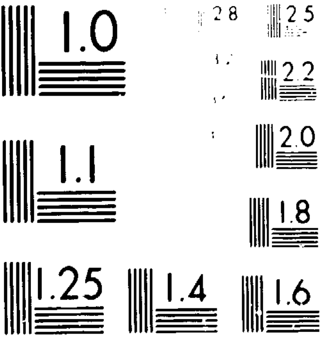
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org


1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

11564

Distr.
LIMITED

ID/WG.368/21
24 June 1982

ENGLISH

United Nations Industrial Development Organization

Petrochemical and Polymer Consultation Week

Porto Alegre, Brazil, 17 - 21 May 1982

THE PETROCHEMICAL AND POLYMER INDUSTRIES IN ARGENTINA*

by

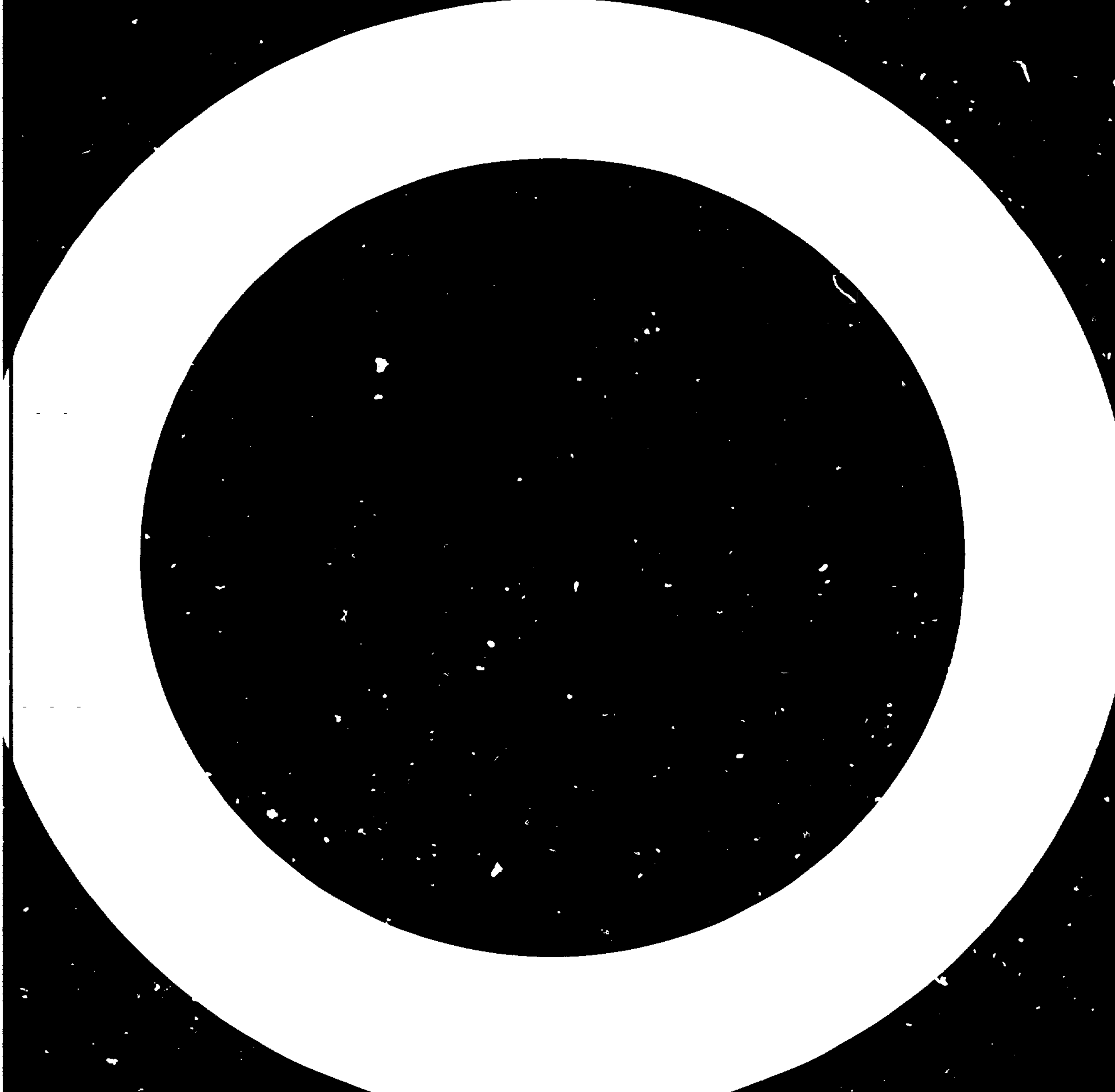
Esteban A. Brignole**

Numa J. Capiati **

* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Planta Piloto de Ingenieria Química, PLAPIQUI, 12 de Octubre 1842, 8000 Bahía Blanca, Argentina.

V.82-28157



CONTENTS

ACRONYMS AND NAMES OF ORGANIZATIONS INVOLVED

DGFM	Dirección General de Fabricaciones Militares, the government agency responsible for industrial development for the national security.
ITD	División de Tecnología Industrial, the part of PLAPIQUI especifically involved in industrial cooperation.
ELECTROCLOR	Satellite company, privately owned, partly by ICI (Imperial Chemical Industries), and one of the two main polyvinyl chloride producers in other locations at present, which will produce polyvinyl chloride in the complex.
G d E	Gas del Estado, specifically the Ethane Plant at Gral. Cerri to extract ethane from natural gas for PBB and to produce LPG.
INDUCLOR	Satellite company, a subsidiary of INDUPA and DGFM, which will produce chlorine and caustic soda for the Complex.
INDUPA	A private Argentinian company, one of the two main polyvinyl chloride producers in other locations at present, which will produce polyvinyl chloride in the Complex.
IPAKO	Originally Industrias Petroquímicas Argentinas Koppers, but for some years now a private Argentinian company, with many businesses including ethylene by cracking and low density polyethylene in another location at present.
MONOMEROS VINILICOS	Satellite Company, a subsidiary of ELECTROCLOR, DGFM, and INDUPA, which will produce vinyl-chloride monomer.

PBB — Petroquímica Bahía Blanca, a mixed private and national Argentinian Company owned by Gas del Estado, DGFM, and IPAKO, which will produce ethylene from ethane for the Complex.

PETROPOL — A mixed private and national Argentina company owned by INDUPA and DGFM, which will produce high density polyethylene from ethylene at the Complex.

PGM — Petroquímica General Mosconi, a national Argentinian company owned by DGFM and Yacimientos Petrolíferos Fiscales (the national oil company), which started up the first petrochemical complex in 1974 at La Plata, near Buenos Aires, using refinery feedstocks.

PIDCOP — Programa de Investigación y Desarrollo del Complejo Petroquímico Bahía Blanca, for UNDP and UNIDO the National Counterpart Organization, of which the operating arm is PLAPIQUI and the members are CONICET, Universidad Nacional del Sur, PBB, GdE, DGFM and now all of the satellite companies.

PLAPIQUI — Planta Piloto de Ingeniería Química, a Chemical Engineering education, research and service organization belonging to Universidad Nacional del Sur (UNS) in Bahía Blanca and Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) in Buenos Aires.

POLISUR — A mixed private and national Argentinian company owned by IPAKO and DGFM, which will produce low density polyethylene from ethylene at the Complex.

PPBB — Polo Petroquímico Bahía Blanca, the total petrochemical complex.

UNDP — United Nations Development Program (Headquarters in New York), the Funding Agency providing international assistance to the project through PIDCOP.

UNIDO	United Nations Industrial Development Organization (Headquarters in Vienna), the Executing Agency for implementation of UNDP assistance to the Project through PIDCOP.

Introduction

Feedstocks availability and potential increase of the domestic market for petrochemical products show that the petrochemical industry in Argentina, could play a key role on its future industrial development.

The last ten years have seen the development of two main industrial projects: an aromatic complex at Ensenada (La Plata) and an olefines pole at Bahía Blanca. The former started production in 1974 and production in Bahía Blanca have recently begun. In both places there are several plants under construction or in the planning stage, once these plants enter in operation, a fully integration will be accomplished within these complexes.

A new petrochemical promotion decree was established in 1979. This decree opened up basic petrochemical production to private firms. Based on this decree a large number of projects have been proposed, summing up a potential investment close to six thousand million dollars.

In accordance with the development plans for the petrochemical industry, the argentinian government, with industrial and international support (UNIDO), put forward a program for establishing a Center for Petrochemical and Polymer Technology at Bahía Blanca. Besides, the Science and Technology Office (SUBCYT) has set up a National Program on Petrochemical Technology to coordinate and promote research and development activities carried out by several research institutes in the country.

In this report, it is given a brief statement of the status of the petrochemical sector in Argentina, covering industry and technology, and a forecast of their future development. Later, it is discussed the need and strategy for establishing a technological center. Finally, it is presented the experience of establishment of a technological center at Bahía Blanca, its present capabilities, results and plans for international cooperation and exchange.

THE ARGENTINIAN PETROCHEMICAL INDUSTRY

1. Legal Framework of the Petrochemical sector

The development of the petrochemical industry in Argentina during the 1960's is related to various legal instruments connected to the promotion of industrial development in general and the petrochemical industry in particular. Within these decrees it is worth mentioning: 14.780/58,, Foreign Investments Law, 14.781/59 General Industrial Promotion and the 4271/69 decree, the first legal instrument specifically promoting the Petrochemical Industry.

Under the Decree 4271/69, various petrochemical projects arose, one of them being the Petroquímica Bahía Blanca Complex, whose organization was commended to DGFM (Dirección General de Fabricaciones Militares) through the decree 3056/71; this decree ordered the constitution of a society where the majority of shareholders belong to the state, for the production of ethylene and a summon's to private enterprises for the utilization of this product.

The activity of the Argentine Petrochemical Industry at present is carried out according to Decree 814/79, which establishes the sectorial regime for the petrochemical industry, which is in force until December 31, 1985. This decree proposes promoting the development of the Petrochemical Industry, on the basis of regional industrial complexes, modelled on a minimum economic scale and incorporating modern technology. A priority is also established for making use of the hydrocarbons as a petrochemical feedstock instead of being consumed as fuels. A majority of private capital in basic petrochemicals production is allowed.

1.1. Price Regulations for the Petrochemical Raw Materials

In the Decree 814/79 it was established that under no circumstances the price of petrochemical raw material could exceed its price as a fuel. Besides, another decree establishes a guarantee to the petrochemical sector of a level of maximum prices for its feedstocks, without changing the prices already agreed for the operating industries.

2. Petrochemical Raw Materials

2.1. Liquid Hydrocarbons

The Oil Industry carries out a significant role in the provision of petrochemical raw materials, at the same time this industry is conditioned to the requirements of the energy market and the availability of crude.

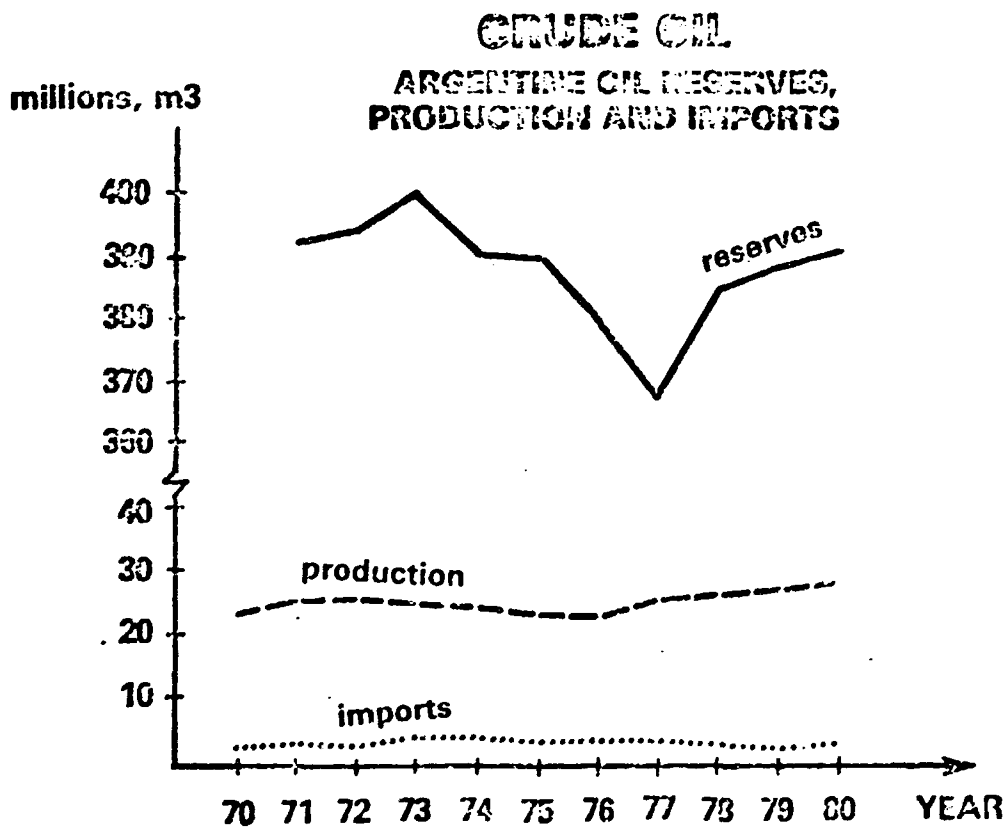
The national energy consumption grew during the 1976-80 period at an annual average rate of 1,5%, totalizing at the end of the 5 year period 37,9 million tons of crude oil. Meanwhile nuclear energy (1,5%) and coal (2-3%) held their percentage in the national energy supply. Oil was substituted by natural gas and hydroelectricity; whereas the oil reduced its contribution from 62% to 57% and natural gas and hydroelectricity increased theirs from 24% to 28% and from 4% to 11% respectively. In this picture of saving and substitution of energy sources, the Argentine Petrochemical Industry will carry out its future activity.

The oil reserves in 1980 amounted to 392 MMm3, which would insure theoretically a 14 year supply, taking into account that the annual production during 1980 was 28,5 MMm3. The importing of oil during the 1970's represented an annual average of 10% of the production, and whose development had two very different aspects in the period analized:

1. 1970-75 stagnation of the production
2. 1976-80 the production grew at an annual rate of 4,5%.

Forecasting an 2.4% annual average rate of increase in the oil production, for the 1970-80 period, the reserves will come to an end towards the present decade. The evolution of reserves, production and imports during the last decade are depicted in Fig. 1. The production expected during the present decade is shown in Fig. 3. It is hoped that as from 1985, the offshore production will begin, otherwise, it will be necessary to fall back on increasing importation. To conclude, in order to get to the year 2000 with a sufficient volume of reserves, means having to discover 900 MMm3,

FIGURE 1


CRUDE OIL
ARGENTINE OIL RESERVES,
PRODUCTION AND IMPORTS
millions, m3
400
390
380
370
360
40
30
20
10
reserves
production
imports
70 71 72 73 74 75 76 77 78 79 80
YEAR

a quantity similar to the total amount of oil found in Argentina since 1907 up to the present date. The main liquid hydrocarbon used in Argentina as a petrochemical raw material is straight gasoline (naphtha).

Naphtha

Is the only hydrocarbon raw material used in the Argentine for the production of aromatics. It is also used for the production of the whole range of olefins. The availability of naphtha depends on the quantity and quality of the oil processed, as in the demand of motonaphtha. Naphtha for petrochemical use represents 2,5% of the volume of processed crude.

The petrochemical demand of naphtha totalized in 1978, 751400 m3, 66% corresponding to Petroquímica General Mosconi (PGM), 25% to Petroquímica Argentina S.A. (PASA) and 9% to Duperial. During 1970 to 1978 the demand of naphtha grew at a rate of 20,5% annual average.

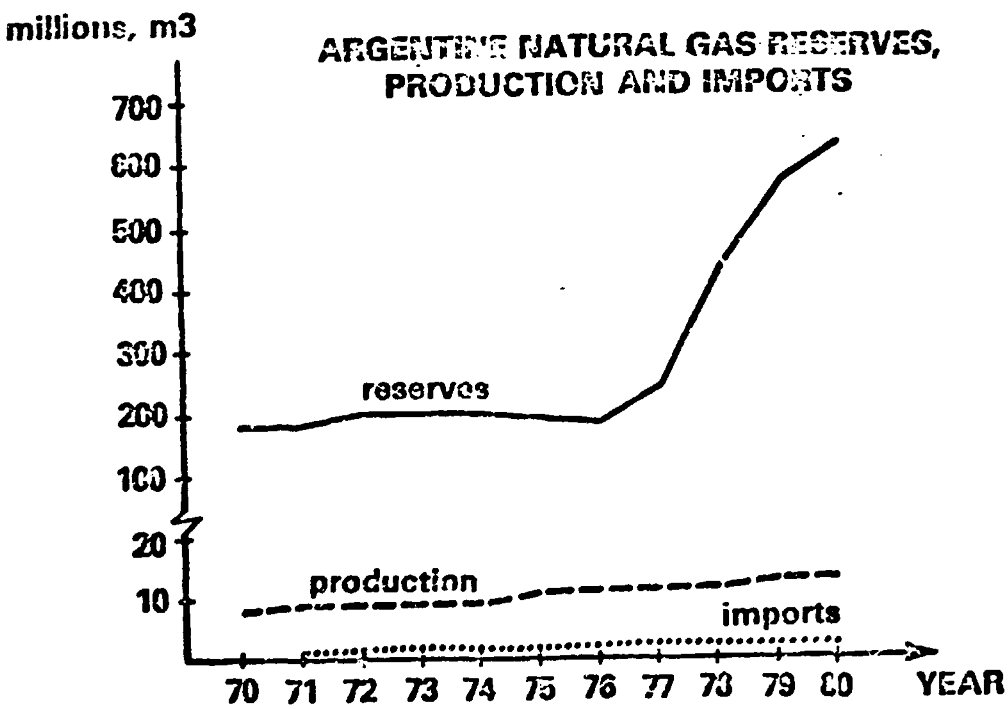
2.2. Hydrocarbon Gases

The reserves of natural gas in 1980 amounted to 641105 MMm3, which represents reserves for more than 60 years taking into account the consumption of that year (9200 MMm3). If the increase in the internal demand is considered, the mentioned reserves would be sufficient for more than 40 years.

The consumption of natural gas represents 27% of the total hydrocarbon consumption and a great demand is foreseen (internal consumption and exporting), theoretically 15700 MMm3 in 1985 and nearly 20000 MMm3 at the end of the present decade. This represents an annual accumulative growth greater than 7%. The natural gas supply is in condition to satisfy the required demand, based on the production of the new gas fields and the increased capacity of the gas pipelines. In Fig. 2 are depicted the evolution of reserves, production and imports during the last decade. The projected production of natural gas for the present decade is shown in Fig. 3.

The consumption of natural gas in the petrochemical industry totalized in 1978 nearly 520000 MMm3, that is, scarcely 6,7%

F I G U R E 2


millions, m3
ARGENTINE'S NATURAL GAS RESERVES,
PRODUCTION AND IMPORTS
700
600
500
400
300
200
100
20
10
reserves
production
imports
70 71 72 73 74 75 76 77 78 79 80
YEAR

of the total gas sold this year. Therefore, the future provision of natural gas to industry is assured.

Refinery Gases (R.G.)

The petrochemical potential of the R.G. is based on the contents of C_2 and C_3+ hydrocarbons. The production of the R.G. depends nearly exclusively on the conversion units of heavy residuals and on the reforming units of catalytic naphtha. This type of gas is a complementary source of raw petrochemical materials and specifically hydrocarbon olefins. It is considered a prefabricated raw material of low cost.

The national production in 1980 was 227000 m3 with a potential of ethylene of 102000 tons. It is hoped that the mentioned production will get to 311000 m3 in 1985 and 500000 m3 in 1980.

Propane - Butane

The national production of L.P.G. in 1980 totalized 667700 tons and it was estimated that in similar quantities came from oil processing and natural gas. The increase of the production in the last 10 years came to 2,5% annually. Gas del Estado imported in 1980 approximately 309000 tons of L.P.G. which represents 34% of the internal market sales of that company.

As from the start-up of the ethane and L.P.G. separating plants in Gral. Cerri, designed to process 18 million Nm3/per day of natural gas, the availability of L.P.G. increased in approximately 250000 tons anually, equivalent to 80% of the imports during 1980.

The present analysis concludes that selfsupply of L.P.G. will be obtainable during 1984. The possibility of disposing of exportable margins depends on the start-up of the natural Gas Processing Plant of the West-Center Pipeline.

Methane and Ethane

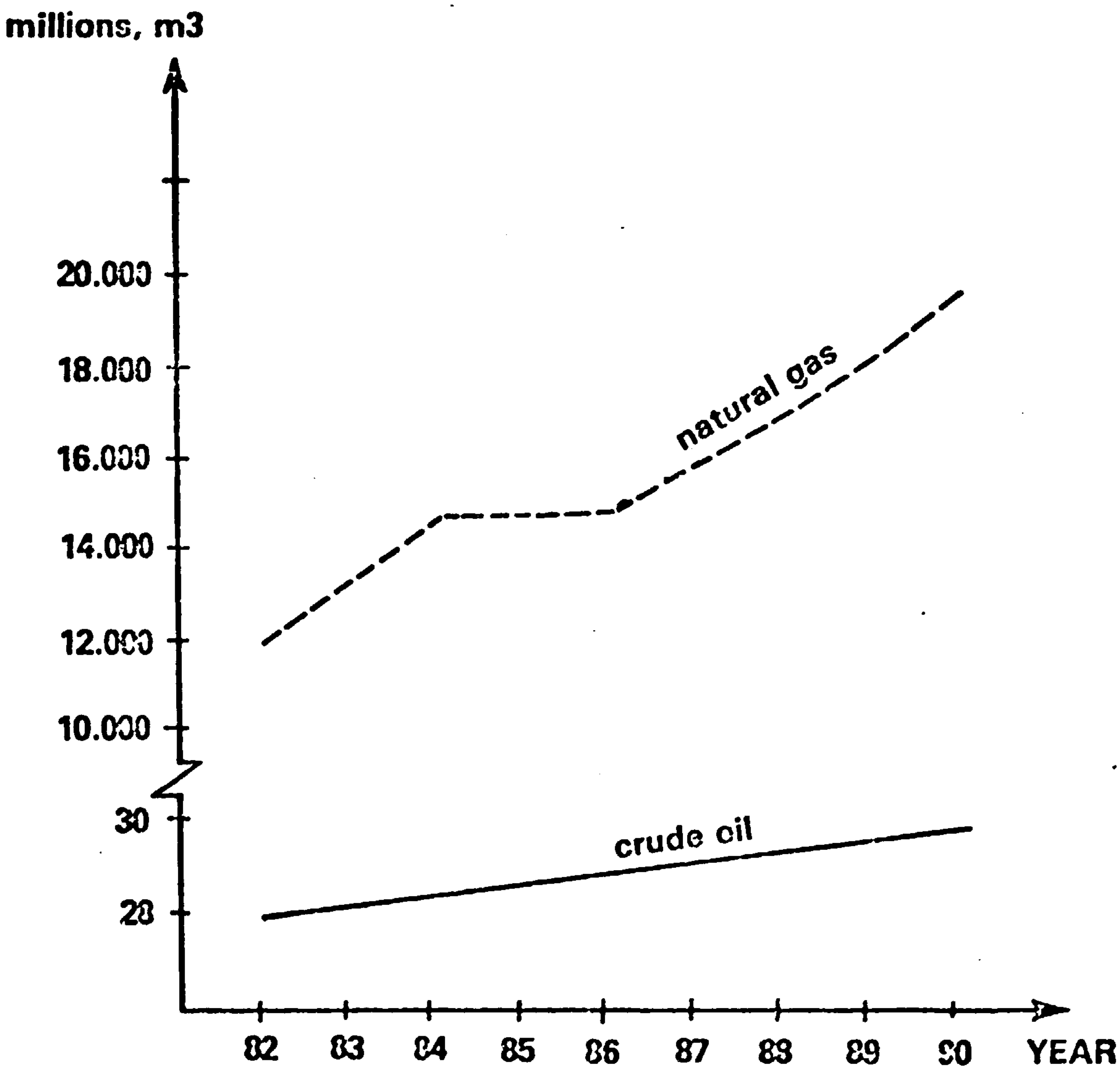
The high contents of methane of the natural gas makes it already available as a raw material for synthesis gas for the production of ammonia and methanol.

The ethane that can be available as a petrochemical feedstock corresponds to:

1. The south and west pipelines processing up to 18 MMm3/per day of

FIGURE 3

PROJECTED PRODUCTION OF CRUDE OIL AND NATURAL GAS FOR THE PERIOD 1982-1990



natural gas in the separating plant of Ethane and L.P.G. located in General Cerri, whose capacity is 280000 tons per year. The production in the months of November and December 1981 came to 47603 tons. The composition of the natural gas at the entrance to this plant is:

CO_2 = 1-2% C_1 = 90%; C_2 = 6%; C_3 = 2% and C_4 = 1%.

2. The West Centre pipeline: Instalation of an ethane extraction plant at the starting point of the pipeline. The ethane can be industrialized on the plant or it can be reinjected to the West pipeline to enrich the contents of ethane and increase its extraction in General Cerri.

3. The North pipeline: Campo Durán Separating Plant of L.P.G. will supply 10 MMm3/per day of natural gas and a stream of gas with an ethane contents of 85% in volume, which represents a potential production of 120000 tons a year of ethylene.

3. Basic Petrochemical Products

Ninety per cent of the petrochemical products of the world market are produced on the basis of olefins (ethylene, propylene, butilene and butadiene), aromatics (bencene, toluene, o-xilene and p-xilene) and synthesis gas (ammonia and methanol). The consumption of these products in Argentine is only 27 kg. per year and per inhabitant. In Table I are reported the production exports and imports of these products in Argentina, for the years 1970 and 1979. In Table II the projected demand for these products are reported for 1985 and 1990.

3.1. Ethylene

Ethylene production in 1979 was 48650 tons which represents a consumption per capita of 1,91 kg. In the period 1970-79 the growth of the production reached a 2,5% annual average. The main producing companies are DUPERIAL (15000 tons/year), IPAKO (15000 tons/year) and PASA (23000 tons/year). As from 1981 the production of Petroquímica Bahía Blanca (PBB) is incorporated, with a capacity of 202000 tons/year. Thus the total production capacity increases to 255000 tons/year. Internal demand foreseen for 1985 and 1990 is of 228000 tons and 424000 tons respectively. Exports were not

TABLE I

PRODUCTION EXPORTS AND IMPORTS OF BASIC PETROCHEMICALS IN ARGENTINE

PRODUCT	1970			1979		
	PRODUCT	EXPORTS	IMPORTS	PRODUCT	EXPORTS	IMPORTS
ETHYLENE	39300	-	-	48695	-	-
PROPYLENE	n/a	n/a	n/a	62316	-	-
BUTADIENE	27500	4600	-	22571	-	-
AMMONIA	52500	482	-	66860	244	-
METHANOL	34652	6978	7	30911	2558	761
BENCENE	39300	-	-	114294	43350	-
TOLUENE	16100	-	500	37594	-	4
O - XILENE	-	-	n/a	21650	500	-
P - XILENE	-	-	-	28100	22600	-
MIXED XILENES	8300	1300	10400	36350	13770	-

TABLE II

PROJECTED DEMAND OF BASIC PETROCHEMICAL PRODUCTS IN ARGENTINA

(TONS)

PRODUCT	1985	1990
ETHYLENE	228000	424000
PROPYLENE	68000	118000
BUTADIENE	45000	60700
AMMONIA	110000	164000
METHANOL	65000	120000
BENCENE	108000	152000
TOLUENE	36000	53000
0 - XILENE	22500	39600
P - XILENE	14000	22000

registered and the import of products derived from ethylene in 1979 represented approximately 114000 tons of ethylene equivalent.

3.2. Propylene

Propylene production in 1979 reached 62316 tons, 25% of this production is destined for the chemical industry and the remaining 75% for Gas del Estado.

The annual production capacity of propylene is 72000 tons, 75% corresponding to Y.P.F. and the remaining 33% to Shell.

The demand foreseen for the years 1985 and 1990 is 68000 tons and 118000 tons respectively. The evolution of the demand of the main derivatives is: polipropylene: 1985 = 36000 tons; 1990 = 71000 tons; acrylonitrile: 1985 = 13500 tons; 1990 = 16900 tons.

3.3. Ammonia

The production of ammonia in 1979 totalized 66800 tons and experienced in the period 1970 - 79 an average annual growth of 3,75%.

The principal producing companies and their corresponding capacities are: PETROSUR (66000 tons/year), D.G.F.M. (12000 tons/year) and ELECTROCLOR S.A. (3000 tons/year). Almost the entire production is destined to the internal market; exports (244 tons in 1979) only represent 0.5% of the production. No imports are recorded. 89% of production is destined to fertilizers; 8% to the chemical industry and 2% to refrigeration. The demand foreseen for 1985 and 1990 is 110000 tons and 164000 tons respectively.

The production of nitrogen based fertilizer in 1979 represented 52400 tons/year of urea and 42900 tons/year of sulphate of ammonia, equivalent to 33100 tons/year of nitrogen. Since the year 1975 the equivalent consumption of nitrogen grew at an average annual rate of 14%.

3.4. Methanol

Production in 1979 totalled 33100 tons. The growth of production from 1972 to 1979 was irregular, reaching nevertheless an annual average rate of 2%.

The companies producing methanol in the Argentine Republic are: ATANOR S.A.M. (18000 tons/year) and CIA. CASCO S.A.I.C.

(20000 tons/year).

Methanol exports have diminished permanently since 1970, year in which they reached 7000 tons. This figure was reduced to 1911 tons in 1977. Imports have hardly been significant in the period under study, with the exception of 1975 (3360 tons) and 1976 (1660 tons).

The demand of methanol foreseen for the years 1985 and 1990 is of 65000 tons and 120000 tons respectively.

3.5. Bencene

Production of bencene in 1979 represented 114294 tons. In the period 1970-79 production increased at an annual average rate of 15,2%, which is the greatest increase recorded for the products analized herein. The principal producing companies are P.G.M. (92000 tons/year), D.G.F.M. (27000 tons/year) and CARBOQUIMICA ARGENTINA (3000 tons/year).

The composition of the internal consumption of bencene indicates: 27,8% for the production of styrene; 17% cyclohexane; 12% ABL; 6% phenol and 2% various. Almost 38% of production was exported in 1978.

The demand foreseen for 1985 and 1990 is 108000 tons and 152000 tons per annum respectively.

3.6. Toluene

Production in 1979 totalled 37594 tons and since 1979 has experienced an increase of 12% per annum on average.

The producing companies are: PASA; P.G.M. (2000 tons); D.G.F.M. (27000 tons) and CARBOQUIMICA ARGENTINA (800 tons).

The exclusive use of this product is the manufacture of solvents and explosives.

Imports over the last years are very small and exports are erratic. It is foreseen that the demand for toluene in 1985 will reach 36000 tons and 53000 tons in 1990.

3.7. Xylenes

3.7.1. 0 - Xylene: Production in 1979 was 21650 tons. During the last five years production grew at 15% per annum.

The principal producing company is P.G.M. with a capacity of 25000 tons/year. 98% of 0-Xylene is used to manufacture phthalic anydride and the remaining 2% for export.

3.7.2. p - Xylene: in 1979, 28100 tons were produced. F.G.M. have a capacity of 40000 tons/year.

This product is exported in its totality.

The forecast for internal demand in 1985 and 1990 is 14000 tons and 22000 tons per annum respectively.

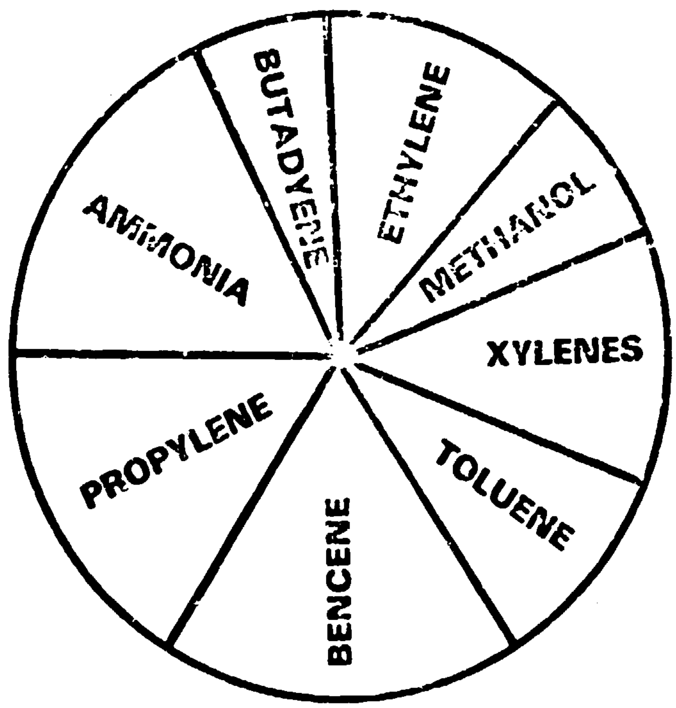
3.7.3. Mixed Xylenes: the production in 1978 was 36350 tons. The producing companies are: PASA, P.G.M. and D.G.F.M. 63% of production is used for the manufacture of solvents and the remaining 16% is exported.

CONCLUSION

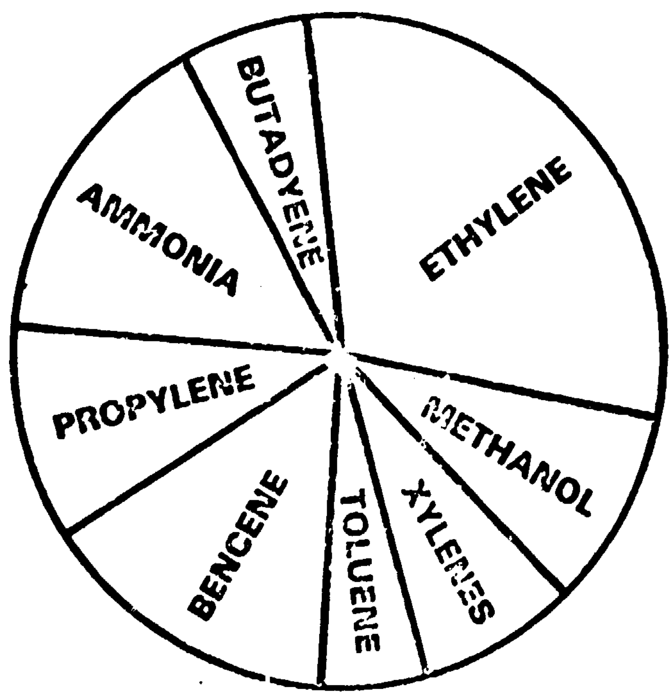
The present trends show that during the present decade there will be a large increase in the consumption of ethylene derivatives and fertilizers and stagnation in the production of aromatics. This situation is depicted in Fig. 4.

FIGURE 4

RELATIVE PATTERNS OF CONSUMPTION



1979



1985

4. New Petrochemical Projects

Under the new regulations for the petrochemical industry (decree 814/79), several projects have been formulated summing up a total investment close to 6000 million dollars. The proposal for basic petrochemical production are listed in Table III.

Given the availability of natural gas (methane, ethane and LPG) most of the new projects are based on this resource or in the use of refinery gases. It can be seen that there are several competitive projects for each petrochemical product. Several projects are based on converting methane in ammonia or methanol in large plants and exporting these products. Even though, there is no firm government decision with regard of these projects, it is fair to say that only a few of them will reach the production stage.

TABLE III

NEW INDUSTRIAL PROJECTS

PRODUCT	STARTING YEAR	PRODUCER	PLACE	CAPACITY (Tons)
ETHYLENE	1984	P.B.B.	Bahía Blanca	100000
	1986	Petroq.Nordpat.	Centenario	90000
	1987	Indupa S.A.I.C.	Centenario	150000
	1986	P.S.Lorenzo S.A.	San Lorenzo	300000
	1986	P.G.M. S.A.I.C.	Ensenada	200000
PROPYLENE	1986	P.S.Lorenzo S.A.	San Lorenzo	175000
	1986	P.G.M. S.A.I.C.	Ensenada	91000
	1987	Indupa S.A.I.C.	Centenario	50000
	1984	P. Huarpes S.A.	Luján de Cuyo	20000
AMMONIA	1985	Indupa S.A.I.C.	Bahía Blanca	345000
	1984	Impagro S.A.	Arroyo Seco	345000
	1982	Petrosur S.A.	Campana	17500
METHANOL	1986	Inversiones BIMA	Pta.Quilla	1250000
	1984	Cía. Casco S.A.	Pilar	60000
	1984	Atanor S.A.M.	San Lorenzo	150000
	1984	Resinfor S.A.	San Lorenzo	150000
	1985	P. Huarpes S.A.	Loma de la Lata	660000
	1985	P. Austral	B.San Sebastián	700000
	1985	Magallanes S.A.	B.San Sebastián	540000
BUTADIENE	1986	P.G.M. S.A.I.C.	Ensenada	35000

RESEARCH AND DEVELOPMENT ON PETROCHEMICAL TECHNOLOGY IN ARGENTINA

The first two petrochemical plants built in Argentina, (1943) were based on processes developed in the country. These were a toluene plant, that used a cut of naphtha (95°C-106°C) and a cromium oxide catalyst , and an isopropyl alcohol unit, that reacted refinery gases with sulfuric acid with subsequent hydrolisis. Both processes were developed at the Research Laboratories of Y.P.F. (the state owned Oil Company) at Florencio Varela. These first technological activities were followed by the establishment of research groups in the Universities of La Plata, Buenos Aires and Santa Fe, during the fifties; other groups were started at Bahía Blanca, San Luis and Salta in the sixties.

During the last decade CONICET, the national science and technology research organization has established research and development institutes, programmes and committees in chemical technology. These organizations have been built on the existing groups and the CONICET has provided special financial support for equipment, training, laboratory facilities and personnel. In Table IV are listed the main research organizations or coordinating bodies engaged in technological activities in the petrochemical field.

The Science and Technology Office (SUBCYT) of the Government has started a National Program on Petrochemical Technology that sponsors prioritary research activities in this field. The Argentinian Government has also requested assistance to UNIDO to set up a center for petrochemical technology in Bahía Blanca. This project has been backed also by CONICET, the University (Universidad Nacional del Sur) and the industries of the complex. This effort was based on an existing institute PLAPIQUI and has contributed to turn it in a large technological center in petrochemicals and polymer technology (PLAPIQUI-PIDCOP). The development of this organization will be discussed in the next section.

TABLE IV

SCIENCE AND TECHNOLOGY PETROCHEMICAL ORGANIZATIONS AND INSTITUTIONS IN ARGENTINA

CAMAT - Comité Argentino de Transferencia de Calor y Materia
Presidente: Dr. Alberto Cassano
Santiago del Estero 2654 - 3000 SANTA FE

CINDECA - Centro de Investigación y Desarrollo en Procesos Catalíticos.
Director: Dr. Enrique Pereira
Calle 47 N° 257 - 1900 LA PLATA

CONACA - Comité Nacional de Catálisis
Director: Dr. J. J. Ronco
Calle 47 N° 257 - 1900 LA PLATA

INCAPE - Instituto de Investigaciones en Catálisis y Petroquímica.
Director: Ing. José M. Parera
Santiago del Estero 2654 - 3000 SANTA FE

INIQUI - Instituto de Investigaciones para la Industria Química.
Director: Dr. Juan Carlos Gottifredi
Buenos Aires 177 - 4400 SALTA

INTEC - Instituto de Desarrollo Tecnológico para la Industria Química.
Director: Dr. A. Cassano
Guemes 3450 - 3000 SANTA FE

IPA - Instituto Petroquímico Argentino
Presidente: Cnel. (R) José P. Villa
Callao 220 - 7° Piso - 1022 BUENOS AIRES

PIDCOP - Programa de Investigación y Desarrollo del Complejo Petroquímico de Bahía Blanca
Jefe de Programa: Ing. Numa J. Capiati
12 de Octubre 1842 - C.C. 717 - 8000 BAHIA BLANCA

PINMATE - Programa de Investigación y Desarrollo de Fuentes Alternativas de Materia - Facultad de Ciencias Exactas y Naturales
Universidad de Buenos Aires
Director: Dr. Norberto Lemcoff
1428 - Ciudad Universitaria

PLAPIQUI - Planta Piloto de Ingeniería Química
Director: Ing. Carlos E. Gigola
12 de Octubre 1842 - C.C. 717 - 8000 BAHIA BLANCA

PROGRAMA NACIONAL DE PETROQUIMICA - Coordinador: Dr. J.J. Ronco
Córdoba 820 - 1054 BUENOS AIRES

Y.P.F. - Yacimientos Petrolíferos Fiscales - Laboratorio de Refinación y Petroquímica - Gerencia de Investigación y Desarrollo
Director: Ing. Abel Ojeda
Av. Calchaquí Km. 23,5 - 1888 FLORENCIO VARELA

ESTABLISHMENT OF RESEARCH AND DEVELOPMENT CENTERS FOR THE PETROCHEMICALS INDUSTRY

The need of reaching a worldwide production scale on basic petrochemical products leads to the organization of large integrated petrochemical poles. The plants participating in these poles use the most advanced and competitive processes and require skilled labour and supervision for their operation.

On the other hand, new industrial complexes are usually located in regions or countries that lack personnel with industrial tradition and competence in those large scale and sophisticated operations. These deficiencies conspire against the optimum operation and future development of the plants. Also, the absorption of technology process is hindered by the lack of a deep understanding of the processses involved, and the properties and characterization of the materials being handled.

There are several alternatives to correct this situation. One of them is to negotiate a program for technology transfer, between the licensor, engineering and or construction companies, and the local industries involved. This approach should be attempted in most cases. However to fulfil its goal in the long range, it must be backed by an organization that absorbs all the skills and know how gained from the transferred know how. This organization should be able of further develop and adapt this technology, to increase the amount and quality of industrial production.

Another possibility is the establishment of a research and development organization. This organization will embody the following functions: technical assistance, training, development studies, consulting, technical services and industrial research. In turn, this organization will master the different processes of the plants with which it interacts, fulfilling the absorption of technology goal. This organization will complement the required technical support and skills in close association with the industries. In the end, this organization will accomplish many of the goals that are pursued through a formal program of technology transfer.

Strategy for Technology Absorption and Development

The efficiency of the process of technology transfer, has been defined by Trindade (1) as the extent of absorption by the receiving end of the essential skills and knowledge of the transferred technology. Furthermore he quantifies this efficiency through the definition of a price P for the transferred technology:

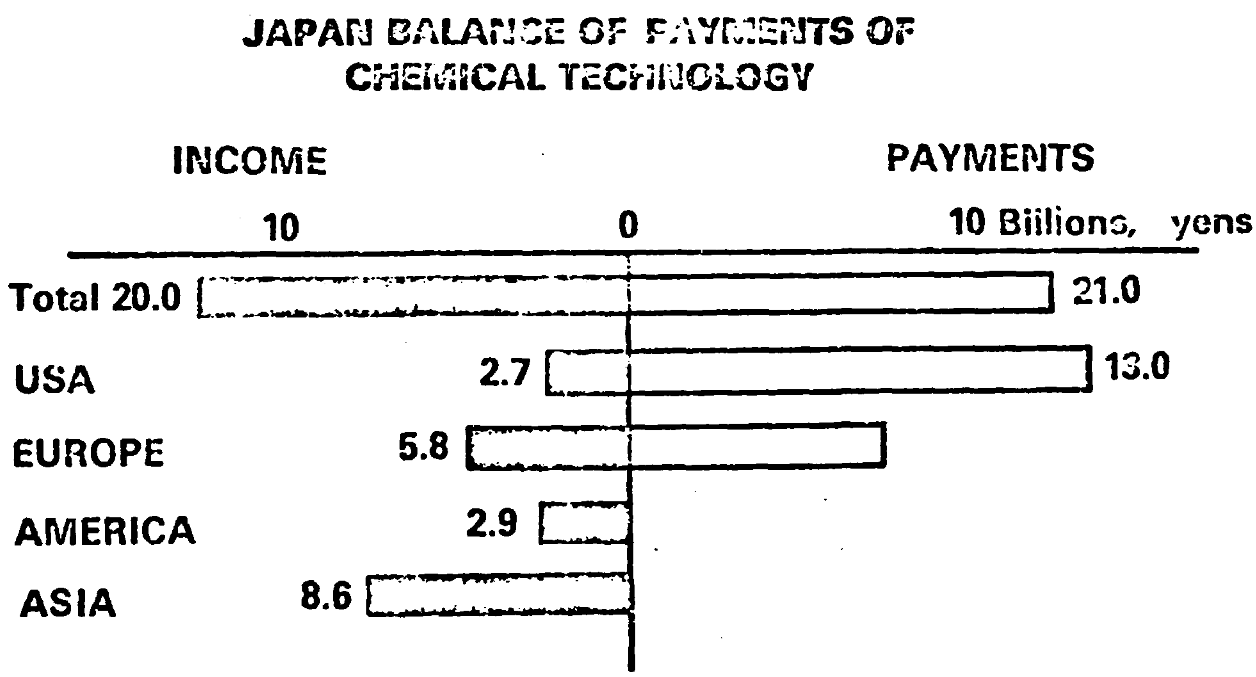
$$P = \frac{\$\text{, value paid for technology}}{Q\text{, fraction of the essential skills and knowledge absorbed}}$$

This equation illustrates how important is the coordination of the industrial and technology effort. If Q is very low, i.e. there is no technological effort, the actual price will be very high. For instance, if the firm (or country) requires again the same technology, will have to pay again for it. Even worse, it will be in the same weak negotiation position as before. Therefore, in this situation the buyer of the technology package does not actually owns it. On the other hand when the fraction of technology absorbed is close to one the original buyer is able to improve on the technology and eventually sell it back to the original seller.

This process is illustrated on a large scale for the balance of payments of chemical technology of Japan. This balance is shown in Fig.5, Japan buys technology from Western Europe and the U.S.A. and is a seller of technology to Asia, Africa and Latinamerica. Japan is in the position of doing this fruitful exchange after carrying out an intense technological effort of learning, adaptation, improvement, optimization and innovation.

Based on the japanese model and the concept of efficiency of technology transfer a strategy is clear for the development of technology: learning, improvement, innovation.

FIGURE 5


JAPAN BALANCE OF PAYMENTS OF
CHEMICAL TECHNOLOGY
INCOME
PAYMENTS
10
0
10 Billions, yens
Total 20.0
21.0
USA
2.7
13.0
EUROPE
5.8
AMERICA
2.9
ASIA
8.6

In the implementation of this strategy there are some vital elements that should be given deep consideration to assure a reasonable chance of success. These vital elements are:

- extent and quality of communications and personnel;
- long range goals and planning;
- development of personnel;
- continuity and size;
- the existence of a market for the technological effort.

The extent and quality of communication plays an outstanding role. This is due to the fast change of technology in recent times and the relatively isolated situation of the technical and research community in many countries of Latinamerica. The ability to break communications barriers depends upon the quality of the local personnel and the extent of its contacts with the international technical community. The flow of information is carried out through people: men in different fields and countries, consultants, managers, engineers, teachers and researchers.

A measure of the quality of communication in an R & D organization, is also given by the internal flow of information, reflected by the interactions between fundamental and applied research staff, extensionists and development personnel. Finally, the relationship of technical and plant managers, and industrial staff with the R & D organization, should be fluid at all levels. Another signs of efficiency in communications are: access to data banks and bibliography, computer and data transmission capability. But the success in this field lie on the caliber of the people inside and of the number and quality of the contacts outside, to know and to be known. The creation of this communication system is the most critical and challenging part in the establishing of R & D organizations.

Therefore, it is the building of the professional staff, of the technology center, the first and prioritary objective. The building of the technical staff, suffers from the local shortage of qualified personnel and the difficulty of recruitment high level educated or highly experienced staff in the international market.

Again a strategy is needed to provide the manpower for the technical organization. The main features of this strategy are:

- long range planning in the development of human resources in specific fields.
- close association of the educational process with the industrial needs and modern technology.
- graduate level education in engineering.
- intensive program of training abroad of local personnel.

In synthesis the strategy is: select and train the best locally available candidates. This approach points to the need of planning and continuity. It takes at least ten years to convert a young graduate in an independent researcher or technical supervisor. At the end of this period, the candidate has to fit the forecasted needs. Besides, on his return, he should have a position and well equipped laboratories, libraries, and computing facilities at his disposal (continuity).

In the next section it is discussed as a case study (*)(3) the establishment of PLAPIQUI/PIDCOP as a R & D Center for Petrochemical technology. The role played by industry, government agencies and the PLAPIQUI team in the development of this center are fully discussed. Thus, an specific example, serves to illustrate the implementation of the strategy for science and technology development considered above.

(*) Extracts from the "1981 Mission Report - Technical Assistance Committee" UNIDO Project ARG 75/021.Technical Assistance to the Bahía Blanca Petrochemical Complex, L.E. Scriven, S. Wanke, J.A. Pearson and C. Battu.

A CASE STUDY ON CREATION AND TRANSFER OF TECHNOLOGY IN THE PETROCHEMICAL INDUSTRY (*) (3)

"The UNIDO Project was established to assist in the creation and transfer of technology in the petrochemical complex at Bahía Blanca, Argentina, and to increase the national capacity for technical decision, scientific research and technological development in the petrochemical field.

Briefly the project has been a notable success. To appreciate why, one must review the situation that existed when the project was formulated in 1976 and 1977. That situation had been developing for more than a decade.

I. BACKGROUND

Beginning

In November 1963 a group of chemical engineering students about to graduate from Universidad Nacional del Sur were dissatisfied with the level of instruction they had received, and so were several of their teaching assistants and assistant professors, themselves recent graduates (the University itself had been established only seven years earlier). One of the latter, as a result of discussion by all twelve about how to upgrade chemical engineering at Bahía Blanca, prepared a plan for the reaching the goal of a department of international standing and national relevance. The plan was adopted and thus began the development which this UNIDO Project assisted fifteen years later.

From early actions of the team one can make out the long-range plan that was being followed. At the start the students involved [illegible] to undertake a final research project in PLAPIQUI as a prerequisite for graduation. The rest of the undergraduate curriculum was shortened, strengthened, modernized, and this process continues to this day. Within a year the PLAPIQUI team were asking chemical companies for small grants of supplies, chemicals, equipment or money; by 1969 twelve companies were donating the equivalent of four teaching assistants' salaries. In 1967 B.F. Dodge, a distinguished chemical engineering professor at Yale University (U.S.A.) came and gave a

(*) "1981 Mission Report - Technical Assistance Committee" UNIDO Project ARG 75/021.

one-month intensive course in thermodynamics, a basic subject; in each of the next few years one or two prominent professors from the U. K. or the U.S. made brief visits (contacts with University of Minnesota were made this way). In 1970 M.C. Williams of University of California at Berkeley lectured for a month on polymer rheology and J.W. Hightower of Rice University for a month on chemical reaction engineering. Hightower brought a modern microreactor that is still in use in PLAPIQUI.

In 1967 four founders went overseas for Masters degrees or equivalents to MIT, UCLA and Imperial College. This was the starting point of an intensive and permanent program for training of PLAPIQUI personnel abroad in centers of excelence. To date more than one thousand men month of training have been carried out.

PLAPIQUI by the early 1970's had grown to a size and strength sufficient to maintain momentum in pursuit of its objectives of national relevance and international standing. Crucial factors were the leadership, vision, cooperation, and dedication within the team, the carefully worked out long-range goals which were shared by the entire team, the working "microenvironment" they created for themselves and shared year by year with students, the attention they paid to consolidating the position of their educational enterprise in the university, and the prospect of having a large petrochemical complex close by.

From then on the long-range plans were aimed clearly at generating chemical engineers and chemical engineering technology for the projected-natural-gas-based petrochemical industry--polymers especially.

Industry-University Linkage

The primary companies of the petrochemical complex: Petroquímica Bahía Blanca (ethylene) and Gas del Estado (ethane), signed agreements of technical cooperation with PLAPIQUI as early as 1973, when neither of them have started yet the construction of their plants. Another agreement was signed with CARBOCLOR, a company near Buenos Aires, to study the feasibility of regenerating a certain catalyst. Thus began the technical services activities of PLAPIQUI.

National Research Council-University Linkage

A crucial development occurred over the years 1971-1973: the working out of an agreement between Universidad Nacional del Sur, of which PLAPIQUI was and still is a part, and the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET-the national research council), which thereupon began providing some of the financial backing, particularly for support personnel and for young team members going overseas for postgraduate study. The agreement was signed on April 30, 1973. It provided that PLAPIQUI must:

- Undertake technological research projects on the basis of the chemical engineering sciences;
- Educate and develop research personnel;
- Work with state and private industries in technology transfer projects, and strive for close working relationships.

II. UNIDO PROJECT

Beginnings

In 1972 by agreement between the government of Argentina and the United Nations Industrial Development Organization a $16.000 technical assistance grant was made by UNIDO to PLAPIQUI to support research in the general area of petrochemicals.

In 1976 a preliminary version of a large scale proposal was transmitted to the U.N. organization by the Argentinian Government. This proposal was revised several times with the assistance of PNUD-UNIDO missions and preparatory assistance started in 1977. Points in the preliminary proposal that were emphasized by several missions were:

1. The adequate quality of the basic education in chemical engineering science being provided by PLAPIQUI.
2. The importance of equipping laboratories well in order to jump to an internationally competitive level in research and technical service to industry.
3. The need for rapid development of computer facilities.

4. The need for being aware of state-of-the-art in relevant fields and for reaching international standards - the PLAPIQUI goal from the very beginning.
5. The need to be of short-term as well as long-term service to the petrochemical complex and thus to perform the true engineering function, which requires confidence to cover all aspects of a problem and to organize projects to specific aims and within specific time-spans.

Satisfaction of the last two was regarded as critical to success. The existing arrangements and immediate intentions of PLAPIQUI were judged to emphasize academic objectives and to fall short of what would be necessary for effective interaction with PPBB.

The polymer area was emphasized, with a very strong recommendation to fit out laboratories in polymer characterization and polymer reaction engineering. The heat and mass transfer area was directed to such heat exchange and separation processes as would be found in PPBB. This and the process engineering area were directed toward computer-aided modelling of the major processes and entire plants in the complex. Acquisition of a larger computer, establishment of a computer center, and the goal of real-time process calculations were all emphasized. Fitting out good laboratories for catalyst characterization, catalysis research and reactor engineering studies was recommended strongly. So was the inauguration of PLAPIQUI activity in corrosion, materials engineering, industrial economics and process synthesis - additional areas of high relevance to the petrochemical complex. As for direct industrial participation in the project, emphasis was placed on

- training schemes for plant engineers and operators
- the use of outside experts
- joint chemical engineering projects of PLAPIQUI with industry.

The UNDP/UNIDO requirement for a National Counterpart Organization to take responsibility for the project led to the formation in 1977 of PIDCOP, the Research and Development organization for the Bahía Blanca Petrochemical Complex (PPBB), which unified the interests of the national research council CONICET, the university UNS, the industries in the complex (originally PBB, GdE and DGFM but eventually all of the satellite companies as well), and PLAPIQUI, its operating arm. PIDCOP was an experiment in institutional and organizational structure designed to establish a firm link between PLAPIQUI and PPBB and thus achieve the creation and transfer of technology to the petrochemical industry in Bahía Blanca. The success of this experiment is evaluated in a later section.

The emphasis placed on points 1 to 5 above by visiting UN missions stimulated mechanisms for integrating fully within PLAPIQUI the three related activities of technical services to and joint projects with industry, longer term research activities, and teaching at both undergraduate and postgraduate levels. The organization that was fashioned to achieve this is the present PIDCOP/PLAPIQUI Division of Industrial Technology, which is discussed in a later section.

The UNIDO funding began in 1977. By the end of Phase I of the project, December 1981, a total 1.800.000 dollars have been inverted in equipment and in financing fellowships and experts.

Other Funding

Still greater support for growth of PLAPIQUI followed rather unexpectedly on the heels of Phase II. In March 1979 a 'matching' loan was advanced by the Interamerican Development Bank (BID) for the development of regional centres of basic and applied research in Argentina. These regional centres fall under CONICET, the National Research Council. One of them (CRIBABB) is being built at Bahía Blanca. One of the institutes in it is PLAPIQUI. Beginning in 1980 the BID-CONICET program has brought substantial funding to expand the research and postgraduate education activities in PLAPIQUI. This program does not, however, address directly the industry-university interaction and industrial development that has been and can continue to be so effectively promoted by UNDP/UNIDO.

But with both UNDP and BID-CONICET support, PLAPIQUI has the major financing it has long needed to reach pre-eminence. There are of course strengths in multiple sources of funding: at this time the principal ones for PLAPIQUI are:

- UNDP/UNIDO project	1977 - 1981 / 1982 - 1984
- BID-CONICET regional centre	1980 - 1984
- CONICET salary contributions and other	ongoing
- UNS faculty salary contributions and other	ongoing
- Industry subscriptions and contracts	increasing
- SUBCYT research grants	increasing

Of those the UNDP/UNIDO project and industrial subscribers have been absolutely crucial to the PIDCOP experiment and the building of the PIDCOP/PLAPIQUI Division of Industrial Technology.

Efforts to get all of the companies in PPBB to join in the project through the PIDCOP organization were successful. By 1980 all had joined, and additional petrochemical and plastics companies from the Buenos Aires area began setting up links with PLAPIQUI to take advantages of its facilities, know-how and advanced engineering skills. Young engineers from other regions began coming to PLAPIQUI for the unique advanced training available there. Thus there is mounting evidence of powerful national impact of the project.

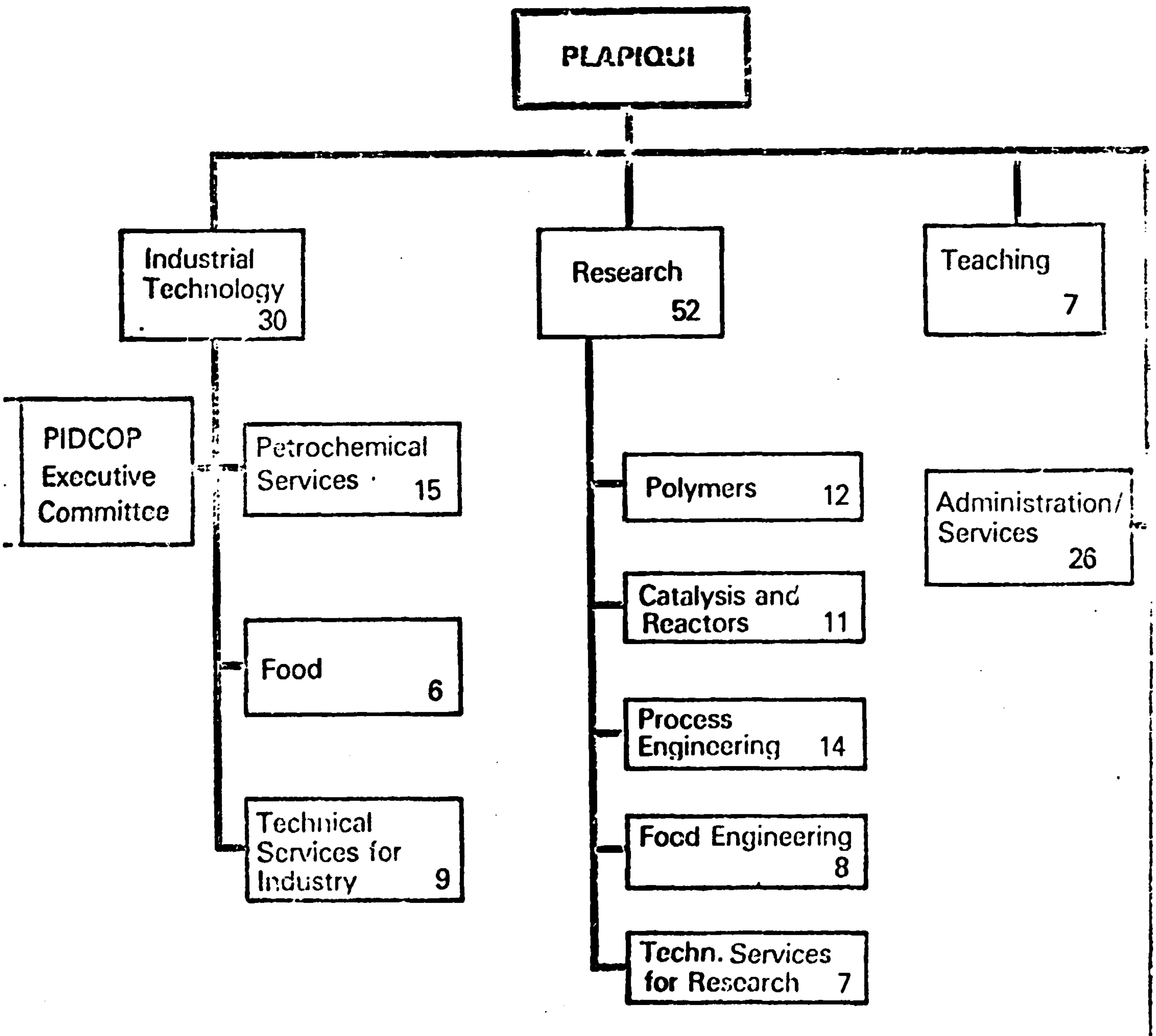
Conclusions

The major achievement of the UNIDO project is the nurturing of an institution, PLAPIQUI/PIDCOP, capable of meeting the development objectives of offering the human resources and technological backing for PPBB, and of increasing the national capacity of technical decision, scientific research and technological development in the petrochemical field. Since 1977 the UNDP/UNIDO inputs have helped sustain PLAPIQUI, which has grown from a team of about 45 to one of about 115 (April 1982). The nature of PLAPIQUI is perhaps most quickly grasped from the effort chart on the next page, which shows how the personnel distribute their work over industrial technology (technical service and special projects), research (including thesis work by postgraduate students), classroom teaching at undergraduate and graduate levels, and administration of the entire enterprise.

There is growing enthusiasm on all sides for this organization, which has grown, slowly at first and not without setbacks, from the group that in November 1963 took as their goal the creation of a chemical engineering department of national relevance and international standing. One recognizes the overwhelming importance of the people involved then: that original group maintained their goals, their distinctness, and their determination. In cooperation with others sharing similar goals they have succeeded in integrating education, research and service to industry in a way that might serve as a model to others".

FIGURE 6

PLAPIQUI Effort Chart



III. THE PIDCOP EXPERIMENT

" As we have seen above, PIDCOP arose from a combination of factors.

a) a dedicated group of young chemical engineers in Bahía Blanca

b) government sponsored plans for a completely new petrochemical complex in Bahía Blanca

c) a lack in Bahía Blanca of engineers experienced in the operation and development of petrochemical plant

d) support from the local university, the National Council for Science and Technology, and members of companies involved in the complex

e) a United Nations project for technical assistance to the petrochemical complex.

The need was associated with b) and c) and the financial means for satisfying the need was provided by d) and e) but the crucial element in the experiment was undoubtedly provided by the people concerned, largely covered by a).

The experiment was ambitious and complex: ambitious in that it aimed at nothing less than parity with the best available in the petrochemical field abroad, scientifically and technologically; complex in that it was planned in a broad interconnected basis linking education, research and industrial technology.

Communications

University Network

It followed that strong working contacts had to be established with leading international centres of research and development: the balanced procedure of sending staff abroad on fellowships, to study at highest level in Universities or R & D institutes, and of inviting foreign academic and industrial experts to Bahía Blanca, on an organized and continuing programmes, has achieved this requirement. At an early stage it was realized that continuing personal contact with active foreign workers was the key to smooth operation of this part of the project. Thus there has been a steady interchange with the Universities of Minnesota and Massachusetts in the United States and with Imperial College, London in the United Kingdom. These form the strongest nodes in a much more extensive but extremely coherent network structure that includes the University of California at Davis, Massachusetts Institute of Technology, the Technical University of Lyngsby, Denmark and the University of Ghent. The network is based on personal contacts often established between University professors and their Ph.D. students, or between colleagues at a given University; these contacts are maintained when one or other of them moves. Such a network has often been called the Invisible College and is regarded by many astute observers as being of much greater importance in the present day development and spread of scientific and technological ideas than either the institutions themselves or the technical literature. PLAPIQUI has now been integrated into the network. If it is to achieve its ambition, it must remain actively connected to as many nodes in the network as possible.

Linkages with Industry

It followed also that members of the participating companies had to be involved in the upgrading process if PIDCOP, through PLAPIQUI, were to provide high level help to the complex: here we found that the human network principle proved to be almost as important as in the academic sector. The most enthusiastic and understanding supporters from the industrial side have in many cases proved to be class mates or one-time colleagues of the founding fathers of PLAPIQUI; many of the most successful man-to-man-relationships between the companies of the complex on the one hand and PLAPIQUI on the other have arisen through individuals who have moved from one to the other--and the movement has been in both directions. Joint participation in training missions or in plant investigations have established or cemented personal links.

Thus the PIDCOP board is itself an important node in a network of people, rather than of institutions. From UNIDO's point of view, PIDCOP is the visible embodiment of the counterpart agency; from the business school point of view, it is part of an organizational chart. From our point of view, is proved to be primarily an interesting group of individuals who have worked backwards on their parent organizations, leaving choice of its activities and direction of its resources to its Director. In practice PLAPIQUI has as often prompted external action through PIDCOP, as has PIDCOP requested action on the part of PLAPIQUI.

Because PBB was a new company with no other external links, and was the first to build its plant, the PBB management established early particularly in process engineering; the plant and the process it embodied has been as open to PLAPIQUI workers as the agreements signed with the providers of the technology could possibly be interpreted as allowing. In consequence the present core of the DTI are all involved with plant simulation for PBB and will participate actively on site during start-up. A computer terminal connected to the PLAPIQUI computer has been installed at the PBB site, and members of the company are familiar with the computational programs available on line at PLAPIQUI. Cooperation has centred on the basic processes involved in ethylene production: thermal cracking, catalytic hydrogenation of acetylene, separation by distillation or absorption. The stimulus provided by this cooperation has been mutual and strong.

GdE, on the other hand, is a well established public enterprise with ess engineering and computational facilites in Buenos Aires. Since ... r first agreement with PLAPIQUI signed in 1973 there have been a growing interaction and a large number of plant studies were carried out. These studies dealt with dehydration with molecular sieves, air fin coolers modelling and verification, gas treating with MEA, overall plant modelling and optimization of the ethane-LPG extraction plant, and technical assistance to the chemical laboratory.

The question of secrecy has already arisen in connection with the two POLISUR polymerization plants, for high-pressure low-density polyethylene production (the ARCO LDPE process) and for low-pressure low-density polyethylene production (the Union Carbide LLDPE process). No arrangement has yet been made for staff from PLAPIQUI or other companies to take part in the start-up operations, which we believe would be helpful to all. A quite different approach is being taken by INDUPA and its affiliate INDUCLOR. The latter regards its electrolysis process as being so well known that secrecy is not a real issue, while the parent company has already engaged the polymers group at PLAPIQUI to undertake cooperative background research into the polymerization of PVC (and copolymerization of PVC and PVA) which is (are) the processes they will carry out at PPBB.

All the potential polymer producers at PPBB have supported the development of a polymer characterization laboratory at PLAPIQUI and have made use of it already. In the case of IPAKO (POLISUR) the investigative talents of the PLAPIQUI personnel have been tested and not found wanting in the solution of a technical service problem. It is clear that PLAPIQUI will be able to fulfil an important role in providing technical service for all downstream members of the Complex to the benefit of plastics processors throughout the country. The extent to which they succeed in this role, and thus in replacing a service that was previously provided by the original foreign parent companies of the polymer producing companies of the complex, will pari passu be a measure of the success of the experiment.

Prerequisites for long term success

"One swallow does not make a summer". In using two specific examples as evidence of the success of an experiment, we are conscious of the fact that only a continuing series of such examples will justify the project. It is the extent to which the PLAPIQUI/PIDCOP relationship can develop into a permanently symbiotic one that we now consider. What then are the prerequisites for long-term success? Here we are convinced of the importance of the tripartite approach; of the combination of education, research and industrial technology that form PLAPIQUI. It has already produced a stream of trained chemical engineers who are directly employed at the complex, and in the future can be expected to increase their number and more importantly the level of training (through MS, Ph.D. and continuing education programmes, added to the basic Engineer course); as we have seen, these people form part of an essential network that maintains the PPBB/PLAPIQUI relationship. It is involved in long-term research programmes that are important in terms of both the technical help that it may be called upon to give the Complex on matters that go beyond the normal competence of even the best plant engineers and the links that have to be maintained with the Invisible College world-wide. Finally it has committed a major proportion of its resources and energy to industrially oriented activities, dealing directly with industry through its DTI. In the absence of alternative institutions fulfilling any of these functions locally, they must all be regarded as prerequisites. We go further and suggest that their combination in a single institution is an essential prerequisite for achieving true self sufficiency at an advanced technological level in circumstances similar to those facing the PPBB at its inception.

Financial support-UNIDO participation

No progress could have been made, nor will it be maintained, without financial support. Fortunately, this has been provided so far in generous measure by UNS, by CONICET and by the UN project, and there is evidence that the companies operating at PPBB will be prepared to make more significant contributions in the future. We believe that this sharing of responsibility for funding has been a further prerequisite for success. Financial committment has ensured that each of the various parties forming PIDCOP has had a vested interest in the success of the experiment and can take a commensurate pleasure in their participation. Fissiparous tendencies have thereby been avoided.

Conclusion

If the planned growth of PLAPIQUI can be achieved, then it would become as large a centre as any in the world, and would moreover represent a unique combination of the three elements -- education, research and industrial technology -- that have already been successfully blended into its structure. As such it would have a strong attraction for all of the petrochemical industry in Latin America: it should be encouraged to act in such an international role. In so doing, it would be stimulated into becoming a centre of excellence, being able to draw on talent from a very wide area.

We see this as particularly important in the field of graduate training. PLAPIQUI as a centre will make its largest impact by virtue of the people who pass through it, taking with them knowledge, skill but above all attitudes. Involvement of its students in industrial problems at the highest level is we believe one of the main potential strengths of PLAPIQUI as an institution. To see modern science and technology being applied to real design or plant problems should be the goal of any major engineering school; otherwise training develops into a sterile exercise, and this is all too often what has happened in other institutions around the world. Weaknesses in the formation of engineers is a cause of worry in several of the most highly developed Western countries, where a divorce of engineering science from engineering practice has become evident; the situation is more severe in some less developed countries. The PLAPIQUI experiment is thus of considerable international importance and we shall follow its development and impact with great interest."

RESULTS AND CURRENT ACTIVITIES - PLAPIQUI/PIDCOP

Besides PBB and GdE, all the other companies in the Complex have, at present joined PIDCOP, broadening the range of requirements and inducing PIDCOP to expand its service and research fields. The new members will complete the picture for a medium size poliolefin-polivinyl complex with: Poliisur (75000 ton/year LDPE and 110000 (low pressure LDPE), Petropol (62000 HDPE), Indupa (45000 SPVC and 15000 EPVC), Electroclor (41500 SPVC), Monómeros Vinílicos (130000 VCM) and Induclor (90000 Chlorine and 100000 NaOH). Consequently, it is clear that the efforts of PIDCOP should emphasize the technical services, research, development and training needs of these plants.

In view of these requirements, a new UNDP-UNIDO Project for the period 1982/1984 has been approved aiming to the following objectives:

1. Development of a centralized Technical Services System for the Complex.
2. To carry out technical requirements through activities of industrial research and development activities in support of industry operations.
3. Contribute to start up and optimization of the Complex.
4. Develop a pilot center for industrial training to satisfy the regional requirements at this fast industrial developing stage.

The intense activity of research and development in progress and planned will certainly contribute to an absorption of technology including learning, adaptation, improving, optimization and development of processes and equipment of external origin.

TECHNICAL SERVICES

The supply of highly specialized services is secured to the industries through the laboratories and technical departments of PLAPIQUI, under the coordination of its Industrial Technology Division.

The four main fields for services are: information and documentation, special service laboratories, computation, training and economics/statistics services.

Information and Documentation:

The expanding science and technology library located at PLAPIQUI owns more than 2000 books and subscribes to 130 specialized journals, covering relevant areas, such as: Petrochemical Industry, Polymer Science, Catalysis and Surface Science, Economics, Academia-Industry Relations and others.

The library operations are in the process of being automated by the use of a computerized inventory and circulation control. Several information services are already implemented or in due process. Among these we can cite: the acquisition of scientific and technical reprints of recently published research work. The preparation of custom made scientific and technological profiles for bibliographic searching, the access to remote bibliographic databases, the edition of reports on literature of interest.

A long range training programme will allow library staff to be permanently incentivated to perform a more intellectual type of activity, rather than the traditional mechanical library operations.

A monthly bulletin on Petrochemical Bibliography is published serving more than 60 subscriptions in the industrial sector. The bulletin contains selected references and comments about material currently published around the world as well as the current library holdings and acquisitions.

An ambitious project, already in progress, is the implementation of a database on Petrochemical Industry in Latin America. This work is done under the aegis of the Latin American Petrochemical Association (APLA).

Training

An intense activity covering different levels of training and education has been carried out at PLAPIQUI/PIDCOP; from courses and seminars for industrial technicians and professionals to the implementation of a graduate program in Chemical Engineering leading to MSc and PhD degrees.

From the point of view of the plannification of the industrial training, two important factors were considered. The first one is the effect of the rapid evolution of technology on the different work positions at the process industry due to:

- the increased automation of the processes by the use of computerized control
- the development of new processes
- the implementation of sophisticated technologies to improve the process energy efficiency

The second one is of regional and social character, depending on the specific context in which the industry or complex is located. In our case, the regional characteristic is the abscence of previous industrial development, since Bahía Blanca is an agricultural-commercial center.

Considering the industrial requirements, the program is developed following two modes, in accordance to the own training plans of the particular industries: 1) Local training carried out at Bahía Blanca within the framework of PIDCOP; 2) External training offered abroad under the auspices of the UNDP-UNIDO Project.

The local activities include:

- Courses and Seminars: that offer highly specialized education to professionals from industry. The Table V shows the courses offered during the last years and the attendant companies.
- Meeting and Conferences: Since 1978 an annual Meeting on Petrochemical Technology is held at Bahía Blanca. The professionals from the industrial sector have there the opportunity to contact and discuss technical matters with a number of invited top class experts. The Table VI lists the experts participating and the subjects covered.
- Training Simulator: The PIDCOP has recently incorporated a Process Simulator as a tool for training control room operators. The equipment is an analog computer which admit a variety of prearranged programs representing process operations. Manipulating the board, the operator can simulate determined real operations, likewise the instructor may introduce perturbations so the student can show the

TABLE V

INTENSIVE COURSES 1979 - 1981

COURSE	PROFESSOR		PARTICIPATING COMPANIES
Catalysts	Drs. J.Butt, S.Wanke A.Weiss, R. Caretta	15	PBB, YPF, GdE, P. Gral. Mosconi Monómeros Vinílicos CINDECA, INCAPE
Polymer Processing	Drs. H. Winter R. Armstrong	12	ELECTROCLOR, INDUPA,DUPERIAL IPAKO, Fca. Militar de Aviones
Gas Chromatography	Dr. A. Weiss	20	PBB, GdE, INDUPA
FORTRAN Programming	Computing Service PLAPIQUI	21	PBB, GdE, PLAPIQUI
SIPREQ Uses & Fundamentals	Industrial Tech. Division of PLAPIQUI	34	PBB, GdE, PLAPIQUI
Polymer Characterization	Dr. M. Tirrel Dr. E. Vallés	16	PASA, IPAKO, ALBA, ELECTROCLOR, GdE, UNS, UNMD Plata, NORENPLAST, VINISA
Introduction to Computation in Process Industry	Ing. J.Ardenghi	24	PBB
Technology of Ethylene	Ings. M. Picciotti H. Simoni	16	Ptrq. Gral. Mosconi Monómeros Vinílicos PASA, PBB, UNS
The Use of Aditives in Polymers	Dr. K. Abbas	22	IPAKO, ALBA, ELECTROCLOR

TABLE VI

PIDCOP PETROCHEMICAL MEETINGS

INVITED LECTURERS

Lecturer	Subject	Institution
Dr. J.A. Pearson	Polymer Rheology	Imperial College, London, U.K.
Dr. S. Wanke	Catalysis and surface Chemistry	University of Alberta Edmonton, Canada
Dr. R. Armstrong	Polymer Processing	Massachusetts Institute of Techn. U.S.A.
Dr. R. Laurence	Polymerization Reaction Engineering	University of Massachusetts, U.S.A.
Dr. A. Weiss	Catalysis	Worcester Polytechnic Institute, U.S.A.
Dr. W. Edmister	Thermodynamic Properties	San Rafael, California U.S.A.
Dr. G. Froment	Chemical Reactors	University of Gent Belgium
Dr. J.B. Butt	Chemical Reactors	Northwestern University, U.S.A.
Dr. H. Sawistowski	Advanced Separation Processes	Imperial College, London, U.K.
Dr. R. González	Catalysis	Rhode Island University, U.S.A.
Dr. T. Jensen	Prediction of Thermodynamic Properties	Instituttet for Kemiteknik Danmarks Tekniske Højskole Lyngby, Denmark
Dr. D. Ramkrishna	Applied Mathematics	Purdue University U.S.A.
Dr. W. Resnick	Modelling of Fluidized bed reactors	Technion, Israel Inst.of Techn., Haifa, Israel
Dr. G.Stephanopoulos	Process Synthesis and Design	University of Minnesota, U.S.A.
Dr. M. Gars	Start up of Polyethylene Plants	Scientific Design - N.York U.S.A.
Dr. L.E. Scriven	Fluid Dynamics	University of Minnesota U.S.A.
Dr. Kent Abbas	Polymer degradation	AB Bofors Plast, Sweden
Dr. C.Mc Greavy	Chemical Reactors	Leeds University, U.K.

failure and correct it.

At present, close to 100 operators have been trained on programs, such as: steam boilers, compressor services, natural convection furnaces, distillation operations, etc.

- External Training: The external training missions carried out by industrial professionals covered a diversity of needs raised in each company which can be resumed to:
  - Plant conservation
  - Start up and operation
  - Basic Engineering
  - Maintenance
  - Advanced analytical techniques for production and quality control
  - Training and organization of work groups
  - Industrial safety

A stepped program was designed starting with senior level professionals, managers and supervisors. Their missions aimed to both, technological aspects and necessary contacting work to secure the continuation, through future missions, of the training programme.

In a second stage, professionals at the level of plant supervisor or sections chief performed external missions. They had the opportunity to participate in plant operation, start up, shut down, emergencies, maintenance, etc., getting an in vivo view of these activities.

Besides the industrial training, several missions were awarded to PLAPIQUI/PIDCOP personnel, mainly in the form of short study tours for research directors and medium range fellowships for junior researchers to continue their graduate study.

During the period 1977/1981, seventy-four fellowships were awarded reaching 176 man/month of qualified training.

Special Service Laboratories

A number of very well equipped laboratories at PLAPIQUI were the basis for the implementation of a highly specialized services to industry. In general, the companies have incorporated modern technologies but they still are strongly dependent upon international technology consultants and laboratories for services other than routine analysis and quality control. In view of this situation and taking advantage of the sophisticated equipment in use to assist the research activities at PLAPIQUI, the PIDCOP promoted a centralized service system for the complex and contributed to set up the laboratories and services listed in table VII.

The main laboratories are:

Laboratory of polymers for characterization, testing and evaluation of polymeric materials. This laboratory is equipped with the most modern instrumentation. At present, mechanical and viscoealstic properties are tested by a Rheometrics Mechanical Spectrometer, Instron Capillary Rheometer, relaxation balance,etc. Calorimetric studies are performed by differential scanning calorimeter, Thermomechanical Analyzer and Thermogravimetric analysis. Morphological features and molecular structure are evaluated by Polarized Microscopy, Infrared Spectroscopy, Gel permeation Chromatography and Laser Scattering.

Laboratory for Catalyst testing and characterization. In this laboratory BET tests are done for surface area determination. Catalytic surfaces are characterized and metallic dispersion assesed. Catalyst selectivity and deactivation analysis are also done.

Laboratory of Materials and Corrosion deals with the prevention and control of corrosion in petrochemical plants and the diagnosis and recommendation on materials failure during operation.

Chemical Analysis Laboratory is being expanded to reach a full capacity service on Chromatographic and Spectroscopic analysis, besides performing the more conventional analytical techniques.

At the present time, more than 50 reports have been issued to GdE, PBB, POLISUR, INDUPA and other companies out of the Complex. The reported results have constituted a substantial contribution to

TABLE VII

L A B O R A T O R I E S

Catalysis

- Specific Surface Area Measurements (Automatized BET)
- Pore Size Distribution Measurement (Mercury Porosimeter)
- Temperature Programmed Reduction
- Mass Spectrometry
- Metal Surface Area Measurements (Volumetric and flow apparatus)
- Catalysts' testing (pulse and flow reactors).

Analytical Chemistry

- Gas Chromatography
- Infrared Spectroscopy
- Atomic Absorption Spectrometry

Materials and Corrosion

- Soil resistivity, metallic wall thickness and electric potential in pipes for cathodic protection
- Material Surface Analysis (ESCA-AUGER)
- Metalography and Chrystalographyc properties of metals
- Endoscopy (fiber optic)

Polymers

- Rheological characterization (Mechanical Spectrometer-Capillary Rheometer)
- Viscoelastic properties (Mechanical Spectrometer, Relaxation balance)
- Gel Permeation Chromatography (Low and high temp.GPC) (Laser Scattering)
- Thermal Analysis (DSC, TMS, TGS)
- Polarized Photomicrcscopy
- Mechanical Properties (Instron tester)

the solution of real problems rather than mere routine analytical work. A non exhaustive list of the subjects covered is:

- Characterization of molecular sieves
- Characterization and evaluation of Catalysts
- Molecular and Rheological characterization of polyethylenes, polyestyrenes and polyvinylchloride
- Corrosion - cathodic protection
- Vinyl chloride content in PVC compounds
- Thermodynamic and equlibrium data
- Special Chemical Analysis

Industrial Economy Service

The Industrial Economy Service was established to support the decision making process in the allocation of resources for industrial development and research in the petrochemical section.

The general activities for the group are:

- Evaluation of investment and technological projects
- Economical modelling of industrial plants. Microeconomical analysis
- Market studies and simulation models
- Energy economy. Optimal use of liquid and gaseous hydrocarbon in petrochemistry
- Data banks
- Economic indicators for the petrochemical industry.

The group is at present carrying out several projects of interest for the complex. A study is under way on the economic analysis of the conversion of natural gas to methanol to be used as a gasoline substitute.

In other project an evaluation of the economic indicators for the local petrochemical complex is in progress. Also the group is publishing periodically a bulletin containing statistics for the main petrochemical raw materials and products.

A preliminary study on the alternatives for the future development of the Ethylene Unit of the Complex is under consideration jointly with specialists from PBB and the assistance of foreign experts.

Two projects will be started in the near future related to the analysis and evaluation for the establishment of a fertilizers plant and polymer processing industry in the region.

Computer Services

The computer services are provided through a central computer located at PLAPIQUI with terminals in the Complex. The computer service has and develops programs for dynamic and steady state simulation of chemical processes, heat exchangers, chemical reactors, separation processes and thermodynamic properties. These are used by associated companies or those which sign specific work agreements.

Information is distributed periodically regarding programs being developed or incorporated into the service. The main packages available for the predictions of thermodynamic properties are SIPREQ, UNIPAC, CHAO-SEADER, PREPROP and GPA. The combinations of these methods allow the prediction of properties for hydrocarbon mixtures, refinery streams, polar compounds,non ideal mixtures and aqueous solutions.

A package for energy efficiency analysis of chemical processes has been developed (EXERLOW) and it is now available on an european computer network.

The computer service offers courses on programming, data acquisition and microprocessor applications.

RESEARCH AND ENGINEERING PROJECTS

The Industrial Technology Division (ITD) coordinates the research and development activities of PIDCOP. It should be noted that the ITD allocates as many researchers and professionals from PLA PIQUI as needed by the specific requirements. Thus, in a sense, it work as a promoting nucleus which assigns the scientific personnel of the Institute to the industrial projects and bridges their communication with industry.

The research fields have covered a wide spectrum of subjects from the development of special maintenance techniques for the ethylene plant, that was mothballed for five years, to studies on structure properties of the new low pressure-low density polyethylene as compared to the conventional LDPE. The current activities are summarized below.

Polymers

- Structure properties relations in LLDPE and blends with LDPE
- Absortion of plasticizers and particle morphology of PVC
- Suspension polymerization of VCM
- Reaction injections molding using TDI
- Gas phase olefin polymerization
- Influence of additives in the rheological and mechanical properties of rigid PVC formulations

Process Engineering

- Evaluation of alternative schemes for aromatics extraction
- Computer Modelling and Optimization of the Ethane Plant
- Plant and engineering studies of the MEA Ethane treating units
- Computer modelling and field tests of air fin coolers and condensers
- Rigorous modelling of a pyrolisis gas quenching unit
- Optimization of the cryogenic sector of the ethylene unit
- Exergy analysis of the ethylene plant
- Mass transfer and plate hydraulic studies in CO_2 removal wash caustic tower

Industrial Economy

- Economic Modelling for the optimization of petrochemical feedstocks.
- Economic Feasibility of Methanol as a fuel

Catalysis and Reactors

- High pressure selective hydrogenation of acetylene. Kinetic studies
- Characterization of Paladium catalysts
- Dynamic and Steady state Modelling of the acetylene hydrogenation reactor
- Modelling of industrial pyrolisis furnaces

POSSIBILITIES FOR INTERNATIONAL EXCHANGE AND COOPERATION OF PLAPIQUI-PIDCOP

Training

The combination of research and industrial activities, technical services and training, development work and graduate education that comprises PLAPIQUI/PIDCOP, offers unique opportunities for training in petrochemical and polymer technology. There are consequently different schemes for this training: training missions at the plants; training with the simulator; a combination of intensive or graduate course with a practice in industry or a formal Master or Ph. D. program.

Most of the research work going on at PLAPIQUI is relevant in character to the petrochemical industry, therefore the graduate thesis work at the Master or Ph.D. levels could be tailored to the particular training needs of the candidates.

Intensive courses (one week) for industry personnel are organized on specific technological subjects. Participation of professionals from other countries will be promoted through APLA and UNIDO.

Graduate Research Opportunities

Many foreign graduates are carrying postgraduate work at PLAPIQUI attracted by the facilities available, the challenge of a close academic-industrial interaction on the active program of visiting experts of international standing. At present there are young scientists from Belgium, France, Australia, Bangladesh and El Salvador.

Technical Cooperation

There is a big potential for association with other research or industrial organizations of Latinamerica on specific projects. This is a subject of the utmost importance and any proposal in this regard will be given high consideration. In this regard, APLA has requested the support of PLAPIQUI/PIDCOP for the implementation of a computer base data bank of the Latinamerican Industry. This bank will be available through APLA to companies and consultants all over Latinamerica.

International Seminars and Meetings

Seminars on a given field with the participation of world known specialists have been and will be organized by PLAPIQUI/PIDCOP. The participation of researchers and professionals of other Latin-american countries in these seminars will be of great potential for the integration and cooperation within the latinamerican technical and research community.

FINAL REMARKS

The science and technology system of a country have to be in accordance with its present and potential needs. How can be set up a policy to accomplish this goal? This is perhaps a too general question! However, if a reasonable diagnostic could be made regarding certain needs, many years in advance, and a long range strategy is followed, the anticipated problems could be tackled and promising results could be obtained.

In this strategy, there are key components: continuity, quality and extent of communications, development of personnel, critical size, a market for the technological effort and financial support, that will be required to guarantee the health of the growing organization. This organization in turn will play a key role in the process of creation and development of technology following the strategy of learning, improvement and innovation.

REFERENCES

(1) Trindade, S. "Technology developments in developing countries". R & D Management, 10 (2) 77 (1980)

(2) Mitsutani, A., "Impact of Japanese Developments on World Chemical Industries", Hydrocarbon Processing, 58 (6) 56 (1979).

(3) UNIDO Project ARG 75/021, 1981 Mission Report, L.E. Scriven, S. Wanke, J.A. Pearson and C. Battu.