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THE CURRENT STATUS OF AND FUTURE PROSPECTS FOR THE DOWNSTREAM PETROCHEMICAL INDUSTRIES IN THE DEVELOPING COUNTRIES

Discussion paper

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INTRODUCTION

1. In today's world, downstream petrochemical products such as plastics, fibres, synthetic rubbers and copolymers have surpassed traditional materials such as metal, wood, glass, natural fibre, rubber and paper not only in economy but also in performance. Processed products from downstream petrochemicals are continuously replacing traditional materials on the basis of enhanced efficiency while finding new uses in areas of basic human needs such as agriculture, food, clothing, shelter, water management and health care and making an innovative contribution to the motor car and electronics industries, space technology etc.

2. To cite a few examples, water treatment and irrigation systems have become much cheaper and more efficient with the use of polyvinyl chloride (PVC) pipes and plastic components. Dramatic advances in personal computers or home entertainment devices such as video cassette recorders would not have been possible if manufacturers had had to rely on metal, wood or glass as their primary materials. With their extensive use of innovative plastics, motor cars and lorries are much more fuel-efficient, and life-saving medical procedures like angioplasty are now routinely available. Several foods, drinks and consumer products could not be marketed without plastic packaging.

3. Much of the improvement in the standard of living in developed regions is associated with the availability of downstream petrochemical products. Table 1 shows the regional consumption of four thermoplastics; the correlation with standard of living is apparent.

Table 1. Per capita consumption of thermoplastics by region, 1991
(Kilograms per capita)

Region	Low-density polyethylene (LDPE)	Linear low-density polyethylene (LLDPE)	High-density polyethylene (HDPE)	Polypropylene (PP)	Total
North America	9.00	6.80	11.60	9.00	36.40
Western Europe	11.70	3.10	8.10	10.10	33.00
Eastern Europe	3.20	1.00	1.40	1.10	6.70
South America	2.56	0.28	1.40	1.36	5.60
Asia-Pacific	1.20	0.50	1.20	1.64	4.54
Africa	1.00	0.20	0.60	0.50	2.30

Source: G. K. Adams, "Polyolefins", Paper presented at CMAI Seminar on Petrochemicals, Houston, Texas, 25 and 26 March 1992.

4. The petrochemical industry evolved in three developed regions, namely, North America, western Europe and Japan, all of which experienced a rapid increase in the consumption of downstream products of the industry. The excess products from these regions were exported to developing countries.

5. The oil price increases of the early 1970s forced the industry to undertake massive restructuring and consolidation. Capacities for basic petrochemicals were built in proximity to the raw materials and the markets or both. Thus, new plants were built in the Far East, the Middle East and Latin America that resulted in overcapacity. This, in turn, led to low capacity utilization and lower margins, which undoubtedly have and will continue to have a negative effect on the whole industry.

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

Table 2. Projected world supply/demand balance for some key petrochemicals, 1995 (Millions of tonnes)

Product	Capacity	Demand	Imbalance	Capacity utilization (%)
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
Ethylene oxide	12.25	9.07	3.18	74

7. By 1995, the world's ethylene capacity is projected to be 86 million tonnes per year against a demand of 72 million tonnes per year, resulting in a capacity utilization of 83.7 per cent. 1/ Some regional imbalances are even greater. In 1990, ethylene production in western Europe was 14.7 million tonnes against a capacity of around 17.5 million tonnes. By 1996, it is projected to increase to 20 million tonnes per year against projected demand of 15 million tonnes per year. 2/

8. In the Far East, ethylene capacity is expected to reach 23 million tonnes per year against a demand of 21.45 million tonnes per year by the year 2000. By that time the Middle East's ethylene capacity will be 6.31 million tonnes per year, amounting to 6.5 per cent of the global capacity. 3/ Thus the Far East, a traditional market for Japanese and Middle Eastern producers, will become a surplus region, prompting Middle Eastern producers to try to sell excess products into the European market.

9. Although the demand for downstream petrochemical products has plateaued somewhat in the developed regions, satisfying the basic needs of the growing population in developing countries without severely depleting precious natural resources could create great demand-led growth for these industries in the developing regions, as evidenced by the currently low per capita consumption.

10. One of the important characteristics of the demand pattern for downstream petrochemical products is that where there is low per capita consumption, demand has been observed to triple or quadruple as soon as products are

manufactured locally. For example, the consumption of plastic resins in Saudi Arabia has reached 300,000 tonnes per year, a 20-fold increase over the 15,000 tonnes per year consumption a decade ago, when the country started to produce its own plastics. More than 200 firms are now involved in processing plastics in that country. 4/

11. Likewise, recent political and economic changes in the former Soviet Union and eastern European countries have opened new avenues for demand-led growth for downstream petrochemical products. In the new countries that once made up the former Soviet Union, there is 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 by imports.

12. Given the global overcapacity for basic petrochemicals, the downstream petrochemical industry could tap the huge potential for demand-led growth for its products, thus easing the strain that the petrochemical industry is undergoing.

I. SCOPE OF THE DOWNSTREAM PETROCHEMICAL INDUSTRY

13. Bulk petrochemical products are converted into consumer items by downstream petrochemical processing industries. The borderline between the upstream and downstream portion of the industry is far from well-defined. In plastics, the production of polymers in powder form is considered to be an upstream petrochemical process, just as blending and granulation, including operations performed within the plant, are also upstream operations. However, the processing of the powders, master blends and granulates by injection moulding, extrusion and calendering into semi-finished and end-products is regarded as a downstream operation.

14. In man-made fibres, the production of polymer or polycondensate chips is an upstream petrochemical activity. Filament and yarn spinning, dying and texturing are considered either, whereas further processing of the resulting products is a textile industry operation. Synthetic rubber production is both an upstream petrochemical activity and a rubber processing activity. Detergent production is deemed a downstream activity. Varnishes and paints are considered either or both.

15. The manufacture of additives and plasticizers, as well as of engineering items such as moulds and dyes for conversion processes, is also considered to be part of the downstream processing industry. In developed countries, these critical sectors work closely so that the plastics industry can be thought of as a network of interdependent skills and technologies that allow efficiency of operation and ensure the quality of products offered to the consumer.

16. In the developed countries, the downstream petrochemical industry followed a path that was characteristic of economic, social and technological conditions in those countries. Developing countries are unlikely to follow a similar path. Particular attention should be paid to planning the end-uses of petrochemical products so that these are appropriate to the prevailing economic, social and industrial conditions.

17. Such end-uses, as well as the efforts to promote them (market development), should aim at satisfying the basic needs of the population and at improving its standard of living in terms of food production and storage, water distribution and management, housing and clothing requirements.

II. APPLICATION OF DOWNSTREAM PETROCHEMICAL PRODUCTS

18. Normally, 60 per cent of petrochemical end-products consist of plastics and resins, 10 per cent consist of synthetic fibres, 10 per cent of elastomers and 20 per cent of other materials. Plastics are the largest group. Not only are they used in countless consumer goods, but they have also made increasing inroads into various industrial applications made possible by the copolymerization and alloying of plastics and the development of new fabrication technology. The former group is known as commodity plastics while the latter is known as engineering plastics. Downstream petrochemical industries are highly service-oriented: they require close contact with customers to cater for specific technical requirements in respect of production, application and performance.

A. Plastics

19. The plastics industry is the dominant and most versatile of the downstream petrochemical industries. It is characterized by its ever-increasing replacement of traditional materials and its penetration into new fields of application. The commodity plastics comprise polyvinyl chloride (PVC), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), ultra-high-molecular-weight polyethylene (UHMW-PE), polypropylene (PP) and polystyrene (PS). The engineering plastics comprise hard polymers such as polypropylenes, nylons, polycarbonates, polyphenylenes, acetals, thermoplastic polyesters, polysulfones and polyphenylene sulphides, all of which are produced in various grades and can be reinforced with glass fibres, carbon fibres etc.

20. Commodity plastics find application in all economic sectors. They are used in pipe and fittings; tubings; siding and window profiles; wire and cable covering; films and sheeting; blow-moulded food containers; automotive fuel tanks; injection-moulded, thin-walled bottles; industrial pallets, crates and cases, bullet-proof vests; fire-retardant safety clothing for industry; food trays; refrigerator liners; luggage; video-cassette covers; automotive ductwork and panels; household appliances; electronic equipment; automotive trim; stadium seats; power tools; and business machine housings. Engineering plastics are especially important in the automotive and electronics/electrical industries, as well as in the aerospace industry.

21. Plastics have a number of advantages that promote demand for them and cause them to replace traditional materials:

(a) Their use conserves natural resources like forest, land and water while avoiding the pollution associated with the extraction of metals;

(b) The lighter weight of the products saves energy;

(c) The products are durable and recyclable;

(d) Machine and labour hours are saved by easier-to-form products;

(e) Labour and costs are saved by easier-to-handle products;

(f) The products are more competitive on the basis of cost and performance;

(g) They are more corrosion-resistant and of better quality, saving maintenance and capital costs;

(h) Their improved thermal, mechanical, electrical and physical properties allow them to withstand severe operating conditions;

(i) New systems and technologies cater to innovative engineering applications;

(j) They can form the basis for cost-effective systems in sectors like agriculture and water distribution;

(k) The products can improve living conditions and satisfy aesthetic demands.

22. These advantages explain, to a large extent, the dramatic growth of commodity plastics, often surpassing the growth of gross domestic product (GDP), despite heavy restructuring in the upstream petrochemicals industry and cyclical overcapacity.

B. Fibres

23. The main application of synthetic fibres is in the textiles sector, which fulfils the basic human need for clothing. The most-used synthetic fibres are polyester, polyamide and acrylic fibres. However, a new fibre, polypropylene, is making a spectacular entry. In 1990 it claimed a market share of 7 per cent, compared with 1 per cent in 1989.

24. Synthetic fibres are continuously increasing their share of total fibre consumption; in 1991 they accounted for 39.5 per cent of fibre consumption worldwide. Owing to technological innovations, polyester now feels more like silk or wool, nylon more like cotton and acrylic more like wool. In the absence of synthetic fibres it would have been impossible to fulfil human clothing needs from natural sources like cotton or wool. Synthetic fibres also promise to satisfy the growing needs in developing countries.

25. Apart from their use in textiles, synthetic fibres are finding increased use in the motor car industry for safety belts, upholstery, tyre cord and carpets, in which use they are more reliable owing to their greater durability. Synthetic fibres are also used for carpet backing, filler in industrial conveyor belting and truck tarpaulins.

C. Rubbers

26. Synthetic rubbers, often in combination with natural rubber and other additives, are used mainly for tyres and related products. In 1990, more than 7 million tonnes of synthetic rubber (61 per cent of the total) were consumed by this application, according to the International Institute of Synthetic Rubber Producers (IISRP). Another 10 per cent went to automotive mechanical goods such as belts, hoses and gaskets. 5/ Automotive mechanical goods are often made of special elastomers selected for their ability to withstand the high temperatures now encountered in engine compartments, which are the result of efforts to reduce polluting emissions and increase mileage.

27. Owing to its sheer size, this application of synthetic rubber spurs the development of new elastomers and the modification of existing ones to allow them to be specified for use in a growing number of automotive mechanical goods.

28. Another large-volume use of synthetic rubber is in mechanical goods for industrial and general applications. These goods include a wide variety of belting, including conveyor belts, and of hoses for many types of service. Synthetic rubber is also used to modify various thermoplastics, usually to impart shock resistance. It is used in footware; construction, mainly as roofing material and pond lining; wire coverings, especially for services where plastic covering does not perform well; vessel linings in industry; and adhesives of many kinds. Including other smaller applications, these industrial and general mechanical uses account for more than 20 per cent of synthetic rubber consumption.

III. RECENT TRENDS IN DOWNSTREAM PETROCHEMICAL PRODUCTION

29. In 1991, world production of the main downstream petrochemicals, i.e. plastics, fibres and rubbers, was estimated to be about 100 million tonnes, representing a value of more than US$ 98 billion. 6/ Table 3 shows production in preceding and future years as well.

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.

30. Of the three materials, plastics are the highest in volume and in value. Moreover, despite their impressive gains, demand for them is still growing, not only in developed countries but also in developing countries, which are characterized by low per capita consumption and which provide huge potential for demand growth. For fibres, the same is true, as they fulfil the basic human need for clothing. The synthetic rubber market, on the other hand, is fairly saturated, and growth has been slow in recent years. The lion's share of this product is consumed in the manufacture of tyres, which is not a basic requirement in developing countries.

A. Plastics

31. According to conservative estimates, by the year 2000 the plastics industry will be at least 50 per cent larger than it is currently. 7/ By then the industry will have learned to cope satisfactorily with environmental issues and entirely new product lines will have been developed. Factors like better fabricating equipment, better lot-to-lot uniformity, new speciality grades and new products, technological innovations and the use of granules instead of pellets in reactors, which eliminates a costly manufacturing step, will contribute to the growth of the industry. Africa, the Asian-Pacific region, eastern European countries, Latin America, the Middle east and the countries that once constituted the Soviet Union will be growth areas for commodity plastics, while

high-value-added engineering plastics will find more applications in developed as well as developing regions.

32. One problem looms: the industry is the source of much non-biodegradable solid waste. In the developed world, plastics account for 7-8 per cent, by weight, of municipal solid waste, mainly rigid containers and packaging films. In terms of volume, the figure is closer to 20 per cent. 8/ Nonetheless, technologies for recycling the waste are already operational. Once the economic hurdles of recycling are overcome, plastic will still be chosen over the traditional materials like metal, wood and paper on the basis of performance and economy of use.

33. Five commodity polymers (HDPE, LDPE and LLDPE, PP, PVC and PS) are the largest in terms of world production.

1. High-density polyethylene

34. World consumption of HDPE will grow to about 14.5 million tonnes per year in 1995 from little less than 10.5 million tonnes per year in 1988. Widespread plant construction will allow capacity to grow and to keep pace with demand. Annual average growth will be 5.7 per cent (table 4).

Table 4. World capacity for and consumption of HDPE by region, 1988 and 1995
(Thousands of tonnes)

Region	Capacity		Consumption		Average annual growth
	1988	1995	1988	1995	(%)
Africa	100	265	210	260	3.40
Asia-Pacific	1 309	2 924	1 571	2 479	8.25
Eastern Europe	940	2 305	856	1 363	8.46
Japan	903	964	760	905	2.72
Latin America	497	932	505	910	11.45
Middle East			140	220	8.16
North America	3 730	5 066	3 679	3 291	6.26
Western Europe	2 380	2 790	2 600	3 500	4.94
Total/average	9 859	15 246	10 321	14 431	5.68

Source: Economist Intelligence Unit, "Petrochemicals: an industry and its future", Special report No. 2067, 1991.

35. The most notable growth in demand will occur in eastern Europe and the countries of the former Soviet Union, where political and economic changes will stimulate demand, and in the Far East, especially in China and countries where there has been particularly rapid growth. By 1995, there will be some overcapacity, which will ease by the year 2000 as the local manufacture of end-products stimulates consumption.

2. Low-density and linear low-density polyethylene

36. World consumption of LDPE and LLDPE will grow from 17.7 million metric tonnes per year in 1988 to over 22.5 million metric tonnes per year in 1995 (table 5). After the mid-1990s, the growth rate will drop below 4 per cent per year. From 1988 to 1995, the growth rate in the Asian-Pacific region will have averaged 9.5 per cent per year and in Latin America, 5.7 per cent per year. In western Europe and the United States it should be about 2.3 per cent and 3.2 per cent per year, respectively. Indeed, LDPE supply and demand should remain in balance throughout the 1990s provided that HDPE demand continues to grow at about 6 per cent per year. This will ensure that swing low-pressure plants, which can make either HDPE or LDPE, continue to make their share of HDPE. In that case, LDPE capacity utilization will be close to 90 per cent; otherwise it will fall to about 75 per cent. Another factor that influences LDPE demand is the market share of LLDPE. At present LLDPE holds about 22 per cent of the total low density polyethylene market worldwide.

Table 5. World capacity for and consumption of LDPE, including LLDPE, by region, 1988 and 1995
(Thousands of tonnes)

Region	Capacity 1988	Capacity 1995	Consumption 1988	Consumption 1995	Average annual growth (%)
Africa	210	450	347	420	3.00
Asia-Pacific	1 485	4 015	2 510	4 187	9.54
Eastern Europe	2 238	3 103	1 968	2 401	3.14
Japan	1 522	2 159	1 353	1 600	2.60
Latin America	1 371	2 008	983	1 380	5.77
Middle East	1 304	1 434	397	520	4.42
North America	6 577	9 300	5 071	6 231	3.26
Western Europe	6 313	7 573	5 080	5 900	2.30
Total/average	21 023	29 870	17 709	22 639	3.97

Source: Economist Intelligence Unit, "Petrochemicals: an industry and its future", Special report No. 2067, 1991.

3. Polypropylene

37. PP has an important advantage: it is an exceptionally adaptable material and has an ever-increasing number of applications. These advantages, together with its affordability, make it especially attractive to developing countries. For example, in industrialized countries, PP is used for garden furniture and appliances; in developing countries, it can be used for furniture in general. Because of its adaptability, it has already begun to penetrate the markets of other polymers, just as it penetrated markets for other materials after it was developed in the 1960s.

38. In the early 1980s, the supply of PP tightened. West European manufacturers were operating at over 100 per cent capacity, and worldwide operations were at 95 per cent of capacity. These high figures persuaded producers to plan new capacity for start-up in 1989-1992. As a result, too many new plants were built, especially in the Pacific Rim countries as well as in Europe and the United States. Supply now appears to be greatly outstripping demand (table 6). However, the closure of high-cost diluent plants, the development of new grades to render the resin more competitive with other materials and the opening of new markets will help to ease the situation.

Table 6. World supply/demand balance for PP, 1988-1992
(Thousands of tonnes)

	1988	1989	1992
Demand	10.9	11.7	14.6
Capacity	11.5	13.3	19.7
Utilization (%)	95	88	74

Source: Chemistry and Industry, 19 November 1990, p. 728.

39. Worldwide demand is forecast to grow 7.5 per cent per year through 1995, with regional growth varying from 5 to 12 per cent (table 7). Traditionally, the PP market has grown as more materials became available, and producers are confident that the resin will continue to do well especially in developing countries, where per capita consumption is still very low.

Table 7. World consumption of PP by region, 1988-1995
(Thousands of tonnes)

Region	1988	1990	1995	Average annual growth 1988-1995 (%)
Africa	125	150	225	8.8
Eastern Europe	740	815	1 240	7.7
Far East/Oceania	1 910	2 190	3 040	6.0
Japan	1 450	1 755	2 150	5.8
Latin America	520	665	1 160	12.1
Middle East	185	225	325	8.4
North America	2 705	3 315	4 515	7.6
Western Europe	3 000	3 420	5 000	7.6
Total/average	10 635	12 535	17 655	7.5

Source: Economist Intelligence Unit, "Petrochemicals: an industry and its future", Special report No. 2067, 1991.

4. Polystyrene

40. As technological advances in product design continue, demand for PS increases. Globally, PS demand will grow by 3.3 per cent annually, reaching 12.55 million tonnes in 2000 from 8.90 million tonnes in 1990 (table 8). Areas of fast growth will be Africa, eastern Europe, the Middle East and the Pacific Rim.

Table 8. World demand and capacity for PS, 1985-2000
(Millions of tonnes)

	1995	1990	1995	2000
Capacity	8.71	10.85	12.05	13.26
Demand	6.45	8.90	10.63	12.55

Source: Oil & Gas Journal, 1 April 1991, p. 21.

41. PS consumption in Asia will grow 4.5 per cent per year during the 1990s, paced by applications in high-tech consumer electronic products in Japan and the Republic of Korea and in basic products in China, Pakistan and Indonesia. In western Europe, which is a mature market, PS consumption will grow 2.5 per cent per year. 9/ Demand in eastern Europe may be stimulated further by an increase in the standard of living, concurrent with rising demand for appliances and more sophisticated packaging.

5. Polyvinyl chloride

42. The world's PVC production facilities are operating at about 90 per cent of capacity, producing 18 billion tonnes per year. The main consumption of PVC is in construction and housing (60% of global production), and packaging (15%). 10/ In the medium term, PVC use will be affected by the solid waste issue, the housing market and motor car sales. PVC demand is closely related to per capita gross national product (GNP), and developing countries will be the most important areas for the expansion of PVC markets. In industrialized countries, where the market is more mature, growth is expected to be slow. Considering these factors, overall growth for PVC is projected to be 3-5 per cent per year. During the next six years, 3.6 million tonnes of new capacity will be added globally, which may lower the capacity utilization rate to about 84 per cent. 11/

B. Fibres

43. After plastics, synthetic fibres are the most important downstream petrochemical products, especially as they have the potential to satisfy the basic human need for clothing. In 1991, the market share, worldwide, of synthetic fibres was 15.16 million tonnes, or 39.5 per cent of the market share for all fibres. 12/ In 1986, this share had been 36 per cent. 13/ Table 9 shows the world production of synthetic fibres by region.

Table 9. World production of synthetic fibres by region, 1987-1991 a/
(Thousands of tonnes)

Region	1987	1988	1989	1990	1991
Asia other than China	3 063	3 344	3 587	3 909	4 377
China	846	1 075	1 224	1 343	1 450
Eastern Europe	1 679	1 725	1 710	1 620	1 333
Japan	1 340	1 352	1 381	1 426	1 430
Middle East, Africa and Oceania	220	226	222	228	230
North America	3 225	3 285	3 245	3 010	3 031
Other Americas	792	785	804	777	803
Western Europe	2 579	2 588	2 601	2 593	2 507
Total	13 744	14 380	14 772	14 906	15 161

Source: Fibre Organon, July 1991, pp. 180 and 181.

a/ Except olefin fibre.

44. Among synthetic fibres, the consumption pattern is shifting towards polyester and "other synthetics" and away from acrylics and polyamides. In 1990, polyester accounted for 54 per cent of the market, followed by polyamides and acrylics, accounting for 24 per cent and 15 per cent, respectively. Demand for polyester fibre is projected to grow about 5 per cent per year, to reach 19 million tonnes per year by 2000; the growth rate for acrylics will be 2.5 per cent. 14/

45. The developing regions' share of synthetic fibre capacity increased from 35.3 per cent in 1986 to 44.7 per cent in 1991. The capacity is shifting towards southern and south-eastern Asia, where there has been a significant expansion of capacity. Together, Taiwan Province of China and the Republic of Korea now have more polyester fibre capacity than all of western Europe; each produces about 1.2 million tonnes per year of polyester staple fibre and filament. 15/ Indonesia also increased its capacity substantially, by 64,000 tonnes per year in 1991. As a consequence, prices came under pressure in all parts of the Asian-Pacific region in 1991. The Republic of Korea and Taiwan Province were able to slightly increase their exports to the United States and west European markets. The overcapacity situation in the Far East calls for the judicious planning of future expansion.

C. Rubbers

46. In the early 1980s, the market for the conventional uses of thermoset synthetic rubber became mature, as evidenced by slight growth rates throughout the rest of that decade. Synthetic rubber's heavy dependence on the tyre industry is the main worry (about half of all commodity synthetic rubber is used for this purpose), because economic recession usually leads to a slump in motor car production. Moreover, new tyre technology means that the finished products last longer.

47. In 1990, synthetic rubber use grew less than 0.4 per cent 16/, and in 1991 it declined 7 per cent from the previous year, 17/ mainly owing to a slump in the motor car and construction industries as well as to economic and political changes in the former Soviet Union and eastern Europe. World consumption of synthetic rubber is expected to grow at 1.5 per cent per year, to reach almost 10 million tonnes in 1996 (see table 10). Regional growth rates will vary from 1.8 per cent to 6.7 per cent. Central Europe and the countries that once made up the Soviet Union will have a negative growth of 3.4 per cent owing to economic slow-down.

Table 10. World consumption of synthetic rubbers by region, 1990-1996 a/
(Thousands of tonnes)

Region	1990	1991	1992	1996	Average annual growth, 1991-1996 (%)
Asia/Oceania	1 812	1 802	1 851	2 063	2.89
Central Europe and the former Soviet Union	2 477	1 917	1 649	1 593	-3.38
China	380	403	427	539	6.75
Latin America	547	553	586	638	3.07
Middle East and Africa	133	127	125	139	1.89
North America	2 506	2 399	2 484	2 744	2.87
Western Europe	2 086	2 050	2 068	2 236	1.81
Total	9 941	9 251	9 190	9 952	1.52

Source: Chemical Week, vol. 50, No. 7 (19 February 1992), p. 14.

a/ Excludes thermoplastic elastomers.

48. Styrene butadiene rubber (SBR) is the most widely used synthetic elastomer, accounting for 38 per cent of the synthetic rubber market share. 18/ Other important synthetic rubbers are polybutadiene rubber (PBR), with about 17 per cent market share, ethylene-propylene rubber, butyl rubber, nitrile rubber, polyisoprene and polychloroprene.

IV. POTENTIAL CONTRIBUTION OF A DOWNSTREAM PETROCHEMICAL INDUSTRY TO DEVELOPING ECONOMIES

49. Thanks to technological innovation and the development of new products and processes, downstream petrochemical industries supply materials to almost all the economic sectors that provide inputs to water management, utilities, communications, transportation, housing, construction, textiles, packaging, health-care, household appliances etc. The products satisfy many of the basic needs of human beings and are replacing traditional materials at an ever-increasing rate.

50. Although the relationship between this industry and the overall performance of national economies cannot be quantified, some important qualitative factors may be mentioned for illustrative purposes:

(a) Downstream petrochemicals are processed in small-scale production units that employ a large number of people;

(b) The value added through processing can contribute significantly to the GNP of a country;

(c) A country's foreign exchange earnings and balance of payments can improve as expensive, imported materials are replaced;

(d) Downstream petrochemical products can have a considerable positive impact on the performance of other production and service sectors and the general welfare of the population;

(e) Because they are more durable, easier to maintain and better-performing, these products make possible greater economic savings;

(f) Products from this industry serve other economic sectors, e.g. agriculture, irrigation and water management, construction and communication, and thus contribute to overall economic development;

(g) The research intensiveness of this industry can have a positive impact on the technological capabilities of a country;

(h) The genuine transfer and mastery of the technologies embodied in this industry can have a synergistic effect on many other industries;

(i) In many cases, the manufacture of the products of this industry requires less energy and creates less pollution. At the same time, the industry helps to maintain an ecological balance by replacing traditional materials such as metal, wood and paper.

V. IMPACT OF TECHNOLOGICAL INNOVATIONS ON THE PETROCHEMICAL PROCESSING INDUSTRIES

51. Technological innovations have led to improved new products and applications for the downstream processing industries. New polymers and composites that are lightweight and corrosion-resistant and that require less capital investment than traditional materials are finding ever-increasing applications in aircraft, motor cars, construction, electronics and consumer products.

52. Miniaturization, which has great potential in the electronics and medical fields, has become a reality thanks to developments in engineering plastics. In production facilities, improved fabrication technology, alloying and copolymerization have introduced tremendous versatility to the regulation of product specifications and to the manufacture of customer-oriented products for particular applications. Not only are alloys, blends and composite plastics with superior mechanical, thermal, chemical, electrical and physical properties becoming the material of choice for some new products but they are in and of themselves the driving force for other new products.

53. Lighter weight radial tyres that have better traction and are more resistant to degradation are the chief outcome of technological innovations in synthetic rubber. Special rubber with enhanced thermal, chemical and mechanical properties is finding increasing application in automotive parts and in mechanical parts for non-automotive applications.

54. No significant breakthroughs in fibre technology have occurred in recent years. The main synthetic fibres, i.e. polyesters, polyamides and acrylics, have held their positions. They, too, are subject to innovative changes like those introduced in plastics to satisfy consumer preference for natural feel and breatheability. Already polyester imitates silk and wool, and nylon has been given the feel of cotton. New entrants such as nylon 4,6, high-strength polyethylene fibres and composite fibres may spur development in the traditionally stable and uneventful fibre sector.

55. These fibre innovations will not have any adverse effect on the demand for commodity plastics. Commodity plastics will maintain their dominance in markets in developed countries and will grow in developing countries. Engineering plastics are opening up new horizons for plastic applications.

VI. ISSUES AND CONSTRAINTS ASSOCIATED WITH DOWNSTREAM PETROCHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES

56. At present, almost all countries of the world have some downstream petrochemical processing industries, irrespective of their level of economic development or the availability of hydrocarbon resources or intermediate feedstocks. While in developed countries the industries are well organized and integrated, the situation is quite different in most developing countries.

57. Unlike the upstream basic and intermediate petrochemicals industry, which is highly concentrated, the downstream processing industries are generally fragmented and small-scale and often require only limited financing for their establishment.

58. The small or medium-size entrepreneur plays a crucial role in the development of the downstream industries. Typically the end-uses are developed based on the ideas and experience of technically oriented people who, with modest funds, proceed with implementation. This kind of development can be haphazard, unless it is carefully monitored and organized.

59. In spite of the apparent simplicity with which downstream processing plants can be established, there remain a number of problems to be solved. The more important are as follows:

(a) The technology is becoming increasingly sophisticated and fast-changing;

(b) Infrastructure needs to be upgraded;

(c) The markets need to be developed, and marketing techniques need to be applied;

(d) Imported technology must be absorbed and assimilated;

(e) Human resources must be developed.

60. Because the production technology is so sophisticated and changes so rapidly, the user requires technical information. However, such information is often too complicated, or it is not readily available in developing countries. Without it, entrepreneurs will find it difficult to make good products and tailor them to customer needs. In the face of this problem, it may be hard to find entrepreneurs who will accept the risks involved, so it might make sense for the public sector to furnish technical support.

61. Most developing countries have failed to recognize that their infrastructure must be developed to support the growth of petrochemical industries. The physical infrastructure, such as roads, transportation and communication systems and storage and distribution networks, will help in raw materials sourcing, production, distribution and marketing. The institutional infrastructure, such as research and development centres, centres of excellence, training institutes, testing centres and laboratories and financial institutions, is also vital. The cost of developing such infrastructure is always high. However, because the infrastructure is important to overall economic development, the cost of its enhancement and maintenance should not be borne by the petrochemical industry alone. Rather, it should be incorporated into the national development plan.

62. In developing countries, marketing and market development often lag behind other activities in the downstream petrochemical industry. The products find applications, particularly in the developing countries, in virtually all economic sectors: agriculture, irrigation, water supply, construction, clothing, health care etc. But the mere existence of a product and demand for it do not guarantee its saleability and applicability; marketing and after-sale services efforts are needed, too.

63. Owing to the fast-changing nature of petrochemical production technologies, the industry requires skilled manpower at all levels, as well as continuing, appropriate backup in production, market research, distribution and marketing. As the developing countries are mostly dependent on absorbing and assimilating imported technologies, personnel must be trained and the appropriate skills imported.

64. The success of a downstream petrochemical industry can be ensured by a strong position in feedstocks, a mastery of the technology and an appropriate scale of operation. Not often, however, do all three factors combine in a developing country. One possible solution to this problem would be bilateral, regional and interregional cooperation among the developing countries.

VII. PROSPECTS FOR DOWNSTREAM PETROCHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES

65. While it is useful to be generally aware of the various advantages and other aspects of the downstream petrochemical processing industries, it remains essential to study the situation in each country on its own merits, paying special attention to the size of the market, the availability of feedstocks, the stage of economic and social development, national priorities, the availability of natural resources and other pertinent factors. A detailed analysis of the development indicators relevant to these processing industries and to end-use sectors such as water management, packaging and storage of foods, agricultural applications, transportation, construction, health care, household appliances and textiles should be carried out in order to identify the market requirements and to forecast market share and the future potential of each segment of the industry.

66. The public sector, through its central statistical office or a similar institution, could play a crucial role in collecting the market information and import/export statistics for the different products. The involvement of academic institutions, research centres and the like in collecting, studying and disseminating technical, legal and financial information could be of great help, especially at the beginning.

67. Since it is private entrepreneurs who will play the main role in the downstream industry, Governments would do well to help them in the construction and operation of their plants. Government-sponsored training and education schemes are an essential element for the success of these industries.

68. Bearing in mind the complexities of these industries and the need to adapt them to developing countries, there must be extensive cooperation between companies and countries, both south-south and north-south. Such cooperation would be most useful in processing needs, product quality control and related technical matters. When considering the pursuit of a downstream petrochemical industry, two issues must be borne in mind: the extent of backward integration and the effect of the downstream industry on other sectors of the economy.

VIII. ENVIRONMENTAL CONSERVATION AND THE DOWNSTREAM PETROCHEMICAL INDUSTRY

69. The last two decades have seen a growing awareness about environmental conservation, and the petrochemical industry is facing increased pressure to act in that direction. Economic and environmental issues are becoming more intertwined, and current industrial and governmental policies must be reassessed in the light of their environmental impact.

70. On the surface it might appear that the money and effort invested in conserving the environment will not earn a profit. However, it must be remembered that the cost of environmental degradation must also be paid, either now or in the future. Investments related to environmental conservation should be considered as an unavoidable and integral ecological cost of production component like costs related to plant safety, accident prevention etc. This calls for greater efforts to understanding environmental risks, including the costs and benefits of reducing them and of integrating economic and environmental interests.

71. The petrochemical industry has to deal with the issue of environmental conservation in two distinct phases: (a) pollution control at the plant level during production and manufacturing and (b) post-consumer waste management and recycling.

72. Modern petrochemical processing plants entail more than 500 different processing sequences, mostly of a chemical nature and involving catalysts, reactants, by-products, intermediates, solvents etc., some of them toxic, that can pollute the air and water. The uncontrolled and untreated release of these materials into the environment may seriously harm the ecological system as well as human health.

73. To address this issue, the petrochemical industry has shifted its emphasis from end-of-pipe controls, which were introduced in the 1970s, to reducing pollution in specific processes and to fundamentally changing the process technology so it uses less hazardous raw materials, catalysts, solvents etc. Process technology in the petrochemical industry has undergone some radical changes in the past two decades. Companies have optimized operations significantly, further reducing fugitive emissions and waste generation. The development and widespread use of new technologies, such as the Union Carbide Unipol process for manufacturing polyethylene, have led to a sharp reduction in wastes.

74. Pollution prevention can also pay off in another way. Waste and effluents in a petrochemical industry normally come from unreacted raw materials, impurities in the reactants, undesirable by-products, unusable materials generated during upsets, start-ups and shutdowns, fugitive releases, spent auxiliary materials (catalysts, solvents etc.), materials generated during sampling, handling or storage and spent maintenance materials. Minimizing waste from these sources will increase productivity and profits and will bring about huge, sometimes hard-to-quantify gains in human well-being.

75. Of the downstream products (plastics, synthetic fibres and rubber), plastics account for the greatest share volume-wise (73 per cent in 1990) (table 3). They are also a major source of post-consumer, non-biodegradable waste. In developed countries, plastics account for 7-8 per cent by weight of municipal solid waste, mainly as rigid containers and packaging films; in volume terms the share is closer to 20 per cent. 8/ The fact is that plastics are often less environmentally costly than the materials that would have to

replace them. Because shopping bags made from paper have to be tough, they are usually made from virgin wood rather than recycled paper. One study found that if paper packaging were to be used instead of plastics, energy consumption and costs for packaging would double.

76. Nevertheless, the industry as a whole has accepted the responsibility for recycling post-consumer plastic waste and is working in that direction. One idea is to reverse the polymerization process, breaking the polymers into their basic chemicals and then reprocessing them. Amoco Chemical is reported to have achieved some technical success in this field. In pilot plant operation it claims to have cracked polystyrene into high yields of aromatic naphtha; polypropylene into aliphatic naphtha; and polyethylene into light petroleum gases and naphtha. 19/

77. In Japan, Nippon Steel, Shinagawa Fuel and Fuji Recycle are building an experimental unit at Okegawa City that is scheduled to begin operating in early 1993. In this plant, household plastic waste will be crushed, washed, melted and subjected to a catalyst that promotes the conversion of the plastic to a substance similar to crude oil. The substance can then be refined into gasoline by normal crude-oil refining methods.

78. Most recycling units go through the same basic steps: sorting, grinding, washing, separating, drying and, in some cases, compounding and pelletizing. Collecting, sorting and cleaning are the most difficult parts of the recycling process. Sorting is still predominantly manual and liable to inaccuracy. Some machine tool companies are working on automated sorting systems.

79. Once the economic hurdle has been overcome, the plastics industry will use recycled materials in ever-increasing quantity. According to a study by Chem Systems and Franklin Associates, the amount of recycled plastics will climb from 227,000 tonnes per year in 1990 to 1.27 million tonnes per year in 2000. More recycled plastics means less consumption of virgin material and more efficient utilization of the world's natural resources.

Notes

1/ European Chemical News, vol. 57, No. 1512 (23 March 1992), p. 17.

2/ Ibid., p. 23.

3/ Chemical and Engineering News, vol. 70, No. 39 (28 September 1992), p. 32.

4/ Chemical Marketing Reporter, 16 November 1992, p. 28.

5/ B. F. Greek, "Rubber demand is expected to grow after 1991", Chemical and Engineering News, vol. 69, No. 19 (13 May 1991), p. 39.

6/ D. Jackson, "World fibers output dips after eight years of growth", Chemical Week, vol. 148, No. 10 (13 March 1991), p. 14.

7/ Chemical Marketing Reporter, 25 March 1991, p. 7.

8/ Chemical Week, vol. 149, No. 21 (18/25 December 1991), p. 28.

9/ Oil and Gas Journal, 1 April 1991, p. 28.

10/ Chemical and Engineering News, 8 October 1991, p. 19.

11/ Chemical Marketing Reporter, 25 March 1991, p. 9.

12/ Fibre Organon, July 1992, p. 127.

13/ Fibre Organon, July 1991, p. 167.

14/ European Chemical News, vol. 56, No. 1462 (11 March 1991), p. 22.

15/ N. Alperowicz, "The ambitious buildup", Chemical Week, vol. 150, No. 6 (12 February 1992), p. 20.

16/ Chemical and Engineering News, vol. 69, No. 19 (13 May 1991), p. 37.

17/ E. Plishner, "Rubber market growth is steady but slow", Chemical Week, vol. 50, No. 7 (19 February 1992), p. 14.

18/ Chemical and Engineering News, vol. 69, No. 19 (13 May 1991), p. 38.

19/ Chemical Engineering, vol. 98, No. 6 (June 1991), p. 23.

20/ Chemical Week, vol. 150, No. 13 (1 April 1992), p. 27.