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Consultation on Downstream Petrochemical Industries in Developing Countries

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MANUFACTURING AND APPLICATION TECHNOLOGIES OF DOWNSTREAM PETROCHEMICAL INDUSTRIES/ MARKETING OF AND MARKET DEVELOPMENT FOR PETROCHEMICALS

Issue Paper*

Prepared by

the UNIDO Secretariat

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I. Introduction

1. The petrochemical industry has experienced, in a relatively short time, an exceptionally rapid growth, fostering vast technological innovations and contributing significantly to international trade by providing an outstanding variety of chemical intermediates used for the manufacture of plastics, fibres, synthetic rubber and many other end products.

2. Tracing the evolution of the petrochemical industry, it would be very difficult to identify any single reason or factor responsible for such a remarkable performance and accomplishment in technological development. Moreover, this spectacular progress may be attributed to a combination of favourable circumstances, notably large demand and availability of abundant supplies of low-cost feedstock.

3. The development of the refining and energy sectors during the 1960's offered an opportunity for cheap hydrocarbon by-products to be supplied to the petrochemical industry, which developed at a rate of five to seven percentage points above the growth rate of GDP in most industrialized countries, providing the market with attractive substitutes for traditional materials and products.

4. During this period, an unprecedented development of new products/processes was recorded. Most of these early technological developments originated in Western Europe and the United States and were quickly diffused in other market-economy developed countries.

5. New technology in almost every petrochemical product area was developed by operating companies, engineering contractors and research organizations. This led to technological innovations in the industry, particularly in the far-reaching development of processes for the production of the first generation products: ethylene, propylene and aromatics, chemical intermediates such as ethylene oxide, acrylonitrile, acetaldehyde, the fibre intermediates, and most importantly, the polymer materials (high density polyethylene, polypropylene, suspension PVC and the elastomers, etc.).

6. Technology innovation during this period was particularly characterized by the scaling up of plant size, simplified processing steps, and greatly improved specification in the action of catalysts, their efficiency and lifespan.

7. While the petrochemical industries and their technology were concentrated in the developed countries and held by a limited number of companies, new patterns were set in the dissemination of technology in the second phase of their development. Some firms started to license their processes to others, often including competitors, so that they could generate higher returns on their research investment from a combination of manufacturing profits and licensing fees and royalties. Some operating companies did, however, continue the traditional industrial policy of using internally-developed technology in their own operations.

8. Moreover, process technology was increasingly available from engineering firms, and therefore, manufacturing technology could be obtained from either operating companies and/or from research and engineering firms. Consequently, new technologies were broadly licensed. Hence, the industry was globally extended in spite of the fact that the increasingly competitive environment had started to narrow profit margins.

9. Petrochemical industries, which had long been a leading sector in industrial development, entered a new and less-favourable phase of development in the 1970's when the conditions vital to its growth worsened. The combination of several different causes, the increase in feedstock prices as a result of the two world oil-shocks, the slowdown in general economic growth, the saturation of major end-use markets and the associated emergence of new producers, especially in oil-exporting countries brought an era of poor profitability, low demand growth and slow rate of technological innovation leading to an inevitable overcapacity.

10. Many of the current routes for the production of most of the basic petrochemicals are now close to their limits in reactor design and catalyst efficiency. The processes are well established, technologies are proven, and per unit production capacities have reached the critical economic size in many of these products. Nevertheless, there have been continuous efforts to improve operational efficiency through the development of more

efficient and longer lasting catalysts, energy-saving through better heat recovery and other measures, lowering the level of wasted utilities, utilization of different feedstock and avoidance of the use of hazardous reactants.

11. Given the global overcapacity for basic petrochemicals, downstream petrochemical industries could tap the huge potential for demand-led growth for its products in the developing countries, thus easing the strain that the petrochemical industry is currently experiencing.

II. Current status of downstream petrochemical industries

12. Today, downstream petrochemical products such as plastics, fibres, synthetic rubbers, co-polymers, etc. have largely surpassed the traditional materials like metal, wood, glass, natural fibre, rubber, paper etc. not only in economy, but also in performance. Processed products from downstream petrochemicals are continuously substituting the traditional materials for enhanced efficiency while finding new usages in the fields of basic human needs in agriculture, food, clothing, shelter, irrigation, and health care, as well as making an innovative contribution to the automotive and electronics industry, space technology etc.

13. To cite a few examples, water treatment systems today have become much cheaper and more efficient with the use of PVC pipes and plastic components; revolutions in personal computers and home entertainment devices such as video cassette recorders could not have been possible if manufacturers had to rely on metal, wood or glass as their primary materials. With the extensive use of plastics, automobiles and trucks are more fuel-efficient; life-saving medical procedures like angioplasty are now routinely available; commercial marketing of several food, drinks and consumer products simply could not be possible without plastic packaging.

14. The increase in the standard of living in developed regions was largely accompanied by the availability of downstream petrochemical products. Table 1 shows the regional consumption of some thermoplastics which also signifies the difference between regional standards of living.

15. The oil price increases of the early 1970's led the industry to undertake massive restructuring and consolidation. Capacities for basic petrochemicals were built in proximity to raw materials and markets or both. Thus, new plants built in the Far East, the Middle East and Latin America resulted in an overcapacity situation which, translated into low capacity utilization and lower margins, will undoubtedly continue to cast a negative impact on the entire industry.

TABLE 1

Regional per capita consumption of thermoplastics, 1991 (in kilogramme)

	LDPE	LLDPE	HDPE	PPT	TOTAL
North America	9.00	6.80	11.60	9.00	36.40
West Europe	11.70	3.10	8.10	10.10	33.00
South America	2.56	0.28	1.40	1.36	5.60
East Europe	3.20	1.00	1.40	1.10	6.70
Africa	1.00	0.20	0.60	0.50	2.30
Asia-Pacific	1.20	0.50	1.20	1.64	4.54

Source: Paper presented on Polyolefins by Mr. Gary K. Adams At CMAI seminar on Petrochemicals, held in Houston, Texas, USA 25-26 March 1992

16. Table 2 shows the projected imbalance in demand and supply of some petrochemicals in 1995.

TABLE 2

Projected global supply/demand balance of some key petrochemicals
1995
(in million ton)

Product	Capacity	Demand	Imbalance	% use
Ethylene	86.00	72.00	14.00	84
Propylene	46.70	39.00	7.70	83
Benzene	35.50	26.00	9.50	73
Methanol	25.35	23.50	1.85	92
Styrene	20.00	18.40	1.60	92
EO	12.25	9.07	3.18	74

Source: Compiled at UNIDO Secretariat from various publications.

17. By 1995, the world's ethylene capacity is projected to be 86 million tons/year against a demand of 72 million tons/year resulting in a capacity utilization of 83.7%. Some regional discrepancies are still more critical. In 1990, ethylene production in Western Europe was 14.7 million tons against capacity of around 17.5 million tons. By 1996, Western Europe's ethylene capacity is projected to increase to 20 million tons/year against the projected demand of 15 million tons/year.

18. In the Far East, ethylene capacity is expected to reach 23 million tons/year against a demand of 21.45 million tons/year by the year 2000. By that time, the Middle East's ethylene capacity will be 6.31 million tons/year amounting to 6.5% of the global capacity. Thus the Far East, a traditional market for Japanese and Middle East producers, will become a surplus region prompting Middle East producers to look harder to the European markets to sell excess products.

Table 3

Current and world projected production of plastics, rubbers and fibres, 1989-1995
(Thousands of tonnes)

Material	1989	1990	1991	1995[a/]
Plastic				
HDPE	9,931	10,249	12,896	16,038
LDPE and LLDPE	17,514	18,149	21,511	23,545
PP	10,488	12,278	14,167	16,185
PS	7,762	8,556	8,983	10,435
PVC	16,719	17,568	18,146	20,902
TOTAL	62,414	66,800	75,703	87,105
Rubber	10,040	10,000	9,080	11,200
Fibre	14,774	14,906	15,161	18,200

a/ Projected

19. At present, although there is a clear trend towards the production of higher-value engineering and high-performance polymers, commodity polymers (HDPE, LDPE, PP, PVC and PS) are progressively gaining ground and expanding in many parts of the world. These polymers constitute the largest segment of petrochemical industries and accounted for over 63 million tons in 1989, about 75 per cent of which were consumed in the developed regions. The world consumption of these polymers is expected to reach over 81 million tons in 1995. For the near future, LLDPE will globally exhibit the highest growth rate among other commodity thermoplastics, followed by HDPE and PP, and PVC and PS; the lowest rate of growth is expected to be demonstrated by LDPE. Thus, commodity polymers will still hold the lead for the petrochemical industry in the future, especially in the developing countries where they still have a low per-capita consumption rate.

20. As for the regional prospects in the relatively important commodity polymers (bulk thermoplastics), two main factors are to be considered, namely, the pattern of end-uses reflected by the products and the stage of market development. However, in general, HDPE remains attractive in view of its broad spectrum of applications. PP and PS applications in the developed regions are mostly concentrated in the automotive sector, domestic appliances, and in packaging. PVC consumption is shared equally between the industrialized regions and the rest of the world. LDPE has maintained its importance in Western Europe, while LLDPE has recorded significant progress in the United States. See Tables 4 through 7 for current and projected supply/demand balance for polyethylene.

21. In the developing countries, and particularly the Middle East, commodity thermoplastics will continue to represent suitable investment opportunities. For PP, the Middle East is likely to achieve a competitive position in the regional market in the short-term and will gradually increase its global competitiveness. PS and PVC markets will exhibit increased growth in the Middle East region and will offer opportunities for petrochemical producers in the region.

22. Although engineering and high-performance polymers have recently experienced high-growth rates, in view of the higher value added, they are almost exclusively produced and largely consumed in the industrialized countries, as the areas for their

application in the developing countries have not yet sufficiently matured. Moreover. the speciality product market is more customer service intensive which requires the identification of the consumers' demands and problems so that the manufacturer can tailor-make the products to suit these specific demands.

23. Recent political and economic changes in the former Soviet Union and eastern European countries have opened up new avenues for demand-led growth of downstream petrochemical products. In the new republics that once made up the former Soviet Union, there are only 1 million tonnes per year of installed polyethylene capacity. It has been predicted that over the next five years, there will be a significant increase in the consumption of plastics in that area and elsewhere in eastern Europe and that this demand will have to be met largely by imports.

Table 4

Global polyethylene capacity additions
(in thousands of m.t./year)

Regions	1992	1993	1994	1995
North America	315	510	135	240
Latin America	290	160	0	0
Europe	715	480	120	60
Asia	210	580	600	520
Middle East/Africa	0	0	140	400
Totals	1,530	1,730	995	1,220

Source: Chem Systems (Tarrytown, NY)

Table 5

Global HDPE supply/demand balance
(in thousands of m.t./year)

	1991	1992	1993	1994	1995	2000
Capacity	12,896	14,157	15,043	15,587	16,038	19,783
Production	12,326	13,067	13,892	14,766	15,639	19,612
Consumption	12,326	13,067	13,892	14,766	15,639	19,612
Operating rate	82%	79%	79%	80%	80%	83%

Source: Chem Systems (Tarrytown, NY)

Table 6

Global LDPE supply/demand balance
(in thousands of m.t./year)

	1991	1992	1993	1994	1995	2000
Capacity	16,274	16,704	17,022	17,367	17,812	19,585
Production	14,225	14,559	14,892	15,287	15,679	17,007
Consumption	14,225	14,599	14,892	15,287	15,679	17,007
Operating rate	87%	87%	87%	88%	88%	89%

Source: Chem Systems (Tarrytown, NY)

Table 7

Global LLDPE supply/demand balance
(in thousands of m.t./year)

	1991	1992	1993	1994	1995	2000
Capacity	8,178	9,587	10,508	11,539	12,549	17,479
Production	5,237	5,883	6,568	7,167	7,866	11,659
Consumption	5,337	5,883	6,568	7,167	7,866	11,659
Operating rate	85%	81%	81%	82%	83%	85%

Source: Chem Systems (Tarrytown, NY)

III. Recommendations formulated by the Global Preparatory Meeting for the Consultation on Downstream Petrochemical Industries in the Developing Countries

24. The Global Preparatory Meeting, after in-depth discussions of the topics raised in the Secretariat's background document "Current Status and Future Prospects for the Downstream Petrochemical Industries", identified the following issues to be submitted to the Consultation on Downstream Petrochemical Industries:

A. Manufacturing and application technologies for downstream petrochemical industries

B. Marketing of and market development for petrochemicals

A. Manufacturing and application technologies for downstream petrochemical industries

25. Imported process technologies could only be meaningfully absorbed by the recipient developing country through the strengthening of indigenous technological capabilities. In that context, the crucial importance of human resource development was emphasized. Technology transfer contracts should be so negotiated that adequate provisions are included for local training in order to enable proper assimilation of the technology. That in return was considered a prerequisite for the efficient operation of the petrochemical plants.

26. The Global Preparatory Meeting agreed that the petrochemical industry was continuously shaped by technological innovations. Therefore, investment decisions in the sector were to be made in full awareness of all available technological options. However, the accessibility by the developing countries to some technologies and process know-how in the petrochemical industry was hampered by a number of constraints. The Meeting recommended that in such cases innovative enterprise-to-enterprise cooperation and joint-venture schemes be explored to motivate the technology holders through vested interests.

27. In order for R&D centres to function effectively, they should cater to the specific needs and requirements of industry and other end-users of petrochemical products. Thus, they not only could provide the impetus for the adoption of imported technology but also could develop indigenous technological options suited to the local socio-economic conditions and industrial realities of those countries. R&D efforts deployed in the petrochemical industries of developing countries could be more gainfully directed towards downstream processes and technology rather than basic petro-chemistry. In this context, adequate consideration should be given to the exigencies of environmental protection, safety and public health.

28. In order to keep abreast with the rapid technological changes and emerging processes in the field, the compilation of a corresponding directory might render useful services. Existing producer associations, international agencies, R&D centres etc. should be called upon for their assistance in this important undertaking.

29. The crucial role of adequate infrastructure, both human and physical, and well-functioning support institutions was emphasized for the development of indigenous resources, adoption of new technologies to local conditions, development of new processes and technologies, improvement of products and grades of polymers with new and innovative applications.

30. Finally, closer interaction and feedback between industry, consumers, R&D centres, vocational training, academia and industrial policymakers should be encouraged to attain the objective of improved technological capabilities in the developing countries.

B. Marketing of and market development for petrochemicals

31. In line with the documentation submitted to the Global Preparatory Meeting, the participants agreed that downstream processing industries be established, wherever viable, to provide industrial inputs to various sectors of economic activity, particularly shelter, agriculture, health care and clothing, which offer a large potential for the absorption of downstream petrochemical products.

32. The establishment or strengthening of product application and development centres was judged by the Global Preparatory Meeting to be an indispensable phase in the overall growth of downstream petrochemical industries in the developing countries. Such efforts should aim particularly at identifying innovative applications and new usage for the products of those industries.

33. The above should form an integrated part of an effective marketing strategy based on realistic assessments of identified consumer needs and market requirements with respect to products, prices, specifications and availability. In that context, the crucial role of product promotion and assistance in end-use was emphasized.

34. Adoption of effective marketing policies required availability and access to reliable information on market-related parameters. Regional and international agencies could provide some assistance to supplement the national efforts of data collection and evaluation. In that context the existing regional information networks could render valuable services.

35. The availability of and accessibility to reliable market-related information was not only required in the formulation of marketing strategies but also constituted an essential element for the identification of investment opportunities in the sector. Therefore, the transparency of supply-demand balances based on realistic assessment of market potential played a key role in the further development of the petrochemical downstream industries.

36. All market development strategies must encompass, as an integral component, an enhanced awareness of quality control and its management to ensure sustained customer satisfaction. This consideration gains added importance when domestic manufacture is primarily aimed at import substitution of petrochemical products.

37. Finally, the Global Preparatory Meeting concluded that in developing countries, marketing in general, and market development efforts for the products of downstream petrochemical industries in particular, had not kept pace with those activities employed elsewhere in the sector such as plant erection and operation. Therefore, there existed a tremendous potential for increasing marketing and market development efforts at the orporate and industrial policy levels.

IV. The Issues

A. Manufacturing and application technologies of downstream petrochemical industries

38. The spectacular growth of the petrochemical industry in the post-war period has been, to a large extent, due to technological breakthroughs in the production of synthetic materials. This was followed by the emergence of processing technologies for the transformation of those derivatives into a multitude of products, particularly for use in such sectors as agriculture, construction, textiles, industrial and, most important, consumer goods. These technologies were developed entirely in the industrialized countries through a concerted effort of research and development strategy based, inter-alia, on the resource and feedstock availabilities and prevalent market characteristics.

39. The developing countries as a rule have depended on foreign technology for the manufacture of petrochemical building blocks as well as conversion in downstream facilities. However, this technology, conceived and implemented under alien conditions and certainly not as an escape route from underdevelopment, does not necessarily correspond to the particular requirements and priorities of the developing countries, a fact which often renders its technical absorption and assimilation an onerous task.

40. Furthermore, the problem can be compounded by a lack of comprehensive technical back-up from the licensors or contractors for the efficient, safe and on-spec operation of petrochemical plants under the general conditions of the developing countries. This also holds true even from the perspective of the initial construction, assembly and erection of plants within battery limits, contributing to significantly higher capital expenditures in comparison with similar projects implemented in industrialized countries.

41. In the final analysis, construction cost escalations and operational inefficiencies are, inter-alia, traceable to an absence of consideration at the R&D stage of local parameters and

their divergence from the industrial environment of the technology holder. The limited technological capabilities of many developing countries greatly aggravates the encountered difficulties and perpetuates the dependence on the industrial component in their economic development. The spin-off effects of petrochemical technology on the vital sectors of the economy such as agriculture, construction and obviously downstream processing, proven to be substantial in the industrialized nations. In the developing countries, available evidence suggests that this multiplier effect is even more powerful given the unrealized potential for absorption of petrochemical products in many sectors.

42. Viewed from the perspective of the developing countries the foreign technology on offer invariably embodies some inherent weaknesses in respect to:

- optimal utilization of indigenous raw material and energy resources;
- capital cost structure of technology;
- operational, maintenance and technical back-up characteristics;
- responsiveness to local market potential;
- socio-cultural acceptability and adaptability;
- chain of technological continuity;
- industrial and infrastructural realities;
- sectoral integration in the overall economy;
- limitations of a genuine transfer of the know-how imbedded in technology; and
- requirement of and impact on manpower training and development.

43. Although obtaining foreign technology for setting-up petrochemical complexes in the developing countries has so far been the routine practice, it nevertheless has on occasions created innumerable problems of "mismatch". Such acquisition and transfer of overseas technology in spite of its imperfections has, however, represented the only mechanism for implementing the industrial aspirations of the developing countries. The cost of this process has however been unduly inflated by the

technological unpreparedness of the recipients to accommodate its exigencies.

44. The root causes of this insufficiency in technological capabilities are undoubtedly diverse. Certainly a major force at play must be the inadequacies of support from and the interaction with indigenous R&D capacity in the absorption and adaptation of foreign technology. The required assimilation cannot effectively take place in the absence of sufficiently developed technological capacities based on home-grown R&D efforts.

R&D options for the developing countries in the petrochemical industry

45. Although the issue of R&D is of fundamental importance, as it plays an indispensable part in the creation of a sound basis of the petrochemical industry in the developing countries, intense impediments have prevented the formation of adequate technological capabilities. Meaningful R&D at the national level obviously necessitates mobilization of considerable resources both in manpower allocation and in capital commitments, which in turn, are only effective in conjunction with well-entrenched scientific infrastructure and technical organization. The required number of qualified scientists, engineers and managerial talents, backed with adequate facilities and equipment, is certainly beyond the means of all but a few developing countries.

46. Another essential ingredient is the existence of and the linkage to appropriate channels for a continuous feedback between the research community and the operating petrochemical industries. This cooperation has proven difficult even in the industrialized countries, in cases where the harnessing of research functions outside corporate confines is attempted.

47. With the exception of a few developing countries, public support for R&D in petrochemicals has not been perceived as a high priority in industrial policies. Neither have technology adaptation concepts successfully counteracted the low levels of R&D productivity in these countries. In developing countries, the role of government in the R&D sector is crucial since many petrochemical companies simply cannot afford to acquire state-of-the-art laboratories for analytical and technical service, pilot

plants, testing, etc. In these cases the organization of back-up facilities and systems can only be state-sponsored or even state-owned.

48. The recent advent of international long-term cooperation arrangements in the sector, notably petrochemical joint-ventures, routinely incorporate provisions for R&D to be jointly undertaken by the partners. In reality, however, the R&D work tends to be dictated by the foreign partners' own corporate strategies and conducted at their facilities with only modest enhancement of the autonomous research capabilities of the host country's petrochemical entities.

49. In view of these limitations inherent in a purely national approach to R&D in the petrochemical sector and the acknowledged shortcomings in the acquisition of foreign technology, common efforts on bilateral, regional or international bases represent a number of viable alternatives for the developing countries. The option of joint efforts in R&D, hitherto largely untapped, can assume a large spectrum of different modalities and operational mechanisms. These can range from co-sponsorship of specific technology ventures at established research facilities in the industrialized countries, to the creation of regional technology clubs, coordinated technology import schemes, development consortia, consultative bodies or even "centres of excellence" with the participation of the world's leading technologists and scientists.

50. R&D in the petrochemical industry has undergone both a qualitative and quantitative transformation. The cornerstone of this change invariably involves a greater synchronization between the corporate functions of R&D, manufacturing and marketing. It no longer suffices to apply the results of R&D activities for the development of a new product before launching it on markets, as has been the traditional approach. Instead, the concept of "total product system" has evolved in which innovative technologies yield quality properties in response to specific customer requirements. Interestingly in such systems, the delivered product itself does not necessarily play the most important role since it includes other vital components such as application technology, product formulation and raw material composition.

51. A good example of such a product system is the manufacture of high density polyethylene pipes extruded from HDP. The integrated system of products extends to fittings, welding technology, insulation materials, etc. R&D closely synchronized with innovative concepts of marketing is generally regarded as the main factor enabling the chemical companies to take up the challenges confronting them. Foremost among these have been the near saturation of markets for commodity-type bulk chemicals, an escalation in the procurement costs of energy and feedstock, coming-on-stream of substantial new capacities and high capital expenditures for pollution control. Not surprisingly R&D in industrialized countries continues not only to maintain but to improve its traditional high priority in corporate strategy in relation to both gross sales and capital expenditure.

52. Pragmatic approaches to technological development in developing countries may include the following:

- Compilation and exchange of information on available technology, pilot or semi-commercial plant operation experience, technological know-how and availability of technical training facilities.
- Development of joint programmes on specific petrochemical industries for production, research and development, training, trade and others. Such programmes may also involve foreign partners, including the encouragement of highly qualified scientists to return to this field in their home countries.
- Establishment of programmes for the exchange of experience and personnel, including exchange through regional and international agencies.
- Coordination and harmonization of laws and regulations in developing countries dealing with technology import, absorption and use and the implementation of common licensing policies.
- Establishment of regional associations of petrochemical producers as a tool for the promotion of close cooperation between themselves and as a common forum for their external relations.
- Seeking assistance where needed to achieve the above-mentioned objectives from international organizations like UNIDO, U.N. Regional Economic Commissions, etc.

B. Marketing of and market development for petrochemicals

53. Marketing of the final product is often the single most important factor for the financial viability of a manufacturing project. It is usually essential to have an assured petrochemical market for at least 50 per cent of the plant output. Petrochemical products are used either as intermediate inputs in downstream manufacturing facilities or as end products. At present, many developing countries' producers of basic and intermediate petrochemical products are dependent upon export markets. With the changing fortunes of industry worldwide, they become vulnerable to external problems like global over-capacity, saturation in export markets, volatility in prices and economic recession in the consumer countries.

54. It has now become crucial for the producers to develop national and regional markets for their products. This is especially attractive, as there exists a large potential in this area because the consumption level of downstream petrochemical products is still low in most developing regions compared to industrialized countries.

55. National and regional markets can be developed, on the one hand, by encouraging the establishment of downstream industries and on the other hand, by an effective marketing strategy. The marketing strategy should encompass the following provisions:

Availability	development and/or adaptation of the plant output to suit the market requirements
Prices	local producers' prices competitive with the traditional suppliers' prices
Specifications and customer orientation	proper quality and management to satisfy customer preferences
Market intelligence and information	full recognition of appropriate information networks on market-related parameters as providing the basis for any effective marketing strategy

56. In order to develop downstream industries' complementarity with other economic sectors and to avoid the creation of a glut or severe undersupply in producing regions, careful planning and coordination are essential. A prerequisite for such planning and coordination is accurate market information. Appropriate networks of information on marketing and market-related parameters will provide the basis for the development and investment in downstream industries, adaptation of the present plant output to suit the market demand and product specifications and required quality control of the product.

57. The development of certain infrastructure such as roads, jetties, tank farms and terminals, and other communication facilities is an important element for marketing products. These are usually cost-intensive and should not be charged to the petrochemical projects alone, but rather be perceived by the government as essential facilities for the overall industrial development of a country.

58. In summary, the major marketing difficulties in the petrochemical industries in developing countries are centred around the following:

- Limited size of the domestic markets for basic and intermediate products because of the slow development of downstream industries and the low per-capita consumption.
- Lack of adequate marketing experience and skill.
- Severe competition in the international markets.
- The increasing role of new forms of trade in the sector by corporate entities.
- Trade barriers, whether among developing countries themselves or on a wider international scale, both of a tariff or non-tariff nature, to discourage the export of petrochemicals to developed markets.
- Lack of cooperation and coordination in the strategic industrial plans of developing countries as well as the absence of such cooperation interregionally.
- Lack of adequate infrastructural facilities for easy transport of products, storage, and distribution.
- Weak, or non-existent after-sales services.
- Unavailability of market information and intelligence.

VI. Problems and prospects of the downstream petrochemical industries in developing countries

59. The petrochemical industry in developing countries, in general, is confronted with three main problems: one is connected with the marketing and its related intricacies; the second is tied up with the lack of technical capability and the methodology of technology transfer; and the third is the lack of genuine coordination and cooperation nationally, regionally and internationally. All other secondary problems such as human resource training, adequate infrastructure, limited manufacturing capabilities, etc., would gradually be solved during the progress of the industries' development and the mastering of the main problems. Moreover, these secondary problems are inherently related to the industrial development process as a whole, and should be tackled in parallel with the development of the other industrial sectors and the overall economy of each developing country.

60. As for the three main obstacles mentioned above, the focus has been placed on them simply because these problems are not normally resolved just by the passage of time or easily overcome through the purchase of technology packages or by entering into licence agreements.

61. The first, that of marketing, stands as a serious obstacle because it determines the whole economic viability of any petrochemical project, involves multi-faceted inputs, requires lengthy experience and a high degree of skill and business acumen.

62. Marketing skill, obviously, is not just a commodity to be purchased or a set of instructions to be learned and followed in all cases and at all times. For example, it cannot be expected that different petrochemical products can be marketed, from one developing country to another with the same strategy, or be successfully promoted through similar sales and marketing conditions.

63. The second major obstacle to the development of downstream petrochemical industries in developing countries is related to technology in general, whether it be the lack of domestic

technological capabilities, or the inadequacies in the methods presently employed in the transfer of technology.

64. In spite of the relative effectiveness of the means followed by a few developing countries in the process of technology transfer through establishment of various joint venture arrangements with experienced and specialized companies from developed regions, such practices usually have little effect on a genuine assimilation of imported technologies by the recipient countries. Other mechanisms used by some countries, such as process licence agreements, operation and management, supervision of construction, erection and contracts for commissioning of petrochemical plants, contribute to the technology transfer process, but again to a relatively modest extent.

65. The most important aspect of technology transfer, however, remains the vertical transfer of technology which forms the backbone of real and consolidated technological capabilities in any developing region. Such a technology transfer process could be conceived and adapted to suit the local conditions eventually leading to self-dependence rendered possible only through one's R&D activities and indigenous support.

66. Such a process would naturally require a great number of prerequisites. Some of these would include highly qualified scientists and well-trained personnel, in conjunction with other related facilities such as sophisticated equipment, laboratories, pilot plants and reliable sources of information with well developed engineering and design organizations and local manufacturing capabilities as well as the existence of government policy incentives to promote the petrochemical industry.

67. Since these technical infrastructures would require a great deal of investment and a relatively long gestation period, as well as numerous human resources, cooperation becomes an important factor whereby the burden of costs would be shared and resources could be pooled to accelerate the process of technology transfer both horizontally and vertically.