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DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY

IN CHILE<sup>1/</sup>

by

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Chile

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## 1. INTRODUCTION

As in other Latin American countries, the intermediates and end-products of chemical industry in Chile have begun, from the nineteen-fifties onwards, to use raw materials that in growing proportions have their origin in the petrochemical industry.

Side by side with this change, and because of the hardening of domestic markets, in certain categories of demand, such as for plastics, paint and adhesives, a vertical integration of the industries in that sector was started between 1960 and 1964, leading to the preparation in Chile of the simpler kinds of polymers, synthetic resins, plasticizers and solvents, which were, however, still dependent on imported raw materials. Thus it is estimated, for example, that in 1964 Chile imported petrochemical raw materials to a total value of US\$20 million; forward trends showed a rapid increase in such imports, thus imposing an ever heavier burden on the balance of payments.

The inauguration in 1964 of the Development Programme of the National Petrochemical Industry, through the establishment of Petroquímica Chilena S.A., radically altered the situation depicted above.

Thanks to this development programme, and to the introduction of an incentives policy for chemical and petrochemical development in Chile, there are in course of installation at the present time a number of plants for basic, intermediate and final petrochemical products, representing investment commitments of some US\$30 million, out of a total investment of US\$150 million to be committed during the period 1965-1972.

In the implementation of the programme the part played by each of the factors concerned should be singled out: the Chilean Government, mainly through the medium of Petroquímica Chilena; the chemical industry and Chilean private enterprise; and, lastly, foreign investment. The responsibility, degree of involvement, contribution and credits of each of these active development factors are worked out and specified for each separate project, in accordance with the guidelines of a general development policy that defines the spheres of action of each of these factors, seeking, preferably, the integration and uniting of efforts by the formation of companies associated with Petroquímica Chilena and in which that Company usually holds a minority interest.

In any case, the production of these basic raw materials for the development of the chemical and petrochemical industry is the special concern of the Chilean Development Corporation (Corporacion de Fomento de la Produccion) acting through its working subsidiaries: Empresa Nacional del Petroleo (National Petroleum), Petroquimica Chilena S.A. (Chilean Petrochemicals), Sociedad Quimica Minera de Chile S.A. (Chilean Chemical and Mining Company Ltd.), Fabrica de Acido Sulfurico S.A. (Sulphuric Acid S.A. Ltd.), etc.

2. PETROQUIMICA CHILENA S.A. AND THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN CHILE

Petroquimica Chilena is a private industrial undertaking, established in May 1966 for the purpose of planning, promoting and developing the petrochemical industry in Chile.

Its shareholders are two autonomous agencies of the Chilean public sector: the Chilean Development Corporation (CORFO), a body responsible for promoting national development, and the Empresa Nacional del Petroleo (ENAP), an agency which, under Chilean law, has the duty of prospecting for, exploiting and refining petroleum in its territory in Chile.

In order to achieve its aims, Petroquimica enjoys the operational flexibility of a private company: it can install its own plant or form companies associated with other undertakings both Chilean and foreign, in Chile and abroad, using for that purpose its own resources or direct or indirect credits. It can also actively engage in the marketing of chemical and petrochemical products, opening up channels of access to both domestic and foreign markets.

Through its close connexion with the Chilean Development Corporation, and thereby with other government agencies, Petroquimica is able to collaborate in the planning and development of the sector - and indeed is doing so at different levels - taking an active part in the handling of factors bearing on the sector's development, such as credit and tariff policies, market expansion and internationalisation, fiscal policy, etc.

Finally, it should be pointed out that a basic requirement for attracting the interest of investors to the sector is to carry out market research and to provide technical and economic studies prepared according to the most up-to-date standards of project evaluation. That is precisely one of the functions

that Petroquimica is carrying out.

For the fulfilment of the purposes and functions mentioned above, Petroquimica relies on a simple and flexible structural organization composed of five main divisions:

- Development Division: This Division, composed mainly of chemical engineers and industrial scientists, is responsible for tanking up, investigating and evaluating new projects, and also for following market developments, promoting investment by the formation of associated companies, and creating the requisite industrial infrastructure.
- Technical Division: This Division is responsible for the technical planning and construction of plants owned by Petroquimica or associated companies, and for the operation of Petroquimica plants.
- Commercial Division: This Division will be responsible for planning the production of Petroquimica plants and also for marketing it.
- Finance Division: This Division is responsible for administering Petroquimica's own funds (registered capital \$100 million, amounting to rather more than US\$10 million) and also credits obtained by the Company for its normal development.
- Administration and Personnel Division: This Division carries out its appropriate functions in accordance with up-to-date concepts of industrial relations and personnel administration.

### 3 CHARACTERISTICS OF THE ECONOMIC MARKET

As a result of the changes mentioned above, and because of the introduction of the Development Programme of the Petrochemical Industry, the Chilean market has undergone a marked change. This can be attributed to the confident expectation that the basic raw materials and intermediate products needed by the intermediates and end-products chemical industry, will very shortly be

available in Chile.

On that assumption, the country's official financial and credit institutions have adopted a policy of market promotion, helping to equip and expand the intermediates and end products chemical industries in those sectors whose development is envisaged in the Programme.

At the same time, the financial and exchange policy-making bodies are co-ordinating their measures with a view to encouraging the supply of raw materials of domestic and regional origin and thus help to integrate the chain of production processes in the petrochemical industry on a national and regional basis.

The plastics industry is a case in point. Up to 1965, the processing industry depended very largely on imported raw materials and equipment, and this, generally speaking, constituted a serious impediment to the normal development of the industry. In 1965 measures began to be adopted to promote the development of the plastics processing industry, for the purpose of enabling it to absorb the future production of petrochemical raw materials envisaged in the Development Programme.

In order to secure a concentrated and effective effort to that end, the Chilean Plastics Institute (Instituto Chileno del Plastico) was established in 1968 on the initiative of Petroquimica Chilena, the plastics processing industry, and the raw materials processing industry for the plastics industry.

Thus, between 1963 and 1973 the market for plastics increased two and a half times, and the upward trend of consumption indicates that between 1968 and 1973 the market for plastics in Chile will increase another two and a half times, thus achieving a consumption of some 8-7 kgs per head of the population per annum.

As a corollary to the above it may be inferred that it is a distinct characteristic of markets for petrochemical end-products, in countries at Chile's stage of development, to respond rapidly to promotional stimuli, if these are part of a definite development programme; hence, the guaranteed supply of domestic raw materials is only one of several factors requiring action by the promotional agencies.

It is probable that this response of the Chilean market to a larger consumption of petrochemical products is also a sign of the degree of sophistica-



tion attained by the consumer, although the extent to which traditional products are replaced by a larger consumption of modern synthetic goods, such as plastics, synthetic rubber, detergents, synthetic fibres, would seem to indicate, up to a certain point, the familiarity of the consumer market with products that have their origin in the more advanced technologies, as in the case with the petrochemical products.

The main limitation of the Chilean market is not, therefore, a lack of familiarity with, or adaptability to, advanced technology products, but their scarcity. Hence the need to expand markets by means of the machinery for economic integration and the agreements for complementing industrial production offered by the Treaty of Montevideo.

#### 4. DEVELOPMENT PROGRAMME OF THE PETROCHEMICAL INDUSTRY IN CHILE

This development programme is closely linked with the very existence of Petroquímica Chilena. Its essential feature is that it is a well-balanced programme based on the country's characteristic raw basis.

The first steps in the preparation of the Petrochemical Programme were taken between 1963 and 1964.

Up to that time the only petrochemical installations existing in Chile were for processing end-products, namely, which may be mentioned chemical solvents, some types of resins, polystyrene, synthetic detergents, etc., and their main feature was that they were run separately from one another and were based entirely on the requirements of the domestic market.

In 1963 CHIC entrusted a private specialist firm with the task of preparing a feasibility study of a possible development programme for the Chilean Petrochemical Industry. It should be mentioned that the market research carried out in conjunction with the feasibility study not only analyzed the Chilean market but also carried out a survey of other I.A.T.A. countries. This feasibility study, completed in 1964, supplied what may be called the basis of the present development programme of the Chilean Petrochemical Industry.

All the proposed installations are to be centralized in four main complexes, namely, the ethylene and olefins complex, the acetaldehyde complex, the ammonia and natural gas complex, and the aromatics complex.

Parallel with this study, the Petrochemical Technical Commission, composed

of representatives of CORFO and ENAH, took up its functions. This Commission, founded finally establishing the basis of the present Development Programme, proposed the creation of Petroquímica Chilena as an affiliate of CORFO and ENAH. This, with the establishment in 1965 of Petroquímica Chilena Ltd., which was later changed to Petroquímica de Chile S.A. (joint stock company), the present Development Programme was finally completed.

This Programme is outlined in the attached chart.

#### Ethylene and Petrochemical Complex

This complex was set up around an olefins plant (steam cracking of naphtha) and its construction in the Salobre de refinery in the Concepcion region, a plant that will be owned by ENAH, will have a yearly output capacity of 1,000,000 tons of ethylene, 400,000-500,000 tons of propylene and about 100,000 tons of butadiene. It will begin operation in the first half of 1970. The ethylene will be used mainly for the production of vinyl chloride, polyethylene, and vinyl acetate monomer.

The first two plants, with another for polyvinyl chloride, belong to the Petrochemical Complex (plastic resin complex) which is being set up in the vicinity of the ethylene plant. The polyvinyl chloride plant will have an installed capacity of 15,000 tons a year, and the polyethylene plant 20,000 tons a year. The output of both plants is designed mainly to satisfy the needs of the Chilean market. They will begin operation in the second half of 1970.

In order to supply chlorine to the vinyl chloride monomer plant, Petroquímica is installing a chlorine-sulfuric acid plant, also in the same zone, and it is to begin operation early in 1970. The sulfuric acid produced will be destined mainly for the following industries: rayon, cellulose, soap, detergents, textiles and cellulose. The chlorine, in addition to the uses already mentioned, will be utilized for the cellulose industries, drinking water, and for the production of chlorine derivatives. With regard to this last point, a study is under way for the installation of a series of plants for the production of organic and inorganic chlorine derivatives with the aim of supplying the domestic market and possibly some member countries of LA TA.

#### Acetaldehyde complex

This complex will produce mainly vinyl acetate monomer and the higher alcohols (2-ethyl hexanol and butanols). The vinyl acetate monomer plant,

whose capacity will be in the region of 15,000-20,000 tons a year, will be based on one of the modern processes using ethylene and acetic acid as raw materials. The higher alcohols will be produced by the FXO process, which uses as raw materials propylene and synthesis gas (X. van Nynhoven). Its installed capacity will be about 20,000 tons, including 2-ethyl hexanol and n-butanol.

Since 1967 there has been in operation a pentaerythritol plant belonging to a private company named OXIQ/II, whose principal raw material is acetaldehyde. A large part of the output of this plant is for export.

#### Ammonia complex

SHAF is maintaining a natural gas separation plant in Haganines, in the southern extremity of the country. One of the products of this plant will be methane, a raw material for the production of ammonia. The installed capacity of the ammonia plant will be around 1,000 tons a day, the size of the plant being comparable with the largest operating in the world at present. A urea plant is also to be installed, with a capacity of 900-1,000 tons a day. The output of both plants will be largely designed for the world market in fertilizers. The size of these plants and the price of the raw materials make it clear that these products will be able to compete with those of other countries.

#### Aromatics complex

This complex, at present in its initial stage, does not envisage the installation of basic plants, since the domestic market does not at present warrant installation on a large enough scale to achieve competitive prices. It is thought first to set up a polyester chip plant, which will use as raw material dimethyl terephthalate, to be imported, in order to complement the petrochemical industry. An ethylbenzene plant is also to be installed, for the purpose of providing raw material for the production of synthetic detergents, and possibly a phthalic anhydride plant, the products of which are mainly used for the manufacture of plasticizers and polyesters.

The plants and processes mentioned above are at present only the skeleton of what will be, in a few years, the petrochemical industry of Chile. The construction of many ancillary plants is being planned, and these, in one way

or another, will increase the viability of those already mentioned, the plans for which are already under way.

#### 5. TECHNOLOGICAL RESEARCH

Chile, in common with other developing countries, has no technology of its own in the field of petrochemicals. There is a clear awareness of this problem, in respect of which many measures could be taken, although they would probably not bear fruit except in the long run. Until then, technology will have to be imported, by payment of licenses (know-how and royalties).

It is generally assumed that by means of research and development it is possible to develop appropriate processes. Ways of achieving that goal are very varied and depend on many factors. The main thing, however, is that efforts should be united, perhaps not merely within a single country but as far as possible within a group of countries, so that each can benefit from the experience of the others, and that investment and efforts should not be duplicated in order to be finally in a position to compete in this field with the developed countries. The areas where classes are likely to take place will first be in the utilization of by-products, which, in view of the poverty of the markets in the developing countries, cannot be adapted to suit various uses, and therefore require to be obtained in a different way from that customary in other countries, and are consequently more expensive than those of other origin. A specific example of this, in the case of Chile, is the use of isobutyl ethylene, a by-product of the FCC reaction. This could be hydrogenated to isobutane and employed as a solvent in various processes not under study, thus giving a preliminary indication of the usefulness of producing it in Chile.

As far as possible this task should be carried out in every country with the combined assistance of the principal producing companies and the universities, and with government support. There is also an obvious need, in this connexion, for the development of engineering firms able to design and install plants for domestic or imported processes. It would be logical for such engineering firms to start with small-scale projects and to expand these as conditions permit.

## 6. HUMAN RESOURCES

Specialization at the various levels of production, from workers to professionals, is not as advanced in Chile as could be desired, no doubt because of the limited progress made up to now by the petrochemical industry. It should be pointed out that the only industry which has been able to train specialists to any extent is the petroleum industry, which has been established in Chile for about twenty-five years already. Nevertheless, this industry is also developing very fast because it calls upon the services of a large number of professionals and experts. Analyzing this problem at the professional level, it is thought that, as the petrochemical industry develops, the universities will keep pace with it and will turn out graduates increasingly better equipped for work in this field.

It is generally known that the petrochemical industry employs relatively little direct manpower, mainly because it is so largely automated. It should, however, be emphasized that studies carried out in countries more advanced in the field of petrochemicals reveal that the generation of indirect employment is estimated at 1:20. In other words, a person employed in basic petrochemical industry creates employment for twenty others in ancillary activities and end-product industries set up because of the basic industry.

## 7. NATURAL RESOURCES: PETROLEUM AND NATURAL GAS

There are two refineries in Chile, one located in Concon, a province of Valparaiso, and the other in San Vicente, Concepcion. There are also two gasoline plants at Huelmo, in the island of Tierra del Fuego.

In 1967, the two refineries processed some 3,500,000 cubic metres of crude oil, of which 1,500,000 were domestic and 2,000,000 imported. In 1968, approximately 4,200,000 cubic metres of crude oil were refined, of which 2,270,000 were domestic and 1,930,000 imported. In other words, Chile was self-supporting as regards almost half (50 per cent) of its petroleum requirements. The remaining 46 per cent was petroleum from Venezuela.

The production of the domestic refineries, for 1967, is shown in the following table:

(in cubic metres)

Product	Concon	Concepcion	Gasoline Plants	Total	
				1968	(1967)
Automobile gasoline	647,500	652,500	21,150	1,361,500	(1,306,950)
Aviation gasoline	36,000	-	-	36,000	(45,000)
Kerosene	182,200	206,500	3,300	394,000	(367,000)
Diesel	344,500	362,700	10,400	787,000	(630,100)
Fuel oil	653,700	32,400	-	1,193,100	(1,092,300)
Liquid gas	78,600	100,200	100,700	466,500	(477,600)
Solvents and miscellaneous	79,500	20,200	-	99,700	(68,800)

The refining capacity of these refineries is some 2,500 cubic metres a day for the Concon refinery and 5,700 cubic metres a day for the Concepcion refinery. This latter will be increased by 3,500 cubic metres a day from the end of 1969. It is also estimated that by the middle of 1973 the Concon refinery will have a capacity of 10,000 cubic metres a day, i.e. capacity will be increased by about 8,500 cubic metres a day.

These refining capacities are quite adequate for supplying raw materials to the petrochemical industry, and the increases undoubtedly took these requirements into account.

The production of crude oil and natural gas in Chile is located in the province of Magallanes, in the southern extremity of the country, both on the mainland and on the island of Tierra del Fuego.

ENAH is exploring in various parts of the country and has obtained, in the Arauco region, near Concepcion, preliminary results that seem to offer some prospect of the existence of hydrocarbons.

### 3. FUTURE ACTION

The achievements and the projects in hand under the Development Programme of the Chilean Petrochemical Industry, now in the stage of consolidation, enable the promoting agency, Petroquímica Chilena, to give a clear picture of future action.

The bases on which future action will be built are three in number:

- (a) Availability at short notice of basic raw materials for the petrochemical industry: ethylene, propylene, chlorine, ammonia, sulphur, sulphuric acid, caustic soda, etc.
- (b) Access to larger markets through the IATA machinery for the integration and complementing of the industrial production of the sector; this machinery is already in operation, or will be shortly.
- (c) Constructive action on the part of the Chilean petrochemical end-products industry, both by diversifying and by expanding its industrial activity, and by upward integration in the use of petrochemical raw materials, both domestic and regional.

Thus, for the next few years the Chilean petrochemical industry will concentrate mainly on the following spheres of action:

1. Continuation of the installation programme of the complexes already under way:
  - Plastic resins complex;
  - Vinyl acetate (VAc) alcohols;
  - Ammonia complex.
2. Study, programming and installation of additional plants for the complexes already under way. Among new plants being considered may be mentioned:
  - Derivatives of acetic acid and vinyl acetate;
  - Derivatives of the chlorine-soda plant;
  - Derivatives of the OXO alcohols.
3. Consolidation and expansion of the present lines of production of the domestic chemical and pharmaceutical industries so as to adapt them to the forthcoming availability of petrochemical raw materials of domestic and regional origin. This joint effort by Chilean private industry and Petroquímica Chilena will be shown in the formation of new production companies in the intermediate and end-products sectors, to develop new production in the field of polymers and synthetic resins and in the field of organic synthesis.

In this way the Chilean petrochemical industry will present, after a few years, an integrated and flexible structure that will enable it to meet the demands of an active and constantly evolving market by the maximum use of available resources and also by the greater technological and economic efficiency brought about by industrial co-ordination at the regional level.

Finally, it should be emphasized that the measures taken in Chile to achieve a planned development of the petrochemical industry are an important factor, in the country's global economy, for enabling it to reach the requisite degree of development in the shortest possible time.



PETROCHEMICAL AND REFINING PLANTS IN CHILE

<u>Product</u>	<u>Capacity tons, p.a.</u>	<u>Year Ending March</u>	<u>Raw Materials</u>
Ethylene	60,000	1970	Naphtha
Propylene	40,000	1971	
Chlorine	33,000	1970	Common salt
Caustic soda	37,000	1970	Common salt
Sodium chlorate	5,000	1971	Common salt
Hydrochloric acid	5,000	1970	Chlorine and hydrogen
Vinyl chloride monomer (VCM)	18,000	1970	Chlorine, ethylene
Polyvinyl chloride (PVC)	15,000	1970	VCM
Polyethylene	20,000	1970	Ethylene
Synthesis gas	30 (millions, normal cubic metres)	1971	Fuel oil, oxygen
n-ethyl hexanol	17,300	1971	Synthesis gas, hydrogen, propylene
n-butanol	2,500	1971	
i-butanol	7,000	1971	
Vinyl acetate monomer (VAM)	15,000	1971	Ethylene, acetic acid
Pentaerythritol	2,000	1967	Formaldehyde, acetaldehyde.
	5,000 (#)	1970	
	7,000 (#)	1972	
Formaldehyde	13,000	1967	Methanol (##)
	23,000 (#)	1970	
Ammonia	330,000	1972-73	Natural gas
Urea	300,000	1972-73	Ammonia, carbon dioxide
Alkylbenzenes	12,000	1971	Benzene, propylene tetramer (##)

(#) Total projected capacity, including present capacity and increases.

(##) Imported raw materials.





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