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THE PETROCHEMICAL INDUSTRY IN ECUADOR, AND ITS RELATION TO THE ANDEAN COMMON MARKET

by

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ABSTRACT

One of the most important Ecuadorean goals is to improve the uses and benefits of its natural resources, while at the same time promoting the development of other sectors in the Economy. This is true particularly for petroleum resources, where exports represent the major source of Ecuadorean foreign trade.

Ecuador plans to utilize its petroleum and natural gas production in developing the petrochemical industry, to supply domestic and Andean Common Market requirements. Exports to other countries will be considered if spare capacity is evident.

On the basis of product assignments, Decision 91 regulates and guides the petrochemical development for the Andean Country Members. In this sense, Ecuador is going to promote its petrochemical industry mainly using the set of products assigned by Decision 91.

The main objective of this thesis is to examine the possibilities for developing the petrochemical sector in Ecuador, using both domestic and regional market as principal supports. The analysis is centered on high and low density polyethylenes, and ethylene glycols, although the framework of the study might be applicable for other products.

The study analyzes the conditions and characteristics of the petroleum industry in Ecuador as well as the existing domestic petrochemical industry, and the Ecuadorean dependence on foreign imports for this kind of products. Domestic and regional market estimations are provided as well as order of magnitude cost calculations. Included in the analysis are some limitations or constraints for the petrochemical industry, and some policy recommendations.

Considering the results of this thesis, the national goals for improving the uses of natural resources, the possibilities for the regional scope that Decision 91 offers, and the favorable impact upon the economy, the development of the petrochemical industry seems feasible, particularly for the mentioned ethylene derivatives group.

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DEDICATION

To:

Ana Maria, whose understanding, intelligence, and moral support made this work possible. Also to Luis Andres.

CHAPTER 1

INTRODUCTION

Objectives

One of the most important objectives of developing countries is to try to satisfy the requirements of their society while efficiently using their natural resources. This is true in the case of Ecuador, and especially true relative to development of the petroleum industry.

Ecuador has large reserves of petroleum with associated gas and large reserves of natural gas. Currently production exceeds domestic consumption by a noticeable amount and this advantageous situation has allowed Ecuador to become an energy exporter.

Ecuador seeks to industrialize its economy utilizing domestic raw materials, thus promoting growth and, at the same time, less dependence on imported raw materials.

Governmental goals include developing not only the primary materials, but utilization of these materials to produce higher value industrial products also.

The major objective of this thesis is to determine the possibilities of developing petrochemical products by Ecuador, using basically the domestic and the Andean Common Markets. The petrochemical products under consideration are high and low density polyethylenes, and ethylene glycols. These products were assigned to Ecuador by the Andean Petrochemical Decision (91). This Decision deals especially with distribution of petrochemical products in the Andean Common Market (ANCOM) countries according to the conditions of the product and producer country or countries.

The possibilities of development for the above mentioned products comprise an analysis of their domestic and regional markets as well as their expected plant costs, availability of technology, and financing. The study also examines institutional, social, and economic conditions in Ecuador, and other factors which influence the economic feasibility of developing the industry.

Scope of Study

This thesis is organized on the following basis:

Chapter 2 is devoted to analysis of the Andean Petrochemical Decision (91) as a basic framework for developing the Ecuadorean petrochemical industry within the Andean Common Market. Decision 91 has various stipulations, such as Common External Tariff Program, Compromise Agreement

among the Andean Members, and Tariff Program, which are incorporated in the analysis of this thesis.

Chapter 3 analyzes the economic environment within the country, where technical, financial, and economic problems will be faced by the new industry. This analysis includes a review of the principal economic indicators for the Ecuadorean economy especially related to the influence from petroleum exports. The present and future potential of the petroleum and natural gas resources as a base for a petrochemical industry are evaluated.

Chapter 4 is dedicated to analysis of the petrochemical industry in Ecuador. Present production and imports of the major products are considered. Special attention is given to market estimates of the polyethylenes and ethylene glycols within the domestic and regional areas. The estimates for an hypothetical petrochemical complex are guided by Decision 91.

Chapter 5 is devoted to providing order of magnitude cost estimates for high and low density polyethylenes and ethylene oxide-glycols plants. In most cases more than one source of basic information is considered to provide alternatives or ranges in the estimates.

Chapter 6 is dedicated to analysis of the major problems that the petrochemical industry has to face and

surpass in Ecuador. Some policies have been recommended in fields such as technology, governmental control, marketing, and financing to make the Ecuadorean petrochemical development more feasible.

The last chapter is concerned with conclusions and a summary of the recommendations.

It is unlikely, that all questions can be answered, but the overall objective will be to arrive at recommendations for type and size of the petrochemical industry that would most benefit the economy of Ecuador.

Previous Work

There are few publications about the petrochemical industry or activity in Ecuador. Most of them are related to basic information such as Decision 91, as legal guideles for the petrochemical industry in the region. The Junta del Acuerdo de Cartagena has made unpublished statistical computations about some petrochemical products in the region.

Ecuador, through CEPE (Corporacion Estatal Petrolera Ecuatoriana) has made statistical estimates and projections for some petrochemicals imports. Presently (February 1979), CEPE is looking at a preliminary study of the "petrochemical industry", prepared by a French-Ecuadorean consortium (The Wall Street Journal, February 9, 1979, p. 10).

Consequently, this thesis is one of the first studies concerning the petrochemical sector in Ecuador.

CHAPTER 2

DECISION 91

The inclusion of this chapter is important to the objectives of this thesis, because Decision 91, the Petrochemical Program of the Andean Market, provides the basic framework for the development of the petrochemical industry in Ecuador.

Decision 91 stipulates which petrochemicals Ecuador can produce. Therefore the projects covered in this thesis, such as high and low density polyethylenes and ethylene glycols, are assigned to Ecuador.

2.1 Decision 91: Objectives and Framework

Decision 91, a program of the Andean Common Market (ANCOM), has as its main objective the efficient, balanced, and integrated development of the petrochemical industry in each of the member countries.

Specific objectives of the program are as follows:

- To improve the utilization of the hydrocarbon resources that the region possesses ;

- To increase the productivity of the existing plants, through greater use of their installed capacity as well as expanding their output for meeting the regional market;
- To encourage an efficient diversification of the regional petrochemical production for meeting the internal demand as well as to create exports;
- To stimulate an adequate supply of the necessary feedstocks for the final petrochemical industry, as well as for the derived industries which use the end petrochemicals as raw materials;
- To facilitate the negotiation, acquisition and assimilation of technology.

Decision 91 was adopted on the basis of Proposal No.44, which the Junta of the Acuerdo of Cartagena (JAC) submitted to the Andean Market country members (including Chile) at the 17th ordinary meetings in July 15 to 20 and August 26 to 29, 1975 (JAC, Decision 91), in Lima, Peru.

Decision 91 was revised as a result of Chile's decision to leave the common market. The revised decision 91A is basically the same as Decision 91 with the changes being made, not in the structure of the program, but only in connection with products involving Chile alone. The Chilean departure from the Common Market is analyzed in another section of this thesis.

Since its approval in August 1975, Decison 91 has served as a guide for activities of the member governments, producers, investors (present or potential), suppliers of fixed capital and technology, and also for regional and foreign consumers of petrochemical products.

2.2 Implementation of the Decision 91 and its Importance in the Petrochemical Development of Ecuador

To fulfill the mentioned objectives of Decision 91, a scheme was designed for distributing or assigning a set of intermediate and end petrochemical products in such a way that each member country could develop them in an efficient and integrated manner.

A total of 161 products are assigned in the following manner: 25 exclusively to one country, 18 shared between two countries, 6 shared among three countries, and 7 shared by all members. The remainding 105 products are not assigned and can be produced by any member.

Production of basic raw materials such as ethylene, propylene, and butadiene is uncontrolled by Decision 91, and therefore depends on each country's requirements and convenience. Processing of intermediate and final products, as was mentionated before, is done according to Decison 91 and must be approved by the Junta of the Andean Pact Agreement.

Decision 91 attempts to organize production, processing, and marketing according to the specific advantages of each country. Consequently, some petrochemicals will be produced by one member country, while others will be produced by two or more members.

Ecuador, as a participant of the Andean Common Market (ANCOM), was assigned petrochemical production as described in Table 2.1. This thesis analyzes Ecuador's advantage in producing certain specific items, namely high and low density polyethylenes, and ethylene glycols and their feedstock ethylene oxide. Similar analyses might be applicable to other petrochemicals as well.

Decision 91 also has a list of products not assigned that can be made for each of the interesded members on the basis of its own purposes. Some of these products are acetylene, ethylbenzene, chloroform, polyester, resins, and acrylic fibers.

In general, Decision 91 covers a great variety of products, most of which are actually imported and which are in considerable demand, either by the region as a whole or by each of the member countries.

To fulfill Decision 91 objectives, a set of mechanisms

TABLE 2.1

ECUADOREAN PRODUCTION ASSIGNMENTS FROM DECISION 91

Products	Producers
ABS-SAN resins	2 (E, C)
Caprolactam	2 (E, C)
Diethylene Glycols	1 (E)
Ethanolamines	1 (E)
Ethylene Chloride	5 (B, C, E, P, V)
Ethylene Glycols	1 (E)
Ethylene Oxide	1 (E)
Glycol Ethers and Esters	1 (E)
Phthalic Anhydride	5 (B, C, E, P, V)
Polyethylene Glycols	1 (E)
Polyethylene high density	3 (B, E, V)
Polyethylene low density	5 (B, C, E, P, V)
Polypropylene	3 (B, E, V)
Polyestyrens	5 (B, C, E, P, V)
Polyvinyl chloride (suspension)	5 (B, C, E, P, V)
Polyvinyl chloroacetate	5 (B, C, E, P, V)
Triethylene glycols	1 (E)

B: Bolivia C: Colombia E: Ecuador

P: Peru V: Venezuela

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* Adapted from Decision 91.

and compromises was established. Three of these are especially important: Common External Duties, the Tariff program (Programa de Liberacion) and the Compromise Agreement of the Andean Members.

2.2.1 Common External Duties

The application of the Common External Duties is obligatory and seeks to protect Ecuadorean (and/or regional) production from competition outside of the Andean Market; on the other hand, these duties are the maximum allowable charges to be applicable to the prices.

The value of the common charges varies from 20 to 30 percent of CIF (Cost, Insurance and Freight). On December 31, 1980, the mentioned common charges will be fully applicable for Colombia, Peru and Venezuela. The charges will become applicable for Bolivia and Ecuador on December 31, 1985. Table A-1 of Appendix A summarizes the common tariff charges on some assigned products to Ecuador, such as: ethylene, propylene, ethylene oxide, ethylene glycols, high and low density polyethylenes.

The application of these common charges upon the production of ethylene glycols can be seen in Chapter 5.

2.2.2 Tariff Program (Programa de Liberacion)

The Andean Pact Tariff Program defines the guidelines,

organization, terms, and conditions of the transition period during which tariffs are gradually decreased, until tariff duties are equated among member countries.

The following table illustrates the charges for the products considered in this thesis.

Table 2.2

Tariff Program Chargeable Duties

Percentages upon (Cost+Insurance+Freight)(CIF) Values

Country Product	Bo	Ec	Co	Ch	Pe	Ve
Ethylene Glycols	-	x	-	-	-	-
Polyethylene low density	30	30	25	25	25	25
Polyethylene high density	30	30	-	-	-	30

Source: JAC, August, 1975.

Bo: Bolivia; Ec: Ecuador; Co: Colombia; Ch: Chile
Pe: Peru; Ve: Venezuela.

Table 2.2 shows that the applicable tariffs vary according to product conditions as well as the particular country's level of development.

Considering the previous situation, products made by Ecuador (and Bolivia) will receive special treatment,

because both countries were qualified by the Junta of the Andean Pact as "countries with less relative development" (MICEI, Oct. 1974, p. 6). The mentioned condition can be explained by the following example: low density polyethylene made by Colombia, Peru, and Venezuela is charged 30 percent of CIF value as duty for being sold in Ecuador and Bolivia; while the same product made by these last two countries is charged 25 percent of CIF value as duty for being sold in the others Andean Common Market (ANCOM) members. These duties should be eliminated in December 31, 1980, for Colombia, Peru and Venezuela, and in December 31, 1985, for Bolivia and Ecuador.

As the previous example shows, product assignment determines the chargeable tariff duties; i.e., ethylene glycol assigned exclusively to Ecuador is not charged at all for being sold in the ANCOM, while low density polyethylene is charged differently. Polyethylene high density will not be charged within the consumer countries (Colombia and Peru), while among the producer countries (Bolivia, Ecuador, and Venezuela) a common charge of 30 percent of the CIF value is charged.

2.2.3 Compromise Agreement among Andean Pact Members

This Compromise Agreement requires the members of the Andean Common Market (ANCOM) not to encourage

activities, authorize foreign or domestic investment, or initiate outputs where the products are not assigned to the respective country. The agreement ends in December 31, 1986 for Colombia, Peru and Venezuela and in December 31, 1991 for Bolivia and Ecuador.

The purpose of this agreement is to insure the market and cost estimates, investments, and returns, when the plant sizes have been designed to meet an extended (regional) market, on the basis of the exclusive and/or shared product assigments.

This agreement is particularly important for the Ecuadorean ethylene oxide-glycols and high density polyethylene (H.D.P) plants, which capacities will be determined on the basis of their respective exclusive and shared product assignment for meeting the Andean Market (see Chapter 4). If the agreement is ignored by any member, the charge of the respective product's Common External Duty is placed on its selling price by the other ANCOM members. However, there are exceptions for this agreement, mainly developed to maintain an adequate Andean supply and product quality.

2.2.4 Other Provisions

Decision 91 also includes other mechanisms and agreements that complement the provisions stipulated previously,

and among these mechanisms are the following: the rule of the origin that regulates the extended (regional) market; rules for export promotions; rules and compromises for presenting technical-economic information February 31, 1979, and for starting production, December 31, 1982; agreements for periodic evaluations of the program; agreement for regional supply; rules for equitative market sharing; and the establishment of the Petrochemical Commitee as a Coordinating Agency of the ANCOM. The details of all these mechanisms go beyond the scope of this thesis, but is necessary state that all these seek an efficient and orderly development of the program.

In summary, Decision 91 provides the necessary framework for the development of the petrochemical industry in Ecuador and in the Andean Common Market. Consequently, based on its agreements, strategies, and rules, each member country is trying to start or to extend this basic industry.

2.3 Departure of Chile

On the basis of the Protocol of October 5, 1976, signed by each one of the members (Bolivia, Colombia, Chile, Ecuador, Peru and Venezuela), the Comission of the Agreement established on October 30, 1976 (JAC, March 1977), Decision 102 which ended Chilean participation (rights and obligations) derived from the Cartagena Agreement.

From the effected technical-economic evaluations resulting from Decision 102, the Junta presented Proposal 85, to incorporate the new conditions within the Andean Common Market.

The principal consequences in the petrochemical sector from the Chilean separation are, among others, as follows:

- The basic scheme of the Decision 91 was not altered and remains the same basically for petrochemical development in the region.
- As the result of Chile's departure, demand for the petrochemical products decreased as did the associated supply of the products that were assigned to Chile. The intensity or impact of the consequences obviously changes according to the products and producer (country or countries) circumstances. These regional market changes are very important at the time of the market estimates in order to avoid overcapacity within the region.

For the Ecuadorean case, the mentioned market consequences can be appraised as follows:

- The ethylene requirements diminished as a consequence of the demand reduction of ethylene oxide and derivates, ethylene glycols, and high density polyethylene. The production of caprolactam and its principal raw material benzene, also had to

be reduced. On the other hand, the propylene and polypropylene capacities had to be increased to meet the unsatisfied demand originating from the Chilean plant participation that shared productions with Ecuador and Peru.

- Proposal 85 recommended transfering the Chilean assignments from the group of "Assigned Products" to "Not Assigned Products". These products will obviously be treated according to the new conditions. In this sense, good possibilities of manufacture by other members were opened for products such as normal butadiene alcohol, alcohol isobutylene, methyl methacrylate, and vinyl acetate monomer.

CHAPTER 3

PETROLEUM AND THE ECONOMY OF ECUADOR IN RECENT YEARS

This chapter summarizes the principle characteristics of the economy of Ecuador in the decade of the 70's. The supply and demand of petroleum are considered in relation to the domestic scene and exports.

3.1 Ecuadorean Profiles

Ecuador, with an area of 270,000 sq. km. and a population of 7,000,000, is bounded by Colombia, Peru and the Pacific Ocean. It is in the northwest part of South America, crossed by the zero parallel. For its latitude, the corresponding climate should be the heat and humidity of the tropics; but the Andes modify the climate, producing not only a great variety of vegetation and fauna, but great variety in the life of the Ecuadorean people.

The Mestizo (the mix of white and indian) is the social representative and the majority of the population. The Spanish and Quechua (indian dialect) are the official languages of Ecuador.

Politically, Ecuador is divided into provinces, each with autonomous provincial and municipal authorities and activities, but all are subject to the central government with regard to planning and realization of national goals and objectives.

The main cities of Ecuador are Quito (the capital), Guayaquil (the principal port and center of the agro-exporting activity), and Cuenca (the center for handcrafts and jewerly). More recently, two other cities have become very important. Esmeraldas, a petroleum exporting port, where a new refinery is operating and the future site of a petrochemical complex; and Manta a new center of commercial fishing activity.

For better understanding of the product-mix of Ecuador, it is necessary to point out the natural or geographic situation, since this has caused a diversification in landscape, production, and even customs. The hot and humid Coast, or Occidental region, traditionally has produced coffee, bananas, cocoa (export products), and lately the african palm tree, with relative success. Relatively flat, with a large amount of rivers, the region also has good fresh water fishing, as well as ocean fishing. The Andean region is formed by the Andes Mountains, which change the climate and form valleys where the majority of the

population lives. In the high altitude zone, all the rivers are born and are thus sources for hydropower energy that can be utilized in the economy.

The Southern region of the country has potential in mineral production, where in the past limestone and other non-metallic minerals have been developed commercially.

The Eastern region has become important recently, since Ecuador's greatest petroliferous basin is located there.

3.2 Principal Macroeconomic Indicators

Undoubtedly, the decade of the 1970's has been tremendously important and has brought great changes in the country's economic situation, changes that have been felt throughout the country.

Since 1972, large petroleum revenues have provided incentives for the economic growth of most sectors, and also have allowed the government to allocate priority expenditures for infrastructure development as well as for basic requirements of the population.

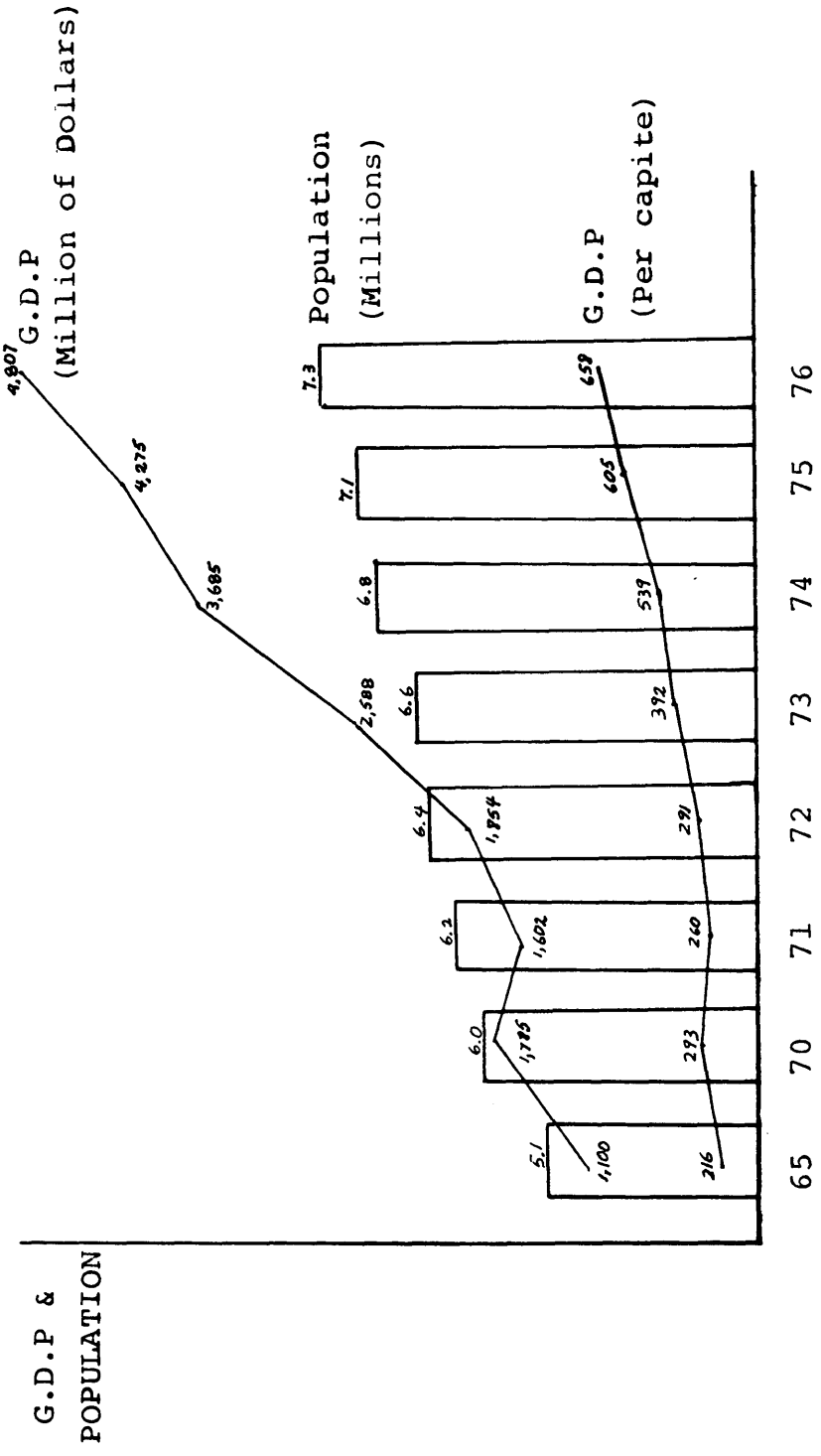
The principal macroeconomic indicators considered in this thesis are the following: Gross Domestic Product, and Foreign Trade.

3.2.1 Gross Domestic Product

Figure 3.1 shows how this economic indicator has grown

FIGURE 3.1

ECUADOREAN GROSS DOMESTIC PRODUCT



Source: Banco Central del Ecuador, (a) 1977, p. 4-6
Current Prices.

in the decade of the 70's, especially as a consequence of the petroleum export influence.

In absolute terms, the G.D.P increase, either in total or in the per capita level during 1965-1976, is more than threefold. This occurs at a very consistant growth rate. The economy now is more dynamic and the output is greater, although this is only one side of the picture, because social conditions have remained the same.

The rate of growth of the G.D.P by sectors, is presented below:

TABLE 3.1

ANNUAL GROWTH OF THE G.D.P (1)

Sectors	Annual Average (1964-72)	Annual Average (1972-76)
G.D.P	5.2	11.2
Farming	2.4	6.9
Mining and Manufacture	4.6	12.9
(2) Petroleum	-	60.6
Construction	7.5	19.9
Electricity gas & water	4.4	15.4
Services	5.6	7.2
Government	11.2	7.4

(1) G.D.P = Factor costs, constant prices 1972
G.D.P = Gross Domestic Product.

(2) Include transport and commerce.

* Elaborated from: National Planning Committee, 1977.

As can be noticed, the sector with the fastest rate is petroleum, followed by mining. Construction also is a sector that in the last few years has had a sustained high rate of growth, creating a great number of jobs, participating strongly in capital formation.

Probably petroleum and its related activities will continue being the sector with the fastest rate of growth, since exploration and industrialization have been considered priorities for the next few years. (CEPE, 1977).

3.2.2 Foreign Trade

The Balance of Trade, for the period 1972-76 shows positive results (Banco Central, 1976, p.7), due to the effects of petroleum exports and because other traditional exports (cocoa, coffee, bananas) have grown; however, other components of the balance of payment, such as freight and insurances, are normally negative (Balance of Payments, 1972-1976).

The United States continues to be the principal partner for trade, either in exports or in imports, with about 36 percent and 38 percent of the total respectively. The Andean market represents the second market for exports, with 23.4 percent, and with about 10 percent for imports, showing favorable trade balances. Panama and the Economic Community of Commerce (ECC) are also very representative.

(Memories of the Central Bank, 1975-76).

Exports of bananas, coffee, and cocoa, the traditional primary export products, still account for more than 25 percent of the total (Balance of Trade, several years); but conditions of their agriculture and cyclical variations in output and fluctuation of the International market have caused severe problems, either to the Ecuadorean "weak" economy or directly to small "weaker" farmers.

Among the industrialized products for the export market, the most significant are shown in Table 3.2.

TABLE 3.2

PRINCIPAL ECUADOREAN INDUSTRIAL EXPORT PRODUCTS

(Million of Dollars)

	1974	1975	1976
Cocoa products	22.7	28.4	60.3
Treated sea products	11.7	12.3	18.4
Hats	5.0	6.5	6.2

* Source:Fedesarrollo, 1977, p. 47.

Appropriate development of the petrochemical industry involves diversification and incorporation of higher national participation, as aggregated value to exports. The petrochemical industry will also complement greatly the import substitution, both impacting positively on the trade

and payments balances. Consequently, the industry should be more profitable than simple crude oil export as a raw material and should also impact positively in other sectors of the economy.

3.3 The Petroleum Industry

Under this heading are considered factors that will influence the Ecuadorean petrochemical industry such as sources of fossil fuels, petroleum productions, domestic derivates consumption, and CEPE* and its activity in Ecuador.

3.3.1 Location of the Sources

The country possesses petroleum and natural gas.

Petroleum: Ecuador actually has two sources for obtaining petroleum:

a) The first is in the Amazon Basin in the north-east, where fields such as Coca, Lago Agrio, Bermejo, and Shushufindi have been developed since the early 1970's.

b) The second source of crude oil is in the Guayaquil Gulf (Ancon).

In 1972, the country began to export crude oil from the Amazon Basin, at rates that theoretically could have

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* See abreviation list

reached 210,000 bbl/d*. In 1976 the average production was 181,000 bbl/d, and the 1977 average was lower. (Latin America/IPE Atlas, 1978, p. 128). Since 1976, 55,000 bbl/d are used as raw materials for the refinery in Esmeraldas.

The reserves of the northeast part are estimated to be 1.5 billion barrels. These reserves at current production rates could last for 17-25 years (World Oil, August, 15, 1978, p. 117). The rapid growth of the domestic consumption could decrease the life time estimates.

Ancon field production is very low. It is the oldest field but for many years it promoted the economic life of that zone, and various small towns were formed around Ancon. It was exploited by Anglo Ecuadorean Oilfields.

Natural Gas: Has been found in two places:

a) One is in the Amazon Basin, the Shushufindi Field, which also produces 85,000 bbl/d or crude (Latin America/IPE Atlas, 1978, p. 128).

b) The other source of natural gas is in the Guayaquil Gulf (but not in Ancon).

From the Amazon Basin a 305 km LP-gas pipeline to Quito will be constructed, with a capacity of 6,450 bbl/d (Estadistica Petrolera, 1978, p. 26). At Quito, the gas will be used for domestic consumption. Currently, most of

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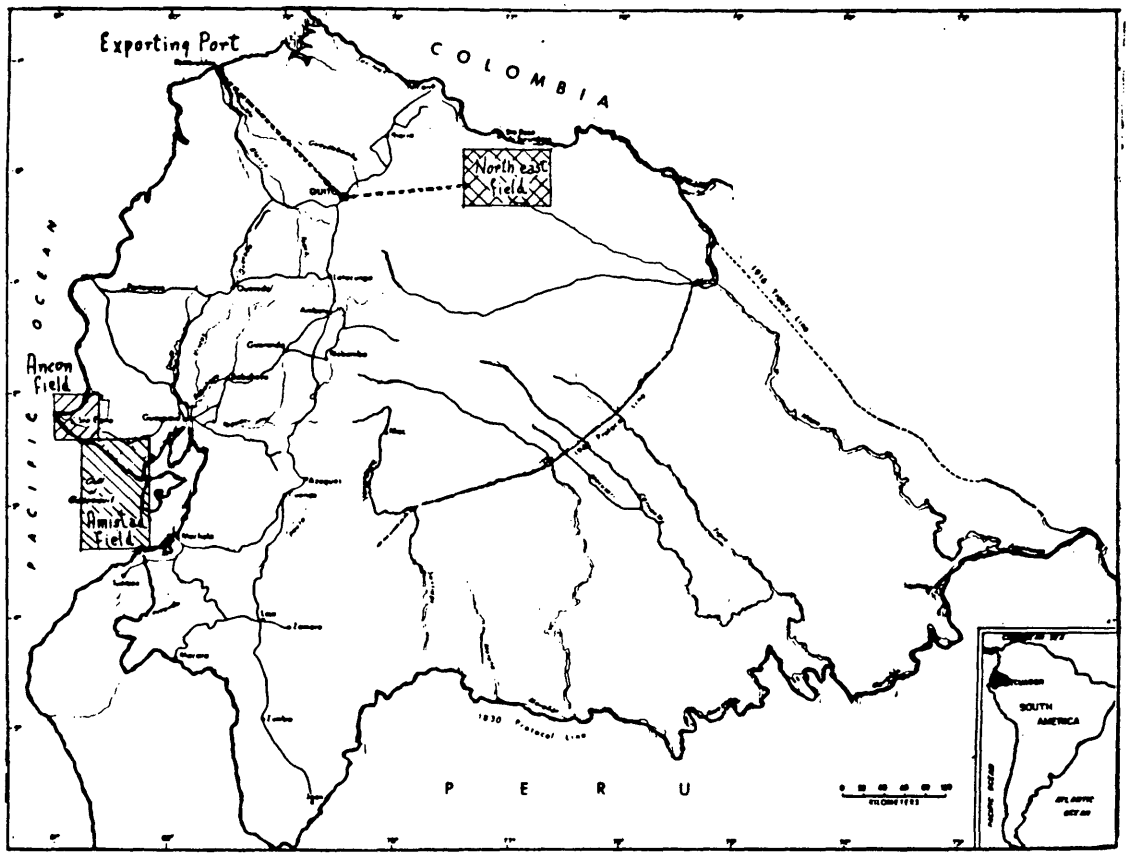
* bbl/d = barrels/day.

FIGURE 3.2

ECUADOREAN PETROLEUM AND NATURAL GAS SOURCE LOCATIONS



Petroleum Field | Gas Field | Trans Ecuadorean Pipeline

Source: The Current Economic Position and Prospects of Ecuador, 1973, p. 102.

the domestic market is supplied by imported gas. (Technical studies of this basin and of the pipeline are being done by Williams Brothers Cia.).

Guayaquil Gulf deposits are offshore at the Amistad Field (Latin America/IPE Atlas, 1978, p. 128). Major reserves are expected, and the firms Norwest & CEPE are participating in developing the area. The firm of Snam-Progetty is making the feasibility study for the site facilities, under-water gas line (46 miles), and a 300,000 ton per-year urea and methanol complex (Latin America/IPE Atlas, p. 128). The urea will be used to produce fertilizer for agricultural requirements.

3.3.2 Petroleum Production

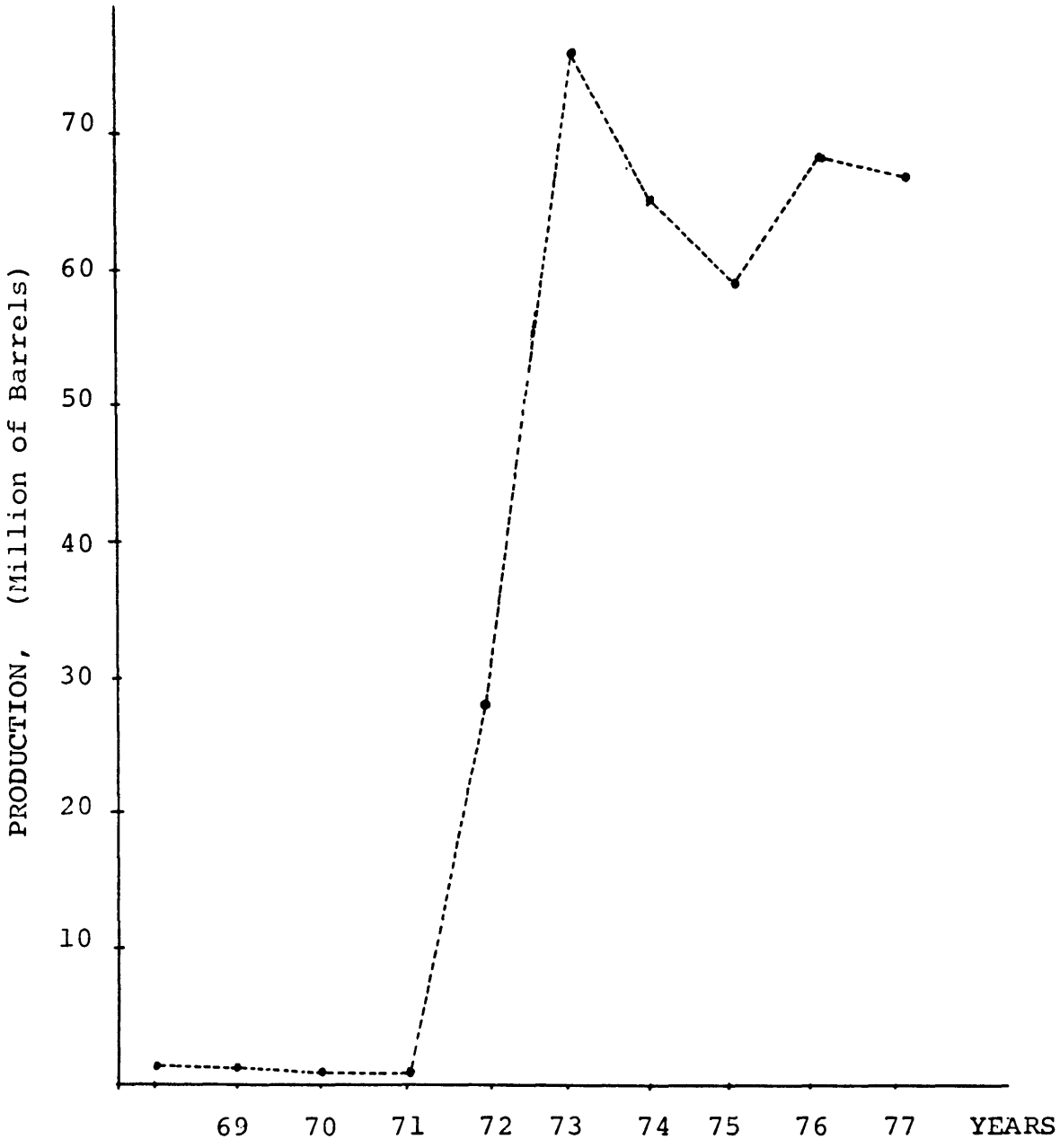
Petroleum production will be analyzed as a support for the petrochemical industry, because crude oil will be the principal raw material. Its availability, characteristics, prices and conditions will influence further developments.

As was mentioned previously, the economy of Ecuador in recent decades has been based on exports of agricultural products such as cocoa, coffee, and bananas. Obviously, such an economy was weaker and totally dependent on the international prices of those products.

In 1972, Ecuador started to export crude oil, and the state began to earn an extraordinary amount of revenues.

FIGURE 3.3

ECUADOREAN PETROLEUM PRODUCTION



Source: Table B1, Appendix B.

The value of crude productions, 250,000 bbl/d at the beginning and 210,000 bbl/d later, was enhanced by the rise in prices from $ 2.8 to $ 13.00 per barrel.

The variations in petroleum production from 1968 to 1977 are presented in Fig. 3.3. Great changes,can be seen, especially in 1972 when Ecuador started exporting crude oil from the northeast part of the country.

Since 1972, an appreciable part of the crude production has been destined for export, principally to the United States, Panama, Puerto Rico and Peru.

In summary it can be said, that the incomes obtained from petroleum export are the greatest ever earned by the Ecuadorean State for exporting any commodity.

3.3.3 Domestic Petroleum Derivates' Prices and Consumption

Ecuador, under the actual international energy circumstances, has a favorable situation, since it is a petroleum exporting country. Internally, however, the picture is not as favorable because of the misuse of the Ecuadorean fossil fuels and the ignoring of alternative energy sources available in the country.

The following table illustrates the prices of the petroleum derivates.

TABLE 3.3

ECUADOREAN DERIVATES' PRICES

TYPE	LOCATION		
	Esmeraldas	Quito	Guayaquil
Current gasoline (63 oct.)	.192	.164	.164
Premium gasoline (80 oct.)	.208	.186	.186
Diesel oil	.144	.142	.126
Turbo oil	-	.213	.168

* Dollars per gallon; 1 dollar = 25 sucres.
* Source: Estadistica Petrolera, 1978, p. 45.

The Table B2 in Appendix B, presents the petroleum derivates' growing demand in the 1970's.

Energy consumption in general has grown enormously, although more predominate are the requirements for gasoline 80 oct., residue,and kerex. For example annual consumption of gasoline of 80 oct. increased threefold from 1972 to 1977, i.e. from 2,397,000 bbl to 6,569,000 bbl. respectively Total petroleum derivatives grew from 9,374,000 bbl. to 18,400,000 bbl. in the same period.(Table B2, Appendix B).

To satisfy its energy requirements, Ecuador has centered on petroleum products mainly for their cheap price and less complex utilization. One example is the overuse of residue

to generate electricity instead of hydroelectric energy to taking advantage of the favorable topographic conditions that the country naturally offers.

The Ecuadorean circumstances require policies to improve or rationalize the domestic consumption of fuels, because the production of derivates and petrochemicals have the same source of raw materials, and a disproportionate use of the former will harm the development of petrochemicals.

3.3.4 CEPE and its participation

CEPE (Ecuadorean State Petroleum Corporation), the national company, was legally created June 23, 1972, by Supreme Decree, to explore, transport, refine, market, and industrialize the hydrocarbons directly or through contracts or associations with domestic or foreign firms.

CEPE acquired first 25 percent of the shares of the Texaco-Gulf Joint venture and later the (total) 37.5 percent of the Gulf Oil Co. shares participation (World Oil, August, 15, 1977, p. 92). Actually, the Corporation is the major partner involved in the Amazon basin crude oil production and exports.

The participation of CEPE in the different stages of petroleum activity has been gaining importance and will be essential for the next few years, especially since CEPE will be an important partner of the petrochemical industries.

Since its creation, CEPE has had to deal with major projects, either because of their nature or characteristics or because of the quantity of money involved. The budget of CEPE is the largest of any organization in Ecuador, as is its activity. In this sense, CEPE must be profitable economically, in order to keep developing its objectives and filling the requirements of Ecuador, even more where the greatest national project, the petrochemical industry has to be developed.

Externally, CEPE could be profitable, but in the internal market, probably the activity could not be, since the prices of the derivates are too low (computated at $ 3.60 bbl.) which does not allow for obtaining a reasonable return. However, the price of the derivates is not controlled by CEPE.

CHAPTER 4

PETROCHEMICAL ACTIVITY IN ECUADOR

The term petrochemical commonly refers to those chemicals and the first generation of derivates that are obtained from crude oil and natural gas processing (Brownstein 1976, p.1).

This activity, relatively new and having a history of only few decades, is actually basic in economic development, especially in the industrialized nations; and it is getting stronger particularly in oil-producing countries. It is characterized by a rapid technological change, with a relatively high level of automation, instrumentation, and computation. It is also capital-intensive and requires personnel with enough background to fulfill difficult responsabilities.

The output of the petrochemical industry is very large in terms of aggregate value and involves a high proportion of fixed costs compared to variable costs. Petrochemical activity depends greatly on the availability and cost of crude oil and/or ethane, because both are its principal raw materials.

The petrochemical industry is a basic activity, because many of its raw materials initiate production of a great number of products such as plastics, textile fibers, paint, solvents, and many others.

Ecuador, as was mentioned before, is going to produce some basic, intermediate, and finished olefins and aromatics such as ethylene, propylene, butadiene, benzene, polyethylene, and ethylene oxide. These products will supply the requirements for other industries such as the textile, plastics and paint.

For the mentioned production, Ecuador is going to build a petrochemical complex. The size of the complex will depend on the size of the market and type of products, since some will be for domestic consumption, others for the common market, and others probably for third areas. Consequently, the Andean Market will play a tremendous role not only in marketing but in technological and financial areas. Commercial help and participation among the countries will be required, particularly since countries like Ecuador do not have previous experience.

In summary, this program will be basic for the development of the petroleum sector as well as for other sectors in the economy.

4.1 Present Production

Ecuador does not make any basic or intermediate products for supplying raw materials for further processes. All intermediate products are imported from different countries.

Actually the following products are or will be made in the near future in Ecuador:

- Polyvinyl acetates (PVA)
- Fibers
- Alquidic resins
- Polyesteric resins.

Source: CEPE, 1977.

The following table contains the future domestic requirements of products actually made in Ecuador.

TABLE 4.1

PROJECTED ECUADOREAN PETROCHEMICAL PRODUCTION

(Tons.)

PRODUCT	Y E A R S			
	1977	1980	1983	1985
Polyvinyl acetate	1,630	2,200	2,970	3,620
Polyester resins	1,700	2,500	3,750	4,750
Alquidic resins	1,700	2,600	3,730	4,800

Elaborated from : CEPE, 1977
MICEI-CEPE, 1977

Polyvinyl Acetate - This product is used mainly as an adhesive for wood furniture and cardboard boxes, and as an additive for paint. Union Carbide of Guayaquil imports PVA (vinyl acetate) and effects its polymerization. The Guayaquil plant has been operating since 1974 filling part of the domestic demand. In the future Union Carbide has to increase its capacity (1200 MTA) to meet both, the total domestic demand and the 10.5 percent consumption rate of growth (CEPE-MICEI, 1977, p. 101), that has been predicted for the period 1977-85.

Polyester Resins - These products have gained importance in the Ecuadorean market, as can be seen in Appendix C, Tables C1 and C2.

The firm TINTESA of Quito, with a capacity of 4,500 tons annually manufactures polyester resins that are used primarily for lamination of boats (CEPE, 1977, p. 37).

The future demand for these products has been projected to grow at rates of 15 percent for 1977-1980 and 12 percent for 1980-1985 (Table 4.1).

Alquidic Resins - These resins are used principally in making paint, demand for which has grown enormously in the last decade. A projection of the country's demand can be seen in Table 4.1. The factory making these products has a capacity of 1200 tons yearly and obviously is covering only a segment of the national requirements, (see Table 4.1).

Consequently, its production should be increased to catch up with domestic demand.

Fibers - Traditionally, the textile activity has been one of the most important for the Ecuadorean economy, both as a part of the industrial sector and as for people's skills, resources, and technology.

Tables C1 and C2 in Appendix C show that the total consumption has increased considerably; for example, it increased almost fourfold from 1970 to 1985. Polyester and acrylic fibers show the most drastic rates of growth, although the future requirements for cotton and synthetic fibers will be considerable.

In general terms, the demand for these fibers can be called dynamic either in rate or volume.

Regarding domestic fiber productions, the Dutch firm Enkador is producing "profile polyester" 4250 MT/Y (CEPE, May, 1977, p. 45). It also plans to produce polyester fiber, and also "polyester chips", important raw materials for the production of synthetic fibers.

It is important to stress the favorable conditions that synthetic fibers and petrochemicals are creating in the domestic market as substitutes for traditional materials. Consumer preferences are changing and creating more demand for synthetics. Many examples exist , such as the increasing

consumption in the rural area, and greater demand in urban areas for shoes, plastics, pipelines and polyethylene bags.

4.2 Imports of the Main Petrochemical Products

The size of the Ecuadorean petrochemical market is small compared to other Latin American markets. However, the country's market-intensive growth has increased dependence on foreign petrochemicals in the last decade.

Tables C2 and C3 of Appendix C show the national cost for imports of plastic materials and resins, and also the volume imported during 1970 to 1976.

The increase in total consumption either in weight (metric tons) or in value (dollars) has been enormous. For example, in 1970, 8,629.7 tons were imported with a value of $3,424,000 ($397 per ton); in 1973, 17,837.5 tons, with a cost of $7,931,700 ($445 per ton); and in 1976, 37,429.3 tons, with a value of $29,123,800 ($780 per ton), (Tables C2 and C3).

The total consumption in tons in 1973 was 207 percent greater than in 1970, and in 1976 it was 210 percent greater than in 1973 and 434 percent greater than in 1970. The average annual rate of growth is 72 percent. The costs for these imports show a similar tendency; i.e.,the costs in 1976 were almost four times greater than in 1973 and eight times greater than in 1970. The total cost per ton increased

TABLE 4.2

IMPORT SHARE OF PLASTIC PRODUCTS AND SYNTHETIC RESINS

Polyethylene (l.d)*	45%	27%
Polyethylene (h.d)**	--	11%
Polypropylene	3%	8%
P.V.C	12%	17%
Polyestyrenes	5%	8%
ABS-SAN resins	2%	2%
P.V.A	10%	3%
Acrylic resins	1%	--
Ureics resins	6%	4%
Alquidic resins	10%	7%
Polyesterics	3%	9%
Polyurethanes	3%	4%
TOTAL:	100%	100%

* (l.d) = low density

** (h.d) = high density.

twofold during this period, although the particular increment differs.

The products considered in the Tables C1 and C2 in Appendix C had obviously different relative participation in fulfilling the Ecuadorean requirements, and Table 4.2 illustrates this situation.

According to composition, polyethylenes (high and low density) are the products with the largest market participation, almost 40 percent of the total. Fig. 4.1 shows polyethylene growth in the Ecuadorean market. Important markets also exist for P.V.C. (polyvinyl chloride), and resins of different kinds; however, most are playing an important role in other sectors, which use them as raw materials i.e. textile, construction, manufacturing, and agriculture.

It is important to recall that most of the products discussed here will be produced in the petrochemical complex of Esmeraldas.

Foreign Currency Costs

Considering the 1978 prices for both high and low density polyethylenes, and the future estimated Ecuadorean demand (Tables 4.8 and 4.9), Tables 4.3 to 4.5 show foreign currency costs for the next few years if Ecuador delays the construction of its respective plants.

Polyethylenes - Low density polyethylene (L.D.P) will experience greater costs than high density, as can be seen in the next tables.

TABLE 4.3

LOW DENSITY POLYETHYLENE (L.D.P)

FOREIGN CURRENCY COSTS

(Thousands of Dollars)

YEAR	Costs F.O.B	Costs F.O.B - 20% (H.C)	Costs F.O.B - 30% (C.E.D)
1978	11,955	14,345	15,535
1979	13,306	15,977	17,290
1980	14,810	17,771	19,240
1982	18,018	21,622	23,400
1985	24,180	29,015	31,400

C.E.D : Common External Duties

H.C : Higher Costs

Price: 31.5 ¢/lb (Ch.M.R*, October, 1978)

Source: Appendix C2

* Chemical Market Report.

For both polyethylenes, overcharges of 20 percent have been assumed for simulating higher costs for transport, handling, and insurance. A corresponding Common

External Duty percentage has been considered.

TABLE 4.4

HIGH DENSITY POLYETHYLENE (H.D.P)

FOREIGN CURRENCY COSTS

(Thousands of Dollars)

YEAR	Costs F.O.B	Costs F.O.B - 20% (H.C)	Costs F.O.B - 30% (C.E.D)
1978	3,597	4,316	4,676
1979	4,938	5,925	6,419
1980	5,678	6,813	7,381
1982	7,125	8,550	9,263
1985	10,010	12,012	13,013

Price: 31.75 c/lb (Ch.M.R. Oct., 1978)

The calculated costs in Table 4.4 did not include exports to the Andean Common Market (ANCOM), in which case the results will be higher. To make the 50,000 ton per year plant feasible, an important part of H.D.P production will require shipments to other ANCOM members.

As can be seen, the costs for both cases are sizeable and grow each year.

Ethylene Glycols - Ethylene glycol shows the following costs:

TABLE 4.5

ETHYLENE GLYCOLS

FOREIGN CURRENCY COSTS

(Thousands of Dollars)

COUNTRY	YEARS								
	1978	1979	1980	1981	1982	1983	1984	1985	1990
Ecuador	1,375	1,578	1,812	2,043	2,317	2,620	2,958	3,350	5,821
ANCOM	15,257	18,325	18,384	20,214	22,209	24,407	26,825	29,474	44,069
TOTAL:	16,632	16,747	20,196	22,257	24,526	27,027	29,783	32,824	49,890

Price: 27 c/lb

Source: Table 4.9

In general it can be said that until Ecuador supplies its own demand, dependence and costs on imported products each year will be greater (not only for the thesis-considered products). This causes negative results on the Balance of Trade.

4.3 Market Estimates

Under this heading are detailed the Regional or Andean Common Market and Ecuadorean requirements for high and low density polyethylenes, ethylene glycols and derivates.

Characteristics and uses of the above mentioned products are described in Appendix C2.

4.3.1 Polyethylenes

The estimates for these petrochemicals are divided at regional and at domestic levels.

a.1) Regional Low Density Polyethylene (L.D.P) Estimates

The following table illustrates the L.D.P projected regional demand.

TABLE 4.6

LOW DENSITY POLYETHYLENE

REGIONAL DEMAND PROJECTIONS

(Thousands of Dollars)

COUNTRY	Y E A R S			
	1975	1980	1985	1990
Bolivia	0.8	1.9	7.0	21.6
Colombia	20.0	40.0	64.4	87.5
Chile	6.7	16.3	31.4	54.0
Ecuador	7.0	21.4	34.8	61.8
Peru	17.8	38.7	68.9	112.1
Venezuela	42.0	82.6	143.1	227.6
REGION	97.9	212.6	360.7	564.6

*Adapted from: (1) J.A.C 1976, p. 9-12
(2) CEPE, 1977, P.E.E p. 6

As was pointed out, the production of L.D.P has been assigned to each of the members so that each country will start and/or will expand its production sooner. In this sense, the sizes of the plants will depend upon their respective national markets, although possible exports to third countries outside the Andean Pact could be considered.

The size and growth rates of almost all the members could allow for the domestic industrialization of L.D.P. Venezuela is the country with the biggest market, and probably more than one plant will supply its requirements. This favorable condition in addition to Venezuela's abundant fossil resources, makes the petrochemical industry more advantageous. Bolivia has the smallest market but the fastest rate of growth; nevertheless, this country will develop its own plant (OPEC Bulletin 1978). Colombia has to increase its 60,000 tons/year plant (MICEI-CEPE, 1977, p. 124) to cover its domestic market. Peru and Ecuador will have to build their respective plants to meet their own demands.

a.2) Regional Demand for High Density Polyethylene (H.D.P)

The following table illustrates the projected regional requirements for H.D.P.

TABLE 4.7

HIGH DENSITY POLYETHYLENE

REGIONAL DEMAND PROJECTIONS

(Thousands of Tons)

COUNTRY	Y E A R S			
	1975	1980	1985	1990
Bolivia	0.70	5.30	13.2	0.7
Colombia	9.70	15.60	22.9	6.0
Chile	2.80	4.50	6.6	0.6
Ecuador	8.13	16.05	28.3	3.8
Peru	12.60	23.80	41.2	5.9
Venezuela	52.00	112.00	200.0	26.1
REGION	86.90	177.25	312.2	43.1

* Adapted from: J.A.C 1973, p.23-29
J.A.C 1977, p. 9-12
CEPE, 1977

Bolivia, Ecuador and Venezuela have the H.D.P assignment of production; therefore regional supply will be covered by them.

Considering the present and future total demand, Venezuela has the largest market and by itself can support H.D.P production in sizes bigger than the estimated minimum feasible economically for the region 30,000 - 50,000 tons yearly, (J.A.C, 1973, p.39).

The situation changes when it is related to the Ecuadorean and Bolivian production , because both countries require necessarily the support of different and greater markets than their own. Colombia, Peru (principally), Chile, and other third countries will also be the center of their productions. Ecuador could be in better circumstance than Bolivia because it has a greater domestic market, but both equally need to compete with Venezuela.

b) Ecuadorean Demand for High and Low Density Polyethylenes

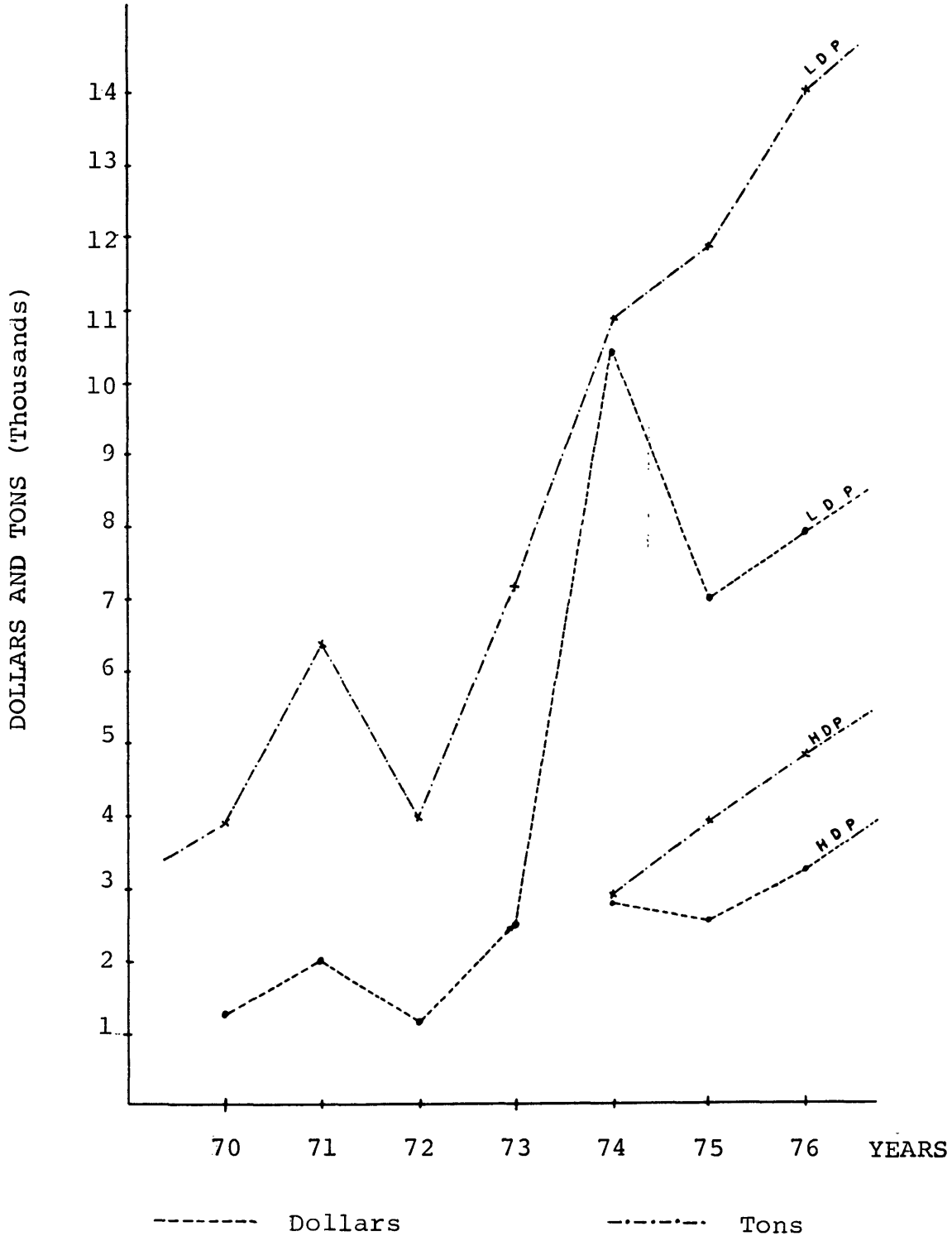
Polyethylenes, both low and high density, show a consistent acceptance in the domestic market since either their imported amounts (metric tons) or their rates of growth have grown intensively this last decade, as the respective tables C2 and C3 in Appendix C illustrate.

From these tables, it can be seen that low-density polyethylene has the greatest demand among any petrochemical products in the Ecuadorean market. Also, its rate of growth is considerable, for example in 1970, 3,823 tons of 8,630 total tons were imported, in 1973, 7,034 tons of 17,838 total tons, and in 1976, 13,980 of 37,429 tons. High density polyethylene although it is a relatively new product in the Ecuadorean market, is in great demand. Fig. 4.1 illustrates the growth of both polyethylenes in Ecuador.

The principal suppliers for both imports have been Dow Chemical (60 - 70 percent of the total), Rohn & Haas and

FIGURE 4.1

ECUADOREAN POLYETHYLENES IMPORTS



Source: Tables C1 and C2, Appendix C.

Union Carbide from United States; Hoechst-Eteco, Basf & Hull-West from Germany; Mitsubishi & Sherry from Japan. (CEPE, P.P.E, 1977, p. 12).

The estimates for Ecuadorean future polyethylene requirements are detailed in Table 4.8. These calculations were based on the previous imported volume, the estimated future necessities of industries which use both polyethylenes as feedstock, the future behavior of the export of bananas, and the criteria and experience of advisors.

TABLE 4.8

POLYETHYLENES

ECUADOREAN ESTIMATED FUTURE DEMAND

YEAR	LOW DENSITY	HIGH DENSITY
1977	15.500 MT	5.350 MT
1978	17.250 MT	5.150 MT
1979	19.200 MT	7.070 MT
1980	21.370 MT	8.130 MT
1981	23.570 MT	9.100 MT
1982	26.000 MT	10.200 MT
1983	28.628 MT	11.420 MT
1984	31.630 MT	12.790 MT
1985	34.890 MT	14.330 MT

* Source: CEPE, P.P.E, 1977, p.6

MT = Metric Tons.

The rate of growth for L.D.P has been estimated as 11.3 percent for 1977 to 1980 and as 10.3 percent for 1980 to 1985; and for H.D.P, 15 and 12 percent respectively.

According to estimates, in 1985 Ecuador will require 35,000 MT of L.D.P, an amount that allows installation of one plant whose capacity would be between 40,000 and 60,000 MT per year. This is the economically feasible amount estimated for the Region. (J.A.C, 1973 p.39).

The size of 50,000 MT/year (with possibilities of further expansions after 1985), would permit use of adequate economic percentages of the installed capacity during the decade of the 80's. This covers the total domestic demand with the alternative of exporting the surplus.

The production of high density polyethylene, in the subregional context, is shared by Bolivia, Ecuador and Venezuela. Ecuador has projected a plant of 50,000 tons yearly for covering the domestic, regional and probably other markets also. The capacity does not seem unreasonable when the future subregional requirements are considered (see Table 4.7). For the economic feasibility of this polyethylene, the establishment of different markets from the domestic is necessary, and in this context the Andean Common Market (ANCOM) plays an important role.

In the Latin American structure, Mexico, Argentina, and

Brazil are the largest producers of polyethylenes (and petrochemicals in general); therefore if Ecuador wants to install bigger plants, it should make special agreements with other Latin American countries for sharing part of their markets.

4.3.2 Ethylene Glycols and Derivates

As mentioned previously, Ecuador has the exclusive assigment for producing both ethylene oxide and ethylene glycols, as well as other less important products.

The ANCOM projected demand for ethylene glycols is presented below.

TABLE 4.9

ETHYLENE GLYCOLS

ESTIMATED ANCOM DEMAND

(Thousands of Tons)

COUNTRY	Y E A R S						
	1980	1981	1982	1983	1984	1985	1990
Bolivia	1.07	1.08	1.53	1.83	2.2	2.63	4.25
Colombia	12.42	13.46	14.59	15.82	17.15	18.59	27.90
Chile	2.88	3.21	3.57	3.98	4.44	4.94	7.65
Ecuador	3.05	3.44	3.90	4.41	4.98	5.64	9.80
Peru	5.27	5.78	6.35	6.97	7.65	8.40	11.36
Venezuela	9.31	10.24	11.26	12.40	13.63	15.00	23.03
REGION	34.00	37.47	41.29	45.50	50.14	55.26	83.99

Include diethylene glycol.

Source: J.A.C May 1976, p. 107 - 108.

The regional projected requirements for di-, tri-, and polyethylene glycols is presented below.

TABLE 4.10

ETHYLENE GLYCOL DERIVATES

ESTIMATED ANCOM DEMAND

(Tons)

PRODUCT	Y E A R S		
	1980	1985	1990
(1) *Diethyleneglycol	2,050	2,740	3,670
(2) Triethyleneglycol	220	250	290
(3) Polyethyleneglycol	1,930	2,830	3,970

Adapted from: J.A.C, 1977, p. 109 - 120.

* Diethylene glycol's demand was included in the Ethylene Glycol estimates.

The glycol regional demand has been estimated to grow at rates of 10.4 percent during 1980 to 85 and 8.6 percent during 1985 to 1990 (Table 4.9). Nevertheless, these rates differ in each country. Bolivia and Ecuador possess the fastest growing demand, in relative terms.

For the considered period, Colombia has the greatest market share since it holds a very active and developed textile industry. Venezuela also possesses a good deal of

the market. Therefore, Ecuador should give special attention to its North market, since it could demand more than 50 percent of its production. Chile has been included in the estimates, although it no longer belongs to the ANCOM. Nevertheless, mainly due to the market closeness, Ecuador could capture a good percentage of the Chile's estimated consumption.

In addition, it is important to recall that present regional demand is fulfilled entirely by imports from outside of the region, causing a great sacrifice in terms of foreign currency (Table 4.5), use of resources and labor.

Considering the ANCOM demand and growth, the present imported supply, and the exclusive Ecuadorean assignment for production of ethylene glycols and derivates, the development of one plant of 55,000 tons per year looks feasible. The plant, after 1985 will have to consider capacity increments, the size of which will depend on future conditions.

4.4 The Structure of the Petrochemical Industry in Ecuador

Ecuador actually has two principal sources of fossil fuels that will be used as raw materials for future industrialization: natural gas and petroleum.

Natural Gas - Natural gas is found in two places:

a) Offshore, in the Guayaquil Gulf, at the Amistad field, from where is projected a 46-mile underwater

gas line, as a first stage of development (Latin American/IPE, 1978, 1.128). As a second stage an ammonia-urea complex is projected.

b) Natural gas is also located in the Amazon Basin (at Shushufindi Field). From there to Quito, a 305-Km, (6" - 4") gas pipeline with a capacity of 6450 barrels per day is to be constructed (Estadistica Petrolera, 1978, p. 26).

The ammonia unit mentioned (a) will have a capacity of 1,000 tons daily (CEPE, MICEI, 1977, p. 104), 300,000 tons yearly (Latin American/IPE, p. 128) and the urea unit per day, 100,000 tons yearly (CEPE, MICEI, 1977, p. 104). The storage capacity will be according to the plant's capacity. According to CEPE, the most favorable application of this gas, given its composition, (Appendix C4) is the production of ammonia-urea.

The production of ammonia will be destined to cover the domestic demand, and the surplus has to be exported. In the national market, its principal use will be as a raw material for the production of urea and for other products such as caprolactam (production has been estimated to start in 1981), (CEPE, E.P.P, 1977, p. 17).

The urea on the other hand will be used to produce fertilizer and cattle feed , mainly for national demand.

The firm Snam-Progetty was contracted to conduct the feasibility study for the project, in which CEPE (69%) and Norwest Pipeline (31%) are participating in a joint venture (Latin American/IPE, 1978, p. 128).

The main utilization of the gas for Shushufindi Field will be as fuel for industrial and residential consumption, because actually most of these requirements are currently met by imported gas.

Petroleum - This fossil fuel is the second and principal feedstock for the petrochemical industry in Ecuador.

Esmeraldas, Ecuador's north-west port, will be the site for the development of the future complex. Reasons for that choice are, among others:

- The existence of a new refinery there;
- The presence of some necessary infrastructures, especially shipping facilities;
- Location advantages, related principally to the closeness of the Panama Canal, Colombia, Venezuela, and American Markets ;
- The desire of creating a new center of development ;
- The existence of abundant supplies, such as water, raw materials for constructions, environmental facilities ;
- The fact that Esmeraldas is the site from which Ecuador exports its crude oil.

The other mentioned source of crude oil, in the Guayaquil Gulf, at Ancon field, is not used for petrochemical feedstock, because its total small production, 1886 barrels daily (Estadistica Petrolera, 1977, p. 29), is consumed totally in refining processess.

The location of the sources, are shown in Figure 3.2

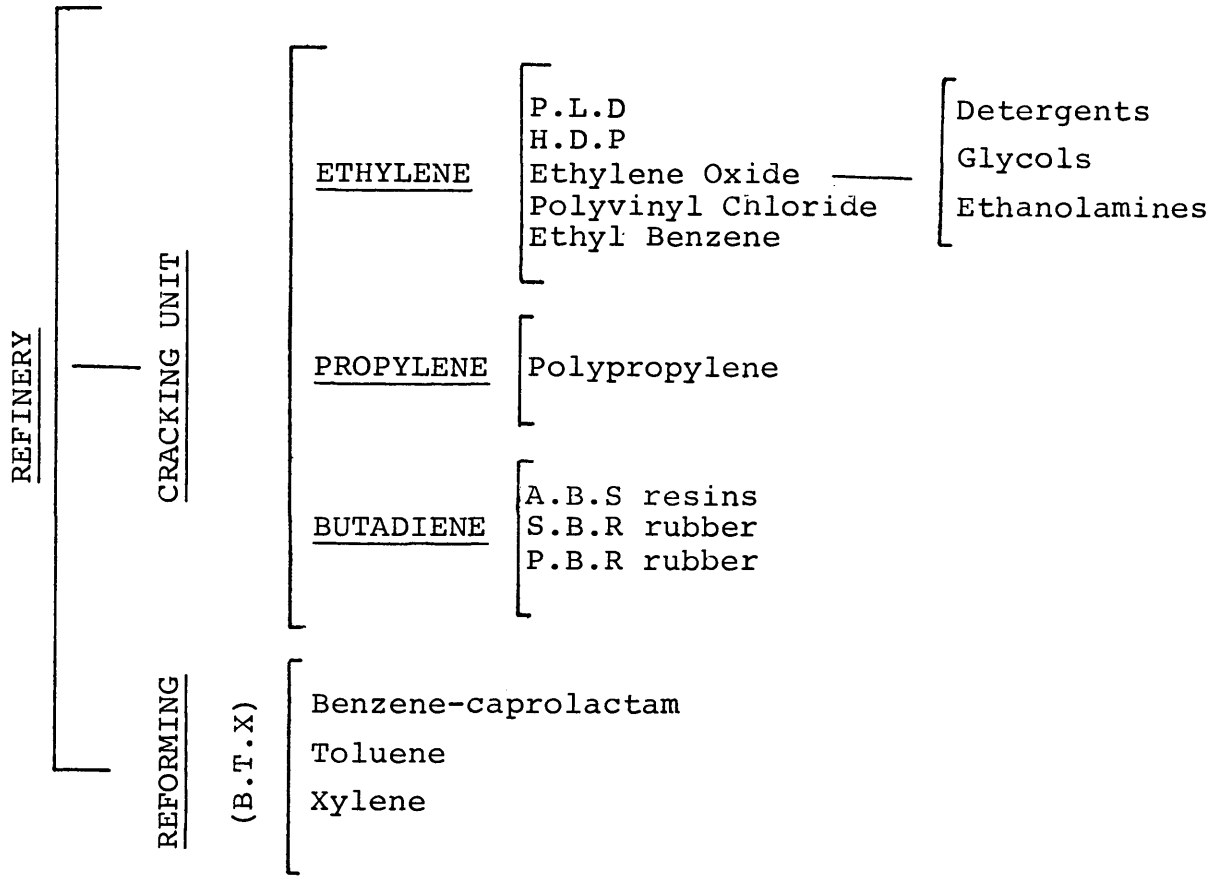
4.5 The Tentative Complex

Ecuador has directed the petrochemical industry to those products whose domestic markets show higher rates of growth and enough demand to sustain production. Examples are low density polyethylene, PVC (poly-vinyl chloride), polypropylene resins (diverse type), and those products whose regional demand allows development, such as high density polyethylene, ethylene oxide, glycols and derivates. In addition, products that can be substituted for the traditional materials, and could be sold much easier in the domestic and foreign markets have been considered.

Although the complex will produce a variety of products, it could be considered in an initial stage, since its participation in the international contest is limited. Probably later, as the experience and market conditions allow, further developments will be considered.

FIGURE 4.2

THE ECUADOREAN TENTATIVE COMPLEX



Source: CEPE - MICEI, 1977, p. 108

The complex will be integrated; i.e., formed by a specific refinery. Others can be reconditioned to provide fuels, other derivates and required raw materials for supplying the petrochemical production. The cracking and reforming units will produce from napthas higher elements or basic petrochemicals such as ethylene, propylene, butadiene, benzene, and toluene. The specific projects, using these basic outputs, will generate a variety of products which can be considered intermediate and

final for the complex, such as L.D.P, H.D.P, ethylene oxide, polypropylene and resins, all of which will feed other industries.

The complex will be horizontally and vertically integrated, as judged best according to the specialized firms, consultants and authors (Wet Ted, April 1978, p. 65, Hahn A, 1970, p. 8-13).

As can be seen, the stipulated production in the complex involves basic, intermediate and final products, in integrated manner, in an effort to increase efficiency.

CEPE, the national conductor of petroleum activities, and the Ministry of Industry, Commerce & Integration, are the state institutions most related with the industry, the first as executor, and the second as negotiator with the Andean Market and other countries.

CHAPTER 5

COST ESTIMATION

The objective of this chapter is to provide order of magnitude costs for some products that will be developed in Ecuador in the near future. The products considered for the estimates are: high and low density polyethylenes and ethylene glycols, although the schemes of the computations could be appliable for other products in the complex.

The cost information is important because it can provide an approximation about the monetary efforts to be made for undertaking the projects. In this sense, the results could enlighten some possibilities in different fields such as partnerships, financial and technical agreements, and foreign and domestic machinery and equipment supply, that could make the projects feasible.

The obtained costs are the results of the most available information, and correspond to the average plant type. In addition, whenever possible, more than one source of calculations is included to provide alternatives to the calculated costs.

The methodology used in the computations was based on adjustments or corrections from projects already developed in United States for time, size, and location to Ecuadorean conditions.

The location cost differences between the United States Gulf Coast (the most representative site for Ecuadorean petroleum equipment imports in recent years) and Manta (mainly), Esmeraldas, Guayaquil in Ecuador are estimated to be 17 percent greater for the Ecuadorean location. The relatively small difference is caused by the Ecuadorean Hydrocarbon Law, which allows the companies operating in the petroleum industry to import,without the payment of any duty or charge , all machinery, equipment, and accessories not produced in the country.

Information and composition about Location Factor is provide in Appendix D1.

Time corrections are made primarily using the Chemical Engineering Plant Cost Index. In addition, Marshall and Swift indexes and Nelson indexes are used.

The costs are updated using the following ratio:

$$\text{Cost Now: (Cost then)} \times \frac{\text{(Index, now)}}{\text{(Index, then)}}$$

The updated costs correspond to November of 1978, and Appendix D illustrates the effected calculations. Table D4 of the mentioned appendix explains the evolution of the

Chemical Engineering index in the decade of the 70's.

Capacity adjustments are made utilizing the exponential technique, which is a well known method that yields fairly accurate results.

The exponential formula is as follows:

$$\frac{C_A}{C_B} = \frac{(P_A)^e}{(P_B)}$$

where:

C_A = Cost of plant A,

C_B = Cost of plant B,

P_A = Annual capacity of plant A,

P_B = Annual capacity of plant B,

e = exponential factor.

The earlier applications of the formula, used a constant exponent value of 0.6 for most type of processes, but subsequent investigations have determined the exponent variation according to the process involved. In this sense, this thesis applies various exponents according to the type and process of the plants under consideration.

5.1 High Density Polyethylene (HDP)

The estimations obtained for the Ecuadorean HDP plant were based upon calculations of similar plants provided by Brownstein (1976) and by the Stanford Research Institute

(SRI) (1973).

The mentioned data of similar plants have to be adjusted to the Ecuadorean location, size, and time, which corresponds to 50,000 tons yearly and the time to November, 1978.

The basic material for the estimations is obtained from two sources:

a & b) Source: Arthur Brownstein

Capacity (P_A): 91,000 tons yearly or 200 MM lbs yearly.

Time: Mid 1975.

Location: Gulf Coast.

Total Capital Investment (C_A): \$54,300*

Method: Ziegler.

Time corrections, from June 1975 to November 1978, are made using the price indices stipulated in Table D4. Size corrections are calculated using two exponential factors a) e_1=0.65 (Guthrie) and b) e_2=0.67 (Gallahar), both factors are directed to high density polyethylene (HDP) size adjustments, therefore the results differ when using the two factors. Location is considered to be 17 percent.

The Ecuadorean high density polyethylene

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* Thousands of Dollars.

capital costs are: a)$52,350* and b)$53,000*.

The procedure is described in Appendix D 2.1.

c) Source: Junta del Acuerdo de Cartagena (JAC) and Stanford Research Institute (SRI)

Capacity (P_A): 40,000 tons per year

Time: June 1973.

Location: Gulf Coast

Fixed Investment Cost (C_A):$23,000*

Similarly to the previous calculations, these costs have to be adjusted for size, time, and location. For size correction the exponential factor of 0.67 is utilized (Gallahar), and for the other corrections the procedure is similar to the previous case. Description about the process is included in Appendix D 2.1.

c) The Ecuadorean capital cost corresponds to $47,630*.

The three cost estimations are in the same range, which have a variation of about 10 percent. The overcharges for location although important are not disproportionate. These overcharges would be in the same range for the region as a whole, because almost all of the

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* All amounts are expressed in thousands of dollars.

petrochemical industries have higher costs transfered mainly from the fixed charges. In this sense, the Ecuadorean high density polyethylene output will be produced competitively in the region, since Venezuela and Bolivia have to consider similar conditions when they develop their program. Outside the Andean Common Market, these higher capital costs could diminish the Ecuadorean, and/or regional plants, competitive position, although other factors could also influence the market preferences such as: market closeness, ans special agreements with other Latin American countries.

5.2 Low Density Polyethylene (LDP)

The Ecuadorean plant was determined convenient to have a capacity of 50,000 tons yearly, and these calculations consider that size.

The basic information for the estimates is obtained as follows:

a) Source: JAC and SRI.

Capacity: 50,000 annual tons

Time: June 1973

Location: Gulf Coast

Fixed Investment Cost:$24,500*.

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* Data in thousands of dollars.

The above data have to be corrected for time (November 1978) and location to reflect the Ecuadorean order of magnitude cost. The procedure for the adjustments is similar to the previous calculations.

The present required capital investment corresponds to $45,100*. See Appendix D 2.2 for calculation details.

5.3 Ethylene Glycols

Cost estimates for an ethylene glycol plant, normally include costs for ethylene oxide production plant, since glycol manufacture requires more than 75 percent of the ethylene oxide output as a feedstock. The remainder is assumed to be consumed by other plants in the complex, principally in the development of products such as ethanolamines, detergents, surfactans, and others. (See Appendix C2).

The ethylene oxide and glycol plant cost estimations are made using three sources of data.

a) Source: Brownstein

Method: Ethylene oxide process

Location: Gulf Coast

Time: Mid 1975

Capacity: 227,000 annual tons, 500 MM lbs.

Cost: $88,800*.

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* Amounts in thousands of dollars.

Correcting for size, time and location, the Ecuadorean size corresponds to 55,000 tons annually, and the time to November 1978. The applied procedure is similar to the previous cases (see Appendix D 2.3) and the total estimated Ecuadorean capital cost is: $43,760*.

b) Source: JAC and SRI

This estimate, as in the previous case, is corrected for the Ecuadorean situation. The adjustments include size, time, and location. The information presented below illustrates the basic material used:

Method: Ethylene oxide

Location: Gulf Coast

Time: June 1973

Capacity: 50,000 annual tons

Cost:$21,500*.

The total 1978 Ecuadorean capital investment corresponds to $42,540, which is in the same range of the previous calculation. (See Appendix D 2.3 for details).

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* Amounts in thousands of dollars.

c) Source: CENDES

These estimations of ethylene oxide and glycols are more detailed and provide information for capital and operating cost. The applied procedure is similar to the previous cost calculations, therefore the results obtained for these oxide-glycols could in some measure, enlighten the market possibilities of the polyethylenes by means of their costs and prices.

The basic source of data has the following characteristics:

Size: Ethylene Oxide (23,000 tons yearly)

Ethylene Glycols (26,000 tons yearly)

Costs: Battery Limits:**

Ethylene oxide	$ 7,500*
Ethylene glycols	$ 2,900*
Offsites:**	
Ethylene oxide	$ 2,400*
Ethylene glycols	$ 900*

The above data are adjusted for present conditions of size and time. For size

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* Amount in thousands of dollars.
** See Terminology Meaning.

corrections specific exponential factors are used, such as Guthrie and Frumerman, and for time corrections, indexes and direct consultations, (see Appendix D 2.3 for details).

According to the market estimates and coefficients of material utilizations, the ethylene oxide plant have a capacity of 50,000 annual tons and the ethylene glycol plant 55,000 annual tons.

From the calculations developed in Appendix D 2.3 can be established the following results:

TABLE 5.1

ECONOMIC REVIEWS

ETHYLENE OXIDE AND ETHYLENE GLYCOLS

A. Capital Requirements	
1. Battery Limits (B.L) Investments*	
Ethylene Oxide (E.O)	23,365
Ethylene Glycols (E.G)	8,647
	32,012
2. Offsites Investments	
Ethylene Oxide (E.O)	7,466
Ethylene Glycols (E.G)	2,677
	10,143
3. Land	180
4. Working Capital	5,940
5. Start-Up Cost	
Ethylene Oxide	320
Ethylene Glycols	101
	421
6. Training Costs	
Ethylene Oxide	150
Ethylene Glycols	80
	230
Total Capital Cost:	$ 44,693

* Includes Process Buildings.

B. Annual Production Cost	$/M.T
1. Ethylene Oxide	
Raw materials and utilities	359.91
Direct cost	8.31
Indirect cost	79.21
Credits (-)	6.16
Net Manufacturing Cost:	461.27
2. Ethylene Glycols	
Raw materials and utilities	379.21
Direct costs	10.56
Indirect costs	27.04
Net Manufacturing Cost:	416.81
Manufacturing Cost/Lb = 19.00 ¢/lb.	

Using the Manufacturing Ethylene-Glycols price (19.00 ¢/lb) some alternatives for the Ecuadorean production can be shown.

TABLE 5.2

ETHYLENE GLYCOLS, PRICE ALTERNATIVES

Manufacturing Price (MP)	19.00 ¢/lb
MP + 25% Price Return	23.75 ¢/lb
United States Price (US) (Ch.M.R.* October 16, 1978)	24.50 ¢/lb
US + 30% (Common Ext. Duty)	31.85 ¢/lb

Considering the different price possibilities, for example 23.75 ¢/lb to 31.85 ¢/lb, the Ecuadorean production

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* Ch.M.R.: Chemical Marketing Report.

will experience a flexible range of operation and a favorable situation for good returns. These alternatives, joined to the stipulated market conditions, imply a need to develop further and more detailed studies, either for these glycols or for the polyethylenes.

5.4 Cost Summary

This point provides a summary of the Ecuadorean required investment for the products under consideration (see Table 5.3) as well as some cost conclusions.

TABLE 5.3

SUMMARY OF THE ECUADOREAN CAPITAL INVESTMENT REQUIREMENTS
(Thousands of Dollars)

Item	Capacity	Capital Cost
High Density Polyethylene		
Basic Data Source		
a) Brownstein-Guthrie	50,000 T/y	$ 52,350
b) Brownstein-Gallahar	50,000 T/y	53,000
c) JAC* and SRI**	50,000 T/y	47,630
Low Density Polyethylene		
Basic Data Source		
a) JAC and SRI	50,000 T/y	45,160
Ethylene Oxide and Glycols		
Basic Data Source		
a) Brownstein	55,000 T/y	43,760
b) JAC and SRI	55,000 T/y	42,540
c) CENDES***	55,000 T/y	42,150

Source: Appendix D3

* JAC: Junta del Acuerdo de Cartagena
** SRI: Stanford Research Institute
*** CENDES: Centro de Desarrollo.

From the estimated cost it can be seen that the different plant computations are in the same range of values. Their differences are small, and in this sense are good approximations.

The applied methodology is systematic and the same in all cases, consequently the results or total investment estimations are similar, although the sources of the basic information are different. Consequently, additional information and results obtained, like in ethylene glycols, can be in some measure applied to the other products, and comparable results adjusted.

Considering the previous paragraph, the market estimates, and effected cost calculations, production of high and low density polyethylenes as well as ethylene oxide glycols seems feasible economically.

Taking into account the imported equipment, machinery, and material requirements, the difference among the Andean Pact Member Countries will not be significant since all members have to absorb similar charges for the required equipment .

Domestic participation in supplying part of those machinery , and equipment is desirable and necessary, because the domestic sharing can encourage the development of other sectors such as machinery, foundry, and chemical.

This allows for greater or more intensive use of available factors like labor, capital and natural resources, and also saves foreign currency for other outside purchases.

CHAPTER 6

POLICIES FOR DEVELOPMENT THE PETROCHEMICAL INDUSTRY IN ECUADOR

As mentioned in previous chapters, petrochemistry is a basic industry but is very complex and dynamic. This is evident from the industry's applied resources as well as the technology, skills, and procedures that its development involves. Based on these factors, the objectives of this chapter, given the order of magnitude level of study, is to consider some basic problems that the development of the petrochemical industry in Ecuador has to face. In addition, some policies related to the governmental participation, since the Ecuadorean Government is the promotor and organizer of the activity in its first stages, are discussed.

6.1 Main Problems

Ecuador is a developing country, where the process of industrialization is relatively limited, along with its private and public managerial experience. The available

domestic technology and investment capacity (mainly private) are too small to face the requirements of a large petrochemical industry. A consideration of these and other obstacles suggests some solutions for developing this priority sector. The problems can be classified as technological, financial-economic, governmental, and marketing limitations.

6.1.1 Technological Limitations

As mentioned previously, the petrochemical industry involves sophisticated and very efficient process technology requiring skilled management for its operation. Consequently, the techniques used, the domestic supply of equipment, and the skilled labor in different areas needs to keep pace with the requirements.

Ecuador does not fulfill all the mentioned conditions, especially with respect to the supply of skilled and knowledgable labor. A few reasons for these limitations, are stated as follows:

- There exists almost total absence of domestic qualified personnel in the design, engineering, and development of large industrial projects, such as the refinery in Esmeraldas and the Transecuadorean pipeline. Most industrial projects are contracted to foreign firms. Consequently other sectors can

not assimilate any advantageous influence from areas more developed, and the dependence and costs on foreign technology are increased.

- Major projects involve relatively small participation with universities, domestic consulting services, research institutions, and domestic engineering firms.
- Usually inadequate negotiation of the technology agreements occurs, which later produces inconveniences for production and/or for further enlargements.
- The domestic business atmorphere is sluggish in planning and implementing major industrial projects, causing delays and losses of favorable investment opportunities.

6.1.2 Financial Limitations

The scope of the domestic financial requirements depends upon the type and size of the petrochemical complex being developed. It also depends on the foreign and domestic (private and public) structure of partnership agreements.

As mentioned before, the Ecuadorean petrochemical complex will be integrated to include the refinery or

refineries for crude oil, the plant for basic products (ethylene, butadiene), and the satellite plants producing intermediate and end products (polyethylenes, ethylene oxide and glycols). According to similar experiences of other Latin-american countries like Mexico, Chile, and Argentina, the refinery and the plant for basic products will probably be state owned; however, the intermediate and final product plants will utilize different systems of partnership. For example they might include 20 or 30 percent state contributions, with the difference fulfilled through foreigh or domestic investments.

The cost involved in developing the petrochemical complex is enormous, and will require great sacrifices of the Ecuadorean state, which also has to consider the necessities of other sectors such as agriculture, education, and infrastructure. If the Ecuadorean state wants to execute the projects through foreign investors, which decreases the requirements for domestic savings, the results vary according to the type of project and the type of partnership desired.

In this sense, two alternatives can be suggested:

a) The absolute petrochemical control by foreign investors. This alternative will not permit an effective and real technological assimilation by

Ecuador, limiting in this form, positive effects upon other productive economic areas.

b) Each satellite or end product project operated as an independent and autonomous unit. Each project must be profitable and subjected to its own income tax, profit distributions for its workers, and reinvestment of its profits. Obviously, the feedstocks and utilities should be shared by the whole complex. Considering the national goals of improving the general conditions of the society, this option can be more advisable.

6.1.3 Limitation due to Bureaucracy

The complexity of the petrochemical activity as well as the requirement of Ecuadorean resources, leads to considering the establishment of a National Agency with autonomy, efficiency, strength, and high decision capability. This Agency would be the National counterpart in the negotiation of agreements with foreign and private investors (joint-ventures), in technical licencing in design, engineering, construction, commerce, and marketing studies for petrochemical complexes.

It might be advisable that the mentioned Agency, although it should have a great deal of state participation have a different structure than that of a state owned

company. A few reasons for a different structure are as follows:

- Minimize bureaucratization with its inevitable slowness of decisions, procedures and operative mechanisms.
- Partially eliminate political influence and pressure on decision making, to allow decisions based on highly technical criteria.
- Avoid low levels of earnings to highly trained personnel to discourage their continuous exodus from state to private companies.
- Maintain stable managerial force and qualified technicians whose participation is essential in the petrochemical development.

6.1.4 Marketing Limitations

Ecuador has based its petrochemical industry on the domestic and regional markets for products assigned by Decision 91. It has also considered sales to other countries, but in the initial stage of development, exports are not vital to the industry.

The size of the Ecuadorean plant has been estimated according to previous assumptions (see Chapter 4); however, the plant sizes for domestic or regional markets, although feasible economically (50,000 tons yearly), are not

internationally competitive. (140,000 tons yearly, Brownstein, 1976 p. 155).

Low density polyethylene is one example of a restricted market, since its production has been assigned to each Andean Pact member. In this sense, the Decision 91 might be technically and economically more advantageous if they were fabricated only by two or three complexes.

The previous analysis is important because it leads one to consider joint-productions of basic or initial, intermediate, and even end products between two countries. This advantageous possibility is analyzed further under policies for developing the Ecuadorean production.

Marketing limitations depend on systems of transport, distribution, and commerce which are very important for efficient and competitive outputs.

In addition, rules and guidelines for environmental protection should be stipulated,since the complex will be located in Esmeraldas, an important center of fishing activity. Time is also a very important constraint since the petrochemical industry is a capital intensive industry and the rate of inflation provocates considerable increase in costs, and also because of Decision 91 deadlines, and for avoiding greater costs for future imports.

6.2 Some Policies for Developing the Sector

The objective of this part is to point out some

guidelines or policies to develop the petrochemical industry in Ecuador, taking into account the limitations described previously in this chapter. The policies for developing the sector are compiled in technical, marketing, financial, bureaucratic and other fields.

6.2.1 Technical and Marketing Fields

Ecuador, as mentioned before, is going to develop the complex in Esmeralds, its North Western port. This is a few miles from Tumaco, Colombia, a port where the Transcolombian crude oil pipeline ends, and where Colombia plans to build a petrochemical complex. Both countries, as members of the Andean Common Market, base their petrochemical production to a noticeable degree on Decision 91, which encourages the formation of multinational joint ventures among the countries. Both countries need to erect plants for producing basic and intermediate petrochemicals which will be used as feedstocks. Both countries traditionally have had satisfactory political and economic relationships.

Considering the previous analysis, the author recommends the building of a Colombian-Ecuadorean joint-venture complex for the production of basic or initial and intermediate petrochemicals. This alternative allows estimating greater capacities and lower costs of the considered products. It allows also obtaining autonomy in producing the

final petrochemicals according to each country's own purposes. Consequently, the plant sizes for basic and intermediate products will be larger, will use the economies of scale, and might produce at internationally competitive costs which provides important advantages for the subsequent productive processes or end products.

The mentioned alternative is an incentive for technical exchange between the countries, generating advantages for Ecuador, which is inexperienced in petrochemicals. It also improves the financial conditions for obtaining credits either from the CAF (Corporacion Andina de Fomento), international borrowers, or domestic institutions. In addition, the sales and consumption of the complexes finished products might be facilitated and encouraged, through greater technical advice to related industries; i.e,textile,fibers and solvents. The conditions for technical agreements or associations or partnership with foreign investors could also be improved.

In summary, the possibility of a Colombian-Ecuadorean joint-venture, encourages the development of the petrochemical industry in both countries, fulfilling also the objectives of Decision 91. Nevertheless, the Ecuadorean scheme alone is still feasible and the conclusions obtained in the market and cost estimates for high and low density

polyethylene, ethylene oxide and glycols are valid (see Chapters 4 and 5); but producing their feedstocks at lower costs and with less technical difficulties due to the engineering and technical exchange, improves the general conditions and results of production.

The lack of qualified personnel is also a serious limitation since the petrochemical industry requires very advanced and sophisticated techniques. One way to overcome this problem will be the application of an integral theoretical and practical formation program in diverse areas of specialization. Management of the projects, the agreement negotiations, and the design and operation of the processes require both theoretical and practical knowledge.

The mentioned technical assimilation could be possible through the participation of national professionals in other petrochemical projects of the foreign technical partner or through the participation of Ecuadorean technicians on petrochemicals or refinery projects in other member countries. Benefits could also be obtained through the participation of the mentioned professionals on enlargements or overhaul of the existing domestic refineries.

The creation of an "Andean Petrochemical Institute" (in any member country) complements the previous policies and helps to overcome technical inconveniences. The

assimilation of technology will have favorable effects not only upon the process plants in the complex, but also upon the subsidiary or derivated plants, which will use the complex's final products for further processing, such as plastics, fibers, and paint industries.

6.2.2 Financial Field

The domestic financial requirements decrease according to the bi-national joint-venture alternative, since the financial charges will be shared between the countries. Also the association with international or foreign investors decreases the domestic contribution.

The peripheric or end product plants such as polyethylenes and ethylene glycols probably will be financed by the state to the extend of 20 or 30 percent. The remainder will be financed by foreign or technical partners and by credits from various development organizations*.

The petrochemical sector has been given top priority in the region and in Ecuador (MICEI, CEPE, 1977, p. 51);

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*These organizations might include: The World Bank, Interamerican Bank of Development, CAF (Corporacion Andina de Fomento), Supplier Credits, as well as by the domestic private sector and Institutions of Development, such as the CFN/CV (Corporacion Financiera Nacional/Comision de Valores), and FONAPRE (Fondo de Preinversion).

therefore, it will receive special treatment, such as low interest rates (8 percent, 15 year loans for capital; 9 percent, 3 year loans for operating capital; 5 percent for 6 year preinvestment study loans). Loans for inter-regional commerce are also stipulated as well as warranties for third lenders (CAF, 1977, p.56-68).

As can be seen, there are various formulas for participation in domestic (private or state) and foreign investments; however, the implementation of these alternatives will depend on the politics and governmental framework, the requirements for financing, and the adoption of policies relating to technology.

6.2.3 Bureaucratic Field

The bureaucratic limitations could be solved in a noticeable manner through the establishment of a "National Agency for Petrochemistry" whose functions were discussed previously.

The Petrochemical Agency will have functions such as promoting and administering the petrochemical program. Consequently, it must undertake the preparation and/or participation and/or contracting of the feasibility studies including the engineering, construction, and commerce of the projects. In addition, it should manage the training of the personnel at its different levels, as well as deciding

about the diverse financial possibilities. In summary, it develop the petrochemical industry technically, efficiently and profitably.

6.2.4 Other Fields

International inflation is affecting strongly the cost and development of capital intensive projects. In spite of inflation, Ecuador should undertake parallel efforts for making prompt decision for avoiding higher cost for machinery and equipment and encouraging the development of the domestic industry for promoting the participation of other Ecuadorean sectors or economic areas.

Finally, Ecuador should establish rules and norms for adequate environmental protection, since presently fishing is the principal economic activity in Esmeraldas.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

This thesis has discussed the possibilities for developing the petrochemical industry in Ecuador, using basically domestic and regional markets. Special emphasis was given to the analysis of high and low density polyethylenes and ethylene glycols.

The following factors were considered of major importance or influence in the petrochemical development: reserves, conditions and influence of petroleum in Ecuador; Andean Petrochemical Decision (91); Market and Cost estimates; specific sectoral problems.

Since 1972 petroleum exports have caused noticeable impacts upon the economy of Ecuador. The presence of large petroleum revenues is still providing important incentives for economic growth in most of the sectors, as shown by economic indicators. However, the social conditions, particularly the standard of living for most of the people, remains unchanged. Unemployment remains high, and the majority of Ecuadoreans still live in poverty.

Therefore, a major government goal for expanding petroleum exports has not been obtained.

Petroleum and natural gas are going to be the principal feedstock for the future petrochemical industry in Ecuador. The petroleum reserves (1.7 billion bbl) have been estimated to be large enough to sustain the projected industrial requirements.

Natural gas, located in the Guayaquil Gulf , will be the raw material base for ammonia-urea production.

Petroleum will be the basic feedstock for the major petrochemical producing complex located in Esmeraldas. This complex will be integrated to produce basic (ethylene, propylene, butadiene), intermediate (ethylene oxide), and end products (polyethylenes, propylenes, ethylene glycols).

Domestic and Andean Common markets are estimated to be the principal target for products from the Esmeraldas complex. Exports to other countries is likely to occur if the demand in these markets declines, or if spare capacity is available.

At the present time the domestic demand for petrochemicals is fulfilled almost totally by imports. Until the petrochemical production starts, greater dependence on raw materials and greater costs on foreign currency will be experienced.

It has been determined in this thesis, that Decision 91 is a basic instrument for developing and guiding the petrochemical activity in the region. Market estimations scheduling of activities, investments, and production will be conducted under its consideration.

Estimated plant sizes to fill mainly Ecuadorean and Andean requirements are 50,000 annual tons each of high and low density polyethylenes, 50,000 annual tons of ethylene oxide, and 55,000 annual tons of ethylene glycols. The stipulated capacities correspond to sizes considered profitable economically for serving these markets. The appropriate plant size for international competition would require larger sizes, in the magnitude of 150,000 annual tons depending on the considered products.

The required investments for Ecuadorean plants show an average of 17 percent greater costs than plants located in Gulf Coast. In this sense, the Ecuadorean production cost will be higher than those prevaling in the United States; however other factors such as price and availability of feedstocks, labor and utilities could diminish the differences.

Considering characteristics of the petrochemical industry, such as advanced technology and engineering, capital intensity, highly qualified personnel, and the

conditions of Ecuador as a developing country, the petrochemical industry has to surpass some domestic problems in technical, financial-economic, institutional, and marketing capability, in order to be as competent and profitable as is desired.

Based on the results obtained in this thesis, the regional possibilities that Decision 91 offers, the favorable impact upon the economy, and the national goals for improving natural resource usage, the development of the petrochemical industry in Ecuador seems feasible. This is particularly true for high and low density polyethylenes, ethylene oxide, and ethylene glycols.

Regarding the analysis performed in this thesis, the author recommends some actions that might improve the environment and concomitantly the development of the petrochemical industry:

- Priority actions must be taken for decreasing the exaggerated petroleum derivatives consumption in Ecuador. The target should be to improve natural resource uses more efficiently.
- A Colombo - Ecuadorean joint-venture should be investigated further to possibly improve the economic, marketing, financial, and technical aspects of the complex.

- Governmental bureaucratic intervention can be decreased by establishing a "Petrochemical Agency" which will be the state promotor and executor of the Ecuadorean petrochemical industry. The Agency founded by state contribution, should be organized as a private firm, and managed autonomously.
- A Regional Petrochemical Institute should be established to exchange theoretical and practical knowledge among the Andean country members. This institute could provide the assimilation of technical, political, and economic information for the joint benefit of all producers.
- Project financing could be made using 20 to 30 percent as State contribution, and the difference through foreign partner participations and credits given by International (mainly) and Andean Development Institutions.
- Further detailed studies, as well as programming, promoting, and constructing producer plants should be undertaken in the shortest possible time either for fulfilling the deadlines stipulated by Decision 91 or for avoiding greater costs. Similarly, rules and guidelines for environmental protection must be set forth; and finally, this thesis is centered

on possibilities for developing the Ecuadorean petrochemical industry with emphasis on a set of specific products; however, studies for other Ecuadorean petrochemical products is a further challenge for research.

APPENDIX A

DECISION 91

APPENDIX A

TABLE A1

COMMON EXTERNAL DUTIES

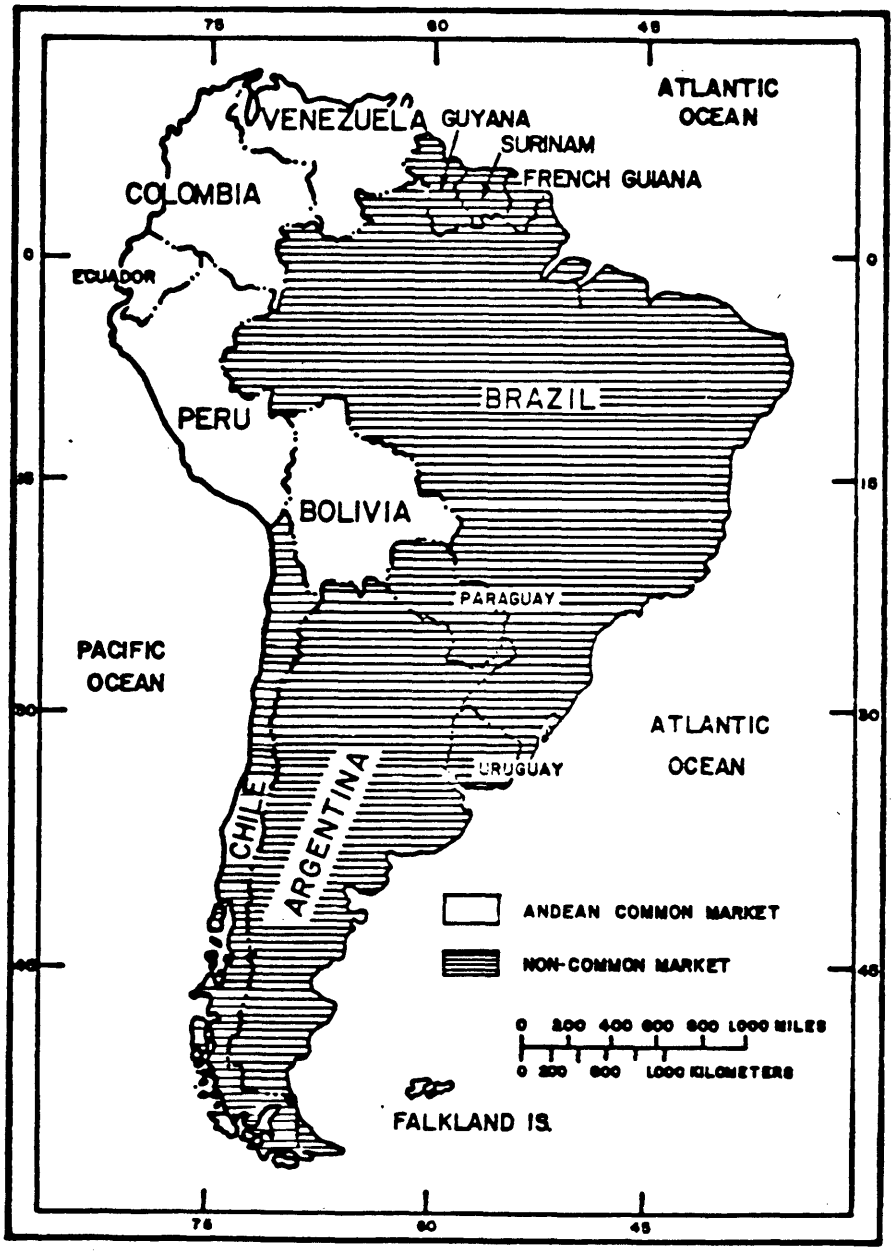
(C.E.D)

NABANDINA	PRODUCT	C.E.D %
20.01.02.01	Ethylene	20
29.01.02.02	Propylene	20
29.01.02.11	Butadiene	20
29.08.01.01	Ethylene oxide	30
29.04.03.01	Ethylene glycols (same charges for its derivates)	30
39.02.01.00	Low density Polyethylene (L.D.O)	30
39.02.01.00	High density Polyethylene (H.D.P)	30

* Source: J.A.C, March 1977.

FIGURE A1

ANDEAN COMMON MARKET GEOGRAPHIC LOCATION



Source: Vargas A, 1976, p. 8.

APPENDIX B

PETROLEUM IN ECUADOR

TABLE B1

(APPENDIX B)

ECUADOREAN PETROLEUM PRODUCTION

(Thousands of bls.)

YEAR	PRODUCTION
1968	1,815.10
1969	1,607.60
1970	1,480.00
1971	1,354.40
1972	28,646.40
1973	76,221.00
1974	64,615.60
1975	58,752.70
1976	68,361.90
1977	67,002.00

* Source: Estadistica Petrolera, 1977, MRNYE, p. 31

TABLE B2

ECUADOREAN DEMAND FOR PETROLEUM DERIVATES

(Thousands of Bls.)

DERIVATES	Y E A R					
	1972	1973	1974	1975	1976	1977
Gasoline 63 oct.	1,307	1,290	1,234	1,275	1,387	927
Gasoline 80 oct.	2,397	2,836	3,499	4,443	5,324	6,569
Diesel Oil	2,115	2,513	2,844	3,209	3,617	2,485
Residue	2,149	2,226	2,481	3,040	3,162	4,355
Kerex	549	699	888	1,416	2,030	2,485
Others	877	835	796	671	563	1,578
TOTAL	9,394	10,399	11,742	14,054	16,083	18,399

* Adapted from: Estadistica Petrolera, 1977, p. 111

APPENDIX C

This appendix is organized as follows:

Appendix C1 contains the following tables: C1: Estimates of the Ecuadorean fibers consumption, C2 and C3: Amounts (tons and dollars) of the Ecuadorean imports of principal petrochemicals, and C4: Composition of Guayaquil Gulf natural gas. Appendix C2 corresponds to uses and characteristics of polyethylenes and ethylene glycols.

TABLE C1

ESTIMATES OF ECUADOREAN FIBERS CONSUMPTION

FIBERS	1970 Thousands of Tons	%	1980 Thousands of Tons	%	1985 Thousands of Tons	%	RATES OF GROWTH 1980-1985
Cotton	10.0	63.7	19.00	47.4	23.00	40.5	3.9
Wool	1.0	6.4	2.00	5.0	2.50	4.4	4.6
Cellulosic	1.4	8.9	4.00	10.0	5.50	9.7	6.7
Synthetic:							
- Polyamidics	0.8		2.76		4.45		10.0
- Polyester	1.0		6.44		11.35		12.0
- Acrylics	1.5		5.91		9.96		11.0
Sub-Total:	3.3	21.0	15.11	37.6	25.76	45.4	11.3
TOTAL:	15.7	100%	40.11	100%	56.76	100%	

* Elaboration from: J.A.C. 1973, Anexos, p. 14.
CEPE, 1977, p. 43-47

TABLE C2

VALUE OF THE ECUADOREAN IMPORTS OF PLASTICS PRODUCTS AND SYNTHETIC RESINS
(Thousands of Dollars)

	1970	1971	1972	1973	1974	1975	1976	TOTAL
Polyethylene (L.d)	1,272.6	1,969.6	1,121.2	2,427.4	10,361.9	6,980.0	7,869.5	32,002.2
Polyethylene (H.d)	-	-	-	-	2,654.1	2,420.0	3,271.9	8,346.0
Polypropylene	158.9	111.4	39.7	194.2	1,779.0	1,022.6	2,361.6	5,667.4
P.V.C	660.7	537.7	1,136.6	1,875.6	7,203.1	3,600.0	5,000.0	20,013.1
Polyestirens	190.1	209.0	355.2	473.5	2,792.0	1,559.8	2,453.6	8,033.2
ABS - SAN Resins	17.4	78.8	107.5	480.0	751.2	598.4	700.0	2,733.3
PVA	307.8	418.5	270.6	343.7	531.4	765.0	750.0	3,387.0
Acrylic Resins	89.3	31.8	60.7	107.8	315.5	98.1	102.0	805.2
Ureic Resins	238.1	276.7	332.0	541.2	727.4	686.2	1,086.8	3,888.4
Alquidic Resins	364.4	441.4	555.6	598.5	1,637.9	1,170.0	1,912.2	6,680.0
Polyester Resins	123.7	131.7	139.9	386.9	341.6	1,565.3	2,598.4	5,287.5
Polyurethanes	-	132.9	297.2	484.9	1,016.1	693.2	1,087.8	3,712.1
TOTAL :	3,424.0	4,339.5	4,415.6	7,913.7	30,111.2	21,158.6	29,193.8	100,555.4

PVA : Polyvinyl Acetate
PVC : Polyvinyl Chloride
L.d : Low density
H.d : High density

Elaborated from : CEPE, May 1977.

TABLE C3

ECUADOREAN CONSUMPTION OF PLASTIC PRODUCTS AND SYNTHETIC RESINS

(Metric Tons)

	1970	1971	1972	1973	1974	1975	1976
Polyethylene (L.d)	3,823.1	6,299.0	3,832.7	7,034.0	10,740.0	11,630.0	13,980.0
Polyethylene (H.d)	-	-	-	-	2,620.0	3,840.0	4,650.0
Polypropylene	371.9	347.1	147.0	418.0	970.0	1,730.0	2,880.0
P.V.C	1,387.0	1,484.6	3,595.7	4,085.0	4,360.0	4,800.0	5,090.0
Polyestirens	537.8	612.4	1,088.3	1,206.0	1,690.0	1,950.0	2,000.0
ABS - SAN Resins	29.4	137.9	203.1	300.0	540.0	670.0	700.0
PVA	682.5	1,117.2	672.0	815.0	714.4	1,000.0	1,000.0
Acrylic Resins	198.3	50.5	121.1	106.6	299.9	91.6	15.0
Uretic Resins	749.2	961.4	1,009.0	1,488.0	1,113.6	1,044.9	1,680.5
Alquidic Resins	600.7	614.1	803.9	862.0	1,461.8	1,192.5	1,927.8
Polyester Resins	249.8	256.4	262.9	809.0	312.0	1,252.5	2,206.6
Polyurithanes	-	194.2	427.0	677.9	1,077.0	723.6	1,164.4
TOTAL :	8,629.7	12,163.5	12,163.5	17,837.5	25,898.7	29,925.1	37,429.3

PVA : Polyvinyl Acetate
PVC : Polyvinyl Chloride
L.d : Low density
H.d : High density.

Elaborated from : CEPE, May 1977.

TABLE C4

COMPOSITION OF THE NATURAL GAS OF GUAYAQUIL GULF

a) COMPOSITION		% MOLAR
	CH_4	98.60
	C_2H_6	0.78
	C_3H_8	0.22
i	C_4H_{10}	0.02
i	C_5H_{12}	0.01
n	C_5H_{12}	0.01
	C_6H_{14}	Traces
	C_7H_{16} (+)	Traces
	CO_2	0.02
	N_2	0.27
	SH_2	-
	TOTAL :	100.0

Specific gravity :	0.5625	
Gal Mol weight :	16.2970	
Total calorific value :	972.6600	BTU/feet^3

APPENDIX C2

CHARACTERISTICS AND USES OF POLYETHYLENES

Ethylene is the most highly developed olefin from a petrochemical viewpoint, and its price and availability exert a considerable effect throughout the strata of the industry from the cost of plastics to the cost of fibers or antifreeze for automobiles.

Polyethylenes are the principal use of ethylene and have been traditionally the major growth factor. It was discovered accidentally at I.C.I in 1933 (Hahn, 1970, p. 225) and also was the first polyolefin plastic to be made commercially.

> "Low density polyethylene is partially crystalline (50-60%) solid melting at 115°C, and has a density of 0.91-0.94 gm/cc. It is the older of the two polyethylenes, and is produced by high pressure polymerization of ethylene. In contrast, high density polyethylene (0.95-0.97 gr/cc) is more than 90 percent crystallyne and is produced via low-pressure polymerization of ethylene. In addition, high density polyethylene is linear, while low-density polyethylene is branched in structure. Hence, low-density polyethylene is often referred to as high-pressure or branched polyethylene, while high-density polyethylene is frequently described as low pressure or linear polyethylene. These differences in structure affect the mechanical properties of these resins and therefore their market applications (Brownstein, 1975, p. 135-37)."

The Ecuadorean use of both products is and probably will be similar to the general utilization in other countries and

particularly within the United States, although the respective percentages could vary.

The principal uses for L.D.P.,according to the U.S. Trade Commission (1975), in order of importance are: film & sheeting, injection molding, extrusion coating on paper, exports, wire and cable coating, pipes, miscellaneous, and blow molding.

Breaking down some of these global demands, the principal uses of L.D.P are as follows: (Data based on Hahn, 1965, p. 230-33).

Polyethylene film: Packing: Produce, bakery goods, frozen foods, meat and poultry, paper products, soft goods, dry cleaning; Non Packing: Construction, household uses, rubber industry, agriculture, other.

Injection molding: Closures, containers, housewares.

Extrusion coating: milk containers.

Cable and wire insulation.

Piping: drainage and irrigation.

Blow molding: jars, toys, housewares.

Foam: wire coating and packing electronic components

Emulsifiable polyethylene waxes: floor polish and textile softeners.

P.L.D : Polyethylene low density.

H.D.P : High density polyethylene.

Non emulsifiable waxes: Hot-melt adhesives, paper coating, packing outlets, printing inks.

This polyethilene is considered as a premium plastic.

The main applications of H.D.P, according to the U.S. Internal Trade Comission 1975, are: blow molding, injection molding (most important), film and sheets, wire and cable coating, pipe and conduit, extrusion coatings, miscellaneous. Principal components of these applications are as follows: (Data based on Hahn, 1965 p. 230-33).

Blow molded: Bottles for liquid detergents and containers.

Injection molding: Housewares.

Extrusion products: Film, coating and pipe.

In Ecuador the polyethylenes are used mainly as covering for exported bananas, packing boxes (substituting the traditional paper), for cable and wire covering, piping, containers, and recipients. In general terms, these uses are similar to those in other countries, but the percentages of utilization in other sectors differ or are less than in developed countries.

Characteristics and Uses of Ethylene Glycols

Ethylene oxide is a chemical widely used in both, the chemical industry and in research laboratories. It is a

highly active molecule whose ring structure can easily be opened under reaction with a variety of reagents, therefore it must be handled very carefully.

The major derivate of ethylene oxide is ethylene glycol, which consumes more than 75 percent of production. Next are ethanolamines, non-ionic surfactants, glycol ethers, and di-tri-and polyethylene glycols. In this sense, the ethylene oxide plant should provide the necessary feedstock for its principal derivate as well as for the others.

Figure 1 in Appendix C2, provides an illustration of the major ethylene glycol and glycol derivates.

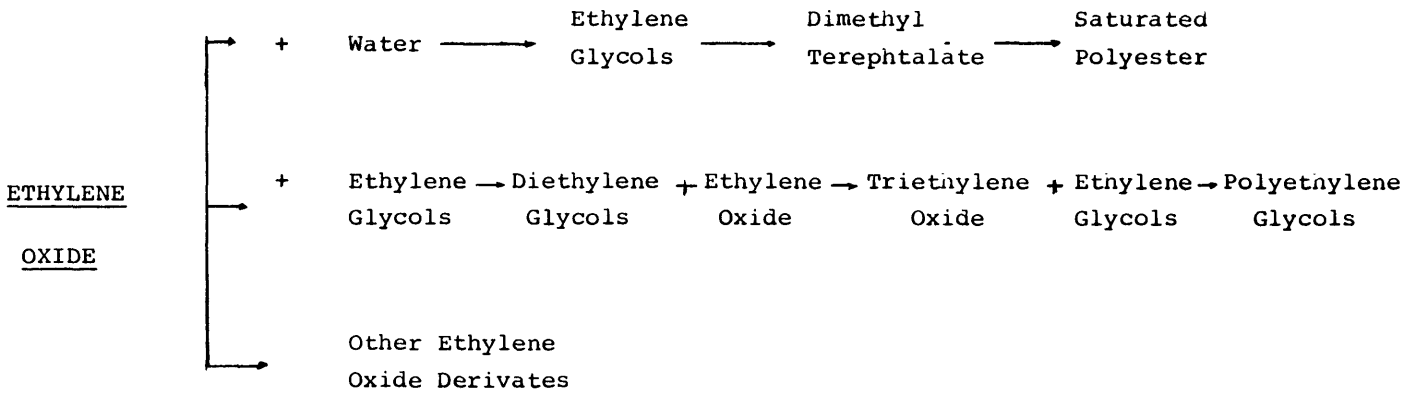
Uses - The principal regional application of ethylene glycol will be as a feedstock for the polyester fiber manufacture (chip of polyester), a very active industry within the ANCOM, and also for alquidic resins. Ethylene glycols' application as an antifreeze has not been considered for the Andean Market estimates because its use is not significative for the region.

Derivates of ethylene glycols, including di-tri-and polyethylene glycols, find their greatest usage in polyester resins, textile processing, lubricants, natural gas dehydration, and cosmetics.

APPENDIX C2

FIGURE C1

ETHYLENE OXIDE PRINCIPAL DERIVATES



* Source: CENDES, 1971, p. III-4 (Unpublisned).

APPENDIX D

COST CALCULATIONS

Appendix D is the longest appendix in this thesis, and in order to make it more manageable, it is divided into sections as follows: D1: Location Factor; D2: Cost Estimations, and D3: Meaning of the Terminology and Assumptions.

APPENDIX D1

Location Factor

The location factor was divided into two parts:

a) Freights, insurance and other costs for transporting the equipment, material, etc., required.

Texaco Co. & CEPE, were chosen as examples, because both have the largest imports in recent years. Normally, the supplier has been, and probably will be the U.S.A. Therefore, the location factor corresponds to that country.

The following table illustrates the location factor:

TABLE D1

Location Factor

ITEMS	Values (Thousands of Dollars) FOB*	CIF*	RATIO
Texaco (1975)			
- Mach. & Equipment	1,203.1	1,322.6	1.099
- Tools	110.7	120.3	1.087
- Materials	746.1	874.0	1.171
- Accesories	11,886.6	12,630.5	1.063
TOTAL	13,946.5	14,947.4	1.072
CEPE (1976)			
- Mach. & Equipment	3,700.6	4,053.6	1.095
- Tools	18.5	21.8	1.177
- Materials	11,963.7	13,607.0	1.137
- Accesories	10,396.4	11,960.9	1.15
TOTAL	26,079.1	29,643.4	1.137

Source: Ministerio de Recursos Naturales y Energeticos. 1977, Estadistica Petrolera, p.126-132.

* FOB: Free on Board
CIF: Cost, Insurance and Freight.

According to the Hydrocarbon's Law, the companies operating in the different phases of the petroleum industry do not pay duties or import taxes for the imports of all materials and products - not fabricated in Ecuador - necessary for the development of their activities.

The advantageous situation, determines a small relative difference (13.7-14% on average) between the FOB and CIF prices.

b) Other factors such as:

- Less labor efficiency (although less expensive) that means longer periods of construction and start-up.
- Greater costs of supervision.
- Use of some equipments and materials, sometimes more expensive than the imported.
- Lack of enough experience in the activity, given its complexity.

This part can mean a 3% higher cost. Probably as soon as Ecuador gains experience, this portion will be less.

In total, the location factor will be 17 percent greater than the cost of a plant of the same type in the Gulf Coast.

APPENDIX D2

This cost estimation appendix is broken down to supply calculations according to the product and source of basic information. The appendix is organized as follows:

D 2.1: High Density Polyethylene Cost Estimations

a & b) Brownstein source of basic material.

c) Junta del Acuerdo de Cartagena (JAC) and Stanford Research Institute (SRI) source material.

D 2.2: Low Density Polyethylene

D 2.3: Ethylene Oxide-Glycols calculations

a) Brownstein source.

b) JAC and SRI source basic material.

c) Centro de Desarrollo (CENDES), source basic material, capital and operating costs.

APPENDIX D 2.1

HIGH DENSITY POLYETHYLENE COST ESTIMATIONS

First will be considered Brownstein, then Stanford sources. All the data is in thousands of dollars.

a & b) Brownstein, 1976, p. 143-146

Size corrections

$$C_A = C_B \frac{(P_A)^e}{P_B}$$

where:

C_A = Cost plant A (Brownstein $ 54,300)

C_B = Cost plant B (Ecuador)

P_A = Annual capacity plant A (91,000 tons yearly)

P_B = Annual capacity plant B (50,000 tons yearly)

e_1 = 0.65 Guthrie, 1974, p. 61, 75.

e_2 = 0.67 Gallahar John, 1970, p. 7

a) Gathrie exponent

$$54,300 = \frac{C_B\ (91,000)^{.65}}{(50,000)}$$

$$C_B = \frac{54,300}{1.59}$$

$$C_B = 36,354.$$

b) Gallahar exponent

$$54,300 = \frac{C_B\ (91,000)^{.67}}{50,000}$$

$$C_B = 36,800$$

Time Corrections

$$\text{Cost now} = \text{Cost then} \frac{(\text{Index now})^* \ (\text{Nov. 1978})}{(\text{Index then})^* \ (\text{Mid 1975})}$$

a) Cost 1978= 36,354 $\frac{(224.5)}{(182.4)}$

Cost 1978= 44,745

b) Cost 1978= 36,800 $\frac{(224.5)}{(182.4)}$

Cost 1978= 45,300

Location Adjustments

Location factor: 17 percent

a) 44,745 x 1.17 = 52,350

b) 45,300 x 1.17 = 53,000

c) Source: Junta del Acuerdo de Cartagena (JAC) and Stanford Research Institute (SRI); (JAC, 1973, p.57)

C_A = Cost JAC plant (22,000)

C_B = Cost Ecuadorean plant

P_A = Annual capacity JAC plant (40,000)

P_B = Annual capacity Ecuadorean plant (50,000)

$$23{,}000 = C_B \frac{(40{,}000)^{.67}}{50{,}000}$$

$$C_B = 26{,}710$$

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* The indices are described in Table D4

Time Corrections

$$\text{Cost now} = \text{Cost then} \frac{(\text{Index now})}{(\text{Index then})} \frac{(\text{Nov. 1978})}{(\text{June, 1973})}$$

$$\text{Cost now} = 26{,}710 \frac{(224.5)}{(142.6)}$$

Cost now = 40,710

Location Adjustment

Ecuadorean Cost = (Gulf Coast) x (1.17)

Ecuadorean Cost = 47,630.

APPENDIX D 2.2

a) Low Density Polyethylene Cost Estimates

The plant has to be adjusted for the Ecuadorean time and location. The process and results are as follows:

Source basic material: JAC and SRI (JAC, 1973, 1. 58)

Time Corrections

$$\text{Cost 1978} = \text{Cost then} \frac{(\text{Index Nov. 1978})}{(\text{Index June 1973})}$$

$$\text{Cost 1978} = 24{,}500 \frac{(224.5)}{142.6}$$

Cost 1978= 38,600

Location Adjustment

Ecuadorean cost = (Cost 1978) (1.17)

Ecuadorean cost= 45,160

APPENDIX D 2.3

Ethylene-Oxide-Glycols Calculations

a) Source: Brownstein (1976, p. 156)

Size Corrections

$$C_A = C_B \left(\frac{P_A}{P_B}\right)^e$$

$$88{,}000 = C_B \left(\frac{227{,}000}{55{,}000}\right)^{.75}$$

$$C_B = 30{,}390$$

where,

C_B = Cost Ecuador

C_A = Cost Brownstein

P_A = Capacity Brownstein

P_B = Capacity Ecuador

e = 0.75 Guthrie, 1974, p. 61.

Time Corrections

$$\text{Cost 1978} = 30{,}390 \left(\frac{\text{Index Nov. 1978}}{\text{Index Mid. 1975}}\right)$$

$$\text{Cost 1978} = 30{,}390 \left(\frac{224.5}{182.4}\right)$$

Cost 1978 = 37,405

Location Adjustments

Ecuadorean cost = Gulf Coast (location factor)

Ecuadorean cost = 37,405 (1.17)

Ecuadorean cost = 43,760

b) Source: JAC and SRI (JAC 1973, p. 60)

Size Corrections

$$C_A = C_B \left(\frac{P_A}{P_B}\right)^e$$

$$21,500 = C_B \left(\frac{50,000}{55,000}\right)$$

$$C_B = 23,093$$

where,

C_B = Cost Ecuador

C_A = 21,500

P_A = 50,000

P_B = 60,000

e = 0.75, Guthrie

Time Corrections

$$\text{Cost 1978} = 23,093 \left(\frac{\text{Index Nov. 1978}}{\text{Index June 1973}}\right)$$

$$\text{Cost 1978} = 23,093 \left(\frac{224.5}{142.6}\right)$$

Cost 1978 = 36,356

Location Adjustments

Ecuadorean cost = 36,356 (1.17)

Ecuadorean cost = 42,540

APPENDIX D 2.3

c) Source basic material: Centro de Desarrollo (CENDES), June, 1971.

Size Corrections

$$C_A = C_B \left(\frac{P_A}{P_B}\right)^e$$

where,

C_B = Cost Ecuador

C_A = Cost CENDES

P_A = Capacity CENDES

P_B = Present capacity

e_1 = Ethylene oxide

e_1 = 0.78 Guthrie and Frumerman, 1974, p. 59 and 410.

e_2 = Ethylene glycols

e_2 = 0.75 guthrie, 1974 p. 61.

Battery Limits

Ethylene Oxide (E.O)

$$7{,}500 = C_B \left(\frac{23{,}000}{50{,}000}\right)^{.78}$$

$$C_B = 13{,}744$$

Ethylene Glycols (E.G)

$$2,900 = C_B \left(\frac{26,000}{55,000}\right)^{.75}$$

$$C_B = 5,087$$

Offsite Investments

E.O

$$2,400 = C_B \left(\frac{23,000}{50,000}\right)^{.78}$$

$$C_B = 4,392$$

E.G

$$900 = C_B \left(\frac{26,000}{55,000}\right)^{.75}$$

$$C_B = 1,575$$

Time Corrections

$$\text{Actual cost} = \text{Cost then } \left(\frac{\text{Index Nov. 1978}}{\text{Index Mid. 1971}}\right)$$

Battery Limits

$$\text{E.O} = 13,744 \left(\frac{224.5}{132.2}\right)$$

$$\text{E.O} = 23,365$$

$$\text{E.G} = 5,087 \left(\frac{224.5}{132.2}\right)$$

$$\text{E.G} = 8,647$$

Total cost 1978 = 23,365 + 8,647 = 32,012

Offsite Investments

$$E.O = 4,392 \left(\frac{224.5}{132.2}\right)$$

$$E.O = 7,466$$

$$E.G = 1,575 \left(\frac{224.5}{132.2}\right)$$

$$E.G = 2,677$$

Total cost 1978 = 10,143

1) Total Capital Cost = 32,012 + 10,143 = 42,155

In addition to the Total Investment (1) the following items have been considered:

2. Land

Source cost : $ 0.376/ft^2*

Applying Nelson Index for inflation

$$\text{Cost 1978} = .376 \left(\frac{688.8}{438}\right)$$

Cost 1978 = $.60/ft^2

Land requirements:

Battery Limits	:	70,000
Offsites and Storage	:	230,000
TOTAL:		300,000 ft^2

Land cost = (300,000) (.6) = $ 180.

---

* ft^2 : square feet.

4. Working Capital :

20 percent of ethylene glycols annual sales

(594 E.G/ton x .20 x 50 tons/year) = $ 5,940

5. Start-up Cost:

1 percent of Total Capital Investment

Ethylene Oxide : 320.12

Ethylene Glycols: 101.43

TOTAL : $ 421.55

6. Training Cost:

Ethylene Oxide : 150

Ethylene Glycols : 80

TOTAL:$ 230

Total Investment : $ 44,693.

TABLE D2

ETHYLENE OXIDE UNIT PRODUCTION COSTS

Method: Direct Oxidation Route
Capacity: 50,000 tons yearly

Raw Materials, Catalyst and Utilities		Unit/MT	$/Unit	$/M.T
Ethylene	MT*	0.99	330.75 (1)	327.44
Ethane	MT	0.002	108.71 (2)	0.22
Power	KWH	540	0.025 (3)	13.5
Fuel	BTU	1,940	2.00 (4)	3.88
Boiler Feedwater	MT	6.4	0.32 (5)	2.05
Cooling Water	M gal.	92.4	0.10 (6)	9.24
Silver Catalyst	MT	0.00023	14,300 (7)	3.29
Softened Water	MT	1.4	0.21 (8)	0.29
Total Raw Materials, Catalyst and Utilities:				$ 359.91
Direct Costs				
Operating Labor (O.L)				2.6
Fringes (40% of O.L)				1.04
Supervision (50% of O.L)				1.30
Maintenance (5% of B.L)				23.37
Total Direct Cost:				$ 28.31
Indirect Costs				
Overhead (100% O.L)				2.6
Depreciation (10% B.L)				46.73
(10% offsites)				14.93
Start-up and training amortization (10%)				0.93
Taxes and Insurance (3% B.L)				14.02
Total Indirect Cost:				$ 79.21
Total Manufacturing Cost:				$ 467.43
Less Credits				
Steam	MT	1.4	3.24 (9)	4.53
Condensate	MT	5.1	0.32 (10)	1.63
Net Manufacturing Cost:				$ 461.27

* MT = Metric Tons
KWH = Kilowatt hour
M.gal. = Thousand Gallons
B.L = Battery Limits.

TABLE D3

ETHYLENE GLYCOLS UNIT PRODUCTION COSTS

Process: Direct Oxidation Ethylene Oxide
Capacity: 55,000 annual tons.

Raw Materials and Utilities		Units/MT	$/Unit	$/MT
Ethylene Oxide	MT	0.76	467.43*	350.56
Process Water	MT	0.3	0.32	0.1
Circ. Cooling Water	M gal.	50	0.10	5.0
Power	KWH	70	0.54	3.78
Steam	MT	6.1	3.24	19.76
Total Raw Materials and Utilities:				$ 379.21
Direct Costs				
Operating Labor (O.L)				1.42
Fringes (40% of O.L)				0.57
Supervision (50% of O.L)				0.71
Maintenance (5% of B.L)				7.86
Total Direct Costs:				$ 10.56
Indirect Costs				
Overhead (100% of O.L)				1.42
Depreciation (10% B.L)				15.72
(10% offsites)				4.87
Start-up and training amortization (10%)				0.31
Taxes and Insurances (3% B.L)				4.72
Total Indirect Costs:				$ 27.04
Total Manufacturing Cost:				$ 416.81

Manufacturing Cost/lb = 19.00 ¢/lb

* Net Manufacturing Cost.

REFERENCES

a) Utility Pricing

(1) Ethylene cost: 15 ¢/lb (assumed)

(2) Ethane cost: 4.93 ¢/lb , Chemical Engineering, January 5, 1976.

(3), (5) Direct consultation: (Empresa Electrica Esmeraldas, INECEL).

(4) Chemical Engineering, January 5, 1976: $2.00/Mill BTU.

(6), (7), (8), (9), (10): Actualized from: CENDES using Chemical Engineering, OPEC Bulletin and direct consultations to Ecuador.

Example: (8): $\frac{\$0.8/\text{M gal}}{3.78\ \frac{\text{m}^3}{\text{M gal}}} = \$\ .21/\text{m}^3$

Steam power: actualized with M&S index for steam power.

b) Labor Cost

The following annual salaries for operating labor were used:

Ethylene Oxide: 20 plant operators.

Ethylene Glycols: 12 plant operators.

Salary : 6,500 per year.

Ethylene Oxide: 20 x 6,500/50,000 = 2.6/Ton.

Ethylene Glycols: 12 x 6,500/55,000 = 1.42/Ton.

TABLE D4

c) CHEMICAL ENGINEERING (C.E) PRICE INDECES

C.E Annual Index*	
1957-59	100
1970	125.7
1971	132.2
1972	137.2
1973	144.1
1974	165.4
1975	182.4
1976	192.1
1977	204.1
1978	224.5

* Source: Chemical Engineering, 1979 Jan/15, V.86 N 2.

APPENDIX D3

TERMINOLOGY AND ASSUMPTIONS

It is necessary to explain the meaning of some terminology used in this study.

Battery Limits (a): Consists of the costs of the equipment delivered to the plant site, the cost of erection (i.e.: foundation, piping, electrical installation, support, insulation, painting, etc.) as well as indirect costs during construction (including license and engineering fees, and expenses for procurement and administration). (a).

Inside Battery Limit (b): Include all materials and equipment required for actual processing.

Outside Battery Limit or Offsite Requirements (c): Consists of an offsite boiler, cooling towers, small fuel systems, tank-truck, loading facilities, water system, air compressor, fire water system, electric sub-station, communication and lighting, painting, etc.

Total Investment: Fixed capital, start-up cost and working capital.

Fixed Capital (d): Battery-limit cost (the cost of production unit): storage, tankage and utilities costs; the cost for general service facilities, land cost, and expenses during construction.

Working Capital: Normally for an order of magnitude estimate 10 percent of the total fixed capital investment is used.

Cost of land, site preparation, and pilings are not included in the estimates. Start-up costs are also omitted. These item vary too much, are interpreted differently by companies, and are capitalized differently depending on individual firms acounting practices.

The cost estimates are for a normal or average plant, therefore specific requirements for any plant will change the estimations.

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* (a) (d): Yen-Chen Yen, 1972, Estimating Plant costs in the developing countries. Chemical Engeneering, July/10/1972.

(c) (b): Baba Theodore and Kennedy James, 1976, Ethylene and its co-products; The New Economics. Chemical Engineering, Jan/5/1976.

LIST OF ABBREVIATIONS

ANCOM = Andean Common Market.

Bbl/d = Barrels/day.

CAF = Corporacion Andina de Fomento.

CED = Common External Duties.

CENDES = Centro de Desarrollo Industrial en Ecuador.

CEPE = Corporacion Estatal Petrolera Ecuatoriana.

CIF = Cost, Insurance and Freight.

E.G. = Ethylene Glycols.

E.O. = Ethylene Oxide.

FOB = Free on Board.

HDP = High Density Polyethylene.

JAC = Junta del Acuerdo de Cartagena.

LDP = Low Density Polyethylene.

MICEI = Ministerio de Industrias, Comercio e Integracion.

MRNYE = Ministerio de Recursos Naturales y Energeticos.

SRI = Stanford Research Institute.

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