exporter.

Angola

Crude reserves, including those of the rich cabinda deposits recently discovered, are estimated at 300 million tons.[3/] The Cabinda crude is of very low sulphur content with average API gravity of 26° (shallow reservoirs) and 36° (deeper reservoirs containing lighter, waxy oil).

Crude production, which started in 1956, expanded rapidly from 67,000 tons in 1960 to over 900,000 tons in 1964. Due to declining output of the Tobias field this fell to 639,000 tons in 1966. As a result, there were no exports of crude in 1966, all of the above production being consumed by the local refinery. Offshore strikes in the Cabinda area and other places are expected, however, to reverse the downward trend. Production of 7.5 million tons (150,000 b/d) is the Cabinda field target by the end of 1970.[4/]

The feasibility of producing petrol from the very large deposits of tar sands has been under investigation since the beginning of 1967. This investigation seems to have shown promise as Portugal already has plans to set up a pilot plant of up to 100,000 tons per annum of tar sands.[4/]

1/ Source: Marchés Tropicaux et Méditerranéens, 24 août 1968.

2/ Source: Marchés Tropicaux et Méditerranéens, 4 janvier 1969.

3/ Source: International Financial News Survey, Vol. XIX, No. 36, Sept. 15, 1967.

4/ Source: World Petroleum, Vol. 38, No. 12, Nov. 1967 and Vol. 39, No. 2, Feb.

Gabon

Crude oil reserves are not known. Estimates suggested 150 million tons in 1967. Information regarding natural gas is even less complete as the non-associated gas situation has, so far, not been the subject of detailed study. However, excluding the Camba field, reserves have been estimated at 3,000 million m^3.

Gabon was among the first African countries to produce oil. It started production in 1957 with output of 173,000 tons. During the 1960-63 period, output averaged about 800,000 tons and steadily increased thereafter to 1.45 million tons in 1966. This increased further to 3.5 million tons in 1967 and was expected to reach the 5 million ton mark in 1968 and 9 million tons in 1970.[1] As regards natural gas, 1960 associated gas output of 7.5 million m^3 rose to 11.5 million m^3 in 1966 showing a steady increase throughout the period. These represent quantities put to use for electric generation in Port-Gentil. The totals exclude gas flared in the field, estimated at about 70 million m^3 in 1966. Total output is expected to increase to 220 million m^3 in 1970.[2]

Earnings from petroleum accounted for 15.5 per cent of total exports in 1966. An export of 1.4 million tons put crude oil as the third export item of importance after wood and manganese. With the expected sharp increase in output the future of crude oil is on the bright side. It may be anticipated that crude oil will occupy first place as an export item toward the close of the decade.

Tunisia

The prospect for hydrocarbon resources in Tunisia is relatively modest. Reserves in 1967 amounted to 48 million m^3 of crude oil and about 100 million m^3 of gas. If exploited at the 1967 (2.2 million m^3 crude) and 1966 (8.4 million m^3 gas) rates, these will last for 20 and 12 years respectively. If they are not augmented substantially by new discoveries, the prospects for hydrocarbons resources are evidently not encouraging.

1/ Source: Petroleum Times, 8 Nov. 1968.

2/ Source: Bulletin de l'Afrique noire, No. 423, 22 juin 1966.

Up to, and including 1966, Tunisia used to import part of her crude requirement. Since 1967 it has become a net exporter. In fact, all 1967 refinery requirements were met from domestic source. During the first half of 1968 production rose sharply to about 1.5 million tons. This compares with about 1.0 million for the same period in the previous year.

Income from crude export is modest, a mere $3 million in 1967. Together with royalty from the El Borma oil field this came to a total of $7 million.

Morocco

Of all the North African countries producing hydrocarbons, Morocco is so far the least fortunate in such resources. 1964 reserves of crude, amounting to 488,000 tons, dwindled to 185,000 tons by 1967. As regards natural gas, Morocco with its 500-550 million m^3 reserve appears to be in a better position than Tunisia.

Production of crude has been falling steadily since 1963 to 120,000 m^3 in 1967. On the average it represents about 10 per cent of the domestic demand. The story regarding natural gas is just the opposite. Output rose from 7.5 to over 11 million m^3 in the 1962-1967 period.

As for the future what was said concerning Tunisia applies to Morocco even more. Unless exploration gives positive results within the near future, Morocco's future in the field of petroleum and natural gas, the former in particular, is dismal.

Congo (Brazzaville)

Hydrocarbon resources are becoming of less significance in Congo (Brazzaville). Output fell from 123,000 tons in 1962 to 62,000 tons in 1966. The reason for the downward trend of production is the small Pointe Indienne unreplenished reserve which in 1967 stood at 1 million m^3 crude.1/ No gas has been exploited up to 1967. The potash mine at Hollo is supposed to have started using gas in 1967/68. Consumption is foreseen at 30 million m^3 per year. The reserve of suitable gas is estimated at 400 million m^3.

1/ Source: Industries et Travaux d'Outremer, No. 65, août 1967.

Mozambique

From available information the crude oil situation in Mozambique is not clear. Regarding natural gas its existence can be inferred from reports that it took Gulf Oil about one year (1966) to control high pressure gas blowout with a flow rate of as high as 10 million feet^3/d.[1/] It is reported that calls for bids were to have been made in September 1966 for the construction of a gas pipeline from Moambo to the Republic of South Africa, a distance of 350 km.

In another development it appears that some kind of hydrocarbon resource from which fuel for automobiles (which has been given the name "Basiline") can be extracted has been discovered in Mozambique[2/]. As is the case with the pipeline project, the fate of this development is not known.

Other countries

In 1965, a gas find was made in Spanish West Africa near the Mauritanian border. It is expected to yield 300,000 ft.^{3} or 9,000 m^3 per day. In its first five year plan (1966-1970), Chad has envisaged drilling in the area north of Lake Chad where the existence of gas is known. Traces of oil have been discovered in the Volta Region in Ghana. Drilling started in October 1966, but it seems that it was discontinued in April 1968. An off-shore oil find in Dahomey results in flow rates as high as 1440 b/d. Discoveries of important indications of oil and gas deposits have been reported in Western Cameroon and as a result the prospect of the oil industry in that country is said to be good. There is already a known reserve of 430 million m^3 gas. In lower Congo (Democratic Republic), adjacent to the rich Cabinda finds, an oil deposit capable of producing 500,000 tons per year is reported to have been discovered. It should be noted here that about three-fifths, or 34 million m^3 expressed in pure methan component of the Lake Kivu gas, may be considered as belonging to Congo (Democratic Republic) and the rest, 23 million m^3, to Rwanda. There has been reports of a natural gas find, although not in commercial quantities, in the Republic of Somali.

1/ Source: Petroleum Times, May 13, 1966, World Petroleum, Vol. 39, No.2, February 1968.

2/ Source: Marchés Tropicaux et Méditerranéens, No. 1136, 19 août 1967.

From the above, it is clear that most of the countries with known potential for joining the ranks of oil producers are on the Atlantic side. That this is so is confirmed by authoritative statements from organizations in the petroleum field. According to Gulf, for instance "... it now begins to appear that the sedimentary basins lying along the West African coast are exceptionally promising for oil exploration". In the words of World Petroleum "from now on there will be 'West African Oil', as well as Middle East, Carribean, North African and Indonesian". The low sulphur content of the 'West African Oil', whose 1970 production forecast is 1 million b/d, is expected to give West Africa a competitive advantage in the oil business.1/

In general, the interest shown by so many oil companies, the numerous licences to prospect for oil acquired by them and the amount of work and money that has already gone into and is still going into exploration in most countries in Africa testify to the future potential of the region in hydrocarbons as raw materials for petrochemicals as well as export items.

Before closing this chapter reference should be made to Table 9. In this table, past and future estimated consumption of petroleum products is compared with refinery capacities. The 1965-1970 capacities relate to those existing and anticipated to be in operation before the close of this decade. At the moment there is over capacity in the established refineries in each of the sub-regions.

As capacity utilization may be expected to satisfy increased demand in the early 1970's, no major increases are foreseen in 1970-1975. In fact, only a few countries (Algeria, the UAR, Nigeria, Ethiopia and Tanzania) are expected to raise their capacities during this period. In contrast the 1975-1980 period is expected to witness a surge in capacity increase.

The implementation of additional capacities planned or envisaged by the countries and those suggested by other studies, including those suggested here on the basis of demand forecasts, would be able to meet with a good part of the petroleum products requirements for the development of the petrochemical industry in the region.

1/ Source: World Petroleum, Vol. 38, No. 12, November 1967.

Table 9: Petroleum Products: Estimated consumption and desirable refinery capacities (1000 tons)

	Consumption 1965	1970	1975	1980	Capacity 1965-70	1970-75	1975-80
North Africa							
Algeria	1185	1430	1830	2410	2700	4700	4700
Libya	350	570	880	1350	500	500	1500
Morocco	1225	1560	2110	2900	1700	1700	3200
Sudan	600	770	1015	1350	900	900	1900
Tunisia	675	880	1180	1570	1000	1000	1800
UAR	5600	6550	8450	10700	8900	10000	11900
Total	9635	11760	15465	20230	15700	18800	25000
West Africa 1/							
Dahomey	31	80	(106)	140	-	-	-
Gambia	10	16	(22)	30	-	-	-
Ghana	515	764	(1050)	1430	1250	1250	1650
Guinea	220	400	(530)	700	600	600	900
Ivory Coast	208	450	(670)	1000	700	700	1400
Liberia	103	350	(500)	700	500	500	1000
Mali	60	100	(135)	180	-	-	-
Mauritania	20	50	(70)	100	-	-	-
Niger	21	55	(90)	120	-	-	-
Nigeria	865	1600	(2330)	3150	1600	2600	4500
Senegal	1244	400	(570)	750	600	600	1600
Sierra Leone	348	230	(330)	450	500	500	850
Togo	41	75	(100)	130	-	-	-
Upper Volta	31	50	(78)	120	-	-	-
Total	3697	4600	(6571)	11035	5750	6750	11900
Central Africa 2/							
Cameroon	..	..	..	..	-	..	..
CAR	..	..	..	..	-	..	..
Chad	..	..	..	..	-	..	..
Congo (B)	..	..	..	..	-	..	..

Table 9: Continued

	Consumption 1965	1970	1975	1980	Capacity 1965-70	1970-75[=]	1975-80[=]
Central Africa (Cont.)							
Congo (DR)	..	..	..	..	600	..	..
Gabon	..	..	..	..	600	..	..
Total	..	..	..	..	1200	..	..
East Africa[3/]							
Burundi [4/]							
Ethiopia	220	(340)	520	(300)	500	1000	1500
Kenya	950	(1180)	1450	(1800)	2000	2000	2000
Madagascar	160	(260)	420	(680)	600	600	1000
Malawi	50	(70)	100	(140)	-	-	-
Mauritius	100	(140)	200	(230)	-	-	-
Rwanda	35	(53)	80	(120)	-	-	-
Somalia	35	(53)	80	(120)	-	-	-
Tanzania	330	(590)	500	(1400)	600	1000	2000
Uganda	160	(235)	350	(520)	-	-	-
Zambia	130	(315)	550	(960)	-	-	-
Rhodesia	450	(650)	950	(1330)	1000	1000	1500
Total	2720	3886	5600	(8200)	4700	5600	8000

Sources: Evolution des industries pétrolière et chimique dans la sous-région Afrique du nord, CEA, 1968.
The Petroleum Industry in the West African sub-region (E/CN.14/INR/110), ECA, 1966.
Petroleum Industry in the East African sub-region (E/CN.14/INR/79), ECA, 1965.

1/ 1970 and 1980 country estimates for West Africa do not include provision for bunkering and feedstocks from petrochemical industries. 1980 total includes such provisions.

2/ 1968 UDEAC consumption is estimated at 597,000 tons.

3/ Fr. Somaliland excluded (1960 bunkering amounted to 970,000 tons)-- 1965 figures are estimated.

4/ Included in Rwanda.

= Own estimates.

( ) Estimated by extrapolation.

FACTORS INHIBITING PETROCHEMICAL DEVELOPMENT

The petrochemical industry, or for that matter any industry, needs certain conditions for its establishment. Availability of raw materials, fuels, power, water, good transport net-work, trained manpower and market are among such pre-conditions. The first two have already been dealt with adequately. They have been found to be in favour of petrochemical development in Africa.

Electric power - In many petrochemical and related industries electric power represents a relatively big item in the cost of production. Although the present electric power situation in many African countries may not be satisfactory the potential for its development - with Africa possessing over 30 per cent of the world hydro-electric potential - is tremendous. Projects already realized and those under construction and planning may, in general, be expected to play a major role in promoting petrochemical industries in the near future.

With the exception of the UAR and Nigeria, however, actual and potential hydro-power availability is outside of the present oil producing countries. This should, nevertheless, not be a deterrent to countries like Libya and Algeria where electricity could possibly be produced by gas fueled generation at a cost not much higher than that possible from a hydro-power plant.

Water - The situation regarding water is similar to that of hydro-power. Water is not as plentiful in certain of the oil producing countries. It is, however, unlikely that it will turn out to be a major constraint.

Good transport net-work - Historically, transport facilities were originally developed in Africa mainly for the purpose of facilitating the movement of goods from the hinterland to the ports. They were, in other words, not meant to link neighbouring countries. As a result there were and still are a number of gaps in transport links between many African countries. Consequently, transport costs figure relatively high in the sales value of goods.

Realising this problem, many countries have given priority to the development of those modes of transport systems best fitted for the different areas. Existing transport systems and port facilities are being improved and expanded and new ones are being opened. The extent to which this rate of progress will permit coping fully and efficiently with the future transport demand remains to be seen. In this connexion it should be noted here that the ECA, through its Transport and Communications Section of the Natural Resources and Transport Division, has been active in preparing studies designed to promote sub-regional harmonization of transport facilities. It is hoped that the implementation of even part of these studies will solve a good number of the problems existing today.

Trained manpower - Lack of trained manpower is characteristic in Africa. This is especially so as regards the capital-intensive and high-calibre manpower oriented industries such as petrochemicals.

Many of the so-called chemical process industries, in existence in a number of African countries, depend on highly paid expatriate specialists for skilled staff. As a result, although representing a small fraction of production costs in most chemical processes, the absolute magnitude of the labour cost component in the cost of production is higher than that in an industrialized country. This situation, coupled with the uncertainty as to the future availability of expatriates in required numbers, may be expected to be more serious with the more complex industries of which the petro-chemical establishments are prominent.

ECA is very much concerned about requirements of critical manpower needs for development. Its Manpower and Training Section of the Human Resources Development Division has already drawn up its 1969-1973 proposed programme of work and priorities in the field of human resources development. Through its Working Party and other committees, and through organized seminars and training arrangements, it is expected that the Section will contribute appreciably to the solution of the problem.

The ECA approach should and will be supplemented by other means. In the contract between a developing country or an organization representing it and the contractor regarding the setting up of an industrial establishment, it has, for instance, become customary to stipulate the training of nationals by the contractor abroad and on the job at home. The former takes place during the period between signing of the contract and the start up of the plant and concerns itself with management and technical and relatively high-skilled personnel. The latter concerning mainly with the start-up of operation, deals with all personnel, but mainly with skilled staff, operators and the like. This can best be done if, as is usually the case, the contractor is given a management contract for a few years.

The above approach, applying to private business (both local and foreign) and a contractor is a practical short-term solution to the shortage of trained manpower. Availability of qualified people for training is a prerequisite to its success. The priority given to education and the emphasis toward technical education by African governments will ensure availability of human resources for training.

Market - From among the factors which may hinder or retard the establishment of chemical industries, the limited size of the market in almost all African countries appears to be the most crucial. Present, or for that matter fore-seeable demand for chemicals in individual countries does not justify their production on a country basis. This is true with many chemicals and partic-ularly so with petrochemicals.

The solution for the limited market and its undesirable consequences on the development of industries sensitive to economies of scale evidently lies in enlarging the market. This can be done by bringing countries into multinational and sub-regional groupings. For a number of years the ECA has been advocating this approach - pooling of domestic markets. In fact, its programme of work and activities is based on and geared to this approach which roughly divides the independent countries of Africa into four sub-regions: North, West, Central and East. Within the sub-regional framework, economic groupings are in a state of emergence. These groupings include the Maghreb Permanent Consultative Committee in North, the Organization of the Senegal River Basin Countries in West, the UDEAC in Central and the East African Economic Community in East Africa. Such groupings could serve as nuclei for the ECA approach.

The pre-feasibility studies carried out by the Industry and Housing Division of the ECA on industrial possibilities in Africa have identified projects feasible on national, multinational, sub-regional and inter-sub-regional scales. As may be expected, the petrochemical sector has been found to make some sense in the last two. In other words, the development of certain products in the petrochemical field have been found justifiable on a sub-regional and inter-sub-regional level.

Having identified the industrial possibilities, the next stage would be to promote their implementation. This will require the establishment of installations and services such as machinery for sub-regional co-operation (administrative secretariats of the sub-regional economic communities), multi-national institutes for industrial research and standardization and industrial promotion centres (IPC's) to function as part of the administrative machinery. A good start has already been made in these areas.

The characteristics of some basic chemical industries to be located near the sources of the major inputs, especially raw materials and in certain cases fuels and electric energy, is a factor that could greatly help solve the limited market problem. Ammonia, ethylene and phosphoric acid are examples of this. Because of economies of scale, the establishment of these and similar industries mainly for export purposes will benefit both the country housing the industry and its neighbours. Part of the basic and intermediate chemicals could be converted to semi-finished or consumer goods on the spot, to satisfy the multinational or sub-regional requirement of the area at lower cost than would be the case if the basic and intermediate chemicals were to be manufactured for local use only.

Another solution to the limited size of the market lies in the hands of machinery and equipment manufacturers. With recent and future technological break-throughs, they should surely be in a position to innovate simple economical processes and techniques to manufacture in the small volumes having relevance to local conditions in developing countries. Small turnkey ammonia units reportedly available, mini-formaldehyde from methanol units (2000 tons capacity costing $400,000) developed by a French company (Protox)1/ and new more economical techniques under development are examples. Others are controlled pyrolysis of methane for the production of acetylene (Donald F. Othmer of Polytechnic Institute of Brooklyn), fluidised-bed

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1/ Source: Chemical Engineering, July 29, 1968.

thermal cracking of crude oil for ethylene (Univ. of Tokyo) and the scramble for sulphuric acid from gypsum. These are but a few indications of the present and near term possibilities in favour of developing nations, especially those endowed with abundant hydrocarbon and other raw materials.

The development of small-scale units could be supplemented by multi-purposes plants which are capable of producing various products whose proportions can be varied relatively easily and at will according to market conditions. Such plants can and should be competitive with large units designed to produce one or a limited number of products. They can, therefore, satisfy market conditions prevailing in developing countries. Polymers are among products that can be made a multi-purpose plant.[1] Production of polymers from imported or local monomers could serve as a good start in the development of petrochemical industries in a number of developing countries. As this approach has a number of advantages, including the possibility for backward integration at a latter stage, its significance to developing countries is obvious.

It is possible that the multi-purpose plant concept can be extended to apply to a combination of similar processes based on the same or similar raw materials. Methanol can, for example, be produced in an ammonia facility incorporating certain modifications. It is therefore, clear that some effort on the part of capital goods manufacturers along the above lines can solve many of the problems related to plant size facing developing countries in the development of petrochemical industries.

The need for and acceptability of small-scale manufacturing units by developing countries may be exemplified by the Dianor technology for ethylene recently developed. Although this new method of producing dilute ethylene from any hydrocarbon capable of being cracked in a tubular furnace has not been tried yet on a large scale, a number of countries have already expressed interest. Morocco has gone to the extent of having preliminary design undertaken on its behalf.[2]

1/ Source: Chemical and Engineering News, November 30, 1964.

2/ Source: Chemical Engineering, April 22, 1968.

Even with all these suggested remedies, some petrochemical plants to be established in Africa may not be in a position to compete with the giant units of 200,000, 500,000 or possibly higher capacities in the industrialized countries. Protection from outside competition appears to be the answer. Unless this is done the development of the petrochemical industry in Africa will have to wait until consumption approaches the capacity of economic size plants by industrialized countries' standards. This will take a very long time, and who knows that history will not repeat itself.

Other factors - The success of a petrochemical venture depends on the economic use of the different products resulting from basic operations such as cracking reforming and pyrolysis. In other words, integration (both vertical and horizontal, e.g., the creation of a complex and its supporting industries) is a prerequisite to the development of the petrochemical industry in a developing country. The supporting industries, as understood here, refer to heavy basic inorganic chemical (acids, alkalies and other compounds) as well as to those oriented toward the production of consumer petrochemical goods such as plastic rubbers and textiles.

Only a few countries in Africa have some of these supporting industries. This implies that the supporting industries would have to be expanded and developed in advance and/or concurrently with the petrochemical complex to be established. These and other factors, such as higher cost of machinery and equipment (due to high transport cost from place of origin to the site), high installation costs (due to the need for expatriate skilled labour and specialists) and provision for one or more ancillary facility (electric power connexion or generation, water supply or purification, waste disposal, etc.) are reflected in higher investment and production costs compared to those prevailing in the industrialized countries.

In general, a number of the above constraints are hopefully temporary in nature. The establishment of supporting industries is on the rise and installation costs will be reduced with the training of local labour, especially skills which should be trained for the purpose. Too, ancillary facilities will be expanded with time through the establishment of industrial estates. It should be noted that those factors inhibiting the development of petrochemicals will be compensated to some extent by abundant and low-cost raw material, fuel and power.

DEVELOPMENT POSSIBILITIES

The estimates of some of the end-products represent potential demand, in the sense that they are supposed to meet consumption of petrochemical products appearing in the market as goods entirely made from petrochemicals, as goods incorporating other materials and as parts in machinery, equipment and vehicles. In developing countries, processing of petrochemicals into end-products is limited to applications of the first two. The extent of production of sophisticated goods varies from country to country. A trend toward diversification is evident in existing establishments in Africa. The plastic industries are, for instance, expanding their output by introducing new products that were hitherto imported. Textile mills are turning out increasingly elaborate, locally woven synthetic fabrics, both mixed or pure. More and more tyre and rubber articles factories are being expanded and established. In short, diversification in the final stage of processing petrochemicals is the trend in Africa.

It should be noted, however, that because of small consumption, special application, complicated processing techniques, product mix, etc., certain final produc s will necessarily have to be imported. In other words, no matter how fast diversification takes place, there will always be need to import a part of the finished goods demand in African countries.

It is not easy to predict to what extent this trend toward diversification will proceed during the coming decade. In other words, it is rather difficult to determine what part of the potential demand will be met from local production. If the petrochemical industry is to be developed in Africa, however, it is necessary to make some assumptions regarding processing of end-products.

There are three alternative approaches that could be used in determining the size of manufacturing units to be envisaged in the development of the petrochemical industry. They have to do with design of units whose capacities are less, greater than, or equal to estimated demands. The first is obviously out of question. Under normal circumstances, the second alternative is the most practical for the plant is intended to cope with increasing demand for some year after the start of operation. As full capacity utilization is not practical in many instances, the third alternative implies production less than demand.

To simplify the approach which is already complicated, the third alternative has been adopted in determining the sizes of manufacturing units proposed. Capacities have in general, therefore, been designed to correspond to 1975 and 1980 demands. This of course does not mean that all the production units will go into operation in these particular years. On the basis of the development of demand, a majority of them are expected to start operation earlier and may reach their maximum outputs in about 1975 and 1980. This would, in effect, mean reverting to the second alternative. In short, this approach seems to be reasonable, as it automatically reduces outputs to less than the estimated demands which in some cases are considered potential demands.

As is well known, the success of a petrochemical venture lies in the economic upgrading and utilization of co-products of the basic operations: cracking, reforming and pyrolysis. Some attempt has been made to this effect in this exercise. In view of the need to spread production facilities among member States of each sub-region, however, integration of facilities processing all co- and/or by-products further to the extent desirable is not practical. Because of this and other factors, such as the small, or in some cases unknown, demand for certain of the products to be derived from the co- or by-products, the extent of integrated development had to be limited.

Although it is not the intention of this exercise to deal with the relative merits of the different raw materials and processing techniques for the production of the basic petrochemicals of interest to Africa, some mention of the types of feedstocks and processes seemingly suited to African conditions would be in order.

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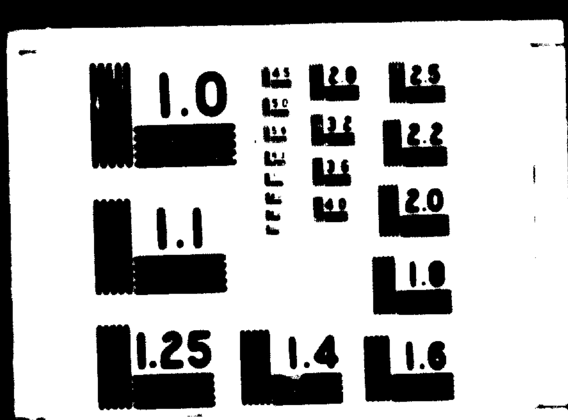

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

The main basic operation assumed applicable for the production of basic petrochemicals is cracking. The hydrocarbon input may vary from country to country and from sub-region to sub-region. The choice of the feedstocks is dictated by the availability of raw materials and the types and proportions of basic products needed.

In countries with natural gas resources, production of ethylene and propylene from gas should be preferred. Propane recoverable from natural gas can be considered a feedstock for steamcracking. Naphtha with or without refinery gas has been assumed to be a practical feedstock in those countries which possess petroleum refineries already large enough or which are expected to increase their capacities to levels which would yield adequate naphtha for cracking.

Refinery butylene and naphtha are the appropriate feedstocks for butadiene production. As the former may not be available in adequate quantities, extraction of butadiene from the C_4-cut of steamcracking of the latter for ethylene production appears to be the choice. If scale of production justifies it, it is cheaper than the butylene route.

In view of the advantages accruing from an integrated approach, and the fact that a relatively higher yield is obtainable than from an aromatics unit in a refinery, recovery of aromatics from the ethylene production by naphtha steamcracking has been envisaged wherever possible. The quantity of benzene (aromatic in greatest demand) can be increased by the incorporation of a dealkylation unit in the aromatics recovery facility thereby reducing cracked gasoline feedstock. This in turn means less naphtha feedstock to the cracking unit.

The above approaches to the production of basic products are general suggestions. For some reason or another, such as lack of adequate feedstock, some of them could possibly prove impractical. For the sake of convenience, however, they have been assumed practical, and the remaining part of this section which deals with specific proposals by sub-regions and countries has been based on this assumption.

It is to be noted that proposals for a number of alternative combinations of production facilities are possible in each sub-region. The ones presented below were based, as much as available information permitted, on a number of factors. These include consumption centers, indicated present and future availability of raw materials, utilities and infrastructures and the need for fair allocation of the production units among member countries.

North Africa

General introduction - In North Africa, the United Arab Republic is the only country which now has some units for petrochemical manufacturing. They are located at Suez and have productive capacities of 15,000[1] tons aromatics (benzene, toluene and xylenes) and 6,000 tons dodecylbenzene.

Morocco and the United Arab Republic have projects which are expected to start operation after 1970. The Morocco project, to be located at Kenitra, is envisaged for a 10,000 tons PVC capacity based on ethylene to be produced locally or to be imported. The United Arab Republic project, for Alexandria, is much more complex, with units for the production of ethylene, polyethylene, PVC, polybutadiene, acrylics, nylon, methanol, phenol and acetone.

The above noted units and country projects cannot satisfy the prospective demands, either in terms of quantity or variety of products. Studies undertaken by the ECA showed further possibilities for development of the petrochemical sector. Additional capacities (in the form of extensions and new plants), therefore, have been proposed by the ECA with a view to making the sub-region more self-sufficient in certain products which seem to have possibilities for development.

End-products - Comparison of potential consumption with capacities of the country projects and ECA proposals shows that demand for some petrochemicals will be met (see Table 10). PVC, polyethylene, polybutadiene (from imported butadiene) and nylon capacities are either higher than or equal to demands.

1/ This figure does not include the 3,000 tons BTX obtainable from the Helwan Steel Works.

Although demand for polyesters and acrylics are higher than capacities, the proposed capacities have been taken as such, because a part of the fibres demand will be imported in the form of fabrics. As regards detergents[1] and insecticides, there is scope for extension of existing units and projects. The detergent unit capacity proposed for Algeria could meet a large part of the Maghreb demand up to 1975. Between 1975 and 1980, a new unit of 10,000 tons would have to be established in Morocco to satisfy the demand for the Maghreb countries, excluding Algeria. The United Arab Republic and the Sudan requirement will be met from the extension envisaged for the existing United Arab Republic plant.

Existing and proposed DDT and BHC units are too small to satisfy the estimated demands of the sub-region. The doubling of the DDT unit in the United Arab Republic to 5,200 tons in 1980 and the establishment of a BHC plant of 2,000 tons during the 1970-1975 period (instead of a capacity of 1,300 tons contemplated by the United Arab Republic), with provision for extension to 4,000 tons in 1980, will solve the supply problem for both the UAR and the Sudan. As regards the Maghreb countries, there seems to be scope for the setting up of a DDT unit of 2,500 tons and a BHC unit of 1,500 ton capacities in 1975 in both Algeria and similar units in 1980 in Morocco.[2]

No production units have been envisaged for the remaining end-products. Estimated consumption of carbon black seems to offer scope for local production. On the basis of market and raw material availability, carbon black products could be planned to take the following operational sequence: 20,000 tons in 1970 (Libya) and 15,000 tons in 1975 (UAR). The former is expected to meet sub-regional demand initially but to be limited to the Maghreb market eventually.

1/ The problem prevailing in developed countries regarding hard detergents is not expected to manifest itself in most African countries for some time to come. It, therefore, appears that if production of hard detergents is more economical there is a case for the development of the detergent industry on the basis of alkylbenzene.

2/ In view of the declining demand for BHC in developed and some developing countries, the BHC units proposed in this study may turn out to be inappropriate. They have been included for the simple reason that there is not adequate information on the type of substitute insecticides for the different conditions prevailing in Africa.

Table 10: Petrochemical capacities proposed for the North African Sub-region (in 1000 tons)

	Morocco			Algeria			Tunisia			Libya			UAR			Sudan			Sub-regional productive capacity			Sub-regional potential demand		
	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980
End-products																								
PVC	-	10.0a/	15.0	-	15.0	20.0	-	-	-	-	-	-	-	20.0a/	35.0	-	-	-	-	45.0	70.0	28.5	44.1	67.1
Polyethylene	-	-	15.0	-	15.0	20.0	-	-	-	-	-	-	-	15.0b/	35.0	-	-	-	-	30.0	70.0	17.5	37.7	67.1
Polystyrene	-	-	-	-	-	/12.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.0	5.1	8.1	11.8
SBR	-	-	-	-	-	/40.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40.0	16.2	26.0	39.5
Polybutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	12.0a/	12.0a/	-	-	-	-	12.0	12.0	4.9	7.8	12.0
Butyl rubber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3	5.3	8.0
Nylon	-	5.0	6.0	-	7.0	7.0	-	2.0	2.0	-	-	/2.0/	-	4.0a/	7.0	-	-	/2.0/	-	18.0	26.0	11.0	15.5	25.0
Polyester	-	-	4.0	-	7.0	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	14.0	3.4	8.0	15.0
Acrylics	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0a/	8.0	-	-	-	-	5.0	8.0	1.7	5.0	10.0
Urea-formaldehyde																				-	7.0	3.1	4.7	7.2
Phenol-formaldehyde																			-	-	3.0	1.4	2.0	3.1
Dodecylbenzene	-	-	/10.0/	-	10.0	10.0	-	-	-	-	-	-	6.0a/	6.0	10.0	-	-	-	6.0	16.0	30.0	14.0	21.8	30.8
DMT	-	-	/2.5/	-	/2.5/	/2.5/	-	-	-	-	-	-	2.6a/	2.6	/5.2/	-	-	-	2.6	5.1	10.2	2.9	5.2	9.3
DMC	-	-	/1.5/	-	/1.5/	/1.5/	.	-	-	-	-	-	-	/2.0/	/4.0/	-	-	-	-	3.5	7.0	1.8	3.5	6.5
Perchloroethylene																			-	-	6.0	2.5	3.6	6.2
Carbon black	-	-	-	-	-	-	-	-	-	/20.0/	/20.0/	/20.0/	-	/15.0/	/15.0/	-	-	-	20.0	35.0	35.0	17.0	24.5	34.0
Monomers																								
Vinyl chloride	-	10.8	16.2	-	16.2	21.6	-	-	-	-	-	-	-	21.6	37.8	-	-	-	-	48.2	75.2	31.0	47.5	72.5
Ethylene for PE	-	-	16.2	-	16.2	21.6	-	-	-	-	-	-	-	16.2	37.8	-	-	-	-	32.4	75.5	20.0	43.0	76.5
Styrene for PS + SBR	-	-	-	-	-	/20.5/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.5	8.5	13.6	20.2
Butadiene	-	-	-	-	-	/38.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.0	15.5	24.8	38.0
Caprolactam	-	(5.5)	(6.6)	-	/16.0/	/26.0/	-	(2.2)	(2.2)	-	-	(2.2)	-	4.4a/	/12.0/	-	-	(2.2)	-	20.4	28.0	12.1	17.0	27.5
Acrylonitrile	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2a/	8.3	-	-	-	-	5.2	8.3	1.8	5.2	10.4
Basic chem. + Intermediates																								
Ethylene (total)	-	(5.4)	/24.9/	-	/25.3/	/61.4/	-	-	-	-	-	-	-	27.0a/	37.0	-	-	-	-	57.7	123.3	39.4	73.7	123.7
Benzene } aromatics b/	-	(6.2)	(11.8)	-	(13.0)	/25.0/	-	-	-	-	-	-	(4.1)	6.0	/30.0/	-	-	-	..	6.0	55.0	38.6	50.0	76.1
Toluene	-	-	..	-	-	-	-	-	-	-	-	-	..	..	..	-	-	-	..	..	..	-	-	-
P-xylene	-	-	(3.1)	-	(5.0)	(8.3)	-	-	-	-	-	-	-	..	..	-	-	-	..	..	..	2.8	6.7	12.4
Dimethyl terephthalate (DMT)	-	-	(4.4)	-	/7.7/	/15.4/	-	-	-	-	-	-	.	-	-	-	-	-	-	7.7	15.4	3.7	8.8	16.5
Ethylene glycol	-	-	(1.9)	-	(2.3)	(3.2)	-	-	-	-	-	-	-	-	-	-	-	-	-	(2.3)	(4.5)	1.1	2.6	4.8
Propylene	-	-	(13.0)	-	14.7	/23.0/	-	-	-	-	-	-	-	14.9	31.8	-	-	-	-	29.6	54.2	21.1	37.0	57.0
Methanol																			-	-	4.3	1.9	2.9	4.5
Formaldehyde																			-	-	9.2	4.0	6.2	9.5
Urea c/																			-	-	4.7	2.1	3.2	4.8
Phenol																			-	-	(2.3)	1.0	1.5	2.3
Ammonia d/				-	(34.0)	(36.0)							-	(9.0)	(25.0)				-	43.0	62.0	26.0	38.0	61.0
Chlorobenzene	-	-	/2.3/	-	/2.3/	/2.3/	-	-	-	-	-	-	2.4	2.4	/4.7/	-	-	-	2.4	4.7	9.3	2.7	4.7	8.3

a/ Existing units or country projects.

b/ 35,000 tons capacity envisaged in the UAR project.

c/ 18,000 tons capacity already exists in the UAR.

d/ Excluding requirements for fertilizers.

() Imports or obtainable from existing or proposed units at separate locations.

/ /Additional proposals made in this exercise or capacities modified to meet additional or other requirements.

The reason given for not proposing an SBR unit was that a capacity of 40,000 tons, which, incidentally, corresponds to the 1980 estimated SBR share in the total synthetic rubber demand, would not be economical on the basis of 30,000 tons butadiene and import of 10,000 tons styrene.[1] Demands and consequently, possible capacities for these monomers could be raised to take into account requirements for polybutadiene and polystyrene. On the basis of 1980 estimates, total requirements for butadiene and styrene work out to 38,000 tons (25,000 + 13,000) and 20,500 tons (8,000 + 12,500) respectively. In other words, since the conclusion reached not to produce SBR locally did not take into account the possibility for an integrated approach, it should be revised in the light of this concept. For the purpose of this study, this approach (provided enough butane or other feedstock is available), is assumed to be workable and, therefore, to be used as such. It should be noted that capacities higher than the 1980 estimated demands should be erected to take care of increased demand during early 1980's. This may be expected to render the project more viable. Algeria is assumed to house this integrated complex.

As regards butyl rubber, in view of competition expected from other types of rubber, its production is not envisaged in this study.

Both urea- and phenol-formaldehyde demands may offer scope for production if integrated with a nitrogenous fertilizer plant producing urea and having provision for methanol made alternately in the ammonia unit. Formaldehyde can be produced in a mini-formaldehyde unit[2], developed to compete with big plants. As processing requirements for the final stage of resin making (co-polymerization) is similar for urea-formaldehyde and phenol-formaldehyde, both resins can be made alternately in the same reactor. This implies that all basic and intermediate chemicals except phenol could be produced in a complex integrated with a fertilizer plant. It is therefore possible that 7,000 ton urea-formaldehyde and 7,000 ton phenol-formaldehyde units could be realities in the 1975-1980 period.

1/ Source: Evolution des industries pétrolière et chimique dans la sous-région Afrique du nord, IFP, 1968. These inputs are on the high side. They have therefore, been reduced to 25,000 and 8,000 tons respectively in this exercise.

2/ Source: Chemical Engineering, July 29, 1968.

The 1980 estimated consumption of perchloroethylene (6,200 tons) requires about 12,000 tons of carbon tetrachloride. The latter is considered to correspond to an economic size unit on the basis of either carbon disulphide or hydrocarbon (natural gas) raw materials. Provision for carbon tetrachloride for other purposes such as fire extinguishing will, of course, render the unit more economical. As carbon disulphide does not come within the terms of reference of this study it has not been possible here to propose the likely better raw material base for the production of both carbon tetrachloride and perchloroethylene. Under the circumstances it is suggested here that appropriate provision be made when and if related projects are planned.

Monomers - Monomer requirements for polymer units are presented in Table 10. Vinyl chloride and ethylene capacities envisaged correspond well with the needed inputs for PVC and polyethylene-making respectively.

The possibility for the production of styrene and butadiene is tied up with the integrated styrene-polystyrene-butadiene-SBR complex. Productive capacities of 20,000 tons styrene and 38,000 tons butadiene (13,000 tons of which is provision for the UAR poly-butadiene unit expected to operate on imported butadiene) would be needed for the complex. These capacities have, therefore, been envisaged in this study.

As regards monomers for synthetic fibres, the proposed extension of the UAR acrylonitrile unit (5,200 tons) to 8,300 tons in 1980 is expected to cover demand for acrylics of domestic origin. Envisaged production of caprolactam for nylon 6 is relatively low, 22 and 55 per cent of 1975 and 1980 requirements respectively. Production units are foreseen for Algeria (11,000 tons in 1980) and the UAR (4,000 tons in 1975 and 7,700 tons in 1980). The polymer units in the remaining North African countries are expected to rely on imported caprolactam. This situation calls for integration with a view to increasing caprolactam production in the sub-region. It seems logical to raise the proposed capacity for Algeria to cover requirements for all Maghreb countries and that of the UAR for the Sudan. The new capacities are shown in Table 10.

<u>Intermediate and basic organic chemicals</u> - The intermediate and basic chemicals inputs required in the production of the monomers and end-products are presented in Table 10. They are assumed to correspond to the productive capacities that should be set up in the sub-region.

If these productive capacities are to be realities, the following approaches and measures will have to be adopted:

(a) Extension of the planned UAR ethylene capacity (35,000 tons) to about 57,000 tons during the 1975-1980 period, and provision for additional production of 7,000 tons ethylene for styrene, for polystyrene and SBR in Algeria;

(b) Extension of the UAR aromatic unit (18,000 tons BTX) to produce some 30,000 tons benzene (19,000 tons of which will be consumed in the UAR) and creation of a 25,000 ton benzene capacity in Algeria based on feedstock obtainable from the Algerian and Moroccan ethylene units in the 1975-1980 period;

(c) Establishment of a DMT unit of 15,400 tons in Algeria to cover the requirement of the plant proposed for Morocco. Ethylene glycol may have to be imported;

(d) Extension of the proposed Algerian propylene unit (19,600 tons in 1980) to the maximum possible production (23,000 tons) to meet most of Moroccan requirements for dodecylbenzene in 1980.

(e) Provision for productive capacities of basic and intermediate chemicals (excluding phenol) for adhesive resins to be incorporated to an existing or planned fertilizer establishment.

West Africa

End-products - There are no existing petrochemical plants in West Africa, nor are there definite country projects. According to a preliminary study undertaken by the Nigerian Federal Ministry of Industries, a PVC-polyethylene complex based on LPG could possibly be set up in 1972 when combined PVC-polyethylene consumption demand is expected to reach 15,000 tons.

The absence of national projects in this sub-region is understandable, as demands for petrochemicals in individual member states (14 of them) are far too small to justify even the smallest possible units. Pooling the market is, therefore, more a pre-condition to the development of the petrochemical industry in this sub-region than in the North African sub-region. The proposals indicated in this exercise reflect this approach and are based mainly on market and raw materials and utilities available (see Table 11).

The making of certain changes (in capacities and in intended time of initial operations on proposals in previous ECA studies) was found necessary to render the ethylene units for the plastics plants more viable. Among the plastics, there was no provision for polystyrene production. It appears that a 15,000 ton unit should be feasible in 1980. In view of advantages to be gained from central location in West Africa and in rendering an ethylene unit for Ghana viable (which could not otherwise be feasible) integration of the polystyrene unit with the PVC plant has been envisaged.

As regards synthetic rubbers, the sub-region being an exporter of natural rubber, no production of synthetic fibres has been foreseen. Whatever synthetic rubber is required for mixing with natural rubber could preferably be imported during the coming decade.

Unlike synthetic rubbers, synthetic fibres production in the sub-region seems to be more realistic. Because of the expected faster rate of increase in synthetic fibres demand, the structure of demand or the switchover from nylons to polyesters and acrylics, capacities proposed in previous ECA studies had to be modified and new units added.

Table 11: Petrochemicals capacities proposed for the West African sub-region (in 1000 tons)

	Nigeria			Ghana			Ivory Coast			Guinea			Senegal			Sierra Leone or Liberia			Sub-regional productive capacity			Sub-regional potential demand		
	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980
End-products																								
PVC	-	/30.0/	/30.0/	-	-	/30.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	30.0	60.0	17.6	34.5	68.6
Polyethylene	-	/30.0/	30.0	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-	-	-	30.0	60.0	12.0	28.9	64.5
Polystyrene	-	-	-	-	-	/15.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.0	3.1	6.3	12.2
SBR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.4	20.0	32.0
Polybutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	-	-	-	-	-	-	..	..	..
Butyl rubber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	4.0	6.0
Nylon	-	5.0	/5.0/	-	-	-	-	2.0	2.0	-	-	-	-	-	-	-	-	-	-	7.0	7.0	4.8	6.1	6.6
Polyester	-	/5.0/	/10.0/	-	/2.5/	/2.5/	-	/1.5/	/1.5/	-	-	/1.5/	-	-	/1.5/	-	-	-	-	9.0	17.0	4.4	8.5	16.9
Acrylics	-	-	/5.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	1.1	2.9	5.6
Urea-formaldehyde																			-	13.0	13.0	3.4	10.5	13.7
Phenol-formaldehyde																			-	6.0	6.0	1.5	4.4	5.9
Dodecylbenzene	-	4.8	10.8	-	2.4	3.6	-	-	1.2	-	-	-	-	1.2	2.4	-	-	-	-	8.4	18.0	5.1	10.3	20.6
DDT	-	-	-	-	3.3	3.3	-	-	-	-	3.3	3.3	-	-	3.3	-	-	-	-	6.6	10.0	2.9	6.0	10.3
BHC	-	-	-	-	-	-	-	-	-	-	20.0	32.5	-	-	-	-	-	-	-	20.0	32.5	10.1	18.9	32.4
Perchlorethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	1.0	1.8
n-hexane a/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	1.1	1.2
Carbon black	-	/15.0/	/15.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	/15.0/	-	15.0	30.0	11.0	17.3	28.0
Monomers																								
Vinyl chloride	-	/21.5/	/43.0/	-	-	/21.5/	-	-	-	-	-	[illegible]	-	-	-	-	-	-	-	43.0	64.5	19.0	37.2	74.0
Ethylene for PE	-	/34.0/	34.0	-	-	-	-	-	34.0	-	-	-	-	-	-	-	-	-	-	34.0	68.0	13.6	33.0	73.5
Styrene for PS + SBR	-	-	-	-	-	/15.6/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.6	5.7	10.6	19.1
Butadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.8	12.6	20.0
Caprolactam	-	/7.7/	/7.7/	-	-	-	-	(2.2)	(2.2)	-	-	-	-	-	-	-	-	-	-	7.7	7.7	5.3	6.7	7.3
Acrylonitrile	-	-	(5.2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(5.2)	1.2	3.0	5.8
Basic chem. + Intermediates																								
Ethylene (total)	-	/32.4/	/32.4/	-	-	/23.0/	-	-	/34.0/	-	-	-	-	-	-	-	-	-	-	52.4	109.4	26.2	57.3	121.6
Benzene	-	/20.0/	/20.0/	-	(3.7)	/22.0/	-	-	(0.6)	-	(26.2)	(24.6)	-	(0.6)	(3.7)	-	-	-	-	20.0	42.0	23.8	43.2	70.2
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
p-xylene	-	8.3	8.3	-	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	(8.3)	(14.1)	3.7	7.0	14.0
Dymethylterephthalate (DMT)	-	/11.0/	/11.0/	-	-	/7.7/	-	-	-	-	-	-	-	-	-	-	-	-	-	11.0	18.7	4.8	9.4	18.6
Ethylene Glycol	-	(3.2)	(3.2)	-	-	(2.3)	-	-	-	-	-	-	-	-	-	-	-	-	-	(3.2)	(5.5)	1.4	2.7	5.4
Propylene	-	(5.2)	(14.1)	-	(3.1)	/12.0/	-	-	/19.0/	-	-	-	-	(1.6)	(3.1)	-	-	-	-	(10.9)	31.0	8.5	18.4	36.3
Methanol																			-	8.2	8.2	2.1	6.4	8.5
Formaldehyde																			-	17.3	17.3	4.5	13.5	18.0
Urea b/																			-	8.7	8.7	2.3	7.0	9.2
Phenol																			-	(4.3)	(4.3)	1.1	3.3	4.4
Ammonia b/		(16.0)	(16.0)																-	21.0	21.0	12.0	18.0	21.0
Chlorobenzene	-	-	-	-	/3.0/	/3.0/	-	-	-	-	/3.0/	/3.0/	-	-	/3.0/	-	-	-	-	6.0	9.0	2.6	5.4	9.3

a/ Sub-regional demands include those of Central Africa.

b/ Excluding requirements for fertilizers.

( ) Imports or obtainable from proposed units at separate locations.

/ / Additional proposals made in this exercise or capacities modified to meet additional or other requirements.

Resins for adhesives are significant in the sub-region. Because of the relatively smaller 1975-1980 increase compared with those of 1970-1975, capacities approximately corresponding to 1980 estimated demands have been envisaged for 1975 or soon thereafter. As was proposed for North Africa, facilities for the manufacture of these products will have to be integrated with nitrogenous fertiliser plants, preferably incorporating a unit for urea manufacture.

The combined capacity of the dodecylbenzene units proposed falls short of meeting the estimated demand. As part of the detergent demands will necessarily involve detergents composed of active ingredients other than dodecylbenzene, the proposed capacities have been retained as such.

Both DDT and BHC units are expected to satisfy demands.

As estimated demands for perchloroethylene and n-hexane are relatively small, no production units have been envisaged for their manufacture.

In view of the expected development of the rubber industry, two units for carbon black production, one in Nigeria based on either natural gas or oil and another in either Sierra Leone or Liberia based on oil, have been envisaged.

Monomers - Capacities of, or demands for, monomers corresponding to those of polymers are presented in Table 11. In general, monomer capacities are for captive uses. An exception is the caprolactam unit proposed for Nigeria. Its capacity has been raised by 2,200 tons to cover requirements for the nylon 6 unit envisaged in the Ivory Coast.

As the 1980 demand for acrylonitrile is small, its production in the sub-region during the coming decade does not appear to be realistic. Production of acrylic fibres is, therefore, expected to be limited to the last stage of processing, that is, polymerization of imported acrylonitrile.

Intermediate and basic organic chemicals - Under the West African situation in the coming decade it may not be feasible to produce all of the intermediates and basic chemicals needs for the production of the end-products and monomers under consideration. From a glance at Table 11, it is obvious that ethylene glycol and phenol will have to be imported.

In varying degrees, the remaining intermediates and basic chemicals seem to have possibilities for development in the sub-region. As explained under "end-products", ethylene consuming units were purposely grouped so as to justify ethylene capacities in these countries. The quantity of benzene extractable from cracked gasoline of the ethylene units is too small compared to the estimated demand. Conversion of other aromatics to benzene for maximum benzene yield has, therefore, been envisaged. This would, of course, mean no local production of p-xylene for the dimethylterephthalate unit.

As both ethylene units foreseen in Ghana and the Ivory Coast are small and as benzene demand in Ghana is expected to be about a third of the sub-regional demand, it has been envisaged that the cracked gasoline from the plant in the Ivory Coast be used to supplement the feed for the aromatics unit proposed in Ghana. Even with this arrangement the expected production of benzene falls short of the estimated demand. Since the alternative process is considered impractical because of low yield, the gap accounting for a third of the sub-regional demand will have to be met from import.

Steam cracking of naphtha for the production of ethylene is expected to provide the necessary quantity of propylene. Although Nigeria could base its ethylene production on natural gas, all the ethylene units for West Africa are, for reasons explained above, assumed to use naphtha feed. Extraction of propylene from these units is expected to meet dodecylbenzene requirement.

Central Africa

End-products - There are no existing petrochemical facilities in this sub-region. The Democratic Republic of the Congo, however, is contemplating a PVC unit based on calcium carbide. This appears to be the only project under consideration in the whole sub-region. From a glance at Table 12, that is from the low consumption estimates, it is clear that this sub-region's prospect for the development of the petrochemical industry is not as favourable as for the other sub-regions. During the decade under review, therefore, there appears to be a case for this sub-region to avail itself of certain products from adjacent sub-regions. This should help some industries in these sub-regions whose capacities may prove to be above the market for which they were intended. It should, in addition, pave the way for inter-sub-regional co-operation.

In addition to the PVC plant contemplated, a polyethylene unit integrated with the PVC plant can be envisaged, provided the PVC unit could be based on ethylene instead of calcium carbide. This approach has been assumed in this exercise.

Production of resins for adhesives seems to offer better scope in this sub-region than in the others apart from West Africa. As was the case with the other sub-regions, integrating facilities for resins production with a nitrogenous fertilizer plant has been envisaged. All inputs except phenol are expected to be produced in the integrated complex.

There are possibilities for the production of polyester, dodecylbenzene and DDT. The first will have to be limited to the final stage of processing, that is, to polymerization of dimethylterephthalate and ethylene glycol. The other two could start from the basic chemicals propylene and benzene. As consumption of these intermediates and basic products are small, local production cannot be considered. They will have to be imported.

Monomers - Vinyl chloride and ethylene corresponding to PVC and polyethylene requirements have been envisaged.

Basic chemicals and itermediates - Ethylene is the only basic chemical proposed for production in the sub-region. As was stated above, all others should be imported.

East Africa

General introduction - A study of the potential for chemical industry development in the East African sub-region was undertaken in 1964-1965.[1] The number of chemicals covered was limited. This was particularly so as regards petrochemicals. PVC and polyethylene were the only ones included in the study.

1/ Investigation on Fertilizer and Chemical Industries in East Africa. (E/CN.14/INR/83), ECA, 1965.

Table 12: Petrochemical capacities proposed for the Central African Sub-region (in 1000 tons)

	Congo (D.R.)			Congo (Brazza)			Gabon			Cameroon			Sub-regional productive capacity			Sub-regional potential demand		
	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980
Sub-products																		
PVC	-	-	25.0	-	-	-	-	-	-	-	-	-	-	-	25.0	6.4	12.7	24.4
Polyethylene	-	-	/20.0/	-	-	-	-	-	-	-	-	-	-	-	20.0	3.3	7.6	16.0
Polystyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	2.0	3.7
SBR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	2.1	2.7
Polybutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	..	..
Butyl rubber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.4	0.5
Nylon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	0.1	1.1
Polyester	-	-	/1.5/	-	-	-	-	-	-	-	/1.5/	/1.5/	-	1.5	3.0	0.8	1.4	2.9
Acrylics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.5	1.0
Urea-formaldehyde													-	10.0	10.0	4.9	7.1	9.5
Phenol-formaldehyde													-	4.0	4.0	2.1	3.1	4.1
Dodecylbenzene	-	-	-	-	/2.0/	/2.0/	-	-	-	-	-	-	-	2.0	2.0	0.9	1.4	2.1
[illegible]	-	-	-	-	-	-	-	-	-	-	/2.7/	/2.7/	-	2.7	2.7	2.8	3.2	3.6
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	..	..
Perchloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.1	0.2
n-hexane a/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	1.1	1.2
Carbon black	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	1.9	2.4
Monomers																		
Vinylchloride	-	-	/27.0/	-	-	-	-	-	-	-	-	-	-	-	27.0	6.9	13.7	26.4
Ethylene for P S	-	-	/23.0/	-	-	-	-	-	-	-	-	-	-	-	23.0	3.8	8.7	18.2
Styrene for PS + SBR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3	6.3	9.2
Butadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.3	1.7
Caprolactam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	1.1	1.2
Acrylonitrile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.5	1.0
Basic chem. + Intermediates																		
Ethylene (total)	-	-	/34.0/ b/	-	-	-	-	-	-	-	-	-	-	-	34.0	8.0	16.8	33.7
Benzene	-	-	-	-	(0.9)	(0.9)	-	-	-	-	(2.2)	(2.2)	-	(3.1)	(3.1)	6.6	9.1	12.4
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
p-xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	1.2	2.4
Dimethylterephthalate (DMT)	-	-	(1.6)	-	-	-	-	-	-	-	(1.6)	(1.6)	-	(1.6)	(3.2)	0.8	1.6	3.2
Ethylene glycol	-	-	(0.5)	-	-	-	-	-	-	-	(0.5)	(0.5)	-	(0.5)	(1.0)	0.2	0.5	0.9
Propylene	-	-	-	-	(2.6)	(2.6)	-	-	-	-	-	-	-	(2.6)	(2.6)	1.4	2.6	4.3
Methanol													-	6.1	6.1	3.0	4.4	5.9
Formaldehyde													-	12.9	12.9	6.4	9.3	12.5
Urea c/													-	6.7	6.7	3.3	4.8	6.4
Phenol													-	(3.0)	(3.0)	1.6	2.3	3.1
Ammonia c/													-	4.0	4.0	4.0	5.0	7.0
Chlorobenzene	-	-	-	-	-	-	-	-	-	-	(2.4)	(2.4)	-	2.4	2.4	2.5	2.9	3.2

a/ Sub-regional demands include those for West Africa.

b/ The Government of the Democratic Republic of the Congo seems to be inclined to use acetylene from calcium carbide instead of ethylene for PVC making.

c/ Including requirements for fertilizers.

( ) Imports or obtainable from proposed units at separate locations.

/ / Additional proposals made in this exercise or capacities modified to meet additional or other requirements.

The situation being what it is in Rhodesia, the country allocation of the proposed industries and those to be proposed had to be considered in the light of this development, that is, excluding Rhodesia. An attempt has, therefore, been made to this effect in the following paragraphs.

End-products - There are no petrochemical manufacturing facilities in the sub-region and the secretariat is not aware of any concrete country projects ready for implementation. The reason for this apparent lack of interest is the same as that for the West African sub-region.

As was the case with the other sub-regions, the possibility of polystyrene production is associated with the feasibility of an SBR unit. If the SBR unit proposed for North Africa for 1980 proves viable, a similar unit to go on stream early in 1980 can be envisaged for East Africa. The production units for styrene, butadiene, polystyrene and SBR presented in Table 13 are based on this assumption. As demand for other synthetic rubbers is small, no provision has been made for local production.

Synthetic fibres offer possibilities for development. The locations of production facilities on the basis of monomers were determined mainly by proximity to markets which are either national, or national plus part or all the market(s) of the neighbouring country or countries.

As explained elsewhere, the development of urea- and phenol-formaldehydes is tied up with the establishment of a nitrogenous fertilizer plant. Such a plant, which should have facilities for ammonia and urea production, does not exist now in the sub-region nor is there a concrete project. Until the time when a project of this kind comes to an advanced stage, there is no possibility of suggesting a location for resins production.

Monomers - The quantities and, consequently, the capacities or imports of monomers needed as inputs for polymerization to the preceding end-products are presented in Table 13. For a great part of the decade, it is anticipated that nylon units will have to depend on imported caprolactam. The establishment of a single unit is envisaged by the turn of the decade. The situation regarding acrylonitrile is more pessimistic. A production unit does not seem to be justified, even some time after the turn of the decade.

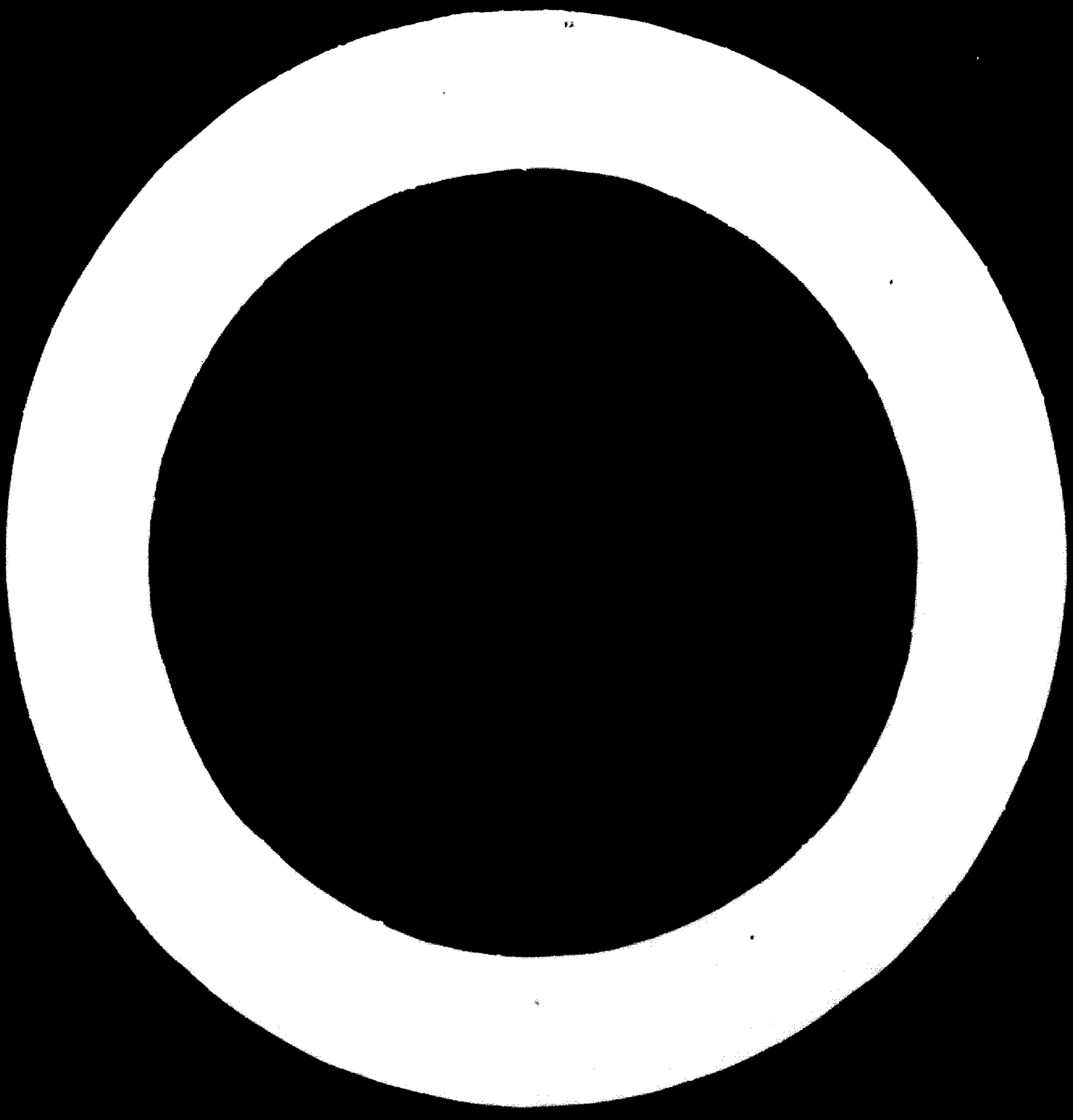

Table 23: Petrochemical capacities proposed for the East African Sub-region (In 1000 tons)

	Ethiopia			Kenya			Uganda			Tanzania			Madagascar			Zambia			Malawi			Somalia			Sub-regional productive capacity			Sub-regional potential demand		
	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980
End-products																														
PVC	-	/30.0/	/30.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.0	30.0	13.2	25.5	48.3
Polyethylene	-	-	-	-	-	/20.0/	-	-	-	-	/30.0/	/30.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	30.0	50.0	16.7	21.6	45.9
Polystyrene	-	-	-	-	-	/10.5/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.5	2.7	4.7	8.6
SBR	-	-	-	-	-	/40.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40.0	9.9	10.2	38.3
Polybutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	..	..
Butyl rubber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	3.6	6.7
Nylon	-	-	/1.0/	-	-	-	-	-	-	-	/5.0/	/5.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	2.9	3.6	4.3
Polyester	-	/2.5/	/2.5/	-	/5.0/	/5.0/	-	-	/1.5/	-	-	-	-	-	/1.5/	-	-	/1.5/	-	-	-	-	-	-	-	5.5	10.0	2.4	5.0	11.0
Acrylic	-	-	/4.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	0.7	1.7	3.6
Urea formaldehyde																											6.0	2.1	4.1	5.1
Phenol-formaldehyde																											3.0	0.9	1.8	2.2
Dodecylbenzene	-	/2.0/	/2.0/	-	/5.0/	/5.0/	-	-	/2.0/	-	-	-	-	-	/2.0/	-	-	-	-	/2.0/	/2.0/	-	/2.0/	/2.0/	-	9.0	25.0	3.8	7.6	14.9
DDT	-	-	/2.0/	-	-	/8.0/	-	/4.0/	/4.0/	-	/4.0/	/4.0/	-	-	/5.0/	-	-	/5.0/	-	-	-	-	-	-	-	6.0	20.0	3.3	10.0	10.0
BHC	-	-	-	-	/5.0/	/5.0/	-	-	-	-	-	-	-	-	/5.0/	-	-	-	-	-	-	-	-	-	-	9.0	10.0	3.5	6.4	12.1
Perchloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	1.0	1.5
Lindane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	..	..
Carbon black	-	/10.0/	/10.0/	-	-	-	-	-	-	-	/10.0/	/10.0/	-	-	/10.0/	-	-	-	-	-	-	-	-	-	-	20.0	30.0	6.8	16.2	20.5
Monomers																														
Vinyl chloride	-	/35.0/	/54.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35.0	54.0	14.2	27.5	58.2
Ethylene for P.E.	-	-	-	-	-	25.0	-	-	-	-	/34.0/	/34.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	34.0	37.0	12.2	24.7	38.0
Styrene for PS & SBR	-	-	-	-	-	/10.5/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.5	4.0	8.4	15.7
Butadiene for SBR	-	-	-	-	-	/30.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.0	6.2	11.4	21.0
Caprolactam	-	-	(1.1)	-	-	-	-	-	-	-	(3.3)	/4.4/	-	-	-	-	-	-	-	-	-	-	-	-		(2.3)	4.4	3.2	3.9	4.7
Acrylonitrile	-	-	(4.2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4.2)	0.7	1.0	3.0
Basic chemicals & intermediates																														
Ethylene (total)	-	/35.0/	/54.0/	-	-	/28.4/	-	-	-	-	/34.0/	/34.0/	-	-	-	-	-	-	-	-	-	-	-	-	-	67.0	127.4	21.6	42.7	86.5
Benzene	-	(0.9)	/11.0/	-	(0.5)	/24.0/	-	(3.2)	(4.6)	-	(3.2)	(3.1)	-	-	(0.7)	-	-	(3.2)	-	(0.9)	(0.9)	-	(0.9)	(0.9)	-	-	48.0	27.0	28.0	51.7
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..	..	..
Xylene	-	-	-	-	-	(0.3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0.3)	2.0	4.2	9.1
Dimethyl terephthalate (DMT)	-	(2.0)	(2.0)	-	(3.3)	/11.0/	-	-	(1.2)	-	-	-	-	-	(1.7)	-	-	(1.7)	-	-	-	-	-	-	-	(6.1)	12.2	2.6	5.5	22.1
Ethylene glycol	-	(0.8)	(0.8)	-	(1.0)	(1.0)	-	-	(0.6)	-	-	-	-	-	(0.6)	-	-	(0.6)	-	-	-	-	-	-	-	(1.0)	(3.6)	0.8	1.6	3.5
Propylene	-	(2.6)	(2.6)	-	(2.9)	(2.9)	-	-	(3.9)	-	/10.0/	/10.0/	-	-	(2.0)	-	-	-	-	(2.6)	(2.6)	-	(2.6)	(2.0)	-	10.6	20.0	6.2	12.8	25.6
Methanol																							-	-	-	-	3.8	1.3	2.5	3.2
Formaldehyde																									-	-	9.0	2.7	3.4	6.7
Urea a/																									-	-	4.0	1.4	2.8	3.5
Phenol																									-	-	(2.3)	0.7	1.5	1.7
Ammonia a/																									-	-	11.5	8.0	10.0	12.0
Chlorobenzene	-	-	1.8	-	-	2.7	-	3.6	3.6	-	3.6	9.0 3.6	-	-	2.7	-	-	3.5	-	-	-	-	-	-	-	7.2	18.0	4.7	9.0	17.0

a/ Excluding requirements for fertilizers.

( ) Imports or obtainable from proposed units at separate locations.

/ / Additional proposals made in this exercise or capacities modified to meet additional or other requirements.

Intermediate and basic organic chemicals - Necessarily, production units of intermediates and basic petrochemicals are limited in number. Some, like ethylene, are intended for captive uses. Others, like benzene, DMT and propylene are meant to cover domestic needs as well as supply those plants not possessing facilities for production.

Although propylene would have been obtained from the steam cracking of naphtha for ethylene production proposed for Ethiopia, the central location seems to favour production of this chemical in Tanzania. Accordingly, production of propylene together with ethylene is expected in Tanzania.

Before closing this chapter it would be in order to mention further possibilities. In some or in all sub-regions the feasibility for the manufacture of certain products has been ruled out. Such products for which demands are relatively small on a sub-regional basis include acrylonitrile, caprolactam, SBR, butadiene, phenol and ethylene glycol. Although not considered in this exercixe an inter-sub-regional approach could possibly render the production of these petrochemicals practical. This approach should be explored.

FIXED INVESTMENT IMPLICATIONS OF THE PROPOSED UNITS

The capacities and locations of the petrochemical units proposed, as noted earlier, are tentative and, therefore, subject to change in the light of better information and new developments. This relates to developments both within and outside the region. This coupled with the fact that it is difficult to take into account factors determining investment requirement for so many individual countries in an exercise of this nature makes it impossible to be definite in the financial implications of the proposed units. All that can be done here is to indicate implications in terms of rough orders of magnitude.

Whenever possible and available, existing investment figures of relatively recent origin were adopted without any change. Such figures were, in addition, used as bases for calculating investments of other units. In this connexion it should be noted that the capital (plant) factor method was applied most frequently. In a few cases, estimates are no more than guesses because available information was not considered adequate for the purpose. In those cases where investment figures in developed countries were used as bases, provision for the following was made: - transport of machinery and equipment; higher installation costs because of lack of skilled manpower and the need for importing equipment for installation; stocking spare parts and supplies in relatively large quantities. Possible need for ancillary facilities etc. have been made. Thus, depending on the processes proposed and the relative location of the African countries vis-a-vis the suppliers of machinery and equipment, investments in the former were raised to 120 to 150 per cent of those applicable in developed countries.

The results of the approach described above are presented in Table 14 by country and by sub-region. According to this table an order of magnitude of 400 million dollars will have to be invested in 1975. An additional 500 million dollars will be needed in 1980 if the proposed units are to be realised. Algeria, the UAR, Nigeria, Kenya, Ethiopia, Morocco and Tanzania, in that order of importance, are each expected to invest more than 50 million dollars by the end of the 1970 decade.

The above group of countries accounts for about 70 per cent of the estimated investment. The first three, and to some extent Morocco, are producers of crude oil and natural gas and have the potential markets of their respective sub-regions. Most of the rest, such as the countries in the East African sub-region have, so far, not found exploitable oil or natural gas. They have, however, refineries which with the proposed or contemplated extensions are expected to be in a position to supply the feedstocks required for the proposed petrochemical ventures.

The investments in question, it should be noted, are for units oriented toward African markets only. In other words no account has been taken in this exercise of export possibilities outside the region. There are a few countries in Africa (Algeria and Libya in particular) which because of their

Table 14: **Rough orders of magnitude of fixed investment requirement for the development of the petrochemical industry in the African sub-regions** (in million $)

	1975	1980	1975	1980	1975	1980	1975	1980	1975	1980	1975	1980	1975	1980	1975	1980	1975	1980
NORTH AFRICA																		
Country	Morocco		Algeria		Tunisia		Libya		UAR		Sudan						Total	
Investment	20	52	82	147	9	9	5	17	69	113	–	12					188	362
WEST AFRICA																		
Country	Nigeria		Ghana		Ivory Coast		Guinea		Senegal		Liberia or Sierra Leone						Total	
Investment	95	107	9	44	14	41	6	10	1	8	–	5					139	229
CENTRAL AFRICA																		
Country	Congo (DR)		Congo (B)		Cameroon												Total	
Investment	–	37	1	1	6	6											18	55
EAST AFRICA																		
Country	Ethiopia		Kenya		Uganda		Tanzania		Madagascar		Zambia		Malawi		Somalia		Total	
Investment	32	57	10	82	2	8	44	52	–	12	–	7	1	1	1	1	90	230
SUB-REGIONS																	Total	
Investment																	435	876

Note: The sub-regional totals include provisions for adhesive rosin units whose locations have not been indicated in this study.

locations have possibilities for export. In such countries the units proposed in this study may have to be revised in the light of developments regarding opportunities for export. Because of economies of scale resulting from bigger units and better utilisation of co-products the petrochemical plants in such countries may be expected to be more viable than those proposed for the purpose of meeting local demands only. It is possible that the additional investment needed for the production of exportable petrochemicals could bring the fixed investment to the level of 1000 million dollars around 1980.

ANNEXES

Table A 1: Rough estimates of some petrochemical end-products in North Africa (in tons)

	Year	Morocco	Algeria	Tunisia	Libya	UAR	Sudan	Sub-region
DDT (75%)	1965	100	400	50	(27)	700	(146)	2684
	1970	400	700	100	(78)	(1340)	(330)	2948
	1975	800	1100	200	(175)	(2350)	(590)	5215
	1980	(1600)	(1730)	(400)	(390)	(4100)	(1050)	9270
BHC (25%)	1965	130	150	8	(13)	(320)	(73)	694
	1970	300	400	50	(49)	(340)	(210)	1849
	1975	600	700	100	(115)	(1560)	(390)	3465
	1980	(1200)	(1220)	(200)	(270)	(2900)	(730)	6520
PVC	1965	3500	5400	750	500	6000	600	16750
	1970	6000	7500	1550	1500	11500	950	28500
	1975	8600	9400	2700	3000	19000	1400	44100
	1980	13500	15000	4000	4600	28000	2000	67100
Polyethylene	1965	1300	585	550	300	4000	200	6935
	1970	3100	4000	1300	900	7700	500	17500
	1975	6600	9800	2500	2000	15800	1000	37700
	1980	12400	16600	4300	4100	28000	1700	67100
Polystyrene (PS)	1965	700	585	75	100	1200	100	2760
	1970	1200	1100	200	250	2150	200	5100
	1975	1900	1800	400	500	3200	300	8100
	1980	2600	2500	650	800	4800	450	11300
Nylon	1965	1980	1900	1270	560	490	800	7000
	1970	2950	2810	1260	680	2530	770	11000
Polyesters	1965	220	220	140	80	70	120	850
	1970	930	890	400	190	760	230	3400
	1975	2200	2200	830	460	1840	470	8000
	1980	4100	4500	1410	920	3300	770	15000

Table A 1: Continued

	Year	Morocco	Algeria	Tunisia	Libya	UAR	Sudan	Sub-region
Acrylics	1965	115	110	75	40	40	70	450
	1970	350	350	150	130	550	170	1700
	1975	990	990	390	440	1770	420	5000
	1980	2050	2220	730	890	3330	780	10000
SBR rubber a/	1965	4700	5300	1500	700	3000	800	16000
	1970	6200	7100	2400	1500	5500	1600	24300
	1975	8800	10100	3400	2700	11800	2400	39200
	1980	12000	14000	4800	5000	20000	3700	59500
Polybutadiene a/	1965	..	..	..	..	..	..	2700
	1970	..	..	..	..	..	..	4200
	1975	..	..	..	..	..	..	6700
	1980	..	..	..	..	..	..	10400
Butyl rubber a/	1965	..	..	..	..	..	..	3000
	1970	..	..	..	..	..	..	4800
	1975	..	..	..	..	..	..	7800
	1980	..	..	..	..	..	..	12000
Detergents	1965	11000	14600	4000	2500	5700	700	38500
	1970	17000	23000	6500	4000	10000	1500	62000
	1975	29000	35000	11000	6500	25000	2500	109000
	1980	45000	50000	17000	10500	45000	4000	171500

Source: Evolution des Industries pétrolière et chimique dans la sous-région Afrique du nord, CEA, 1968

a/ Explanations regarding these estimates are given in the text.

Figures in brackets were calculated from total pesticide estimates using relationship between DDT and BHC with total pesticides as obtained for Morocco, Algeria and Tunisia.

Figures in parenthesis were obtained by extrapolation.

Table A2: Rough estimates of some petrochemical end-products in West Africa (in tons)

	Year	Nigeria	Niger	Dahomey	Togo	Ghana	Ivory Coast	Upper Volta	Guinea	Sierra Leone	Liberia	Gambia	Senegal	Mauritania	Mali	Sub-region
DDT (75%)	1965	267	67	10	4	267	101	7	340	7	4	-	70	3	33	1180
	1970	800	134	20	10	600	427	20	550	14	9	1	200	8	67	2860
	1975	2000	267	40	27	1320	743	60	880	33	20	3	400	20	133	5960
	1980	4000	535	80	55	2000	1064	135	1400	68	48	7	600	40	268	10300
BHC (25%)	1965	1000	300	50	24	1200	1383	60	650	40	23	1	500	23	200	5454
	1970	2700	600	80	50	2100	1720	180	1050	70	50	5	1000	45	400	10050
	1975	6500	1200	160	100	4000	2200	400	1690	140	100	15	1500	90	800	18895
	1980	12000	2400	300	200	6000	3500	800	2700	280	200	40	2200	150	1600	32370
PVC	1965	2500	125	50	40	300	2200	80	1150	40	15	-	1200	35	40	7750
	1970	6000	350	150	150	2000	4000	240	1850	130	40	20	2400	70	160	17560
	1975	13000	1000	400	400	5000	6000	720	3000	400	150	70	3600	140	600	34480
	1980	28000	3000	1000	900	10000	9000	2200	4850	1200	500	150	5400	270	2100	68570
Polyethylene	1965	1250	125	40	30	100	2000	60	-	30	70	-	300	23	25	4053
	1970	4500	350	130	100	1000	3000	200	800	120	150	10	1400	60	130	11950
	1975	12000	1000	350	300	4000	5000	650	1300	350	300	50	3000	120	500	28920
	1980	28000	3000	1000	900	10000	8000	2200	2100	1200	650	150	5000	270	2000	64470
Polystyrene (PS)	1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1360 a/
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3100 a/
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6300 a/
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12200 a/
Nylon 6	1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3300
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4800
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6100
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6600

Table A2: Continued

	Year	Nigeria	Niger	Dahomey	Togo	Ghana	Ivory Coast	Upper Volta	Guinea	Sierra Leone	Liberia	Gambia	Senegal	Mauritania	Mali	Sub-region
Polyester	1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2100
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4400
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8500
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16900
Acrylics	1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	340
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1100
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2900
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5600
SBR	1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7000
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	(12400)
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	(20000)
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	32000
Butyl	1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1400
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	..	(2500)
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4000
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6000
Detergents	1965	5090	230	160	107	2380	1450	235	205	524	436	52	1360	41	120	12890
	1970	11170	490	350	240	5300	2560	530	480	900	670	100	2300	85	300	25485
	1975	24490	1020	790	540	9800	4500	1200	1100	1560	1030	200	3900	180	740	51050
	1980	53700	2200	1700	1200	18000	8000	2600	2500	2700	1600	370	6500	370	1850	103290

Sources: Research into the Chemical Industry and Fertilizers in West Africa (E/CN.14/INR/109), ECA, 1966
Possibilities of developing a Synthetic Rubber and Fibres Industry in Western Africa (E/CN.14/INR/150),

a/ Calculated on the basis of polystyrene to PVC + polyethylene relationship derived from available data on the North Africa sub-region.

Figures in parenthesis were obtained by interpolation.

Table A3: Rough estimates of some petrochemical end-products in Central Africa (in tons)

	Year	Chad	Cameroon	Gabon	Central African Republic	Congo (B)	Congo (D.R.)	Sub-region
DT (75%) a/	1964/65	..	..	..	..	..	160	370
	1970	..	..	..	..	..	1200	2830
	1975	..	..	..	..	..	1370	3200
	1980	..	..	..	..	..	1540	3600
HC (25%)	1964/65	..	..	..	..	..	..	..
	1970	..	..	..	..	..	..	..
	1975	..	..	..	..	..	..	..
	1980	..	..	..	..	..	..	..
VC a/	1964/66	81 a/	670 b/	144 a/	62 b/	275 c/	1255 c/	2587
	1970	(160)	(1180)	(280)	285	(470)	4000	6375
	1975	290	1990	500	503	790	8650	12728
	1980	470	3080	810	820	1270	13900	24431 c/
Polyethylene d/	1965	..	..	..	..	..	..	1080
	1970	..	..	..	..	..	..	3300
	1975	..	..	..	..	..	..	7600
	1980	..	..	..	..	..	..	16000
Polystyrene e/ (PS)	1965	..	..	..	..	..	..	430
	1970	..	..	..	..	..	..	1030
	1975	..	..	..	..	..	..	2000
	1980	..	..	..	..	..	..	3700
Nylon 6 d/	1965	..	..	..	..	..	..	620
	1970	..	..	..	..	..	..	820
	1975	..	..	..	..	..	..	1040
	1980	..	..	..	..	..	..	1100
Polyester d/	1965	..	..	..	..	..	..	390
	1970	..	..	..	..	..	..	760
	1975	..	..	..	..	..	..	1440
	1980	..	..	..	..	..	..	2900

Table A3: Continued

	Year	Chad	Cameroon	Gabon	Central African Republic	Congo (B)	Congo (D.R.)	Sub-region
Acrylics d/	1965	..	..	..	..	..	..	60
	1970	..	..	..	..	..	..	190
	1975	..	..	..	..	..	..	500
	1980	..	..	..	..	..	..	950
SBR e/	1965	..	..	..	..	..	..	1240
	1970	..	..	..	..	..	..	1600
	1975	..	..	..	..	..	..	2100
	1980	..	..	..	..	..	..	2650
Butyl g/	1965	..	..	..	..	..	..	250
	1970	..	..	..	..	..	..	320
	1975	..	..	..	..	..	..	410
	1980	..	..	..	..	..	..	530
Detergents = =	1965	71	546	194	101	262	383	1445
	1970	180	900	290	200	420	2300	4290
	1975	360	1380	390	310	620	3700	6760
	1980	600	2130	520	480	910	5700	10340

Sources: = IV Sous-région économique africaine, études sectorelles, industrie chimique (CEA/C/03), CEA, 1969.
= = Prospects for some consumer-oriented chemicals in the Central African sub-region, ECA, 1968.

a/ 1964.
b/ 1965.
c/ 1966.
d/ Calculated on the basis of estimated West African per capita consumption.
e/ Calculated on the basis of polystyrene to PVC + polyethylene relationship estimated for the North African sub-region
f/ Includes 4081 tons for sack making.
g/ Estimated on the basis of some information on tyres and inner tubes imports and consumptions.

Figures in parenthesis were obtained by interpolation.

Table A4: Rough estimates of some petrochemical end-products in East Africa (in tons)

	Year	Ethiopia	Afar and Issa territory	Somalia	Kenya	Uganda	Tanzania	Rwanda	Burundi	Madagascar	Mauritius	Malawi	Zambia	Rhodesia	Sub-region
DDT (75%)	1964/65	50	-	-	300	200	310	30	30	150	50	100	360	300	1880
	1970	200	-	-	750	800	1000	220	180	750	-	300	650	500	5250
	1975	350	-	-	1450	1550	2000	320	260	1370	-	/400/	1470	810	9960
	1980	650	-	-	2800	3000	4000	500	400	2500	-	/500/	3300	1300	18950
BHC (25%)	1964/65	260	-	200	600	-	300	-	-	400	-	-	30	-	1790
	1970	400	-	320	1500	-	-	-	-	1200	-	-	60	-	3480
	1975	600	-	520	2070	-	-	-	-	2320	-	-	130	-	6440
	1980	900	-	850	5500	-	-	-	-	4500	-	-	300	-	12050
PVC	1964/65	300	-	-	300	100	280	-	200	300	-	-	400	1600	6100 a/
	1970	900	-	200	550	200	500	50	400	250	200	300	650	2600	13200 a/
	1975	1530	/150/	420	1030	530	1450	170	770	610	470	470	1050	4100	25500 a/
	1980	2600	400	900	2100	1400	1200	600	1500	1500	1000	800	1700	6500	48300 a/
Polyethylene (H.P.)	1964/65	20	-	-	800	50	430	-	-	100	-	-	200	2000	3[illegible]00
	1970	1200	-	400	2000	400	1000	200	300	500	200	400	600	3500	10700
	1975	3460	/200/	690	3100	1100	2000	550	690	1270	330	720	1550	5900	21640
	1980	10000	600	1200	5000	3000	4000	1500	1600	3200	500	1300	4000	10000	45900
Polystyrene	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	1120 b/
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	2650 b/
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	4660 b/
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	8600 b/
Nylon 6	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	(2300)
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	(2900)
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	3550
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	(4250)

Table A4: Continued

	Year	Ethiopia	Afar and Issa Territory	Somalia	Kenya	Uganda	Tanzania	Rwanda	Burundi	Madagascar	Mauritius	Malawi	Zambia	Rhodesia	Sub-region
Polyester	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	(1400
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	(2400)
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	5000
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	(11000)
Acrylics	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	230
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	680
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	1700
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	3600
SBR	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	5350
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	9900
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	18200
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	33300
Butyl	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	1070
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	2000
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	3630
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	6650
Detergents	1964/65	..	..	..	..	..	..	..	..	..	..	..	..	..	10000 b/
	1970	..	..	..	..	..	..	..	..	..	..	..	..	..	19000 b/
	1975	..	..	..	..	..	..	..	..	..	..	..	..	..	38000 b/
	1980	..	..	..	..	..	..	..	..	..	..	..	..	..	74500 b/

Source: Investigation on Fertilizer and Chemical Industries in East Africa (E/CN.14/INR/83), ECA, 1965.

a/ Calculated on the basis of estimated West African per capita consumption.

b/ Calculated on the basis of polystyrene to PVC + polyethylene relationship derived from available data on the four African sub-region.

Figures in brackets are estimates.

Figures in parenthesis were obtained by inter- and extrapolation of 1962 and 1975 figures.

.. Country estimates considered on the low side.

Table A5: African and world oil seeds production expressed in oil equivalent (1,000 t)

	1934/38	1954	1955	1956	1957	1958	1959	1960	1961	est. 1962
West Africa	1132	1716	1661	1818	1770	2035	2035	1870	1995	2065
Rest of Africa	370	701	699	628	785	740	990	1050	1170	1070
Total	1502	2417	2360	2446	2555	2775	3025	2920	3165	3135
World	21587	25863	26834	28432	28895	29325	31610	32135	33000	33620

Source: Le Marché des Oléagineux Tropicaux, Rapport Général, SEDES, mai, 1964.

Table 16: 1957-1960 average actual and 1970 estimated output of oil seeds in Africa

(expressed in 1,000 tons oil equivalent)

	1957-1960 average Ex. F.N.A.	Ex. F.N.A.	Ex. F.N.A.	Others	Total	1970 estimates Ex. F.N.A.	Ex. F.N.A.	Ex. F.N.A.	Others	Total
Cotton	1	1	8	184	194	1	1	11	255	268
Groundnuts	-	285	41	563	889	-	300	80	700	1080
Soybeans	-	-	-	2	2	-	-	-	3	3
Sunflower	-	-	-	30	30	-	-	-	60	60
Rape	-	-	-	6	6	-	-	-	6	6
Olive	133	-	-	8	141	250	-	-	12	262
Sesame	-	1	3	93	97	-	2	55	130	137
Copra	-	-	-	66	66	-	-	-	70	70
Palm Kernel	-	41	4	335	380	-	50	6	370	426
Palm	-	85	5	910	1000	-	90	3	1070	1163
Linseed	5	-	-	17	22	5	-	-	15	20
Castor	-	-	-	32	32	-	1	-	65	66
Ibrasin	-	-	-	12	12	-	-	-	20	20
	139	413	61	2258	2871	256	524	105	2776	3661

Source: Le Marché des Oléagineux Tropicaux, Rapport Général, SEDES, Paris, mai, 1964.

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