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FERTILIZERS: PROSPECTS FOR SUPPLY AND PRICES

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Preface

This document analyses some of the repercussions of the current energy crisis on the supply of fertilizers - especially nitrogenous fertilizers - in Latin America. The preliminary conclusions that have been reached on the matter serve as the basis for a more detailed study in each individual country of the aspects evaluated here, using more accurate information than that which was available for this report.

References to the situation of the productive sectors of Latin America are based essentially on previous ECLA studies 1/ and on information published on the recent development of this branch of the chemical sector and, for a variety of reasons - including the haste with which this study had to be prepared - have not been verified by direct research in the countries concerned.

The document is divided into five sections:

1. Introduction
2. Situation in Latin America
3. Prospects for the supply of nitrogen
4. Some production costs
5. Technology

The document also contains three annexes:

I. Prices of nitrogen
II. New ammonia plants in the region
III. Urea: production capacity in the area

Finally, despite the efforts made to limit as far as possible the use of technical jargon, the reader must forgive the inevitable dryness of a technical and economic analysis of such a specific

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1/ La oferta de fertilizantes en América Latina, (E/CN.12/761), November 1966, document prepared for the Seminar on the fertilizer and pesticide industry; UNIDO, Río de Janeiro, November 1970; La situación de la industria de fertilizantes en la subregión andina y sus perspectivas hacia 1980-1985, October 1972, document prepared for the Board of the Cartagena Agreement.

/problem as

problem as this. Useful though sections four and five are as background, the main interest of this report is its conclusions on which he can concentrate his attention.

Conclusions

The main conclusions of this summary analysis of the situation of the fertilizer industry, the prospects for future supply and the relationship between the price of hydrocarbons and the cost of producing ammonia and nitrogenous fertilizers are fairly encouraging for Latin America, at least in the medium-term (1977-1978).

Up to 1967-1968, the prices of both ammonia and the principal nitrogenous fertilizers remained at levels that were considered normal. Their decline as a result of technological progress and of the increasing substitution of natural gas for traditional raw material (coal and coke) was accentuated by fierce competition up to the beginning of 1971. This competion derived from the surplus production capacity that had been accumulated since 1965, together with the tendency of countries producing natural gas to use it to produce ammonia.

Between 1971 and the end of 1972, this trend of the world market in fertilizers was reversed as a result of the reduction in investment and the increase in the price of natural gas in the developed countries. Under these circumstances, prices quickly recovered more or less the pre-1968 levels; this, had it not been for the crisis in petroleum prices, would perhaps have led to a new period of stability as world demand became equated with the normal expansion of production capacity.

The immediate consequences of the restrictions on the supply of petroleum products and of the increase in prices at the end of 1973 was the sudden cutback in production in plants whose profitability was marginal (either because of their size or age) and which, faced with the unavailability of natural gas, were

/using liquid

using liquid hydrocarbons, especially naphtha. Specualtive prices therefore appeared on the market that bore no relation whatsoever to the price of the principal raw material (natural gas) - a situation which should not last beyond 1976.

The conclusion can be reached from an examination of the operating cost of modern plants and plants whose capacity is nowadays considered normal that their production costs are no higher than those prevailing at the beginning of the 1960s in plants whose capacity was a fifth or a sixth of their size, calculated on the basis of the prices for natural gas which are being discussed in the middle of 1974 for long-term supply contracts.

The nitrogenous fertilizer industry in some countries of Latin America (Mexico, Venezuela) and that which is planned in others (Argentina, Brasil and probably Chile and Ecuador) is of a nature and size such that its costs are low enough to make it competitive on the world market.

Total installed capacity towards the end of the 1970s is not only ample to meet regional demand but poses problems of opening up or maintaining external markets in the face of the efforts which other areas making to be self-sufficient (China, India and the Soviet Union) or to increase their current exports (Arab countries, Canada, Eastern European countries).

The Latin American countries will probably have to continue depending on supplies at speculative prices for the rest of this year and perhaps in 1975, and this will necessitate the signing of urgent agreements with exporting countries, especially Venezuela and Trinidad and Tobago.

/1. Introduction

1. Introduction

In the industrialized and most other countries, the fertilizer industry has for the most part been characterized by:

(a) Limited profit margins, either because of competition or because of price control exercised by governments that consider the fertilizers to be an essential input of the agricultural sectors;

(b) Permanent availability of raw materials on the world market at fairly stable prices, thanks to the large scale of operation of extractive activities which are concentrated on a certain number of major sources (potassium, phosphorus rock). In the case of the nitrogenous fertilizer industry, the cost of raw materials was determined by the international cost of a unit of energy in petroleum and petroleum products. In the case of natural gas, which is available in some countries in a volume greater than the local capacity to utilize it as fuel, its opportunity cost for production of ammonia and nitrogenous fertilizers is even lower than its energy equivalent.

Within this general trend there was cyclical fluctuations in the prices of certain raw materials such as sulphur and potassium salts, owing to temporary disequilibria between growing demand and the rate of investment for increasing extractive capacity. Among phosphates and petroleum based raw materials (natural gas, naphtha, fuel oil) the fluctuations were smaller because of the vast quantity of the resources being extracted and the relative marginality of demand for the latter from the fertilizer's sector in terms of the enormous size of the world market in petroleum products.

The situation of nitrogenous fertilizers is directly dependant on the primary product which is the base of almost all synthetic nitrogenous fertilizers,2/ i.e., it reflects the trend of ammonia. To sum up the most important aspects of developments in the world

2/ The principal examples of which are urea (46 per cent nitrogen), ammonium phosphate, ammonium nitrate (33 per cent nitrogen) and ammonium sulphate (20/21 per cent nitrogen).

/in recent

in recent years, the production of ammonia involved more and more use of natural gas and crude naphtha as the only raw materials from the end of the war in 1945 to 1960 and, for economic reasons, plants using gas from petroleum refineries or gases produced as a byproduct of coking processes or which turn coal into gas for this sole purpose declined in importance around the 1960-1965. At the same time - at the beginning of the 1960s - there was a major technological advance that led to a considerable decline in the volume of investment per unit of product and to the possibility of building plants three times bigger than any that had existed hitherto 3/ (the technical maximum rose from 300 to 600 and then to 1,000 tons per day and has now reached 1,300 and 1,500 tons per day). As a result, there was an increase in economies of scale and the installed production capacity rose beyond the demand curve, ending in the last years of the 1960s with low prices, dumping, a loss of interest in investment and the withdrawal of a number of transnational petroleum enterprises from this activity which no longer held the attraction of an appreciably higher profit per unit than that of actual refining activities. Under these circumstances, moreover, the developing countries could not implement projects designed to take advantage of natural gas resources, whose opportunity cost was very low. 4/ The drop in prices towards 1969-1971 (ammonia between 26 and 30 dollars per ton in 1967-1970, and urea between 40 and 45 dollars, for example) led to the postponement of new projects; in addition to this prime reason for a levelling off of supply, a number of large centres of

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3/ Replacement of the piston compressor by the centrifugal compressor.

4/ In the Magallanes area and in the petroleum region of Bolivia, for example; naphtha and gas in countries with large petroleum resources in the Middle East and Asia (Iran, Saudi Arabia, etc.); in 1960-1965, a price of less than 5 US cents per thousand cubic feet at the well head was barely attractive and, in some places far from the markets, was insufficient to convince those who had the technology and the access to the markets to invest.

/production experienced

production experienced technological problems in their new plants that postponed their entrance on the market as suppliers. The first signs of preoccupation with the availability of raw materials (restriction and price increases of natural gas in the United States) aggravated the situation around 1972 and caused prices to be consolidated (urea recovered its former price 70 to 90 dollars per ton).

This being so, as the world market characterized by fierce, permanent competition among countries and groups of sellers 5/ to obtain contracts with the large undersupplied markets (India, China and, to a much lesser degree, Africa and Latin America) became a sensitive market with sharply rising prices that rapidly exceeded those prevailing before the technological boom caused by the massive introduction of natural gas and plants producing 1,000 tons per day. 6/

At this critical stage of the nitrogen industry, two new factors arise: (a) the general realization of the future exhaustion of raw materials and, above all, the forthcoming end of natural gas reserves (United States); and (b) the sudden increase in petroleum prices and, as a direct result, of naphtha prices. The year 1972 saw the beginning of a shortage of ammonia and high prices, culminating towards the beginning of 1974 in a state of absolute anarchy with isolated offers of ammonia ranging from

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5/ Japan (JUASIA), the NITREX European Consortium, socialists countries (especially Poland and Rumania), South Corea, etc. See the trend of prices of principal nitrogenous fertilizers between 1959 and 1974 in Annex I.

6/ The magnitude of the problem can be gauged from the fact that the capacity-production ratio of nitrogen at the world level was 1.22 in 1970 and 1.17 in 1972. World consumption of nitrogenous, phosphate and potassium fertilizers, according to FAO was 24 million tons in 1957/1958, 77.2 million tons in 1971/1972 and 79 million tons in 1972/1973, some 41 million tons of which consisted of nitrogenous fertilizers.

/220 to

220 to 300 dollars per ton 7/ compared with prices which fluctuated between 70 and 75 dollars in 1973.

The situation on the phosphate market is interesting, although the latter have not directly suffered the impact of the increase in hydrocarbon prices in so far as they have registered generally large prices rises which will have equally serious repercussions on the expenditure of the agricultural sector at the world level. The immediate causes can be reduced to the rise in sea freight, to which a raw material such as phosphurus rock (with a useful content of 30 to 32 per cent) is highly sensitive, and the decision of certain major centres of production (Africa) to raise their prices in line with the policy pursued by the petroleum producing countries. Prices have thus reached a level of 55 to 60 dollars per ton FOB, compared with a traditional level of 6 to 8 dollars per long ton in Florida and 16 to 24 dollars per ton in Northern Africa and European ports. This means that it is highly desirable to speed up the extraction of vast available natural resources in Latin America 8/ and merit a separate analyses.

Following this brief outline of the situation, a number of critical points need to be further examined. What is the present supply situation and what prospects are there of insuring a normal supply of nitrogenous fertilizers for Latin America? What relationship is there between the increase in the price of raw materials and the cost of production of ammonia? What market price level would reflect the increase in the cost of raw materials without being affected by an atmosphere of panic and crisis in supply? This study does not intend to consider the effect of the price of fertilizers in the agricultural sector, which has been

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7/ In the early months of 1974, prices on the domestic United States market ranged from 110 to 170 dollars per ton.

8/ The main deposits are the Sechura phosphates (BAYOVAR, Perû) and potassium salts in the northeastern part of Brasil (Sergipe).

/discussed in

discussed in several expert international fora, or the additional impact of the increase in the cost of transport, nor the effect that these factors will have on the balance of payments of the developing countries.9/

2. Situation in Latin America

The following global figures, which include mainly Argentina, Brazil, Mexico, Uruguay, Central America and the Andean Group, illustrate the trend of the Latin American market in fertilizers (see table 1).

It should be pointed out that the projection after 1980 is strongly influenced by the tremendous development of consumption in Brazil between 1967 and 1972 and the targets that the country has set itself for 1980. The trend in Brazil is as indicated in table 2.

In general terms, Latin America depends on imports for a large part of its supplies of fertilizers but is at the same time rapidly increasing its productive capacity. The most striking aspects of the market are as follows.

9/ See La alimentación en América Latina dentro del contexto mundial, ECLA/FAO PANEL, 16 and 17 August 1974, (Thirteenth FAO Regional Conference for Latin America, Panama, 12 to 23 August 1974; and United Nations, Preparatory Committee for the World Food Conference, Preliminary Assessment of the World Food Situation, present and future (E/Conf.65/Prep.6, April 1974).

/Table 1

Table 1

LATIN AMERICA: TREND OF THE MARKET IN FERTILIZERS

	1964	1970a/	1972a/	1980
Consumption and projections of physical volume (thousands of tons)				
Nitrogen (N)	540	780	1 066	2 670
Phosphurus (P_2O_5)	400	696	1 238	2 830
Potassium (K_2O)	160	451	550	1 880
Total	1 100	1 927	2 854	7 380
Estimated value of consumption of final products at the price to the producer (millions of dollars)				
At usual 1965-1970	150	263	390	900 to 1 000
Prices at 1974 (Prices first half)	-	-	750	1 800

Source: ECLA estimates, based on various sources.

a/ Preliminary figures not including Cuba and Central America. For 1970-1971 FAO estimates a total of 3.1 million tons of nitrate, phosphurus and potassium for all of Latin America, rising to 3.7 million tons in 1972-1973.

/Table 2

Table 2

BRAZIL: CONSUMPTION AND PROJECTION
(Thousands of tons: 1959-1981 average)

	1960	1965	1968	1970	1972a/	1980b/ (targets)
Nitrogen	55	70.5	144.3	276.0	466	950
Phosphurus	70	86.7	214.1	375.3	830	1 600
Potassium	78	99.7	184.3	307.0	404	1 450
NPK Total c/	203	256.9	542.7	958.3	1 700	4 000

a/ Preliminary estimate; earlier plans (1968) forecast 1.2 million tons in 1972 and 1.4 million tons in 1974.

b/ Estimate of the National Association for the Distribution of Fertilizers: 80 kilos of NPK per cultivated hectare and increase in the area cultivated from 30 to 50 million hectares.

c/ 1960-1970; annual growth rate of 16.8 per cent; 1965-1972, annual growth rate of 31 per cent; 1972-1980, annual growth rate of 11.3 per cent.

/(a) Nitrogenous

(a) Nitrogenous fertilizers

Domestic production needs imports of ammonia as an intermediate raw material and is complemented with imports of final products, especially urea, ammonium sulphate, ammonium nitrate and compound fertilizers.

In 1972, imports of ammonia amounted to nearly 380,000 tons, with a calculated value of 26 million dollars. The origin of these imports are as follows:

	Imports in 1972 (tons)	Origin
Argentina	13 000	Trinidad and Tobago
Brazil	38 000	Trinidad and Tobago and the United States
Colombia	46 000	United States and Dutch West Indies (Aruba)
Mexico	204 000	United States
Others	77 000	United States, Trinidad and Tobago and Soviet Union (13 000)

In 1972, Trinidad and Tobago was the third largest exporter of ammonia, with 432,000 tons, followed in seventh position by the Dutch West Indies, with 123,000 tons.

One of the largest importers of final products is Brazil (1972), with 188,000 tons of urea and almost half a million tons of ammonium sulphate, valued at an estimated 40 million dollars at average 1972 prices. Following Brazil, lower down the scale, come Mexico, Central America, Cuba, Peru, Chile, Uruguay, Argentina and Venezuela. Venezuela is expected to begin exporting large quantities of urea in 1974. Towards 1968-1969, the production of Latin America amounted to two thirds of its consumption, with a volume of 680,000 tons of nitrogen (Mexico 54 per cent and Chile 27 per cent of the total).

(b) Phosphate fertilizers

With the partial exception of Brazil, the region depends on other countries for its supply of phosphate raw materials (apatites and phosphorites); small-scale production is only to be found in Colombia, Mexico and Peru (guano). A certain amount of final products are being produced in Colombia (compound fertilizers), Peru, Uruguay and Venezuela, which only meets part of the demand. Production is larger in Brazil, despite the enormous increase in consumption in 1972 (60 per cent between 1971 and 1972) had to be met by imports of 580,000 tons of triple super phosphate and 515,000 tons of diammonium phosphate, in addition to other minor imports (about 504,000 tons (P_2O_5) compared with the consumption of 704,000 tons).

Since 1972-1973, Mexico has been the only exporting country, particularly of phosphoric acid, whose production involves the use of apatites from Florida (United States) and domestic sulphur. Its capacity, which is increasing, is over 600,000 tons of which more than 60 per cent is exported (to Brazil, Colombia, Europe, India, etc.).

The largest known deposits of Latin American phosphorites are in Peru (Bayovar, with estimated reserves of 50,000 million tons).

(c) Potassium fertilizers

Despite the sharp increae in consumption in Brazil, demand for potassium occupies the lowest rank in Latin America. With very few exceptions (Chile, for example, has sodium and potassium nitrate) its supply depends on imports of potassium chloride and potassium sulphate from the major centres of production (Canada, United States, France, Federal Republic of Germany and Soviet Union). Known natural resources consist of deposits of sodium and potassium salts in Brazil (Sergipe) and potassium salts in the ground water of Bayovar (Peru). So far, the pricing policy followed by the major exporters has discouraged national interest in exploiting these deposits.

/3. Prospects

3. Prospects for the supply of nitrogen

The increase in the productive capacity over the next five years in countries with major reserves of raw material may do much to alleviate the supply crisis that has been felt since the middle of 1973.

Several countries of the area are opening new ammonia plants, mostly for the production of urea; new projects are also being announced and feasibility studies carried out in certain regions possessing natural gas.10/ Of special interest is the planned capacity of Venezuela and the possible projections of recent agreements for the use of natural gas in Bolivia which the country has signed with Argentina and Brazil.

All in all, the plants being constructed and projected would represent an increase in the productive capacity of the area of at least 12,000 tons of ammonia per day, or 3,200,000 tons of nitrogen per year, by 1980. Since capacity up to 1972-1973 amounted to around 1,200,000 tons of nitrogen per year, the total available capacity in 1978-1980 would reach some 4,400,000 tons of nitrogen per year, an altogether satisfactory figure given the previously mentioned estimates of probable consumption up to that date of about 2,700,000 tons a year.

Consequently, provided there are no major changes in the outcome of projects to be implemented between 1975 and 1977, the area will not have any problems of supply of nitrogenous fertilizers and should become one of the suppliers of other regions. The latter possibility must, however, be looked at in the light of the considerable efforts of areas that have hitherto had a shortage (India, China) to become self-sufficient. Most important will be the plants being projected in China (where it was recently decided to construct eight plants),11/

10/ See details by country in Annex II.

11/ China has signed contracts with Kellog International BV (Netherlands) for a total of eight urea plants with a production capacity of 1.620 tons per day and with Toyo Eng. and Mitsui Toatsu for a ninth plant. In all, these plants will produce 4,760,000 tons of urea per year. Production will begin in three of the plants in 1976. By 1978, China will no longer need to import nitrogen since its production capacity will reach 5,200,000 tons per year. The ammonia plants required to supply the urea plants (1,000 tons per day each) are also being set up by Kellog and Japanese firms.

/the Soviet

the Soviet Union (six plants with a capacity of over 1,000 tons per day each) and the petroleum and natural gas producing countries and regions in the Middle East.12/ As a result of these projects, a new gap between demand and world supply could occur around 1978-1980 and make it difficult to sell surplus production. Producers using naphtha as their raw material would be particularly affected since they could not reduce their costs, unlike producers using their own ample supplies of natural gas (Bolivia, Ecuador, Chile, Mexico and Venezuela).

The theoretical surplus of the area would amount to 1,500,000 tons of nitrogen per year, excluding the production of Trinidad and Tobago and the existing capacity of Aruba (Netherlands Antilles). The countries with the largest exportable surpluses will be Venezuela (from 1974) and, subsequently, Mexico, Chile, Bolivia (joint projects with Brazil and Argentina) and Ecuador.

As regards the region's capacity for converting ammonia into nitrogenous fertilizers, the figures given in annex III point to a rapid growth in Latin America's production of urea (currently the most sought-after fertilizer, with a nitrogen content of 46 per cent), corresponding to 1,050,000 tons of nitrogen in 1974-1975, 1,250,000 tons in 1976-1977 and 1,500,000 tons in 1978-1979, excluding Central America or the CARIFTA countries.

12/ In addition, efforts have been made by Canadian and United States consortia to build large plants in Alberta (Canada). Seven out of a total of 22 projects are believed to have been authorized so far by the Canadian Government.

/4. Production

4. Production costs

The impact of the increase in the price of raw materials obtained from petroleum on nitrogenous fertilizers may be determined with an acceptable margin of error. The production profiles used previously in analysing economies of scale and the effect of technological changes on the manufacture of ammonia and urea have been adopted for the purpose,13/ and the variations in cost have been examined in terms of the price of natural gas. At the same time, corrections should be introduced because of the increase in the cost of manufacturing equipment, energy installations, etc., which has been more vigorous since 1972-1973.

(a) Ammonia

Comparisons of production costs obtained on the basis of different prices of raw materials give the following results:

Table 3

AMMONIA: COST OF PRODUCTION ON THE BASIS OF NATURAL GAS a/

(Dollars per ton)

	Price of natural gas in US cents per 1,000 cubic feet				
	5	20	50	85	100
Natural gas (930 m^3)	1.82	7.28	17.04	28.97	34.10
Electric energy	0.10	0.17	0.20	0.25	0.30
Water for cooling and boilers	0.68	0.68	0.75	0.80	0.80
Catalysts and chemical products	0.70	0.70	0.70	0.70	0.70
Direct manpower	0.66	0.66	0.66	0.66	0.66
Maintenance (3 per cent investment)	1.90	1.90	1.90	1.90	1.90
Capital expenditure b/	11.00	11.10	11.20	11.20	11.20
Indirect expenditure (administration, etc.)	0.70	0.70	0.70	0.70	0.70
Total	17.56	23.19	33.15	45.18	50.36

a/ Capacity: 908 tons per day; investment: 20 to 20.5 million dollar (in 1971).

b/ Covers 10 per cent depreciation, 6 per cent interest and 1.5 per cent taxes and insurance amounting to 17.5 per cent of total investment.

13/ See ECLA, La oferta de fertilizantes en América Latina (E/CN.12/761), annex I, November 1966.

/To these

To these costs placed at the plant must be added about 2 dollars per ton for storage (depreciation and operation); the effect of the capital must then be corrected in line with the increases of approximately 20 per cent recorded by investment in equipment between 1971 and the end of 1973. With these corrections, the following cost series are obtained for delivery at the original plant, up-dated to 1974:14/

Price of natural gas (US cents per 1,000 cubic feet)	Cost (Dollars per ton of ammonia)	Sales price 15/ (Dollars per index ton)	
5	22.14	22.50	80
20	27.80	32.00	100
50	37.80	43.50	136
85	49.50	57.00	178
100	55.00	63.20	197

If the supply of natural gas at 0.20 dollars per 1,000 cubic feet is accepted as being representative of a favourable location in Latin America in 1971-1972, it will be seen from the table that in the extreme case of natural gas at 1 dollar per 1,000 cubic feet the increase in the price of ammonia would be 97 per cent, and it could be delivered at about 63 dollars per ton.

According to some European sources,16/ with natural gas at 0.95 dollars per 1,000 cubic feet (or 3.60 dollars per million kcal) the cost would be 61 dollars per ton, which is somewhat higher than the cost of 55 dollars calculated here, because of the larger investment than that considered in the previous example (32 million dollars instead of 24 to 24.6 million). This cost is also equal to that obtained on

14/ No corrections have been introduced in the cost of manpower, which is calculated at 4 dollars per man/hour.

15/ On the basis of the lower prices ruling in 1969-1971, a margin of 15 per cent over the cost is accepted, which would include profit margin, marketing costs, delivery, etc.

16/ European Chemical News, 31 August 1973.

/the basis

the basis of naphtha at 36 dollars per ton, or fuel oil at 34 dollars per ton. Considering Latin America's experience,17/ it seems reasonable to assume that investment will reach that level in 1974 (30 to 32 million dollars per unit with a capacity of 1,000 tons daily). Allowing for this additional factor, the representative prices of ammonia obtained from natural gas in units with a production capacity of 1,000 tons daily constructed in 1974-1975 would fall within the following range:

Price of natural gas (US cents per 1,000 cubic feet)	20	50	85	100
Price of ammonia (dollars per ton)	36	47.50	61.50	67
Index	100	136	170	186

As regards the calculation of production costs under the conditions prevailing in 1970-1971, with natural gas at a maximum price of 0.20 dollars per 1,000 cubic feet - i.e., about 23.20 dollars per ton of ammonia - the foreseeable increases in 1974 on the basis of probable natural gas prices would mean the following indexes of increases in costs at the plant over 1970-1971:

	US cents per 1,000 cubic feet	Dollars per ton	Index
1970-1971	Gas at 20	(23.19)	100
1974	Gas at 20	(27.80)	120
	Gas at 50	(37.80)	163
	Gas at 85	(49.50)	213
	Gas at 100	(55.00)	237

Brief reference will be made to the manufacture of ammonia from liquid fractions instead of natural gas. The longest experience in the last 8 to 10 years has been the use of naphthas, i.e., light fractions (gasolines/kerosene) obtained in oil refineries or directly in the oilfields themselves (topping gasolines).

17/ And allowing for repercussions on the cost of machinery, equipment, freight, etc.

/Similar calculations

Similar calculations to those presented above for natural gas give the following relation between the price paid for the raw material - naphtha - and the price of the ammonia produced:

Price of naphtha (dollars per ton)	Price of ammonia (dollars per ton)
25	47
36	54
40	58
60	77

It will be noted, moreover, that the sales prices calculated for ammonia obtained from naphtha were already unfavourable compared with those of ammonia obtained from natural gas under the conditions prevailing in 1965.18/

It may be concluded that the price of 60 dollars per ton of naphtha makes the cost of ammonia higher than if it were obtained from gas at 1 dollar, or even 1.20 dollars, per 1,000 cubic feet, with no chance of competing against producers with supplies of natural gas at 0.60 or 0.85 dollars per 1,000 cubic feet. Thus, in addition to reasons of a temporary nature - supply difficulties and speculative prices - there is a strong presumption that naphtha will be completely replaced within the medium term as a raw material for the production of ammonia. This trend, as well as the costs resulting from both these alternatives, were analysed in March 1973 19/ by representatives of M.W. Kellog Co., an enterprise responsible for the design and installation of most of the plants constructed over the past 10 years. At that time, 11 US cents per gallon of naphtha (approximately 37 dollars per ton) was considered to be an acceptable ceiling price for a cost of 58 dollars per ton of ammonia produced, since the cost of obtaining it from coal would be 55 dollars per ton.

18/ See, La oferta de fertilizantes en América Latina, op. cit., annexes I and II. The prices calculated in 1965 for production units with a capacity ranging from 270 to 900 tons per day, using naphtha at 24.60 dollars per ton, were, respectively, 47.23 and 37.19 dollars per ton of ammonia. With natural gas at 0.20 dollars per 1,000 cubic feet, the prices calculated were 33.38 dollars (270 tons per day) 29.82 dollars (900 tons per day).

19/ Seventy-fourth national convention of the American Institute of Chemical Engineers.

/(b) Urea

(b) Urea

Taking urea as being representative of the finished nitrogenous fertilizers, the impact of increases in cost of ammonia on its price is examined below.

In broad outline, consideration is given to a medium-sized plant, typical of the scales of production existing in the region, with a capacity of 500 tons daily or 165,000 tons annually,20/ which in 1966 required an investment (including auxiliary services and working capital) of 10.5 million dollars, corrected to 12 million dollars under the conditions prevailing in 1971.

The main components of its production costs are:

	Dollars per ton of urea
Raw materials	
Ammonia, 0.60 tons at 23.20 dollars (1971)	13.92
Carbon dioxide gas from the ammonia plant: free	-
Services	
Electric energy (170 kWh at 0.80 US cents)	1.36
Steam, water, etc.	2.50
Chemical products and catalysts, etc.	2.70
Manpower and supervision (4 dollars per hour)	2.40
Indirect capital expenditure 21/	13.45
Indirect administrative and other expenditure	1.57
Total	39.40

The variations in cost in line with the increases in the price of capital goods (equipment and facilities) would mean, in the previous example, an increase of 2.70 dollars per ton in 1974,22/ thus raising the previous calculation to 42.10 dollars, while the increases in the cost of raw material for the production of ammonia would result in the following corrected values:

20/ See, in the annexes, Latin America's capacity in 1971-1972 and its foreseeable capacity in 1976 and 1978-1980.

21/ Depreciation 8 per cent, maintenance 3 per cent, interest 6 per cent, and taxes and insurance 1.5 per cent: total, 18.5 per cent.

22/ Reflecting higher investment (1971-1974) in ammonia units (24 million dollars) and urea units (14 million).

/Ammonia

Ammonia (dollars per ton)	Natural gas (dollars per 1,000 cubic feet)	Cost of urea at plant (dollars per ton)	Index
27.80	20	44.86	100
37.80	50	50.86	113
49.50	85	57.90	129
55.00	100	61.20	136
70.00	145	70.20	157
100.00 23/	(235)	88.00	196

The conclusions which may be drawn from the above calculations are clear as regards the expected increase in costs of fertilizer plants using natural gas and operating with a capacity of 900 tons per day (ammonia), as in the case of Mexico and Venezuela (in addition to Trinidad and Aruba), the new projects of these same countries and of Argentina and Brazil, and the possible projects (1975-1978) of Chile and Ecuador. Urea plants with capacities close to that considered, or even larger, are found in Mexico, Venezuela and Peru, and are planned for Argentina and Brazil.

The increases in gas prices to 85 and even 100 US cents per 1,000 cubic feet would bring the costs to values far below the spot price in the first few months of 1974, which are still favourable compared with the normal price of urea up to 1965, and again in 1972-1973, i.e., values below 90 to 100 dollars per ton.24/

23/ Assuming abnormal situations in the production of ammonia, since it is unlikely that gas will be used at 2.35 dollars per thousand cubic feet, it being preferable to resort to the gasification of coal.

24/ For illustrative purposes, some domestic prices are indicated in 1972, 121.60 dollars in Mexico, 113.50 dollars in Italy; in 1973, 98.50 dollars in Argentina, 128.95 dollars (imported) in Argentina.

/Moreover, the

Moreover, the processes now being developed to produce natural gas by means of synthesis are aimed at reaching costs of 1.54 to 1.70 dollars per million Btu,25/ i.e., 1.50 to 1.63 dollars per 1,000 cubic feet (of natural gas). On the basis of these costs, the production cost of urea would still be below 75 to 80 dollars a ton. Furthermore, in recent studies 26/ the cost of liquid natural gas (Algeria and the Persian Gulf) placed at destination (the United Kingdom) is estimated at not more than 0.50 and 0.60 dollars per 1,000 dubic feet, while the cost of natural gas from the Soviet Union is estimated at 0.56 dollars per 1,000 cubic feet placed in Norway or Sweden. These figures indicate ceiling prices for natural gas from Latin America which would be used to supply ammonia production units, and permit the conclusion that it is feasible to produce ammonia at a cost of not more than 50 dollars, and urea at a maximum cost of 50 to 54 dollars per ton, placed at the plant.

In the very long term (depletion of natural gas reserves) the probable cost of obtaining gas from coal may mean costs of up to 80 to 90 dollars per ton of urea.27/

To sum up, it may be concluded that the saving achieved in the operating costs of large-scale units, which are the norm today, both for ammonia (1,000 to 1,500 tons per day) and for urea largely compensates for the increases due to the price of the raw material. At the beginning of the 1960's,28/ on the other hand, it was usual to find units with capacities ranging from 100 to 200 tons a day (and 35 to 50 tons of urea), with natural gas at 10 to 20 US cents per 1,000 cubic feet.

25/ Lurgi and Hygas processes, using coal priced at 24 dollars per ton.

26/ D. Keens and M.R. Parry, document on supply options for the Scandinavian countries, presented at the Scandinavian Congress on Chemical Engineering, Copenhagen, January 1974.

27/ These values do not allow for possible monetary variations and are therefore expressed in 1974 dollars.

28/ In La oferta de fertilizantes en América Latina op. cit., a cost of 43 dollars is estimated, with gas at 0.20 dollars per 1,000 cubic feet, placed at plants with a capacity of 90 tons per day.

/5. Technology

5. Technology

It should be remebered that natural gas and later naphtha and other liquid hydrocarbons - liquified petroleum gas (LPG) and middle oils - only acquired real importance as raw materials for obtaining ammonia as from 1960, for in those countries where output was high this was based on the use of residual gas from coke ovens, oil refineries, the gasification of coke and coal, and the production of hydrogen through electrolysis. Thus, for example, the production of ammonia in the Soviet Union was based on the following feed-stock (expressed in percentages of the total):29/

	1958	1964	1966
Natural gas	0.6	54.9	62.9
Coke oven gas	35.4	18.6	17.3
Gasification of coal and coke	44.9	17.8	13.9
Electrolytic hydrogen	19.1	8.7	5.9

The situation was similar in other European countries (Belgium, Bulgaria (lignite), Czecheslovakia (up to 1964-1966)), where gas from coke ovens and the gasification of coke and coal was the main or sole source of ammonia.

World ammonia production capacity between the end of 1958 and the beginning of 1972 based on the use of the following sources (in percentages of the total):

Sources	1959	1961-1962	1966-1967	1971-1972
Natural gas	31	50	58	63
Oil fractions (and others)	15	19	14	7
Naphtha	...	13	15	21
Gas from coke ovens, coal, etc.	40	18	13	9
Other sources (gases from refineries, electrolysis, etc.)	14	...	...	...
Total capacity (thousands of tons per year)	...	15 600	31 700	51 000

29/ Use of gas in the chemical industry, ST/ECE/GAS,30, December 1969.

/The processes

The processes used for the synthesis of ammonia consist of obtaining a primary gas - a mixture of hydrogen and carbon monoxide - through the partial combustion of coal (or coke) in the presence of water vapour. In the case of heavy hydrocarbons, partial oxidation is performed, while for light hydrocarbons (naphtha light oils) steam reforming is preferred. In all cases the subsequent stages include the conversion of the monoxide into dioxide with the release of hydrogen, separation and purification of the hydrogen, and mixing of the hydrogen with nitrogen (obtained generally through the liquifaction of air)30/ after which the product is sent to the section where the actual synthesis is carried out: there, under the influence of high pressure and through the use of catalysts, the hydrogen (three part by volume) and the nitrogen (one part) react to give ammonia (NH_3). The preference for the use of natural gas is based on the fact that it is easier to use and gives a higher yield (for lower investments) because of the capacity of methane (CH_4), its main element, to release hydrogen and carbon monoxide when subjected to high temperatures (partial oxidation or steam reforming).

It should be noted that a great quantity of carbon dioxide is released by the process, and this, together with ammonia, constitutes the raw material for obtaining urea; for this reason urea plants are always associated with those producing ammonia.

The ratios of the investments required for a given capacity, depending on the raw materials used, are approximately as follows:

Gas from coke ovens and refineries	85
Natural gas	100
Oil: light fractions	100 to 112 (France)
Oil: heavy fractions	178 (Soviet Union)
Coal	140 (Bulgaria)

30/ Except in a few cases where nitrogen is introduced together with the air used in the partial combustion of the initial primary gas.

/When ammonia

When ammonia first began to be synthesized on the basis of its constituent elements (Haber, 1914-1915), use was made first of all of gases obtained in the coking of coal and later of "synthesis gas" (hydrogen and nitrogen) prepared by various methods from coke or directly from coal. All these techniques, which were displaced as we said by the use of natural gas and later by liquid hydrocarbons in the 1950s are likely to be brought back in so far as coal is used to supplement the shrinking reserves of natural gas and oil, not only to provide raw materials but also to replace natural gas as a source of energy. It is estimated that between 1980 and 1982 there will be industrial-scale plants for the direct gasification of coal which will provide a new source of raw material for ammonia at competitive prices.31/

In addition to the alternatives indicated above, it remains to be seen whether there is any economic advantage to be gained from processes employing electrical energy, as used for decades in Norway. These processes are based on the separation of hydrogen from water by electrolysis followed by the traditional synthesis process with nitrogen separated from the air. This method lost its attractiveness in the middle of the past decade, but today some existing plants in Scandinavian countries are being brought back into operation. The simultaneous release of oxigen in the electrolysis process means that this activity could advantageously be integrated with the iron and steel industry, which uses oxygen in the current methods of producing steel (LD-OBF).

Plans for the more distant future look to the possibility of the direct fixation of nitrogen from the air, either through the use of high levels of energy (plasma or others), or through the use of microorganisms whose metabolism may be geared to the production of compounds containing sufficient nitrogen to warrant their industrial processing or their direct use on the land.

31/ It should be noted that 1,800 tons of coal are needed to produce 1,000 tons of ammonia.

/No special

No special mention is made here of the contribution of the natural Chilean nitrates, since their magnitude, although fairly large, would not exceed 180,000-200,000 tons of nitrogen, which is only a small fraction of future regional demand. Nevertheless such production is of interest to Chile, both with respect to supplying its own agricultural needs and to the value of the nitrates as an item which finds a ready export market in the present circumstances.

/Annex I

Annex I

NITROGEN PRICES

Some information concerning the evolution of nitrogenous fertilizer prices has been collected, from, among other sources, contracts signed and offers received by various countries. This information is given below in chronological order with the indication - if any - of the terms, origen, and volume offered.

Year	Product	Destination	Price in dollars/ton	Thousands of tons	Origin	Dollars/ton of nitrogen a/
1959	Urea	(average price)	115 (delivered)			250
1960	Urea	(average price)	103 (delivered)			224
1968	Urea	India	84.30 CIF	267	Japan	183
1968	Urea	Burma	73 to 88 FAS	47	Various offers	(160 to 190)
1969	Urea	India	51.50 FOB	25	Italy	(112)
1969	Urea	Pakistan	58-60 FOB	180	Eastern Europe	(126 to 130)
1970	Ammoniun sulphate	Brazil	22.50 CIF	697	Average import price	110
1970	Urea	India	54.90 CIF	30	Saudi Arabia	120
1970-1971	Urea	China (annual)	54.00 CIF		Japan	117
1971	Urea	Turkey	41.50 to 45.50 CIF in bags		Yugoslavia	90 to 100
1971	Urea	India	53.90 CIF in bags		Bulgaria	128
1971	Urea	Egypt	41.50 CIF in bags		Bulgaria	90
1971	Urea	Nepal	58.90 CIF	2	Bulgaria	128
1971	Urea	Peru	56.50 CIF	6	NITREX	123
1971	Urea	Brazil	64 CIF (posted customs price)			140
1971 2nd. half of year	Urea	Egypt	41.50 CIF	175	Kuwait	90
1971 2nd. half of year	Urea	India	54.40 CIF in bags	20	South Korea	118
1971 2nd. half of year	Urea	Indonesia	48.50 CIF bulk	21	Australia	105
1971 2nd. half of year	Urea	Indonesia	65 CIF in bags	61	Japan	141
1971 2nd. half of year	Ammonium sulphate	Indonesia	33.50 CIF in bags	6.8	Australia	161
1971 2nd. half of year	Ammonium sulphate	Mexico	18 CIF in bulk	10	United States	88

a/ Prices in brackets are FOB or FAS offers.

Annex I ... (continued)

Year	Product	Destination	Price in dollars/ton	Thousands of tons	Origin	Dollars/ton of nitrogen a/
1972	Urea	Israel	63.50 CIF	52	South Korea	138
1972 March	Urea	India(purchase)	66.00 CIF(in bags)		Kuwait Saudi Arabia	143
1972 July	Urea	India	70 CIF (delivery Nov./Dec)		Japan	153
1972	Ammonium sulphate	Mexico	25-27 FOB (delivery Nov./Dec 1973)		NITREX AND JUASIA	(122-132)
1972 November	Urea	Israel	79.50 CIF	10	Japan	173
1972 November	Urea	Israel	77.50 CIF	10	Iraq	168
1972-1973	Urea	India	61 FOB Salina Cruz (delivery 1973)		Mexico	(133)
1972-1973	Urea	India	70 CIF (delivery July 1973)		Japan	
1973 January	Ammonium phosphate	India	92 FOB Vancouver		Canada	(144) (N+P)
1973 January	Ammonium phosphate	Pakistan	107.80 FOB (in bags)		Canada	(168) (N+P)
1973	Ammonia	United States	104 CIF		Kuwait	127
1973	Ammonia	South Africa	120 CIF		Iran	146
1973	Ammonia	Brazil	120 CIF		Australia	146
1973	Urea	India	111 CIF		Japan	241
1973	Ammonium sulphate	India	45 CIF (in bulk)		Japan	219
1973	Urea	Uruguay	118.50 CIF (in bulk)		...	258
1973 December	Urea	South Vietnam	146 FOB (205 CIF)		United States	(317)
1973 December	Urea	Egypt	153 CIF		Federal Republic of Germany	333
1973 December	Ammonium sulphate	Egypt	72 CIF		Federal Republic of Germany	351
1974 January	Urea	China	200 FOB	100	Italy (ANIC)	(434)
1974 January	Ammonium sulphate	China	100 FOB	200	Italy (ANIC)	(488)
1974 January	Urea	Italy	125 (posted price)		Italy (ANIC)	270
1974 January	Ammonium sulphate	Italy	73 (posted price)		Italy (ANIC)	(356)

a/ Prices in brackets are FOB or FAS offers.

Annex I ... (concluded)

The most significant change began in May-July 1972, as May be seen from the following price-ranges for urea b/ before the sharp rise in prices of raw materials: c/

	Period	Dollars per ton
1972	January-February	46 to 52
	March	48 to 52
	April	50 to 54
	May	50 to 54
	June	54 to 57
	July	55 to 60
	August	60 to 62
	September	61 to 65
	October	64 to 68
	November	65 to 71
	December	66 to 72
1973	January	68 to 73

b/ International prices published in Nitrogen Journal, London.

c/ Spot prices in 1974 (May): quotations at 350 dollars (Chile), equivalent to 760 dollars per ton of nitrogen.

Annex II

NEW AMMONIA PLANTS IN THE REGION

The most outstanding recent developments in the production of ammonia (nine plants or projects became operational) are given below:

Mexico	A plant with a daily capacity of 1,000 tons of ammonia began operations in Coatzacoalcos. There are plans to build two additional units of equal capacity (1976 and 1978).
Trinidad and Tobago	The extensions to the plant at Point Lisas (Grace) include a new unit with a daily capacity of 1,200 tons of ammonia.
Venezuela	The Tablazo complex (Maracaibo) began operations; it is expected to be operating at full capacity on both production lines by the end of 1974, with a daily capacity of 1,800 tons of ammonia and 2,400 of urea. Plans are under way for the construction of two more units with daily capacities of 1,000 and 1,500 tons respectively.
Brazil	PETROBAS (through PETROQUISA and later PETROFER) has entered into a contract for the building of a second unit at Camacari (Salvador) with a daily capacity of 1,000 tons of ammonia and 800 tons of urea. On the basis of the negotiations under way with Bolivia it is expected that a new producing centre with capacities of over 1,000 tons per day, using Bolivian natural gas, will be built by the end of the decade.
Argentina	Negotiations are in progress with Bolivia concerning the use of natural gas from Santa Cruz for a joint project with a capacity of 1,500 tons of ammonia per day.
Chile	Interest has been renewed in the completion of a project for the production of ammonia in Punta Arenas with a capacity of 1,000 tons or more per day. In any event, the nitrates plants are to be extended and improved to raise their capacity to over one million tons per year (160,000 tons of nitrogen).
Peru	The new ammonia and urea plant at Talara should come into operation in 1975 (300 tons per day).

/Annex III

Annex III

UREA: PRODUCTION CAPACITY

The capacity for the production of urea in the region is given in the following table, in thousands of tons per year.

	1971/1972	Projects under way or completed in 1974	Projects begun or under study a/
Argentina	115	-	... a/
Brazil	167	-	390
Colombia	106	-	...
Chile	-	-	... a/
Cuba	62	180	...
Mexico	483	...	... a/
Peru	-	165	-
Venezuela	17	1 030	...
Total	950	1 375	1 000 b/
World capacity	30 850	(11 650)	

a/ Although exact figures cannot be given, these projects may provide an additional 600 000 tons per year by 1978-1980.

b/ Approximately.

It appears from these figures that the region should be capable of producing some 2.3 million tons by 1974-1975, 2.7 million by 1977-1978, and 3.3 million by 1978-1980. World capacity, for its part, should rise to 42.5 million tons of urea (20 million tons of nitrogen).