THE PETROCHEMICAL INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN

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LATIN-AMERICAN ENERGY ORGANIZATION

THE PETROCHEMICAL INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN

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FOREWORD

The incidence of energy on, and its interaction with, the petrochemical sector, especially with basic petrochemistry, led the Latin American Energy Organization (OLADE) to investigate the general situation of this sector which is so important in the economic development of many countries in the region.

At the request of OLADE, the present work was undertaken by Dr. Francisco Szekely, an advisor for this Organization and a professor and researcher at the University of Texas. Herein, it was sought to present, as objectively as possible, the status of the regional petrochemical industry, as well as the levels of production and consumption of basic petrochemical products.

From the economic and social points of view, an attempt has been made to demonstrate the drawbacks and benefits that the development of this industry entails for our countries, especially in terms of employment, investment, State control, and technological dependency. This study also assesses the industry's interrelationship with the environment and the health of the population, as well as the impact on regional development.

It is imperative to note that the growth of this industry in our region has been made manifest in a very special way during the last two decades —as Dr. Szekely points out— many times as a substitute for cotton, wool, furs, hides, etc.; and this has necessarily given rise to new socio-economic patterns in many of our countries. This has led to the urgent necessity of defining a policy which, without hindering the development of the petrochemical sector, would orient it to a broader satisfaction of the needs of our populations, on the basis of a wholesome equilibrium between the technical dependency associated with the secondary petrochemical processes and the economic and employment impact involved in the production of traditional natural products by our populations. Such an equilibrium would really aid in compensating the socio-economic sectors which are currently displaced by the invasion of petrochemical substitutes in the markets, by taking advantage of the lack of, or deficiency in, the policies associated with the use of these important products in the modern life of our societies.

Gustavo Rodríguez Elizarrarás,
EXECUTIVE SECRETARY OF OLADE.

CONCLUSIONS AND RECOMMENDATIONS

a) Conclusions

1. Petrochemistry has had one of the highest industrial growth rates over the last 30 years.
2. The basic petrochemical products are distributed among a reduced number of intermediate consumers who re-process them in order to meet the demand of the large markets for petrochemical end products such as plastics, fertilizers, synthetic fibers, and others.
3. The petrochemical industry has displaced the use of some natural products such as cotton, agave, wool, etc.
4. Basic petrochemistry is currently growing rapidly in the United States and in Latin America; whereas in Western Europe and Japan, production has declined in recent years. The Arab countries have a relatively new petrochemical industry, but they intend to produce 5% of the world demand by the year 2000.
5. In Latin America and the Caribbean, three countries (Mexico, Brazil, and Argentina) account for 85% of the basic petrochemical production, with a lesser participation by other countries such as Venezuela, Colombia, and Peru.
6. Latin America and the Caribbean show a deficit in their internal petrochemical demand, for they generate 3.8% of the world production but demand 4.7% of the same. A large percentage of the existing petrochemical plants have been financed with extra-regional capital, and this has contributed towards a very high foreign debt for the Latin American and Caribbean area.
7. Latin America and the Caribbean constitute the region of non-industrialized dependent countries (NIDC's) having the largest growth rate for both production and demand. The principal products for consumption are: ethylene, propylene, and ammonia on the basis of methanol. Just between 1977 and 1980, the regional production of propylene, benzine, and ethylene increased by 284, 275, and 217%, respectively.
8. The regional consumption of basic petrochemical products has a 15% annual growth rate.
9. The technology of the petrochemical industry is sophisticated and capital-intensive. This suggests that the NIDC's which promote this industry need to have access to capital, know-how, and specialized personnel. Latin America and the Caribbean currently divert large sums of money to the purchase of petrochemical technologies and the use of patents.
10. Petrochemistry has generated employment in Latin America and the Caribbean. Seventy percent of this employment is skilled labor, and 30% unskilled. In 1976, petrochemistry employed 29,500 persons in the region; and it was expected that 19,600 direct jobs, and 136,000 indirect ones, would be created by the end of 1980. However, taking into account the production/employment ratio, we see that as production increases, fewer personnel are employed: production has increased by 70-80% and employment by only 20%.
11. Energy consumption in the petrochemical industry is quite reduced in comparison with that of other industrial operations.
12. The Government of Mexico manages all of that country's petrochemical industry. In Brazil, the owners of this industry include the government and both domestic and foreign private enterprises; but PEQUISA —a subsidiary of PETROBRAS, the state oil company— coordinates and develops Brazilian policy in this area.
13. Up to now, regional cooperation in the field of petrochemistry has had a North - South orientation. More concrete action is necesary with respect to intra-regional cooperation.
14. The petrochemical processes generate environmental interaction among the availability of

resources, ecology, human health, and the socio-economic realm. The impact that such interaction fosters should be evaluated quantitatively and qualitatively, witihin the framework of a global perspective.

15. The petrochemical products have displaced the use of many natural ones, and, thus, a percentage of the employment that depended on related activities, as well. The petrochemical products have also given rise to environmental deteriorarion much greater than that generated by certain natural products. One of the consequences of this situation is a possible deterioration in human health.
16. To worry about the quality of the environment does not imply to oppose industrial development: "Development" and "Environment" are complementary concepts. It is possible to develop a petrochemical industry without jeopardizing the environment. Sufficient information exists so as to be able to achieve environmentally suitable industrial development.
17. Petrochemical products are linked to the satisfaction of certain basic needs such as food, shelter, and health. Nevertheless, only part of the regional population benefits from these products; and, therefore, only part of the population is able to satisfy its basic needs through petrochemical consumption.

b) Recommendations

1. It is recommended that petrochemical development be promoted in Latin America and the Caribbean, with a holistic vision which takes into account the interrelationship of the financial, technological, ecological, and socio-economic aspects.
2. It is suggested that the integrated development of petrochemistry and natural resources be promoted.
3. It is recomended that regional training programs be formulated in order to supply the regional petrochemical industry with qualified personnel, specifically to prepare design engineers, plant operators, maintenance workers, managers, administrators, and salespeople. OLADE could contribute to the organization and implementation of this training activity.
4. Technological cooperation is recommended on a horizontal level, i.e., among the Latin American and Caribbean countries; and it is suggested that OLADE promote, and serve as a mechanism for achieving, this objective.
5. It is suggested that the initiatives of the WCO and the UN be supported in their promotion of the diffusion of technological know-how based on more appropriate designs for patents and transfer of technology contracts.
6. It is recommended that the real overall impact of petrochemistry be analyzed with respect to the unemployment problem in Latin America and the Caribbean. This action can be carried out by the countries with the aid of international organizations such as OLADE.
7. It is recommended that the environmental variable be included in the petrochemical development process and that a policy be adopted for protecting the environment and for minimizing the petrochemical impact thereon. This can be supported by OLADE's activities, by the Office of Industry within the United Nations Environment Program (UNEP) and by UNIDO.
8. It is recommended that a detailed study be done to verify the possibilities for orienting petrochemical production towards a maximum satisfaction of the needs of the Latin American populations.
9. It is recommended that a considerable percentage of the economic benefits generated by petrochemistry be directed towards promoting regional development and towards fostering alternatives for the transition to other products that do not depend totally on the availability of gas and oil.
10. Petrochemical development in Latin America and the Caribbean can fall within the framework of intra-regional cooperation. The suitable forum for formulating the strategies for action already exists: OLADE. It is recommended that the mandate of OLADE be expanded to include petrochemical development among its functions and responsibilities.

I. Introduction

Chemistry is one of the oldest sciences studied by humanity. From the time of alchemists, to the appearance of the scientific method, to the fission of the nucleus of the atom, the study of chemistry has permitted humanity to benefit from a knowledge of the properties of matter and its changes. Nowadays, chemistry is an indispensable science for many human activities.

Two important events that occurred in the nineteenth century contributed to the afirmation of chemistry as a priority science: the work of Liebig who, in 1834, found benzine in pitch and the findings of Caro, in his work with synthetic dyes.[1]

The discovery of benzine encouraged a great amount of research on the chemical nature of distilled carbon products. In 1892, acetylene began to be widely used for two principal applications: lighting and obtaining organic chemicals. Later, in 1913, the first large - scale ammonia plant was put into operation. With this event, carbon became the fundamental resource for the chemical industry.

The use of petroleum as a fuel became generalized during the middle of the last century. This process was independent of the development of the chemical industry. However, at the beginning of the Twentieth Century, the massive use of automobiles resulted in an increased demand for gasoline, which at the same time fostered more detailed research on the process of oil refining, in order to optimize the use of gasoline.

In 1912, W. Burton put into operation the first commercial process for the thermal degradation of petroleum. This operation permitedd the conversion of fuels with low calorific values into more combustible gasolines. Until then, the gases emitted during the process of thermal degradation had been burned initially or simply given off into the air. However, in an attempt to utilize these gases, several companies developed technological processes for their improvement and recovery, by manufacturing propylene by-products such as acetone. Thus, in 1920, the petrochemical industry was born.

Petrochemistry has grown quite rapidly, especially of late. World production increased from 3.5 million tons in 1950 to more than 65 million in 1978. [2] This was principally due to: 1) an industrialization strategy based on an oil-intensive model —which considered petroleum as a resource which would always be abundant and cheap— and 2) the advantageous position of petrochemical products over natural products insofar as their cost.

The petrochemical industry currently represents a great source of income for the countries which have developed it. In the United States, for example, petrochemistry contributed more than 5 billion dollars to the balance of trade for this area during 1978. [3] Furthermore, this was accomplished with a very low energy consumption (less than 5% of the total energy consumption in the United States during that same year). The aforesaid suggests that it would be important to evaluate the possible contribution that petrochemistry could make to the economies of dependent countries which produce oil and gas.

This idea should be carefully analyzed, however, from the perspective of the real situation confronted by the NIDC's at present, with stress on aspects such as the realities facing these countries due to the small dimensions of their national markets; the great difficulties in introducing themselves into foreign markets and in obtaining financing and adequate technology under just

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[1] James, J. L. and Shore, D. "Basic Petrochemical Processing," **The Environmental Aspects of the Petrochemical and Light Refinery Industry.** Trondheim, August 1975.

[2] United Nations. Informative Document: UNIDO Mex-79-01, March 1979, Mexico.

[3] Little, Arthur D. **Trade Trends in Petrochemicals.** Cambridge, Massachusetts, July 1979.

and equitable conditions; the effects of more capital-intensive technologies, the lack of qualified personnel; and the lack of expertise for the sound management of the environment where they operate.

Latin America and the Caribbean have already embarked on petrochemical development. Argentina, Brazil, and México are the regional leaders in that regard, and it seems that the potential for petrochemical development in these and other countries of the region is bound to increase during the next few years.

Until now, the studies which have been done on petrochemistry in the NIDC's have had a sectorial —and, therefore, partial— focus. In other words, the tendency has been to examine only aspects such as the economics, engineering, and resources involved. The resulting studies are useful, but their conclusions are frequently limited since they are removed from the reality of the NIDC's.

The present study analyzes the petrochemical industry within the global context of development in Latin America and the Caribbean. This investigation uses an interdisciplinary methodology to examine the real contribution of current and future petrochemical operations both to the process of economic and social development, in general, and to the standard of living of the inhabitants of the region, in particular. In other words, this methodology of analysis has been chosen so as to take into account technical, economic, physical, ecological, socio-political, and environmental aspects, and so as to emphasize the way in which these aspects interact, influence each other, and generate inter-dependencies. Thus, the contribution of this study lies in the fact that it complements those which have been done previously with a partial vision.

II. The Petrochemical Industry

a) Evaluation at a World-wide Level

Petrochemistry is an extremely complex industry, for a great diversity of material imputs and sophisticated processes of technological production are used in its operation. The basic petrochemical products are distributed among a reduced number of buyers because it is necessary to process them further before they are sold to the final consumers. However, this complexity has not represented an obstacle to the growth of the industry.

Petrochemistry was strongly stimulated towards the end of the Second World War, as a substitute for the large demand which was generated at that time for products of natural and artificial origin. Petrochemical products were very successful, mainly because of the large reduction that their production costs managed to reach per unit of investment when the concept of economy of scale was introduced.

The petrochemical apogee of the 1950's and 60's began to decline as of the 1970's, when several problems —unforeseen in the genesis of this industry— began to become evident. On the one hand, the basic inputs of the industry (gas and petroleum) suffered a considerable price hike as a corrollary of the so-called "1973 energy crisis". On the other hand, the environmental costs associated with petrochemical operations —especially their effects on human health— began to exert pressure on this industry in order to force it to protect the environment. Both of these factors represented economic costs to be absorbed by the petrochemical industry. As a result, the previously displaced natural products returned to the international markets; and, in addition to being able to compete economically with petrochemistry, the natural products seemed to offer great environmental advantages over their petrochemical equivalents. This latter aspect is examined in greater detail in Chapter V of this study.

The national economies have been strongly affected by the combination of the processes of world inflation and recession which manifested themselves during the decade of the 1970's. Although the magnitude of this impact was greater in those countries with more fragile economies

(such as the NIDC's), the petrochemical industry anticipated a considerable overall decrease in its activities all over the world. Reality, nevertheless, proved different. In the United States, for example, the production growth rate for the 50 most important organic and inorganic products increased by an annual 6.1 and 3.2%, respectively, during the 1969—79 period. [4] Even more, from 1978 to 1979, the organic products increased their production by 14.8%. [5] During the first nine months of 1980, production decreased somewhat, but prices rose enough to make the industry's total earnings continue increasing. [6]

In the Western European countries, petrochemical production grew until 1970 and only began to decline as of 1973. Of course, there have been variations between the individual economies of those countries. West Germany and Ireland, for instance, experienced high growth rates (4.3 and 6%) in their economies, while England underwent almost no growth at all. The low economic efficiencies were due to a combination of factors: the rise in the price of energy, unemployment growth, and high inflation rates. Consequently, petrochemical production in Western Europe has been more limited in recent years: the petrochemical plants operate at a maximum of 70—75% of their installed capacity. Meanwhile, the United States exported more than 17 billion dollars' worth of chemical products in 1979, a third of which (5.4 million) were exported to Western Europe.

The case of Japan is similar to that of Western Europe. Before October 1973, the growth of the Japanese petrochemical industry was accelerated. Until 1975, production was still increasing —although to a lesser extent— but with the rapid increases in oil prices, the high production costs resulted in reduced values and even more reduced volumes. Since 1979, the Japanese have had to recur to importation, especially of naphthas.

The Socialist countries of Europe have given high priority to the development of the petrochemical industry, especially during the 1976—80 period; however, world economic problems and the total external dependency of some of the countries (as in the case of East Germany, which imports 100% of its crude oil and 90% of its natural gas from the USSR) have made it difficult for them to attain the goals which they had laid out.

In China, the production of some petrochemical products has increased considerably. Great plans for the construction of ammonia plants for fertilizer production are being implemented. This is due to the new policy of the current government, which has concentrated mainly on agriculture, light industries, and textiles.

The Middle Eastern countries have also begun to promote their own chemical industry. Israel, for example, has a highly diversified chemical industry; Qatar has formed an association with France to produce low-density polyethylene; and Saudi Arabia has signed agreements with firms in the United States, Japan, and Taiwan.

In sum, the industry is growing in the United States; it has declined in Western Europe and Japan; and the large oil-producers of the Middle East are working towards an increased petrochemical capacity. The goal of these last countries is to attain 5% of the world petrochemical production by 1990.

b) Evaluation at the Latin American and Caribbean Level

Within the Latin American and Caribbean region, Mexico and Brazil are the countries which have most encouraged the petrochemical industry. Other countries such as Argentina and Venezuela,

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[4] Anderson, V. "World Chemical Outlook," **Chemical and Engineering News.** December 1979.

[5] "Facts and Figures for the Chemical Industry," **Chemical and Engineering News.** June 1980.

[6] **Ibid.**

which had begun their petrochemical development with a relatively low impulse, are now making great efforts towards participating in the petrochemical market.

At the regional level, Mexico, Brazil, and Argentina constitute the principal contribution to economic activity and industry, in general, and to petrochemistry, in particular. This is because these three countries alone account for 65% of the regional population, 75% of the industrial production, and 85% of the petrochemical activities.

Within the world petrochemical scope, the region that will experience the greatest growth —outside of the United States and Europe— is Latin America. This is because the growth in demand for petrochemical products which has been generated in the region (calculated as 15% annually during 1976—81) greatly exceeds the average growth in demand in the industrialized countries (approximately 6% annually).[7]

Obviously, the potential for petrochemical development in the region is intimately linked to the socio-economic situation which the countries of the region must face as a whole and individually. The region itself has been severely affected by the "1973 energy crisis". The gross national product, which grew at an average rate of 7.2% annually between 1968 and 1974, descended to 4.5% by 1978. In addition, the foreign debt —which was 36,235 million dollars in 1973 and which had grown at an aproximate rate of 15—25% annually— rose to 109,797 million dollars in 1978, equivalent to a 61% annual increase as of 1973.[8]

Of course, it cannot be assumed that the petrochemical industry in Latin America and the Caribbean has developed homogeneously, for there are important differences within the region. Mexico has perhaps the greatest comparative advantage with respect to the other countries, since in addition to having ample oil and gas resources of its own, on land and at sea, it has absolute control over the petroleum industry; and this proves quite advantageous in coordinating, planning, and receiving economic benefits. For that reason, Mexico has developed its petrochemical industry more rapidly than Brazil, which has an energy deficit in its oil and gas supplies, and than Argentina, whose economy has suffered under the effects of a sharp inflation in recent years. However, economic analysts are optimistic and forecast an increased petrochemical demand in the region during the upcoming years.

The participation of other countries in the region is very reduced in this field: 15% of the total Latin American petrochemical production; but it represents an important activity in those countries which have undertaken its development, as in the case of Chile, Colombia, Venezuela, Trinidad and Tobago, and Peru.

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[7]Anderson, V. E. "Petrochemicals Are the Focus for Ambitious Expansion Plans," **Chemical Engineering News.** December 18, 1978.

[8]Inter-American Development Bank. 1979 Report: **Social/Economic Progress in Latin America.** Washington, 1979.

III. PETROCHEMICAL PRODUCTION AND CONSUMPTION IN LATIN AMERICA AND THE CARIBBEAN

Before analyzing petrochemical production and domestic consumption in Latin America and the Caribbean, it is necessary to set forth some basic concepts to define this industry. In speaking of petrochemistry, reference is made to a large number of products and by-products, which can be classified as follows:

1) Basic products
2) Intermediate products
3) End products.

The products embraced by each one of these divisions can be appreciated in Chart 1, in accordance with the sequence which each basic product undergoes and the various intermediate and end products which are obtained along the way. Chart 1 illustrates that the petrochemical industry, as a whole, is responsible for a large number of products. If we add to that the main uses of each end product, the magnitude is even greater. However, in speaking of petrochemistry in general, we normally refer to the broad categories which correspond to the heading of "end products" in Chart 1.

For the purposes of the present study, it has been decided to undertake a detailed examination of basic petrochemistry; thus, we will refer to intermediate and end products only occasionally. This decision has been made because the intention herein is to verify the degree to which the initial petrochemical industry has contributed to the process of development in the Latin American and Caribbean region in general, and in certain countries in particular. This focus does not preclude providing information and analyses for those countries which only import intermediate or end products, thereby forming a secondary petrochemical industry; but these countries are not considered generators of an endogenous petrochemical industry.

a) Basic Petrochemical Production

Basic petrochemical production has grown rapidly all over the world, especially during the last 15 years. For example, during the 1965—79 period, world ethylene production increased from 8 to 26 million tons (325%) and that of propylene and benzine increased from 4.4 to 13.7 and from 4.7 to 13.3 million tons (311 and 283%), respectively.[9] Such sharp increases in production are perhaps the highest that the world-wide industrial sector has experienced during this period.

Up to 1965, the participation of the NIDC's in basic petrochemical production was negligible, except in the case of a few special countries. Approximately 13 NIDC's currently have an important basic petrochemical industry, e.g., Algeria, Brazil, India, Korea, Mexico, and Venezuela. In order to evaluate the Latin American participation in this context, Chart 2 illustrates recent world production for the principal petrochemical products. Except in the case of methanol, Latin America and the Caribbean constitute the region of NIDC's with the highest level of basic petrochemical production.

Concretely, Chart 2 shows that the region contributed to world production as follows: 4% of the ethylene and orthoxylene, 3% of the butadiene, and 2% of the propylene, benzine, methanol, and paraxylene. However, this situation should not be considered static, for in cases such as that of Mexico —as we shall see later on— considerable impetus is given to this industry.

The data provided in Chart 2 are aggregate. It is important to know the internal structure of basic petrochemical production within the region, and Chart 3 contains such information. Several important observations should be made at this point. The regional petrochemical production experienced an exponential growth similar to that observed for the world situation during the last

[9] United Nations. **1980 Statistical Yearbook.** United Nations, New York, 1980.

CHART 1

STRUCTURE OF THE PETROCHEMICAL INDUSTRY

Basic Products	Intermediate Products	End Products
1 Methane[a]	Acetic acid Formaldehydes Solvents	Plastics Solvents Pesticides Herbicides
2. Ethylene[b]	Ethylene dichloride Ethylene glycol Ethylene oxides Olefins	Plastics
3. Propylene[b]	Acrylonitriles Docecylbenzine Propylene oxides Acetone	Detergents
4. Butadiene[b]	Ethybenzine Styrene	Synthetic
5. Benzine[c]	Adipic acid	Synthetic fibers
6. Toluene[c]	Phenols	Solvents
7. Paraxylene[c]	Terephthalic acid Dimethyl terephthalates	Polyester fibers
8. Orthoxylene[c]	Phytolic anhydrides	Plastics

[a]Synthesized gas
[b]Olefins
[c]Aromatics.

four years. For example, propylene production has increased by 287%, and that of benzine and ethylene by 275 and 271%, respectively.

Just as world-wide production reflects a heterogeneous situation, that of Latin America and the Caribbean is also quite unbalanced. With the aid of Chart 3, the individual analysis of one single chemical permits us to observe this situation.

In the case of ethylene, for example, Brazil and Mexico are the major producers. Within the current production capacity of 8.9 million tons of basic petrochemicals, Mexico can produce 432,000 tons of ethylene per year; and this figure will be notably increased during 1981 when the "La Cangrejera" plant begins to process 500,000 tons annually. Furthermore, Mexico's state oil company (PEMEX) is not only working on the new "Morelos" petrochemical complex, which will

[10]UNIDO. **First World Study on the Petrochemical Industry: 1975 - 2000.** UNIDO/ICIS.83, December 1978.

[11]Diaz Serrano, J. **1980 Annual Report.** PEMEX, Mexico, March 1980.

produce another 500,000 tons,[12] but also on the "Laguna de Ostión" and "Dos Bocas" complexes, which will have an annual ethylene production capacity of 500,000 and 400,000 tons, respectively.

Brazil is also contemplating considerable growth in its petrochemical industry. Of course, the Brazilian situation is more difficult than the Mexican one, since Brazil has a petroleum deficit which has to be covered by imports. Brazil has invested enormous efforts and capital in its new northwestern "petrochemical pole": Camacari, which promises to be the largest integral petrochemical operation in the world.[14] In Camacari, 540,000 tons of ethylene are currently being produced. Brazil is about to build its third petrochemical pole in Porto Alegre, in the state of Rio Grande do Sul; and that will add another 420,000 tons to the ethylene production.

CHART 2

WORLD-WIDE BASIC PETROCHEMICAL PRODUCTION IN 1977

(thousands of tons/year)

Region or Country	PRODUCTS						
	Ethylene	**Propylene**	**Butadiene**	**Benzine**	**Paraxylene**	**Orthoxylene**	**Methanol**
Western Europe[a]	14,165	8,020	2,153	5,802	1,220	848	3,920
Eastern Europe[b]	2,955	1,553	340	3,460	327	285	2,513
North America[c]	14,450	7,100	2,270	6,400	1,908	603	4,624
Latin America[d]	1,250	514	173	308	75	72	125
North Africa	120	—	—	—	—	—	110
East and West Africa	—	—	—	—	—	—	—
South Africa	200	—	20	—	—	—	17
Middle East	190	40	33	—	—	—	54
Southeasr Asia[e]	192	100	36	69	17	—	33
East Asia[f]	480	215	77	134	42	—	585
Japan	4,510	2,800	872	2,550	636	315	1,164
Pacific Area[g]	290	80	34	—	—	—	33

[a]Northern Europe, Southern Europe, and Western Europe, excluding Yugoslavia.

[c]Latin America and the Caribbean

[e]East Asia excluding China and Japan.

[b]U.S.A. and Canada.

[d]Southeast, South-Meridional Asia.

[f]Oceania, Melanesia, Micronesia, Polynesia.

[13]Anderson, V. "Mexico and Brazil Have Ambitious Chemical Plans," **Chemical and Engineering News.** December 1979.

[14]For a broad discussion on this subject, see Szekely, F. "The Chemical Industry in Latin America and the Caribbean," UNEP. Geneva. 1979.

CHART 3

BASIC PETROCHEMICAL PRODUCTION IN LATIN AMERICA AND THE CARIBBEAN IN 1977 AND 1980[13][a, b]

(thousands of tons/year)2

	PRODUCT													
	Ethylene		Propylene		Butadiene		Benzine		Paraxylene		Orthoxylene		Methanol	
Country	1977	1980	1977	1980	1977	1980	1977	1980	1977	1980	1977	1980	1977	1980
Argentina	55	150	——	115	35	67	60	140	40	40	20	20	34	114
Brazil	730	1.080	237	628	115	167	130	250	——	160	30	110	58	118
Chile	60	180	40	40	——	——	——	——	——	——	——	——	——	——
Colombia	20	20	10	10	——	——	43	43	——	17	8	8	——	——
México[b]	230	366	137	137	23	17	75	79	35	39	14	16	33	174
Peru	5	5	——	——	——	——	——	——	——	——	——	——	——	——
Venezuela	150	550	90	260	——	——	——	——	——	——	——	——	——	——
TOTAL	**1.250**	**2.351**	**514**	**1.190**	**173**	**251**	**308**	**512**	**75**	**256**	**72**	**154**	**125**	**406**

[a] UNIDO estimates.

[b] The official Mexican estimates correspond to the years 1977 and 1979. PEMEX, **Memoria de Labores 1979.** Mexico, 1980.

With respect to basic petrochemical production in Latin America and the Caribbean, it can be concluded that Brazil, Mexico, and Argentina account for the majority (85%). Venezuela participates with a smaller ethylene and propylene production; and Chile, Colombia, and Peru contribute to an even lesser extent. (See Chart 3).

b) Basic Petrochemical Consumption

Again, it is fundamental to refer to the global framework in order to understand the Latin American and Caribbean position within the framework of world consumption of basic petrochemicals. The current consumption of these products depends on the demand which has been generated for end products such as plastics and synthetic fibers, inter alia. Chart 4 indicates the world demand for the principal petrochemical end products. It can be observed therein that the percentage corresponding to the majority of the NIDC's is only approximately 11% of the total. Latin America and the Caribbean demanded 44% of that figure, with the most requested products being synthetic detergents and fibers (with 20.3 and 19.3% of the total, respectively).[15]

The consumption of petrochemical products in the industrialized countries exhibits a stable demand. For Latin America and the Caribbean, and for the NIDC's in general, demand has grown quite rapidly-despite the effects of the "1973 energy crisis". However, as can be observed in Chart 4, in general, the region shows a deficit, for it accounts for 4.7% of the total world consumption when its petrochemical production of basic and end products does not even reach 3.8%[16] This situation has a definitive effect on local economies. Even, Mexico and Brazil — despite being the largest producers in basic petrochemistry— do not manage to cover their internal demand. In Brazil, for example, the importation of chemical products reflects a 10:1 ratio with

[15] **Ibid.**

[16] UNIDO, **op. cit.**

respect to exportation. Mexico has exported a great deal, especially ammonia since the "Cosolecaque" and "Salamanca" plants entered into operation at the end of 1978, with productions of 445,000 and 300,000 tons, respectively. Nevertheless, Mexico is also experiencing a deficit in the balance of trade for its chemical products, and imports still amply exceed exports.

CHART 4

CONSUMPTION OF PRINCIPAL PETROCHEMICAL END PRODUCTS IN 1974[18]

Region or Country	Percentage
Western Europe	31.61
Eastern Europe	11.91
North America[a]	31.68
Latin America[b]	4.71
Africa	1.81
Asia[c]	4.07
Pacific	1.31
Japan	11.81
Middle East	1.01

[18]UNIDO, **op. cit.**

[a]Only Canada and the U.S.A.

[B]Includes the Caribbean.

IV. PETROCHEMISTRY AND ECONOMIC DEVELOPMENT IN LATIN AMERICAN AND THE CARIBBEAN

a) Technology and Capital

The technology used in basic petrochemistry is capital-intensive and quite sophisticated. It requires that the countries which develop —or intend to develop— a petrochemical industry have the initial conditions of abundantly available capital and an adequate infraestructure for the development of scientific and technological research.

Latin America and the Caribbean are certainly confronted with limitations in both these aspects. On the one hand, the principal regional promoters of basic petrochemistry (Brazil, Mexico, and Argentina) have frequently had to recur to loans and external financing in order to carry out their plans for industrial development. A recent study by the World Bank affirmed that the 1978 foreign debt of Brazil, Mexico, and Argentina —as a percentage of their Gross National Products (GNP)— was 28.7, 15,6, and 6.4%, respectively.[19] This means that the regional situation for industry in general, and for petrochemistry in particular, depends a great deal on foreign countries; since, in addition to the fact that the region has to import, it also has to recur to foreign financial support in order to develop its own local industry.

[17]PEMEX reported that Mexico exported 107.7 million dollars' worth of petrochemicals and imported 331.6 million dollars' worth in that year. PEMEX. 1979 annals. Mexico, 1980.

[18]UNIDO, **op cit,**

[19]World Bank. **1980 Report on World Development.** Washington, August 1980.

UNIDO has estimated that in 1978 a petrochemical plant with the capacity to produce approximately 400,000 tons of ethylene per year, and some 1 million tons of other basic petrochemical products, would cost on the average of one billion dollars in an industrialized country.[20] If we extrapolate this figure to the NIDC's the investment would have to be even greater because the infrastructure for any such development is generally not very widespread in these countries.

In addition to the lack of capital for industrial investment, technological limitations also severely affect the region. Latin America and the Caribbean divert enormous sums of money to the purchase of technology, know-how, design contracts, operation and maintenance of plants, and the use of foreign patents.

There has been much discussion about the ownership and control of technology. For some, technology is a resource which only belongs to those who have developed it. For others, technology should be an asset available to all humanity without charge. In its Seventh Extraordinary Period of Sessions, the United Nations General Assembly approved a resolution on international economic and technological cooperation and development, the first paragraph of which reads as follows:

> The developed countries and the developing ones should cooperate in order to establish, reinforce, and develop the scientific and technological infrastructure of the developing countries. The developed countries should also adopt suitable measures, such as contributing to the establishment of a bank of information on industrial technology and considering the possibility of creating regional and sectorial banks in order to put at the disposal of the developing countries a greater flow of information which would allow them to select technologies, particulary advanced ones. In addition, the possibility of establishing an international center for the exchange of technological information should be studied, in order to share the results of research which prove of interest to the developing countries. To that end, during its Thirtieth Period of Sessions, the General Assembly should examine institutional arrangements within the United Nations system.[21] [22]

In accordance with this resolution, the U.N. General Assembly approved the creation of the institutional arrangements necessary for the transmission of technology.[23] The results of this initiative have not become evident as yet. However, one positive by-product of these activities is perhaps the fact that the WCO has proposed that the technology patent documents contain sufficient relevant information, so as to provide: (1) technological information, (2) data on the patent holder, and (3) costs of the process.[24] For the NIDC's, access to this information would be extremely useful in creating their own capacity for research and technology.

During the first consultation meeting on the petrochemical industry, organized by UNIDO (Mexico, March 1979), the difficulties that the NIDC's face in acquiring technology were widely discussed. It was concluded that instead of analyzing the subject of the transfer of technology in an isolated way, the aspects of patents, licenses, and know-how should be considered jointly.[25] Concretely, the following recommendations were made:

a) The licenser should be obligated to permit access to the technological secret or know-how.

b) In transferring technology, the capacity for generating technology should also be transferred.

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[20] UNIDO, op cit.

[21] World Copyright Organization (WCO). Latin American Seminar on Technological Information Contained in Patent Documents. Mexico, 1977.

[22] United Nations. Seventh Extraordinary Period of Sessions. Resolution 3362 (S-VII), New York, 1974.

[23] United Nations. Thirtieth General Assembly. Resolution 3507 (XXX), New York, December 15, 1975.

[24] WCO, OP CIT.

[25] UNIDO. The Preparation of a Model Contract Covering the Licensing of Patents and Know-how in the Petrochemical Industry, First Consulation Meeting on Petrochemistry, Mexico, 1979.

c) Data should continue to be provided on related technological innovations.

These suggestions —as those of the WCO— would certainly represent an important contribution to the region.

b) Employment, Human Resources

A petrochemical complex needs more highly trained personnel; the ratio being approximately 70% skilled labor and 30% unskilled. The problems involved in training engineers, managers, operators, maintenance specialists, etc., in order to provide such skilled labor is translated into a need for a large investment of resources not readily available in the NIDC's.

It has already been noted that the petrochemical industry is capital-intensive. Its introduction into a region of the world where millions of unemployed or underemployed exist[26] is an action which has to be carefully considered. In general, the petrochemical industry requires an investment of US $ 200 — 300,000 dollars/job. This in itself represents a serious hindrance for the development of the petrochemical industry in Latin America and the Caribbean.

In 1976, the petrochemical industry as a whole employed 82,000 people from NIDC's of which, 36% (29,500 people) corresponded to Latin America and the Caribbean. Of those 29,500 workers, approximately 17,000 were skilled laborers and technicians; 3800, administrative personnel and salespeople; and only 8800, unskilled laborers.[28] This means that only 30% of the industry contributes to the regional problem of "massive unemployment" (which mainly consists of unskilled labor). It was expected that by the end of 1980, 54,000 additional jobs would have been created within the petrochemical industry of the NIDC's, and 378,000 more in related industries, of which, 19,600 direct and 136,000 indirect jobs would correspond to Latin America and the Caribbean. Nevertheless, if we take into account the production/employment ratio, petrochemistry's contribution to employment during that period was very low; for while employment grew at a rate of 20% annually, the corresponding equivalent production grew at a rate of 80% annually. (See Chart 2). With an overall evaluation, it can then be concluded that as production increases, the petrochemical industry contributes to generating a smaller proportion of employment. In addition, it is obvious that as petrochemical products displace the use of other, natural products —as in the case of synthetic fibers and cotton— it is also displacing workers in the primary economic sector, which is very important in the NIDC's.[29]

Another important aspect with respect to the skilled labor demanded by petrochemistry in Latin America and the Caribbean is the fact that with an annual growth rate of more than 80% in production, the availability of local skilled labor should be growing at a rate comparable to its demand. According to studies by UNESCO, the volume and experience of such personnel (engineers, administrators, operators, etc.) is currently inadequate to cover the projected demand.[30]

c) Material Resources

The petrochemical industry requires a series of economic, technical, human, and material inputs for its operation. The most important material ones are: (1) the basic resources for

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[26]The International Labor Organization (ILO) has calculated that by the middle of the 1970's, there were 760 million illiterates and 300 million unemployed in the NIDC's. ILO. **Employment Growth and Basic Needs.** Overseas Development Council. Praeger Publishing, 1977.

[27]ILO. **Manpower Aspects of Establishing Chemical Industries in Developing Countries.** Geneva, 1976.

[28]UNIDO, **op. cit.**

[29]The previous analysis should not be interpreted as an argument against the regional petrochemical industry. An attempt is merely made to point out the side effects of a development strategy introduced within a specific reality.

[30]UNESCO. **Formation of Engineers and Environment: Trends and Prospects.** Paris, November 1979.

petrochemical production (naphthas, gas, kerosene, coal, fuel-oil, etc.) and (2) the energy resources to be invested in the production process. Chart 5 contains information in this regard; and it can be observed therein that the energy requirements vary according to the product. In general, the olefinic products consume more energy than the synthetic gases and aromatics.

Due to the recent energy price hikes, industry in general, and petrochemistry in particular, has made special efforts towards conserving energy by implementing more efficient production techniques. These efforts have generally been successful, and the petrochemical industry now consumes less, per unit of production. In 1979, for example, this industry consumed 5% less energy than in 1978.

CHART 5

PETROCHEMICAL ENERGY CONSUMPTION (per ton of product)[31]

PRODUCT	Fuel	Electricity	Steam	Cooling water
	10^6kcal/ton	kwh/ton	ton/ton	m^3/ton
Olefins[a]	0.3	156	—	170
Methanol	—	40	—	230
Aromatics[b]	2.5	60	1.6	—

[31]UNIDO, op. cit. (modified).

[a]Based on the process of naphtha/gas disintegration.

[b]Benzine, toluene, xylenes.

d) Control in the Petrochemical Industry

The different actors in the basic petrochemical industry are governments, transnational companies, and local private enterprises. These have different ways of participating in the administration and control of the industry, according to the nation in question. In Latin America and the Caribbean, various situations are found, as illustrated below.

In the case of Mexico, petroleum is considered as part of the national patrimony and, therefore, its administration corresponds exclusively to the State. The functions of the state oil company (PEMEX) thus include every thing from exploration to refining, and all of the basic and intermediate petrochemical activities. Private investment exists only in the secondary petrochemical sector, where Mexican participation has to be at least 60% of the total.

Due to the broad nature of its activities, in a country with abundant resources, PEMEX is currently considered to be among the 10 largest companies in the world. Its contribution to Mexican development is proportional to its importance. PEMEX pays taxes to the government at a rate of 15% for the sale of petrochemicals, 27% for other products, and 38.58% for its sale of crude oil, natural gas, and petroleum products.[32] It is calculated that the petrochemical contribution to Mexico's gross national product is between 0.6 and 0.8 percent.

The case of Brazil is different from that of Mexico. In Brazil, the owners of the petrochemical

[31]UNIDO, **op. cit.** (modified)

[32]U.S. Department of Energy. Office of International Affairs. **The Role of Foreign Governments in the Energy Industries.** Washington, 1977.

industry include the government and both local and foreign private enterprises. However, the state oil company (PETROBRAS) coordinates and develops the Brazilian policy for petrochemical development through its subsidiary organization Petrobras Quimica, S.A. Most of the basic petrochemical products in Brazil are sold directly to foreign manufacturers who operate in the country (Union Carbide, Dow, Hoescht, Dupont, ICI, Rhone Poulenc, et. al.).

In Venezuela, an important petrochemical complex has been developed in El Tablazo, Zulia. The Venezuelan government created Pequiven (Petroquimica de Venezuela) as a branch of PETROVEN, the state oil company, to be in charge of the country's petrochemical development.

In Argentina, there are three large centers of petrochemical development: Bahia Blanca, San Lorenzo, and La Plata. Participation in the ownership is mixed, including both public and private capital.

e) Institutional Participation

Petrochemistry in Latin America and the Caribbean has developed within an extremely short time. From 1965 to date, the industry has had progressively greater momentum. Up to now, the cooperation which has been achieved in the development of the Latin American petrochemical industry has been mainly of a bilateral type among countries, or else strictly commercial. In the case of bilateral cooperation, this has occurred mainly between Latin American governments and others outside the region —a typical North-South type of cooperation.

There have even been initiatives directed towards formulating alliances between industrialized countries and NIDC's in the field of petrochemistry, as evidenced by the interest of the chemical industry in the United States in forming a North American alliance, composed of the U.S.A., Canada, and Mexico,[33] in a trilateral agreement of mutual benefit for these three countries. This proposal grew out of the idea of the first country that Canada and Mexico desire to develop their petrochemical industries further and that their markets are dependent, to a great extent, on the United States.[34]

From the perspective of the Mexican governement, the implementation of this idea has not been warmly received. This is an understandable attitude since, in addition to the features of the historical relationship between Mexico and the United States with respect to natural resources, the proportions are so unequal that it would be very risky to suppose that Mexico would benefit from such an arrangement.

Intra-regional cooperation would be more suitable. The common culture, language, and experience of the Latin American and Caribbean countries provide initial conditions appropriate for promoting the exchange of technological, ecological, economic, and social experiences.

The Latin American Energy Organization (OLADE), in accordance with its founding document, the Lima Agreement, currently promotes intra-regional cooperation in the field of energy. This forum and its organization could serve as the appropriate mechanism to promote Latin American petrochemical development, with the participation of Latin Americans.

V. PETROCHEMISTRY AND STANDARDS OF LIVING

The development strategy which has been applied in Latin America and the Caribbean during the past thirty years has basically consisted of promoting rapid industrialization and implanting

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[33]Anderson, V."North American Trade Alliance Gains Support," **Chemical and Engineering News.** July 1980.

[34]Forty-five percent of the Mexican exportation of chemicals goes to the United States, and fourteen percent to Canada. As for imports, Mexico and Canada depend on the United States for 52% and 28%, respectively; while only 5% of the chemical exports of the United States are destined to Mexico and Canada. **Chemical Engineering,** July 1980, **op. cit.**

a scheme of import substitution which would eventually bring about economic self-sufficiency and a higher standard of living for the inhabitants of the region. This strategy was, in reality, an imitative interpretation of the development process which propelled the industrialized countries. Its implantation in Latin America, where the initial conditions were different from those in Europe and the United States, also had different effects; for although the region grew both economically and industrially,[35] no wide-scale improvement has as yet been observed in the standard of living of the majority of its inhabitants.

The countries with the largest initial economic resources —and above all, those nations with their own oil and gas reserves— accepted the idea of petrochemical development with a view to generating an internal market, but with the projection and desire of participating actively in international markets.

This idea perhaps seemed very attractive when analyzed in an isolated manner. However, the world itself is more complex, the result of the interaction of many ecosystems wherein diverse interests, behaviors, and power correlations are expressed. In this regard, it is imperative that any value judgment made with respect to petrochemistry, or any strategy designed for its promotion, be preceded by a global analysis to study the interaction of the different participants in a process, and its effect on them and their surroundings. A valid way of initiating such an inquiry would be to ask: To what extent has petrochemical development contributed to raising the standard of living in the region? What benefits and problems does the development of this activity carry with it? To what extent are petrochemical products related to the basic needs of Latin America and the Caribbean? Is this region prepared to promote rapid industrial development without jeopardizing its environment? The ideas presented below attempt to clarify some of these questios and to promote ideas for action.

a) Environment

Neither the concern about the adequate management and conservation of the environment, nor the problems imposed on the same, are new. Historical evidence demonstrates that genuine environmental preoccupation has existed for many years[36] Modern man has worried, once again, about the quality of his environment because its degradation generated a boomerang reaction, by means of which both the efficiency of converting natural goods into "satisfiers" and even human health were threatened.

The first world-wide conference on Human Environment took place in Stockholm during June 5—11, 1972. From among the numerous contributions which were made at this event, it is worthwhile to mention two fundamental ones: (1) the discussion with respect to the global definition of "environment" and (2) the concept of "development and environment".

The definition of "environment" has mainly received two interpretations. The one, which reduces it to its physical dimension (pollution), was adopted by the majority of the developed countries during the Stockholm conference. The other, broader definition considers both the physical and social aspects as inseparable elements of environment. This definition, mainly adopted by the NIDC's, can be expressed as follows:[37] "Environment'is sum total of the physical, biological,

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[35]The quantitative indicators of this growth can be seen in: Economic Commission for Latin America (ECLA). **Economic Analysis of Latin America and the Caribbean.** Santiago, 1979.

[36]See Exodus 2:11-12 and Leviticus 25: 1-7, for an explanation of how the Hebrews formulated the sabbatical year, by means of which they applied a degree of environmental management to the use of agricultural soils.

[37]In this regard, we have elaborated amply in: Szekely, F. **The Environment in Latin America and Mexico.** Nueva Imagen (publishers), Mexico, 1978.

and natural elements that surround Man, the interactions of these elements among hemselves and with Man, and the interactions between Man and Society.[38]

The present study has adopted the latter definition. Thus, when reference is made to the environment, we are not only speaking about pollution, but about resources, development, standards of living, etc., as well.

The concept of "development and environment"is seen as a conservationist attitude apposed to economic growth —and definitely opposed to development.[40] For others, however, "environment" and "development" are compatible, complementary concepts. This position is, without doubt, more appropriate; for in specific cases such as this one, it can be affirmed that an environmentally suitable development of the Latin American and Caribbean petrochemical industry is possible, as long as this development is undertaken in accordance with ecological rationality in the surrounding areas and as long as its premises are directed towards the satisfaction of the needs of the majority of the population where such development is being carried out.

In petrochemistry, important environmental interactions can be identified, such as those in Chart 6, wherein it can be observed that there is a series of positive and negative impacts, with respect to the resources, ecology, health, and degree of economic development which occur in an ecosystem. The evaluation of these impacts constitutes a great difficulty. On the one hand, the environmental problems have not been studied in their totality; in fact, there is a possibility that some of the problems have not even been identified. On the other hand, there is no conclusive scientific evidence for specific impacts derived from given stimuli. It is in the scientific field where the greatest controversies and differences of opinion exist. Perhaps one way of obtaining at least a general vision of environmental interactions within an industrial operation such as petrochemistry is by (1) identifying possible impacts, (2) analyzing the methodology with which this impact can be scientifically evaluated; and (3) evaluating the degree of knowledge that we have with respect to the impact. An initial inventory is found in Chart 6.

The integration of the various forms of evaluation which are expressed quantitatively (q_1) and qualitatively (q_2) therein presents difficulties, because it is hard to combine numerical evaluations with others based on quality. Despite this fact, an effort must be made at integration; since a consideration of only one or the other would be incomplete. The evaluation of the degree of knowledge about each environmental interaction (Column 4 of Chart 6) is based on a deterministic criterion. A high degree of knowledge (H) is that which can be substantiated scientifically (for both the physical and social aspects); an average degree of knowledge has some scientific elements, but not conclusive ones. A null evaluation would be something which, despite having been identified, cannot be scientifically evaluated. It can be appreciated in Chart 6 that the qualitative evaluations are more abundant and that an average degree of knowledge prevails. The conclusion is that a lack of accuracy still hinders the development of such an evaluation, as a whole and in detail. Nevertheless, this would not justify failing to act on the basis of what is known, or foreseen, to be important in benefit of the environment.

b) Health

Petrochemical products are derived from fossil fuels. As more and more of such products are produced, these finite resources are progressively depleted. Two questions to be posed in this regard are: (1)whether or not the profits from petrochemistry are being invested in the generation

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[38]UNEP, OLADE, UNDP. **Energy Alternatives in Latin America: A Study on the Capacity for Using Non-conventional Sources of Energy.** Quito, Ecuador, 1979.

[39]United Nations Conference on Development and Environment. Founex, Switzerland, June 4-12, 1971. Mouton, Paris, 1972.

[40]For example, the attitude and philosophy of the Sierra Club of the United States and in general, the Club de Roma.

CHART 6

ENVIRONMENTAL INTERACTIONS IN THE PETROCHEMICAL INDUSTRY

Environmental Indicator	Impact	Form of Evaluation	Degree of Knowledge
Resources	Land use	Q_1, Q_2	A
	Depredation of resources	Q_1, Q_2	H
	Displacement of use of natural resources	Q_1, Q_2	H
Ecological balance	Environmental quality: air	Q_1, Q_2	H
	water	Q_1, Q_2	H
	soil	Q_1, Q_2	H
	sound	Q_2	A
	flora and fauna	Q_2	A
	Temperature	Q_1	H
	Radiation (ionizing)	Q_1, Q_2	A
	Quality of human habitat	Q_2	A
Health	Occupational health	Q_2	A
	Public health	Q_2	A
	Psychological balance	Q_2	A
Socio-economic Development	Satisfaction of social needs	Q_2	A
	Control and sovereignty over resources	Q_2	A
	Employment	Q_1, Q_2	H
	National development	Q_1, Q_2	A
	Technological dependency	Q_1, Q_2	A
	Development and environment	Q_2	A

Q_1 = quantitative
Q_2 = qualitative

H = high
A = average

N = null

of other resources and in promoting development and (2) what the substitution of natural products by petrochemicals implies. The generation of new energy resources in the region is still in an embryonic stage. The substitution of natural products has made the countries of the region more dependent on certain resources (oil and gas), whose control and use escapes the possibilities of many countries, making them dependent, and therefore sensitive to the fluctuations of the international market and to political disputes with respect to this resource.

A frequent worry of environmentalists is that petrochemistry introduces foreign matter into the ecosystem; and since this does not form part of the same, it accumulates and generates environmental deterioration. The natural products, they say, did not impose this cost to society.[41] Others think that petrochemistry is really inevitable, since the demand for many products (construction materials, clothing, etc.) could not have been satisfied only with natural products.[42] It is difficult to prove

[41] An excellent discussion on this subject can be found in: Commoner, B. **The Closing Circle.** Alfred Knopf, New York, 1971.

[42] For a very articulate view of this argument, see: A.D. Little Inc. A Report to the Petrochemical Energy Group (PEG). **The Petrochemical Industry and the U.S. Economy.** Cambridge, Massachusetts, December 1978.

either of the two positions conclusively. However, there is full agreement and evidence that petrochemistry has given rise to environmental degradation, and that this is in some way proportional to the volume of production and to the degree of industrial management; in other words, to: (1) the amount of petrochemical products and (2) the management and environmental control of petrochemical wastes (in the air, in the water, and on land).

Chart 7 indicates the growth of regional production for some petrochemical end products. Without being able to prove fully the degree to which environmental deterioration has occurred with respect to petrochemical production, this information provides an indicator —above all, for regions such as Latin America and the Caribbean, where petrochemistry has grown a great deal and where environmental control is negligible. While Chart 7 illustrates the fact that plastics have increased their production by 7166% between 1957 and 1975, it would be difficult, for example, to know how much of this increase corresponded to a concrete pollutant such as sulfuric anhydride (SO_2), or whether the SO_2 emissions have also increased proportionally, with a total accumulation of 7166%. An attempt is simply made herein to indicate that environmental deterioration has occurred with a certain degree of magnitude— in this case, a high degree.[43] A more detailed discussion of the environmental effects of petrochemistry with respect to resources and pollution is available in Chart 8.

Chart 8 consists of a list of the principal pollution problems generated by petrochemistry. The form of evaluating the effect that these pollutants have on the environmental depends on: (1) the concentration of the pollutant; (2) the duration of the stimulus; (3) the ecosystem's capacity to disperse the pollutants and its resiliency;[45] (4) other activities in the area where the pollutant is released; and (5) environmental control prevailing in the ecosystem concerned. Of course, all of these considerations have ecological, economic, technological, social, political, health, and industrial zoning implications.

CHART 7

PRODUCTION OF SOME PETROCHEMICAL END PRODUCTS IN LATIN AMERICA AND THE CARIBBEAN[44]

Pollutant	Year	Annual Production (10^3tons)	Year	Annual Production (10^3tons)	Increase %
Nitrogenized fertilizer	1960	942	1974	4028	327
Plastics	1960	4.5	1974	327.1	7166
Synthetic fibers	1960	95.3	1974	499	425
Cellulose	1960	726	1970	2142	195
Detergents	1959	123	1970	666	541

[43]Szekely, F. **The Chemical Industry and the Environment, op. cit.**

[44]ECLA. **Latin American Statistical Yearbook: 1976.** Chile, 1977; and the Symposium on the Development of the Latin American Chemical Industry. st/ECLA/Conf. 15/1 (D1.18). (modified).

[45]Resiliency is an ecosystem's capacity for returning to its original state when the environmental deterioration stimuli imposed on it are suspended.

A detailed analysis of the aforementioned —on the basis of Chart 8— would be quite extensive and would exceed the scope of the present study. A more concrete aspect, such as the effect of these pollutants on health, would perhaps provide a general idea of the magnitude and importance of this type of environmental deterioration. Such an analysis is found below.

CHART 8

POLLUTION GENERATED BY THE BASIC PETROCHEMICAL INDUSTRY

I. Air Pollutants

Hydrocarbons	(HC)
Carbon Monoxide	(CO)
Hydrochlorides	(HCl)
Nitrogen Oxides	(NO_x)
Particles	
Sulfuric Anhydride	(SO_2)
Sulfuric Acid	(H_2S)

II. Water Pollutants

Petroleum Wastes (paraffins, olefins, nitriles)
Leftovers from chemical reactions
Spills and tank washing
Sewage

Organic chemicals, heavy metals
Solids in suspension
Cooling water (high temperatures)

III. Sensorial Pollution

Noise
Odors

IV. Soil Pollution

Solid wastes

c) Petrochemistry and Basic Needs

The products of the petrochemical industry currently provide a series of important "satisfiers" for modern society, and any change in the volume of production of this industry would affect this consumption. Thus, we can see the importance of analyzing the relationship between petrochemical consumption and the satisfaction of basic needs.

A diversity of opinion exists with respect to the definition of what human needs really are;[46] however, there is a consensus insofar as that the basic needs (those for survival) are food, health, and shelter (the latter includes clothing).

The petrochemical end products play a very important role in satisfying these basic needs, as illustrated below:

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[46]In this regard, it is recommended that the reader see the ILO publications, **op. cit.**; World Bank. **Poverty and Basic Needs**, Washington, September 1980; Bariloche Foundation. **Catastrophe or A New Society: A World Model for Latin America.** IDRC, Canada, 1976.

Basic Need	Petrochemical Product
1) Food	Fertilizer production Crop drying Pesticide production (insecticides, herbicides, etc.) Artificial feed Food-packing
2) Shelter	Construction materials Clothing fibers plastics detergents packing transportation
3) Health	Pharmaceutical products Medical material Medicines

The intensity with which these products are related to the basic needs of a population depends on the access to their consumption. For Latin America and the Caribbean, for example, only a percentage of the population can consume these products;[47] however, everybody lives in the same environment which, when affected, would have a given social cost.

Although petrochemical products provide these benefits, it is also certain that they carry with them an environmental cost (see the previous section). No attempt is made herein to assume a position favoring the exclusive use of either natural or petrochemical products. Both have advantages and disadvantages in technical, economic, and environmental terms. To reduce the petrochemical industry now would imply a consideration of the following factors: (1) whether petrochemistry is essential or not; (2) if it is possible to satisfy the petrochemical demand with natural products; and (3) what effects this would have on economies such as those of Brazil, Mexico, and Argentina, which have invested a great deal in this industry. It is a reality that the industry exists; and its promotion can represent a real contribution to the satisfaction of human needs, if in defining such needs the following factors are taken into account: (1) the interaction between industry and environment and (2) the participation of the population in determining these basic needs.

d) Health

When the environmental effects of an anthropocentric transformation are translated into effects on public health in general, the decision-makers give special attention to the problems involved. In the primary petrochemical industry, the effects imposed on health mainly fall under two headings: occupational health and public health.

Currently, there is evidence of health problems, especially related to pollution in the air and water and on land. Of course, the pollution which is generated depends on the inputs used for petrochemistry. Herein, we will concentrate on those effects on health arising from petroleum products in primary petrochemical production.

Chart 9 identifies the effects that contact, ingestion, inhalation, or absorption of primary petrochemicals would impose on human health. The standards indicated therein correspond to

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[47]ECLA has calculated that approximately 50% of Latin America and the Caribbean was receiving an annual per capita income of 112 dollars in 1978. This social sector certainly has no access to the consumption of petrochemical products. ECLA. **Economic Survey of Latin America.** Santiago, Chile, 1979.

the work environmental, e. i., the petrochemical plant. The standards provided are those limits which, if exceeded during that time period, would represent a potential risk for human health. Of course, the effects will depend on the initial health of each individual —and this, in turn, will depend on the eating habits, amount of rest, socio-economic origin, and other factors which characterize the person.

CHART 9

ENVIRONMENTAL DETERIORATION EFFECTS ON HUMAN HEALTH DUE TO PRIMARY PETROCHEMICAL PRODUCTION[48] [49a]

Primary Petrochemical Product	Form of Ingestion	Health Effects of High Concentrations	Standard for Occupational Health Hazards (8 hours)
Benzine	Inh, Con, Ing, Abs	Cancer, in some cases. Bone marrow destruction.	10 ppm
Ethylene	Inh, Con, Ing, Abs	Mucous irritation	b
Propylene	Inh, Ing	Dermatitis	b
Butadiene	Inh, Con	Irritation of eyes, nose, and throat	1000 ppm
Methanol	Inh, Ing	Dermatitis, nausea	200 ppm
Xylenes	Con, Inh, Ing, Abs	Nausea, vomiting	100 ppm
Toluene	Inh, Con Ing, Abs	Skin irritation and conjunctivitis	100 ppm

[a]Inh = inhalation
Con = contact
Ing = ingestion
Abs = skin absorption

[b]Produces asphyxia

It can be concluded that primary petrochemistry can generate effects on health such as cancer. This suggests that the environmental preventitive measures should be intensified as much as possible in order to avoid these side effects.

[48]NIOSH/OSHA. **Chemical Hazards.** U. S. Department of Health, Education, and Welfare. September 1978.

[49]American Conference of Governmental Industrial Hygienist. **Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980.** Cincinnati, Ohio, 1980.

e) Petrochemistry, Environment and Development

By integrating the concepts and information examined above, some useful reflections can be formulated.

The petrochemical industry makes a substantial contribution to the production of a broad range of goods and products. These goods are related to satisfying the basic needs of populations, e. g., food, shelter and health. Those who have access to these petrochemical products can somewhat raise their standard of living.

However, petrochemical consumption also generates problems such as financial and technological dependency, environmental degradation, displacement of the use of certain natural products, and the promotion of very select employment (mainly highly skilled personnel).

In order to achieve the harmonious integration of petrochemistry, development, and environment, it would be necessary to consider a development strategy which contemplated: the basic initial imputs (gas, oil, capital, technology, skilled labor); the appropriate management of the environment; a clear participatory definition of the basic needs of the population; and an adequate long-terms use of natural resources.

The complex nature of basic petrochemistry requires that its promotion and regulation in Latin America and the Caribbean be undertaken within a global framework, such as the one this study has attempted to provide.