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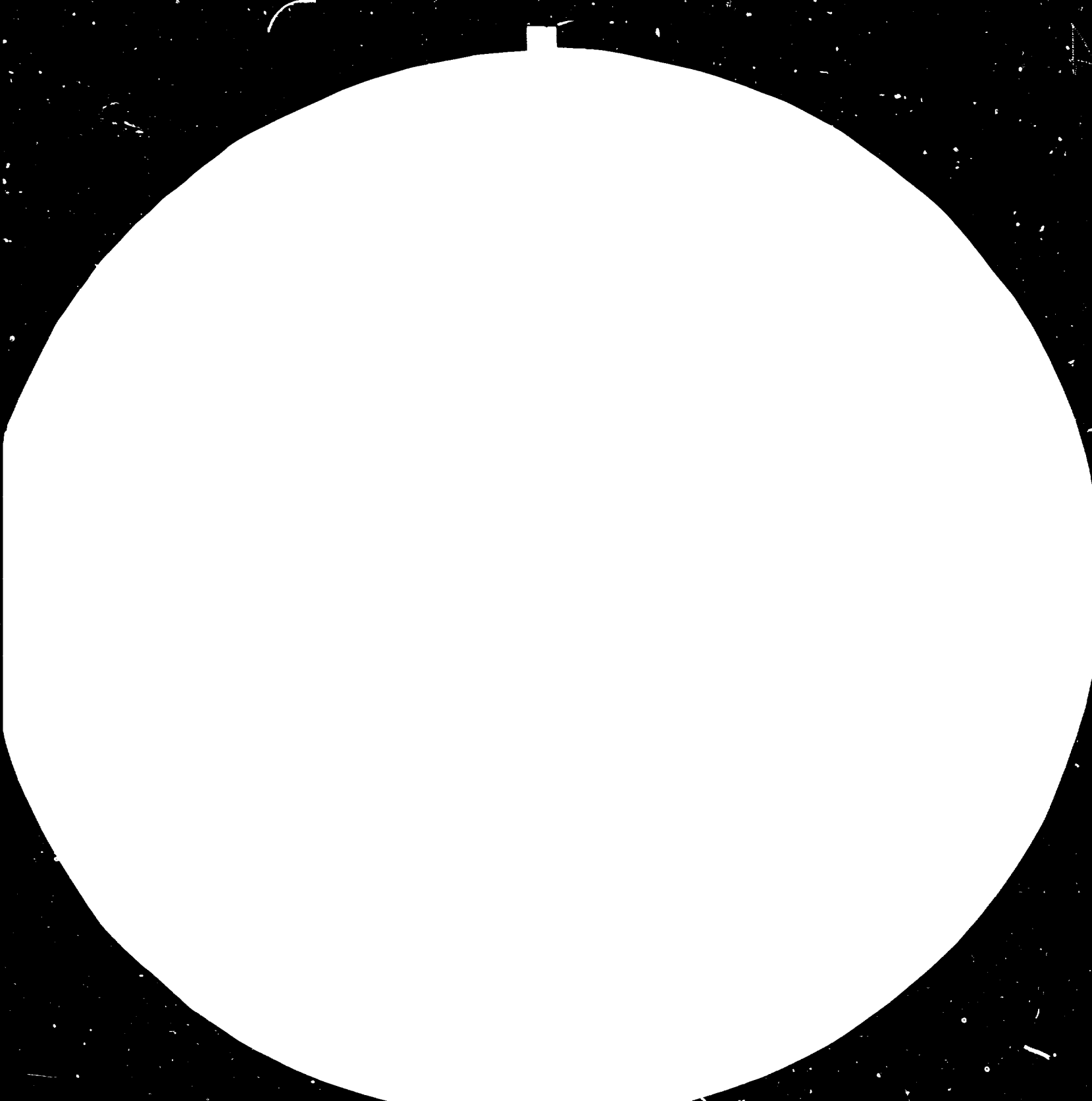
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12988



United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.406/2
17 October 1983
ENGLISH

Fourth Consultation
on the Fertilizer Industry
New Delhi, India, 23 - 27 January 1984

THE CHANGING STRUCTURE OF THE
INTERNATIONAL FERTILIZER INDUSTRY*

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* This paper was read before the Fertilizer Society in London. The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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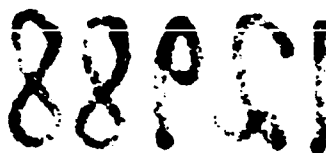


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THE CHANGING STRUCTURE OF THE INTERNATIONAL FERTILIZER INDUSTRY

1.0 INTRODUCTION

The future of the international fertilizer industry is assured if we are to continue to feed a growing world population. To do this we will need, in step with demand, to continuously increase our facilities for producing the three major nutrients nitrogen phosphate and potash.

Each of these sectors, with their different types and sources of raw materials and because of their different economics, markets and group of competitors, require separate analysis.

This paper attempts to forecast the capacity needs for each nutrient to meet increasing world demand and discusses some of the economic factors likely to influence the location of these plants and the effect that this will have on international fertilizer trade.

2.0 WORLD FERTILIZER CONSUMPTION AND FUTURE DEMAND

2.1 World Fertilizer Consumption

Any attempt to examine the changing structure of the fertilizer industry must be based on both historical and future fertilizer demand which in its turn depends on its single market - agriculture.

The international fertilizer business began essentially in the middle of the nineteenth century following Leibig's doctrine of mineral plant nutrition. By the end of the nineteenth century, annual world fertilizer consumption had reached about 2 million tons and during the fifty years thereafter had risen to about 14 million nutrient tons and was then about to "take off". By 1977 the annual world consumption of fertilizer nutrients exceeded 100 million tons and the use of fertilizers had become an important and indispensable factor in agriculture to maintain soil fertility. A rapidly

increasing demand for food, particularly in developing countries, accelerated fertilizer demand when used with the new high-yield varieties of wheat and rice which triggered the green revolution. A.J.S. Sodhi, in a recent paper to I.F.A. (Reference 1) outlined the importance that fertilizers together with other inputs have played and will continue to play in increasing crop productivity. In many countries yields have been increased from one to three tons per hectare with fertilizers contributing increased production of 7-17 kg per hectare for every kg of fertilizer nutrient applied and on average about 50% of increased food production has been due to increased fertilizer use. In a paper to the Fertilizer Society in 1980 A. Von Peter (Reference 2) also gives an excellent account of the patterns of fertilizer use in developing countries and the contribution that fertilizers have made to increased yields. Undoubtedly these developments have been extremely important for the developing countries of the world with their growing need for food and high potential for improving food production yields.

The rapid increase in the growth of fertilizer consumption throughout the world over the last thirty years has meant a constantly changing pattern of fertilizer production and use as can be seen in Figures 1 and 2. In 1950 about 70% of all chemical fertilizers was produced and used in the Developed Economies mainly in Western Europe and North America. About 20% of world fertilizer use and production took place in the Centrally Planned Economies mainly in Eastern Europe and the Developing Economies used only about 10% of total world fertilizer consumption and produced slightly less. Inter-regional fertilizer trade was relatively small and less than two million tons of nutrients per year.

During the 1950's and 1960's, fertilizer use grew steadily in all regions and particularly in the Developing Economies which started from a small

base. In the 1970's the rate of increasing demand in the Developed Economies slowed down relative to the other two major economic regions so that at the end of the decade the use of fertilizers in the Centrally Planned Economies was almost equal to that in the Developed Economies (about 40%) and the Developing Economies had almost reached half of this level (20%).

Generally the same type of trend had been taking place with regard to production although at a slower rate. The fact that fertilizer production did not always develop in the same place as demand has resulted in a considerable fertilizer export trade, a business which has grown steadily during the last three decades from about 2 million tons per year in 1950 to more than 35 million tons per year in 1980. There has also been a considerable increase in trade in fertilizer intermediates such as phosphoric acid and ammonia.

Table 1

Fertilizer Trade (Million Tons)

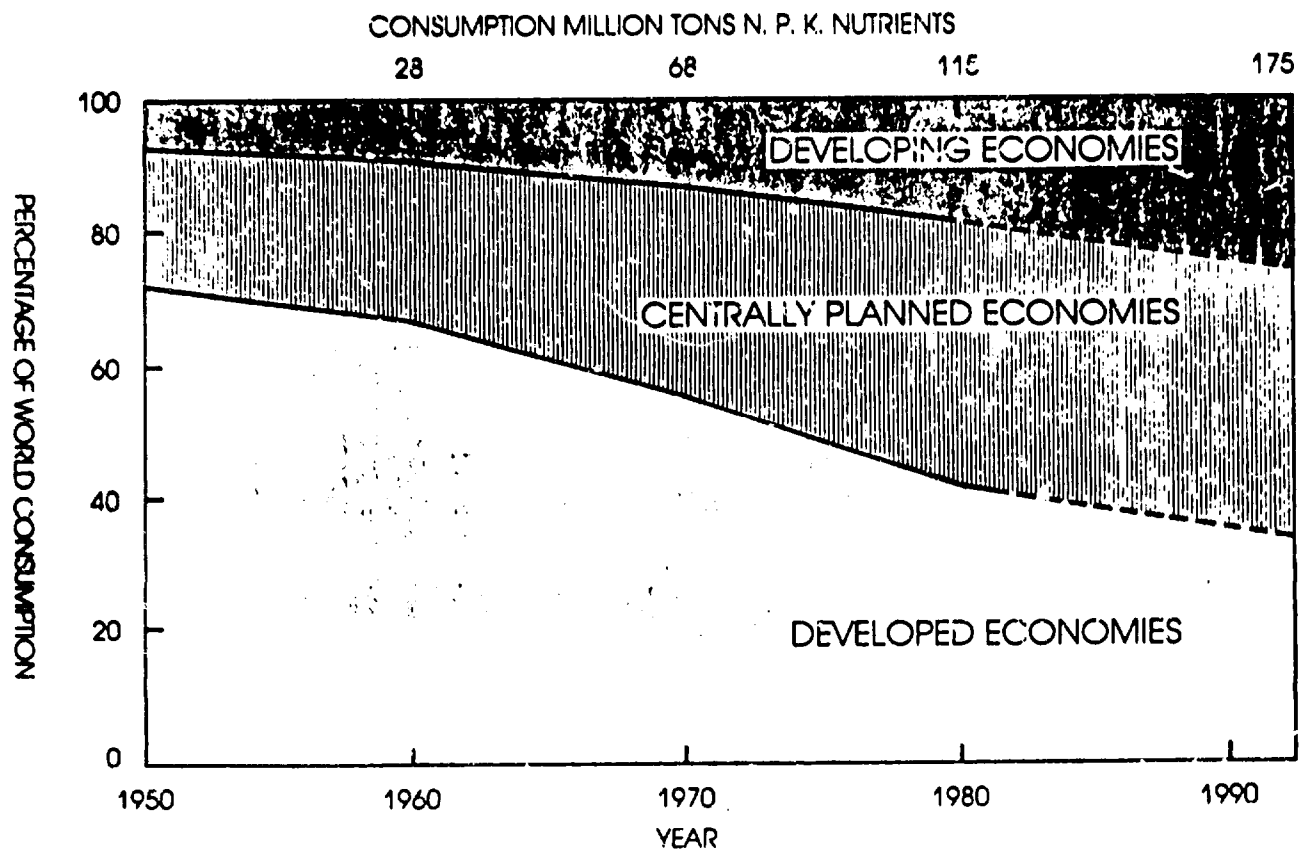
	1960	1980
Phosphate Fertilizers (P ₂ O ₅)	1.2	6.7
Nitrogen Fertilizers (N)	2.6	12.1
Potash Fertilizers (K ₂ O)	3.4	16.6
Phosphate Rock (Product)	20.0	52.3
Phosphoric Acid (P ₂ O ₅)	—	2.5
Ammonia (N)	—	6.4

2.2 Future World Fertilizer Demand

The demand projections of the World Bank/FAO/UNIDO Fertilizer Working Group which were made in March 1983 are shown in Table 2. These indicate that from 1981/82 through 1992/93 fertilizer consumption growth will average 3.5% in each major nutrient.

The highest overall growth will be in the Developing Economies, 5.8% compared with 3.4% in the Centrally Planned Economies and the Developed Economies about 2.5%. By 1992/93 total fertilizer demand should reach about 170 million tons per year.

REGIONAL CONSUMPTION OF FERTILIZERS



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Figure 1

REGIONAL PRODUCTION OF FERTILIZERS

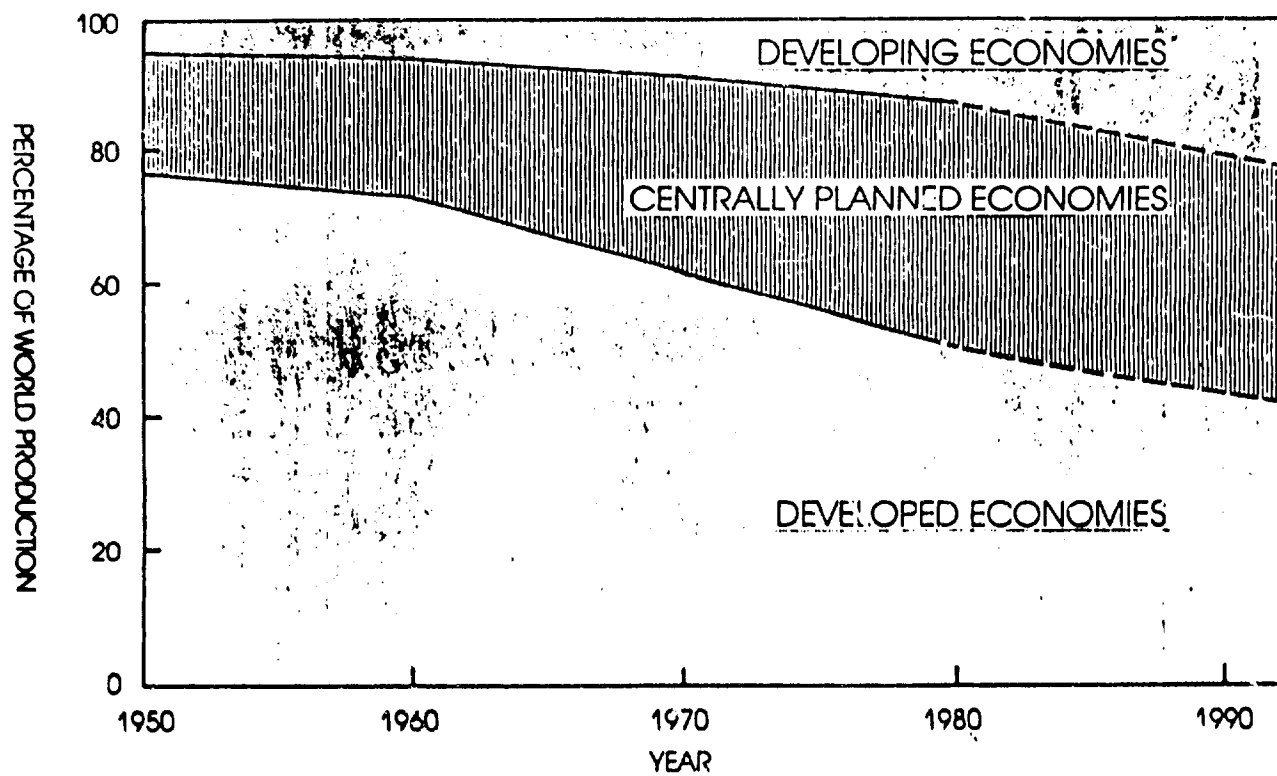


Table 2

	<u>Fertilizer Demand Forecast by Region</u>								
	<u>Million Tons of Nutrients</u>								
	N			P ₂ O ₅			K ₂ O		
	81/82	87/88	92/93	81/82	87/88	92/93	81/82	87/88	92/93
Developed Economies	22.3	26.1	29.6	12.7	14.7	16.4	11.6	13.7	15.0
Developing Economies	12.8	18.4	23.5	6.2	9.2	11.0	3.0	4.4	5.5
Centrally Planned Economies	25.4	31.3	36.0	12.1	15.4	17.6	9.2	11.7	14.3
TOTAL WORLD	60.5	75.8	89.1	31.0	39.3	45.6	23.8	29.8	34.8

In 1981/82 world fertilizer consumption showed an overall slight fall compared with 1980/81.

The forecasts above were based on the assumption that the world economy would recover shortly, and as a result of this fertilizer demand would also pick up. Any delay in a recovery will also delay the realization of these forecasts accordingly.

The supply demand balances that have been prepared by the Fertilizer Working Group for the period 1983-88 indicate that present world capacity should be more than adequate through this period but after that time, it will therefore be necessary to provide additional capacity to meet the increasing fertilizer demand.

It is estimated that between 1987/88 and 1992/93 nitrogen demand will increase by 13.3 million tons, phosphate demand will increase by 6.3 million tons and potash will increase by about 5.0 million tons.

In planning new investment for fertilizer plants, consideration must be given to an increasing extent, to replace worn-out capacity, or capacity that may have become redundant because of changes in its economic operation -- for example increases in gas prices or because of structural changes on the phosphate industry. In order to calculate new investment requirements for replacement plant it is assumed that the life of an ammonia/urea plant is 25 years; the life of a phosphoric acid plant and phosphate complex about 25 years and a potash mine about 30 years. From FAO fertilizer statistics and based on the life of the plants assumed above it is projected that in the years 1987/88 - 1992/93 it will be necessary to replace or refurbish about 15 million tons of fertilizer nutrient capacity as shown in Table 3.

2.3 New Technical Developments

Although the last 20 years or so have seen considerable development in fertilizer technology, most of this has been related to the improvement of existing processes in efficiency and scale. It is anticipated that this trend will continue and there will be no major changes in fertilizer technology over the next decade or so and it seems safe to assume that investment requirements can be projected on existing experience and cost data.

Although much attention has been focussed on the improvement of natural symbiotic associations of crop plants with nitrogen-fixing bacteria and

the development of catalytic nitrogen-fixing systems primarily based on the functionality of the enzyme nitrogenase, no major developments are expected within the next decade.

For nitrogen fertilizers it seems likely that urea, ammonium nitrate and ammonium sulphate will remain the principal products. The main source of phosphate fertilizer will involve the acidulation of phosphate rock with sulphuric acid. Potash will be produced mainly from dry mining of sylvinite in Canada and the USSR.

Fertilizer development is likely to continue its present course of increasing nutrient concentration (to save distribution costs), improving process efficiency and energy consumption and reducing costs by larger scale operations.

2.4 World Fertilizer Plant Capacity and Investment Requirements 1987/88 - 1992/93

Based on current projections for increased fertilizer demand and anticipated needs to replace existing plants, some rough projections have been made of new capacity and investment needs for the period 1987/88 - 1992/93.

Table 3World Fertilizer Plant Investment Requirements 1987/88 - 1992/93

	Nitrogen ^a (N)	Phosphate ^b (P ₂ O ₅)	Potash ^c (K ₂ O)
<u>New Demand</u> (Million Tons)	13.3	6.3	5.0
New Capacity Needed (Million Tons)	15.6	7.4	5.8
New Plants Needed	47	22	5
<u>Replacement Supply Capability</u> (Million Tons)	9.0	5.0	1.5
Equivalent Capacity Needed (Million Tons)	10.0	5.6	1.7
New or Refurbished Plants Needed	30	17	1

a Assumes life of plant 25 years. New nitrogen complex based on 1000 t.p.d. ammonia plant. Assumes plants operate at 90% utilization and distribution losses 5%.

b Assumes life of plant 25 years. New phosphate complex based on 1000 t.p.d. P₂O₅ plant plus corresponding phosphate fertilizer plants. Assumes plants operate at 90% utilization and distribution losses 5%.

c Assumes life of mine 30 years. New potash mine of 2 million tons per year capacity product. Assumes mine operates at 90% utilization and distribution losses 5%.

The estimates of new plants calculated above look rather high and therefore need to be qualified somewhat. The figures assume that fertilizer demand will recover in the next year or so and will average about 3.5% over the next decade for each nutrient. In considering the new plants required to meet increased demand between 1988 and 1993 it is appreciated that some of these plants are already planned and will come on-stream either before or during this period. The replacement capacities are also relatively high because of the unusually high growth of fertilizer capacity during the 1960's which will need replacing in the next decade. Much replacement capacity may also be in the form

of revamping of old plants on the same site although others will not be replaced in the same place because of changes in the economic basis for the plant such as increases in raw material prices. Taking all these factors into account, however, and assuming that the rough estimates for new plants may have to be reduced by up to a third, the requirements are still formidable.

3.0 THE WORLD NITROGEN FERTILIZER INDUSTRY

3.1 Historical Aspects

Up to about 1960 most of the world ammonia capacity was in the developed countries such as the USA, West Europe and Japan. Plants were small and served local markets and a wide range of feedstocks was used. There were very few nitrogen plants in developing countries and only a small quantity of fertilizer was imported by these countries.

During the 1970's several major changes took place in the industry. In technology, the trend to large plants that could use centrifugal compressors had a major impact on reducing the cost of producing ammonia. Although the price of oil and naphtha rose steeply during the 1970's, generally, natural gas became more available and in many cases remained relatively cheap. For example in the USA, the largest producer of ammonia at that time, the average 1980 price of gas to ammonia plants was still less than \$2.0/MM BTU. In Europe also, gas became available at reasonable prices to the fertilizer industry with the development of new gas fields in Holland and in the North Sea. In a number of developing countries natural gas for fertilizer production became available at low prices.

Perhaps the most important development that took place for the nitrogen fertilizer industry during the 1970's as mentioned earlier was the so-called "Green Revolution" which opened up tremendous possibilities for increased

food production using the new high yield varieties of seed together with increased fertilizers and other agricultural inputs. Many of the larger Developing Countries increased their fertilizer consumptions significantly in the early 1970's but the fertilizer crisis of 1974/75 caused a serious check in world-wide demand. The events of this time clearly demonstrated to the major Developing Countries the dangers of depending on the vagaries of the international fertilizer export market for their rapidly developing agricultural programs.

For example in 1974/75 (expressed in 1982 US dollar values) the price of urea rose to US\$650/ton, for TSP to US\$620/ton and for potash to US\$130/ton. The extra money that India needed to meet its fertilizer requirements at that period (about \$600 million) would have been sufficient to build several new fertilizer plants. Small wonder therefore that many developing countries decided not to depend on imports but to erect their own fertilizer plants. Between 1970 and 1980 fertilizer production capacity in developing countries increased by nearly 10 million tons per year (mainly in nitrogen) compared with 5 million tons during the previous decade. Nearly all of this new capacity in the developing countries was for increased domestic use and up to about 1980 there was very little change in the trading patterns for nitrogen fertilizers with the developed countries still remaining the main exporters.

Among the developing countries, the growth of the nitrogen industry was particularly rapid in China and India. In China the growth of the nitrogenous fertilizer industry has been phenomenal. When the Peoples Republic of China was established in the late 1940's the annual output of nitrogen fertilizers was only 5000 tons with ammonium sulphate the main product. Over the last 30 years the industry has developed vigorously and in 1981/82 produced 10.1 million tons of nitrogen fertilizers making China the third largest

producer after the USA (10.5 million tons) and the USSR (10.2 million tons). From 1950 to 1980 the output of nitrogen fertilizers increased at an average annual growth rate of almost 30% per annum during which period the application rate for chemical fertilizers increased from about 0.6 kg/ha up to 120 kg/ha in 1980.

China also imports about 2 million tons per year of nitrogen fertilizers so with about 12 million tons of nitrogen consumption China has the highest nitrogen usage in the world. It is anticipated however that the growth rate in nitrogenous fertilizers will fall off somewhat as China puts more emphasis on increasing the use of the other two major nutrients.

The growth rate of the Indian nitrogenous fertilizer industry has also been spectacular. In 1960 the installed nitrogen capacity was about 160,000 tons per year but in 1983 capacity exceeds 5.0 million tons per year. India is the world's fourth largest producer of nitrogen fertilizer.

Undoubtedly the growth of the nitrogen fertilizer industry in India has done much to help to make that country self-sufficient in food products.

3.2 The Future of the World Nitrogen Fertilizer Industry

3.21 General

The discussions in the previous sections indicate that the growth in demand for nitrogen will continue to be higher than the other two nutrients. The investment needs for nitrogen fertilizer plants in the five years between 1987-1992 will be considerable and many new nitrogen fertilizer complexes will be required to meet increased demand and to replace worn-out or uneconomic plants.

The patterns of production and trade resulting from these investments will depend on many factors. Although it is possible to forecast fertilizer demand requirements of each country and region based on historical trends and

future agricultural needs and programs, etc. these do not necessarily tell us where new plants will be built or how future trading patterns will develop.

The economics of nitrogen fertilizer production are complex and dynamic, particularly as the cost of feedstock and fuel can vary significantly in price. In the past decade the relative costs of feedstock such as gas, fuel oil, naphtha, have also been particularly important. However, at the present time more than 80% of all ammonia plant capacity is based on natural gas and it seems reasonable to assume that up to the year 2000 at least gas will remain the main feedstock for ammonia production so that those locations with cheap gas available will have the best economic potential to develop a nitrogen fertilizer industry.

It can be expected that some nitrogen fertilizer capacity in the future, as it has been in the past, will be erected based on less than optimal economic conditions for strategic reasons where a country regards the extra cost as an insurance to maintain a reliable source of fertilizer to protect its agricultural programs. However, it seems certain that most of future capacity will be determined essentially by the inter-relationship between the cost of feedstock, the investment cost (and hence the unit capital cost of the product) and the cost of transporting the fertilizer to the marketplace.

3.22 Availability and Opportunity Cost of Natural Gas

As natural gas is expected to remain the dominant feedstock for nitrogen fertilizer plants throughout the 1980's, those countries which are well endowed with gas are likely to have a competitive advantage in nitrogen fertilizer production. A summary of the reserves, production and disposition of natural gas throughout the world are shown in Table 4. It is of interest to note that in 1977 about 200 billion M³ of natural gas were flared, sufficient to

feed about 400 large ammonia plants or almost twice the current world production of nitrogen fertilizers. The main deposits of natural gas are in the USSR, the Middle East and North America. Significant quantities of natural gas are being flared in the USSR, the Middle East and in several countries in Africa such as Algeria and Nigeria.

Table 4
Production and Disposition of Natural Gas (Reference 3)

Billion M ³				
<u>Region</u>	<u>Reserves</u>	<u>Production</u>	<u>Reinjection</u>	<u>Flared</u>
North America	7,600	700	37	5
Latin America	3,000	90	26	13
Western Europe	3,800	190	1	12
Africa	5,900	75	8	41
Middle East	20,400	160	18	101
Asia & Oceania	3,500	64	2	11
Eastern Europe	<u>26,400</u>	<u>425</u>	-	<u>23</u>
TOTAL	70,600	1,704	92	206

One of the most important factors determining the feasibility of ammonia production in any country will be the economic (opportunity) value of natural gas. This can vary significantly from location to location depending on the size of the resource and the alternative (opportunity) uses of the gas. If the gas can be used for oil substitution then the economic value of the gas should be linked to the value of the oil - at the present time about US\$5.0 per MM BTU. However, in many countries particularly some energy-rich developing countries, oil substitution is not available and the value of the gas is determined by other alternatives in which the gas has a lower value.

These alternative uses of gas include the fertilizer and petrochemical industry such as methanol, or LNG manufacture for overseas markets. Where

deposits of gas are small, ammonia and urea plants are usually the most attractive proposition. Where deposits are large LNG manufacture may be feasible. Even so, the cost of liquification and transport of natural gas is expensive and the netback value of the gas will vary from about \$1.0 to \$2.5 per MM BTU depending on location of resource and market (Reference 3).

The opportunity cost of gas for ammonia manufacture, therefore, in many areas of the world is likely to be between about \$1.0 - \$2.5 per MM BTU. Although the opportunity cost will set the lower level of gas price on which economic returns are calculated, in many cases financial prices are set at a higher cost depending on what the market will bear.

In attempting to forecast the pattern of production and trading for the nitrogen fertilizer industry in the next decade or so, it is important to review the energy costs in some areas which either by virtue of their large market for fertilizers or because of favorable resource endowment will be important in the future.

U.S.A.: Compared with other developed countries in the past, the price of gas in the USA has been relatively low, and even in 1981 the average price to ammonia plants was only \$2.3 per MM BTU (Reference 4). In this situation and with efficient relatively low-cost plants, the USA has been able to provide cheap nitrogen fertilizers for the domestic market and also to be a competitive exporter.

However, the situation in the USA with regard to future gas pricing is not clear. The Natural Gas Policy Act (NGPA) was designed to allow the price of "new" gas to reach free market levels, but this was based on an energy price of oil that was assumed to have reached \$15 per barrel. The situation is complicated by the fact that there are currently 22 categories of natural gas pricing. Although it was intended to achieve decontrol of gas prices by 1985

many analysts do not expect that gas will immediately reach prices equivalent to fuel oil. On the basis of an oil price equivalent to about \$5.0 per MM BTU it is assumed that gas prices will approach \$4.0 per MM BTU by the mid-1980's but thereafter the difference between energy prices from oil and gas will narrow very slowly.

Canada: Here the situation is somewhat clearer. A National Energy agreement in September 1981 related oil and gas price from which it would appear that the price of gas netted back to Alberta will be about \$2.5 per MM BTU. As a result of these favorable gas prices in Western Canada, several new nitrogen projects are being studied in addition to four new projects planned to go on-stream there in the next few years. The North Central area of the USA would be a natural market for these projects.

Western Europe: Although a few companies in Europe have favorable gas contracts based on gas from the North and Irish Sea and from the Dutch gas fields most others do not. Europe is already importing natural gas from North Africa and Eastern Europe and in considering the future of nitrogen fertilizers in Western Europe it is assumed that the overall average price of gas will approach the equivalent energy price of fuel oil by 1985.

East Europe (Including USSR): This region has the world's largest proven reserves of natural gas and is also the largest producer of gas. It is difficult to put a price on natural gas to ammonia plants in the USSR in the future, as this is likely to depend on political as well as economic considerations. The USSR has already exported ammonia at very low prices equivalent in some cases to a zero energy component. Although the USSR will increase its sales of gas to Europe by pipeline which could net-back to about \$3.0-4.0 per million BTU, nevertheless with its large resources of gas it is still in a position to maintain a large nitrogen fertilizer export business with gas at a much lower price if it wishes to do so.

Middle East: In terms of gas availability at low economic prices, the Middle East region is extremely well placed to produce nitrogen fertilizers. Taking into account the very large quantities of gas available in the region and the fact that the LNG market may not develop as quickly as expected, it seems likely that gas could be available in some countries at economic prices of about \$1.0 per million BTU, although as mentioned earlier, gas prices in financial terms may be related to market conditions.

Central and South America: Mexico, Trinidad and Venezuela are already major exporters of ammonia based on cheap natural gas and Mexico has further capacity planned to come on-stream in the mid-1980's. Chile is also considering building a plant to produce urea for export based on cheap natural gas.

Africa: Several new nitrogen fertilizer plants which are being considered in Africa such as Libya, Nigeria and Tanzania will be export-based using low cost gas.

South East Asia: Indonesia was one of the first developing countries to develop its nitrogen fertilizer industry based on cheap natural gas. Further expansion in both Indonesia and Malaysia is now under way.

3.23 Investment Costs for Nitrogen Fertilizer Plants

Investment cost for nitrogen fertilizer plants can vary widely depending on site location and infrastructural requirements. Figure 3 (Reference 4) gives a rough indication of how the total investment costs will vary for an ammonia/urea complex (1,000 tpd ammonia and 1,700 tpd urea) for various locations. The lefthand ordinate represents the battery limit total production costs for a plant in a developed country like the USA or Western Europe. The additional costs for the different regions are due to increased engineering costs in developing and remote areas and the need to provide differing amounts of infrastructure. It is also pointed out, however, that for many developing areas the cost of building new plants is falling, particularly

as new industrial sites become established or as they build up their infrastructure. For example, a new fertilizer complex in Saudi Arabia which seven years ago was estimated to cost about US\$600 million, in real terms today might cost just over half of that figure, if build on one of the new industrial estates in that country.

3.24 Total Production Costs for Nitrogen Fertilizers

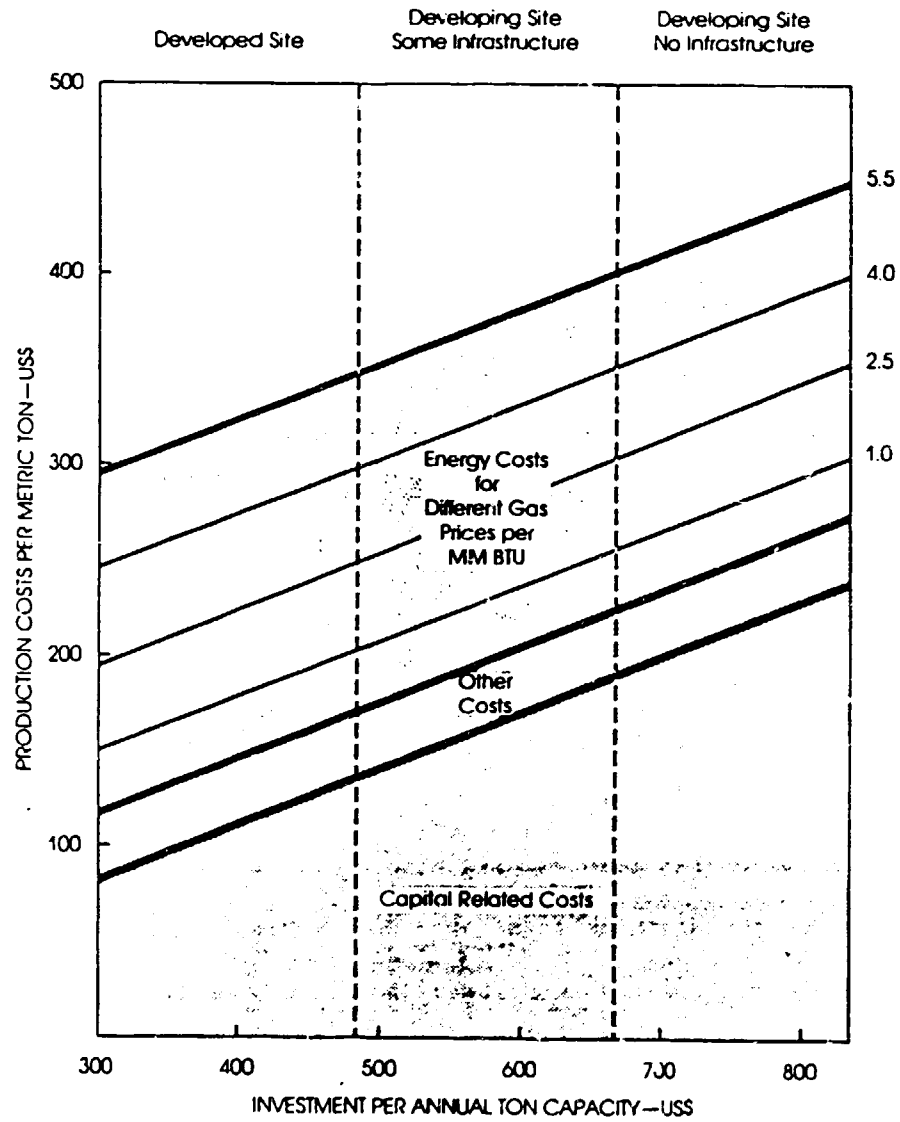
Based on the data of Figure 3 and the discussions of the previous sections it is possible to estimate the potential relative economic total costs for nitrogen fertilizers in different locations and hence to some extent forecast the most likely prices and production and trading patterns. The specific investment costs are based on a knowledge and review of the investment data for similar projects. In the case of the USSR no comparative data are available and the figure used is one of judgement.

The "total production cost" or "realization price" is the price that would have to be obtained to realize an adequate return on investment and includes all direct and indirect charges and a return on investment. In all cases an IRR of 15% has been assumed although it is appreciated that in some areas for political or other reasons other IRR figures may be acceptable.

A 90% utilization has been assumed also in all cases and has been used as the basis for production costs in Figure 3. Once again this figure will vary from place to place although recent experience indicates that many developing countries are now achieving these rates. In any case plants are usually built on the expectation that they will achieve 90% utilization.

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UREA PRODUCTION COSTS FOR DIFFERENT LOCATIONS INVESTMENT COSTS AND ENERGY PRICES



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Table 5

Total Production Costs for Urea for Various Countries
US\$(1982)

<u>Country</u>	<u>Gas Price</u> \$ per MM BTU	<u>Investment Cost</u> \$ per ton of Annual Capacity	<u>Total Production Cost</u> \$ per ton of Urea ^b
<u>Developed Economies</u>			
USA	4.0	400	275
Canada	2.5	450	245
W. Europe	5.0	425	310
Japan	5.5 ^c	425	325
<u>Developing Countries</u>			
Mexico			
Indonesia and Malaysia	1.0	400 ^a -600	205 ^a -240
Middle East			
<u>Centrally Planned</u>			
USSR	1.0	600	240

a/ Built on existing industrial estate or existing site.

b/ Assumes 90% utilization in each case.

c/ Based on imported LNG.

3.25 FUTURE WORLD NITROGEN FERTILIZER DEVELOPMENTS

The realization prices calculated in Table 5 are based on economic considerations and show the relative total costs of producing nitrogen fertilizers in different regions. The results indicate the effect of energy prices on total urea production costs and hence the competitive advantages of

many cheap resource-based projects. Taking into account freight rates that are likely to prevail in the future it would seem that many developing countries have sufficient economic advantage to compete in the domestic markets of the major developed countries of Japan and Western Europe and to a lesser extent in the USA.

After 1987, however, many new plants will be needed each year to meet increasing future demand and it seems unlikely based on present intentions that there will be sufficient development of new projects in the gas-rich Developing Economies to meet more than a relatively small part of these needs. The very large investments together with the major task of planning and implementing these projects will be a major constraint for the poorer developing countries who may have the potential resources to produce nitrogen fertilizers for exports.

On the other hand some of the wealthy gas-rich countries in the Middle East who appear to be most favored to develop a nitrogen fertilizer industry, and are also well placed for the expanding markets in South East Asia, show little inclination to expand their activities in this field.

The Eastern Europe situation is more difficult to analyze although the Russians have already demonstrated their ability to greatly increase their ammonia capacity. With exports of about 0.8 million tons N per year as nitrogen fertilizers and 1.4 million tons N per as ammonia, the USSR is already the world's largest exporter of N and is certainly capable of consolidating this position in the future with an estimated export potential of about 4 million tons of N by 1985. With large reserves of gas, a rapidly expanding ammonia capacity and a need to export to earn hard currencies, the USSR will press hard to dominate the international nitrogen market.

Overall in the future, Western Europe will be one of the most expensive producers, and current exports from Europe are expected to diminish in the face of lower cost competition nearer the growing international markets. Many countries in Western Europe who are non-resource based will increase their imports of nitrogen products particularly from the USSR and overall the region is likely to slowly develop into a net importer.

The case of the USA is particularly interesting. With energy prices probably more favorable than Western Europe the domestic industry is less threatened by exports from the USSR and the Middle East but on the other hand is more vulnerable to exports from Mexico, Trinidad and Canada. The USA is already a net importer of ammonia and within the next few years will probably become a net importer of nitrogen.

The US industry is currently hard pressed with rising production costs and unreasonably low priced imports of ammonia and about 3.5 million tons of capacity is reportedly idle. However, it seems certain that this idle capacity plus additional capacity will be needed in the second half of the 1980's as well as increasing imports in order to meet US demand.

The nitrogen industry in Japan, the other major developed economy, is in a very unfavorable position with high cost feedstock. Japan has already started to rationalize its industry and look for overseas sources of nitrogen. The most economic sources are likely to be Southeast Asia, the Middle East and possibly Alaska or Western Canada.

With regard to nitrogen importers, China, India, Turkey and Brazil will be the major markets in developing countries. Several other traditional importers such as Pakistan and Bangladesh have already significantly reduced their imports as their new plants come on-stream.

4.0 THE WORLD PHOSPHATE INDUSTRY

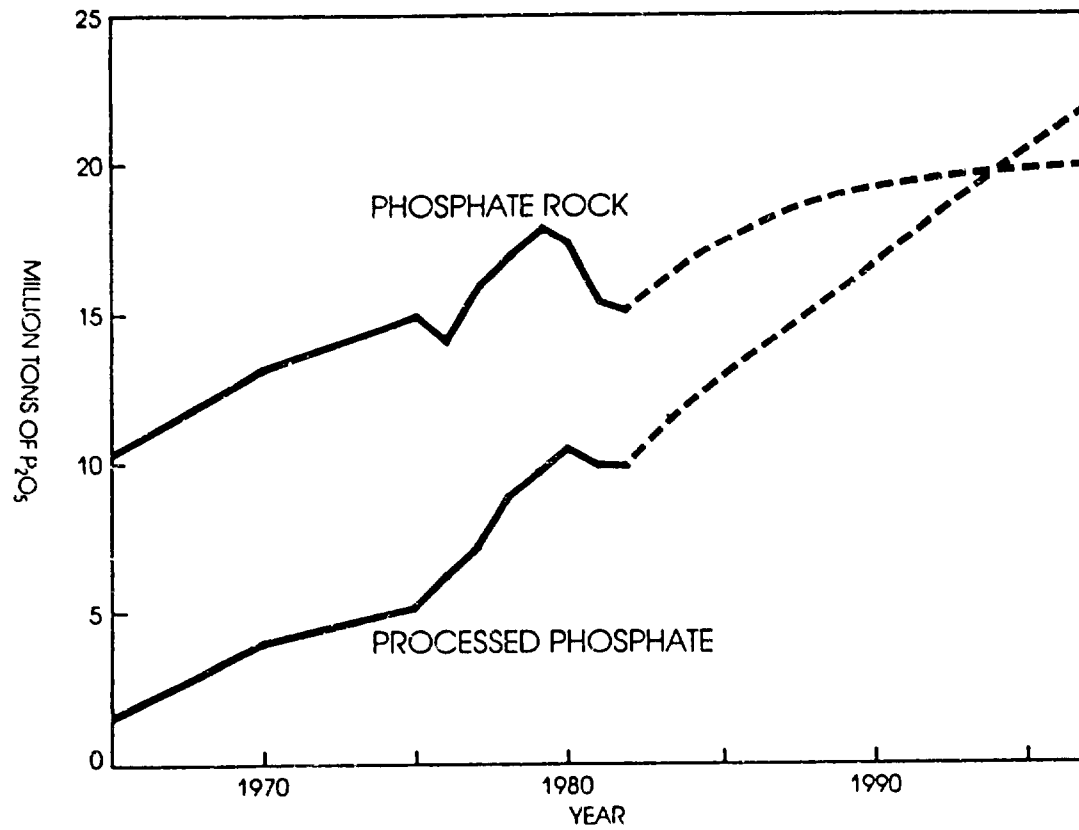
4.1 Historical Aspects

Traditionally, a very large share of the world use of phosphates is based on imports. The phosphate products traded can be in three different stages of processing: (a) as a raw material in the form of phosphate rock; (b) as an intermediate product such as phosphoric acid, MAP, DAP and TSP ; and (c) as a finished fertilizer which incorporates processed phosphate.

Originally the phosphate processing industry developed in industrialized countries which were and still are, the principal users of phosphate fertilizers. With the major exception of the USA, this industry was generally based on imported rock. The main finished phosphate fertilizer material for almost a century was superphosphate of about 15-18% P₂O₅ content and this was exported from the processing industries in the developed countries (again the USA excepted) rather than directly from the place the rock was mined. With the development of higher grade finished phosphate intermediates like DAP, TSP and phosphoric acid, the economics of phosphate production and logistics have changed. Figure 4 clearly shows the structural changes in phosphate trade over the last ten years. Economics now generally favor the construction of large-scale phosphate intermediate complexes at the rock source which allow economies of scale. The gradual depletion of higher grade ores will make this advantage even more pronounced in the longer term. The disadvantage of non-resource based plants has increased because of the dual price structure for phosphate rock which has prevailed in some major producing countries since about 1973.

This had the effect that producers who had to import phosphate rock found their margins squeezed between a relatively expensive raw material and a cheaper finished product originating from resource-based operators who in turn

WORLD PHOSPHATE TRADE (Million Tons of P₂O₅)



could charge rock into their own plants at little over cost (in some cases this could be as low as half the equivalent export price of the rock). Another factor is the serious environmental problem of by-product gypsum disposal and restrictions increasingly imposed in many of the industrialized countries which make phosphoric acid production in these countries less attractive.

An increasing share of phosphate rock is now being processed in the raw material supplying country and trade in processed phosphates has increased at the expense of rock trade. In 1960 about 15% of total P_2O_5 phosphate trade was accounted for by the latter. In 1977 the figure was 23% and in 1982 nearly 40%.

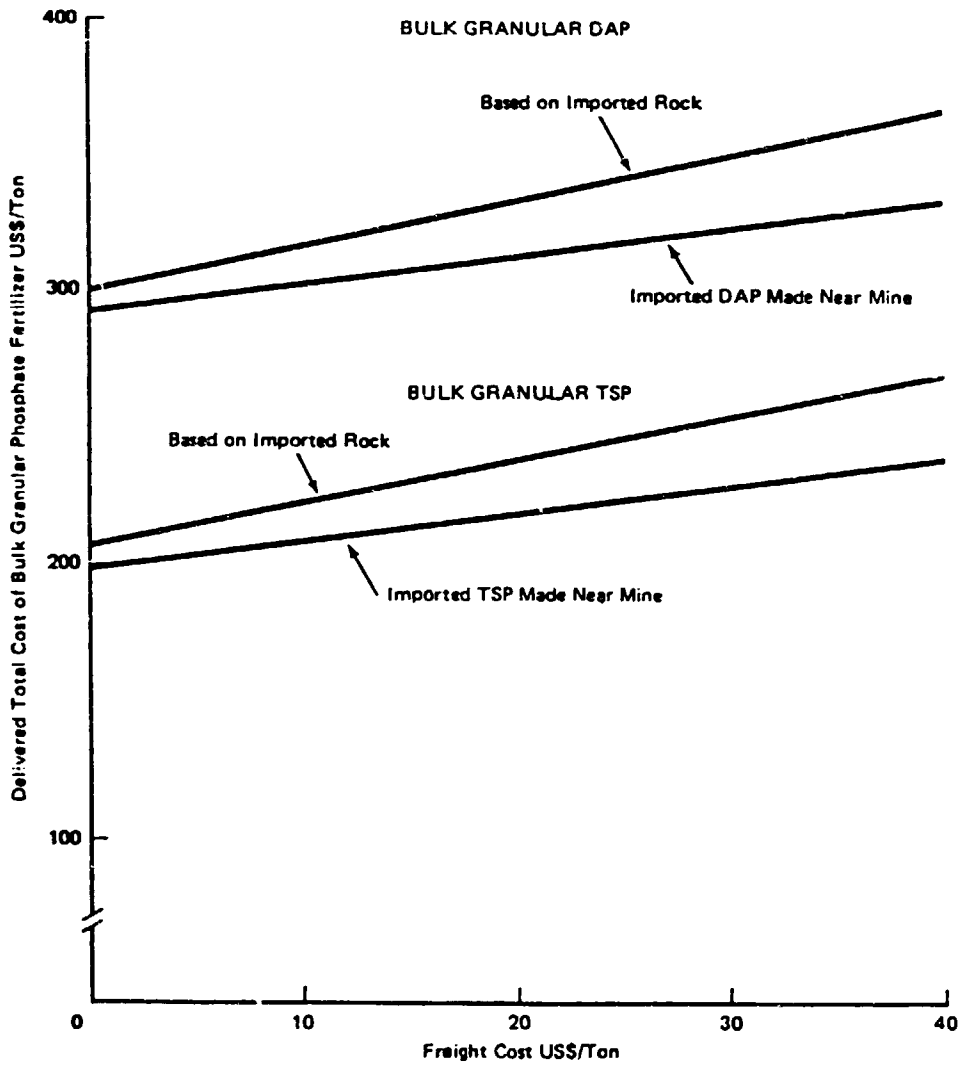
4.2 The Future of the World Phosphate Fertilizer Industry

4.21 General

The future of the phosphate fertilizer industry lends itself to much easier economic analysis than the case for nitrogen. One factor which might complicate the analysis is the future price and availability of sulphur and this is referred to later in the discussions.

It seems certain that the trend towards vertical integration of rock mining and processing will continue steadily and for good economic reasons. Even assuming that the rock producer has no special advantage with regard to technical processing or transfer price, the procedure offers a significant advantage in freight costs. If one assumes that sulphur C.I.F. is a common cost, there is roughly a 40-50% savings in overall product freight using integrated phosphate production. Figure 5 compares the delivered cost of DAP and TSP for new phosphate fertilizer complexes for integrated and non-integrated projects. In the case of the integrated producer it is assumed that the rock does not need to be dried and this together with savings in loading costs is equivalent to about \$5/ton of rock.

Comparison of Total Costs of Phosphate Fertilizers from Integrated and Non-Integrated Projects



In practice the savings are likely to be greater than indicated if account is taken of the two tier price structure of phosphate rock to domestic and export plants and also, that a lower grade of rock is usually processed when the mine is near the process units.

In this situation it seems unlikely that many new phosphoric acid plants will be built based on imported rock unless a country has some special situation which favors this. Two possible cases are discussed briefly below.

4.22 Sulphuric Acid Availability

The recent very high increases in sulphur prices mean that for many producers the cost of sulphur is now more important than the cost of rock. This is particularly so in the case of the two major producers of phosphate intermediates, the USA and Morocco. The future for sulphur is uncertain and will depend on the increasing demand for phosphate fertilizers. Some analysts believe that elemental sulphur availability will remain tight and particularly so if phosphate demand recovers and the stock piles of sulphur in Canada are depleted in the second half of the 1980's. If the price of elemental sulphur increases significantly it could favor further development of the pyrites industry for expanding sulphuric acid manufacture. The use of pyrites for acid manufacture has stayed more or less unchanged at about 11 million tons (of sulphur equivalent) over the last few years equivalent now to about 15% of the total supply capability. Although the cost of building acid plants based on pyrites is very high, delivered sulphur prices for certain locations have already risen to a level that makes pyrites competitive and the next few years could see further development in this area mainly in Eastern Europe and in South Europe. In this situation there may be a few cases where phosphoric acid plants could be justified economically near the sulphuric acid production based on pyrites.

4.23 Nitrophosphates

One of the main advantages of the nitrophosphate process is that it does not require sulphur and when sulphur prices are relatively high which is the case at the present time, there is always a renewed interest in the nitrophosphate route.

The most likely situation for a nitrophosphate process to compete with a sulphuric acid based process would be for a country with a relatively large fertilizer use, preferably with a cheap domestic source of ammonia, where ammonium nitrate is an acceptable form of nitrogen fertilizer and where there is a seasonal uniform demand for a relatively high N:P₂O₅ fertilizer ratio.

Countries which have already invested considerably in this process include Western Europe, Eastern Europe, USSR and China. Other countries such as India, Indonesia, Egypt are currently investigating its use.

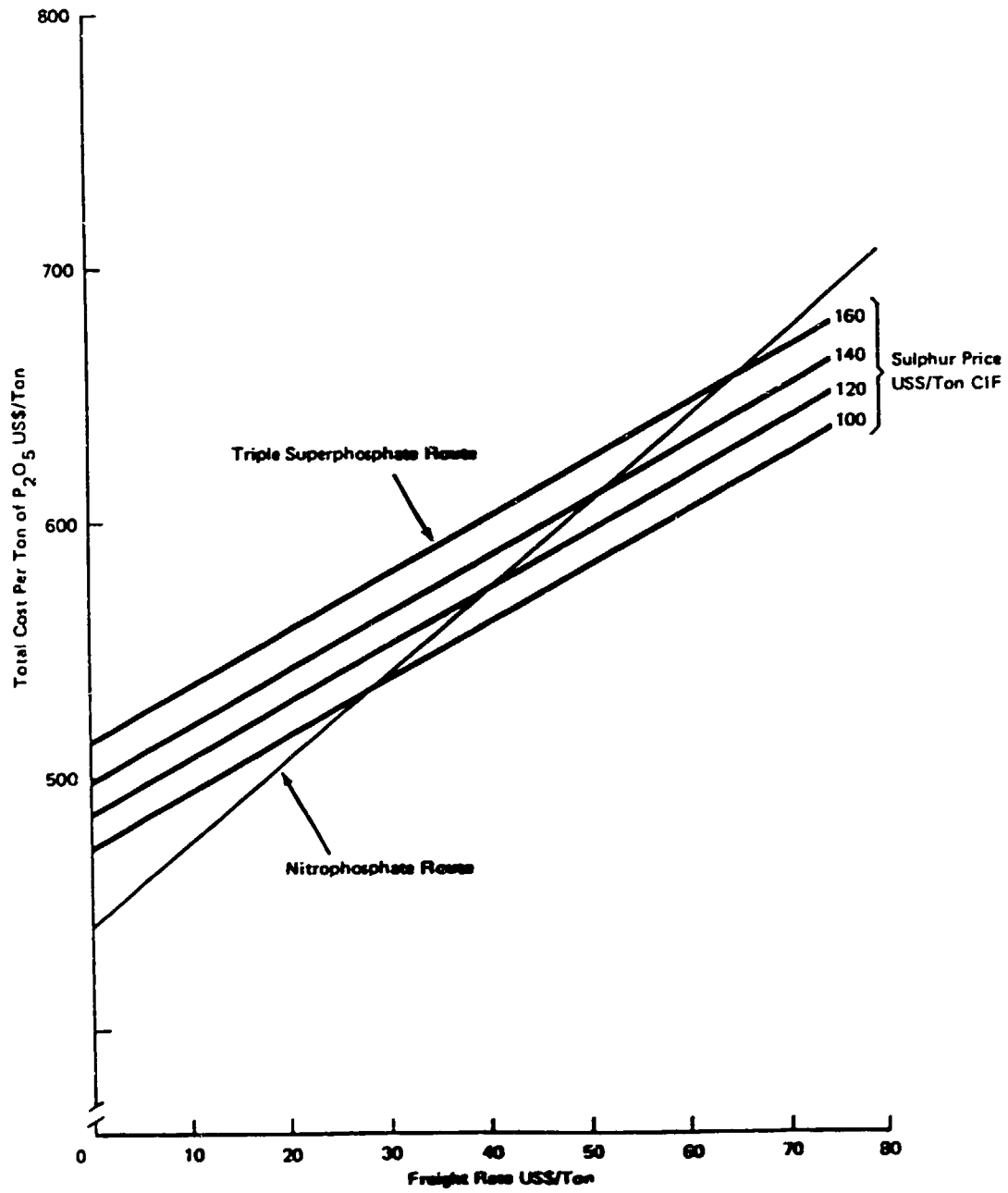
The comparative costs for nitrophosphate and other process routes are given in Figure 6. Basically the graphs compare the price of obtaining one ton of P₂O₅ from a nitrophosphate process with one ton of P₂O₅ delivered as triple superphosphate. It relates the effect of sulphur prices for TSP production and the freight cost of both rock and TSP in the comparative costings.

The calculations indicate that within the current and anticipated range of sulphur and freight prices the nitrophosphate process appears to show an economic benefit when compared with the alternative route. Even allowing for the lower concentration of nitrophosphate materials, provided the product can be integrated into a country's fertilizer sector, it offers some inherent economic advantages.

4.24 FUTURE WORLD PHOSPHATE DEVELOPMENTS

With a few exceptions, it appears that most phosphate fertilizer capacity development will occur in those countries which are resource based and which already have established rock mining industries.

Comparative Total Costs of Producing one Ton of P_2O_5 by Triple Superphosphate and Nitrophosphate Routes Including Freight



The production of phosphoric acid in the non-resource based Developed Economies is expected to decline particularly in Western Europe and Japan. In these circumstances phosphate rock exports will grow at a much lower rate than processed phosphate exports. Countries which currently export rock will look increasingly at the possibility of increasing their production of processed phosphates as a means of maintaining or improving market share. These include Morocco, Tunisia, Jordan, Senegal, Togo, Egypt, etc.

The Centrally Planned Economies are already large importers of phosphates and are expected to remain so. Based on existing information, however, their plans for increasing domestic phosphate production are not sufficient to meet demand and they will continue to depend on imports to meet their needs. Most additional capacity requirements for the period 1988-1993 will have to come from the U.S.A. and resource-based Developing Economies.

The major development in the world phosphate industry throughout the 1980's will undoubtedly take place in Morocco. Large though these additional capacities are, they will only amount to about 30% of the new supply capability to meet increasing demand in the Market Economies during their period of implementation.

Although there are several other plants now under construction in Developing Countries (Tunisia, Senegal, Egypt, etc.) and there are plans for others (Togo, Peru, etc.) and assuming that all of these are realized in aggregate in addition to new capacity in Morocco, it would still leave a shortfall of new capacity requirements which could only be met by new plants in the USA in the second half of the 1980's. The situation in the USA is rather grim at the moment for the phosphate industry exacerbated by a number of special factors such as the very large fall in P_2O_5 consumption in the USA itself in the last year or so and the high value of the US dollar.

However, the U.S. industry remains the largest and one of the most competitive producers of processed phosphates and it seems likely to retain this position in the foreseeable future.

The availability and price of sulphur for phosphoric acid production will depend essentially on phosphate demand. If demand increases at a sufficiently high rate - say above 3% - then it may become necessary to increase Frasch sulphur capacity, in which case sulphur prices are expected to remain high, particularly if stocks in Canada are being depleted.

This situation would encourage some further development of sulphuric acid production from pyrites particularly in South Europe. To a limited extent it might entice some of the larger Developing Economies to build nitrophosphate plants but this would not have any significant effect on future world trading patterns.

5.0 THE WORLD POTASH FERTILIZER INDUSTRY

5.1 Historical Aspects

The first major source of potash became available during the exploration of salt deposits in Strassfurt, Germany in 1861 and production started shortly afterwards. Production was started in the Alsace-Lorraine area of France (then Germany in 1912) and although a small amount of potash was produced in the USA during the First World War period, France and Germany remained the major producers after the War and operated on a cartel basis.

However, when production started in Poland (1920), Spain (1926), USA (1931) and the USSR (1932), the situation changed and the structure of the cartel was gradually weakened. The division of Germany after the War reduced its power even further. At the beginning of the 1960's there were further major changes in the structure of the potash industry following developments of the

vast potash resources in Canada. By 1970 Canada had developed an industry that produced 7.5 million tons per year K_2O and had become the second largest producer after the USSR.

Although the oligopolistic situation has widened since the original French-German arrangement a limited number of companies still produce the bulk of the material. In Western Europe, the pre-World War II cartel has been abolished, but it has been replaced by other forms of collaboration conforming with the EEC regulations.

In North America the activities in Canada now exceed the operations in the USA but Carlsbad, New Mexico, is still an important producer of potash and several US companies are also producing potash in Canada. In the Middle East the capacity for producing potash from the Dead Sea has recently doubled to about 2 million tons per year following the commissioning of the plant in Jordan in 1982. The Eastern Europe Block including the USSR is the largest producer of potash with about 40% of the world's total capacity.

The world production of potash over the last 30 years with predictions for the next 5 years is shown below.

Table 6

World Production Million Tons K_2O

	1962		1980		1987 ^a	
		%		%		%
North America	2.4	(25.5)	9.2	(35.8)	10.8	(33.1)
Western Europe	4.0	(42.6)	5.7	(22.2)	5.3	(16.3)
Eastern Europe	2.8	(29.8)	10.0	(38.9)	14.5	(44.5)
Others	0.2	(2.1)	0.8	(3.1)	2.0	(6.1)
TOTAL	9.4	(100.0)	25.7	(100.0)	32.6	(100.0)

^{a/} Estimated supply capability taking into account expansion plans.

5.2 Future World Developments

The future of the potash industry is probably much easier to predict than for the other two nutrients, N and P_2O_5 . Major reserves of potash are limited to a few countries or regions where there is also a major demand and it seems likely that most of the future development will take place in these areas.

North America

Canada, with the largest potash reserves in the world, will continue to expand capacity to meet increasing world demand. By 1987 it is forecast that Canadian supply capability will increase from about 7 to 9 million tons. About 0.5 million tons of new capacity will come on-stream in New Brunswick and the remainder will take place in Saskatchewan. On the other hand, US supply will continue to drop off slowly from its present level to 2 million tons.

Western Europe

In 1981 potash production in Western Europe was about 5.7 million tons. The reserves in Europe have now been worked for more than a century and the higher quality ore is nearly exhausted. It is estimated that supply will fall slowly to about 5.3 million tons by 1987. Many European potash companies in this situation will be looking for other opportunities overseas such as Canada and elsewhere.

Eastern Europe

Potash production in Eastern Europe takes place in two countries - the German Democratic Republic (GDR) and the Soviet Union. In 1981 the production in the GDR was about 3.4 million tons of K_2O and in the USSR about 8.1 million tons. At the present time the Soviet Union is the world's largest potash producing country and has ambitious plans to expand its industry further to about 11 million tons production to meet growing internal demand and to expand exports. These exceed the expansion plans in Canada but much will depend on

whether or not the Russians can overcome the production delays and low operating efficiencies which have plagued its potash industry in the past.

New Developments Elsewhere

It seems highly unlikely that there will be any major developments elsewhere that will change the current structure of the industry or have any major impact on world trade before 1990.

In Brazil, a potash mine in Sergipe will come on-stream after 1985 with a capacity of about 0.5 million tons per year K_2O . Extensive exploration is being carried out in Thailand to develop the large deposits there. Obviously if this can be done, the project would have many advantages as it would be in the middle of a growing market with significant freight advantages. It is possible that Thailand could be a producer by 1990 but not a major one.

Several possibilities are being examined elsewhere, for example in Ethiopia, Tunisia, Mexico, Chile, Peru, etc. and there is also the possibility of a further development in the Amazon area of Brazil. Most of these will be small projects at least initially and are unlikely to have any significant impact on the overall scene during the 1980's.

China has a growing demand for potash with the realization that its current fertilizer application ratios are very much out of balance. China is currently producing only about 25,000 tons per year of potash but is actively seeking help to develop potash recovery from brine lakes. It could have a modest sized project in operation within the next decade.

World Summary

It seems likely that most new developments will take place in Canada and the USSR and that by 1987 these two countries will share nearly 60% of the world production of 33 million tons of K_2O . Both Western Europe and the GDR in

Eastern Europe will retain about 20% of production capacity. Although there will be some inter-regional sales about 75% of potash consumption will continue to be in the producing countries.

Overall, therefore, there will be little change in the structure of the potash industry over the next decade but rather a consolidation of the major change which started in the 1960's with the major expansions in the two largest resource based countries, Canada and the USSR.

6.0 OWNERSHIP OF THE WORLD FERTILIZER INDUSTRY

Thirty years ago, even before the rapid growth of the world fertilizer industry had commenced, about one third of the industry was owned by the public sector. (Most of this public ownership was in Eastern Europe.) Today, due to large expansions in production in the Centrally Planned Economies and in some of the larger Developing Economies, about half of the industry is public sector controlled, and by the year 1990 it is forecast that at least two thirds of the fertilizer industry will be in the public sector as indicated in Figure 7.

The growth of public sector involvement in the Developing Economies reflects the importance that national planners place on fertilizer use and the role it plays in food production and economic development. Also fertilizer plants are normally major investments and in the Developing Economies can only be realized with the help of government resources and backing and where the needs of finance, transport and agricultural development can be coordinated. Without such government support, there would have been a much more limited growth of the industry in these countries.

In the Centrally Planned Economies where all industry is government-controlled, considerable emphasis has been placed on this sector as a result of which both Eastern Europe and China have seen a relatively high and sustained fertilizer production growth rate, albeit, from a low base.

Even in the Developed Countries during the last decade there has been a significant increase in public ownership. For example, in Canada, the growing involvement of the Potash Corporation of Saskatchewan (PCS) amounts to about 25% of the Canadian potash industry. In the USA the take-over of Texas Gulf by Elf-Aquitaine now means that the US phosphate industry, previously an exclusively private sector, has some public sector involvement.

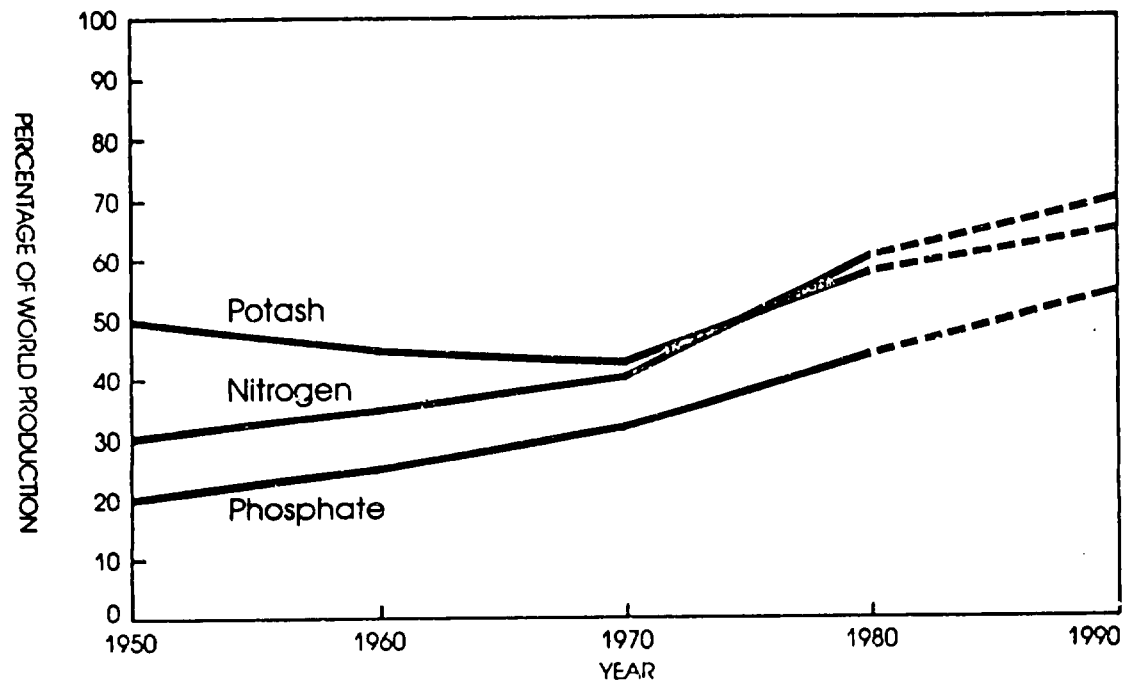
In Europe, there is already a significant government ownership of the industry in Austria, Ireland, Italy, Portugal and Holland, and recent changes in the French Fertilizer Industry and several acquisitions by the Norwegian company Norsk Hydro in Holland, Sweden and the UK have recently increased public sector involvement.

With a higher percentage of future fertilizer production capacity being erected in the Centrally Planned and Developing Economies the percentage of the world industry controlled by the public sector will continue to increase. In nitrogen there will be continuing growth of the industry in Eastern Europe and in Developing Countries with gas resources. The trend towards vertical integration of the phosphate industry in Africa and the Middle East will also come mainly under public sector control. In potash, the largest expansion plans are in the Centrally Planned Economies of Eastern Europe.

It is difficult to predict what the long-term effect of this increasing trend towards public control of the fertilizer industry will mean.

One of the trends which is likely to evolve from increasing public ownership is the growing popularity of barter deals. For example, the greater part of the USSR's ammonia exports is through barter deals. Several other Eastern European countries pay North African countries for imports of phosphates through barter deals. Brazil has recently been purchasing East German potash through barter deals.

GOVERNMENT OWNERSHIP DEVELOPMENT AS PERCENTAGE OF WORLD FERTILIZER PRODUCTION



Not unnaturally, some parts of the private sector particularly in the U.S.A. feel that it will be increasingly difficult to compete against state-owned companies and that the trend offers a threat to free trade. On the other hand, the growth of bilateral long-term agreements between producing and consuming nations could help to introduce a small degree of stability into an industry which goes from one cyclical crisis to another.

7.0 CONCLUSION

The world fertilizer industry is currently suffering one of its worst recessions reflecting unfavorable world economic conditions. Hopefully, the industry will soon commence its recovery and continue once more on a path of economic growth which is essential if we are to meet the food requirements of a growing world population.

The world fertilizer industry has grown very rapidly in the last three decades and the structure of the industry has also changed as both demand and production in the Developing and Centrally Planned Economies have increased at a more rapid rate than the Developed Economies. This trend will continue through the next decade and largely as a result of this the proportion of production capacity in the public domain will also increase steadily. About two-thirds of the world fertilizer industry is forecast to be in the public sector by 1990 and this trend could have important implications on future fertilizer trade.

Although there appears to be adequate supply capability for the next few years, by 1987 supply/demand should once again be balanced but after that time considerable new capacity and investment will be required each year to meet increasing demand.

From economic considerations, new nitrogen capacity should go where the natural gas is cheap and plentiful; for example, the Middle East but constraints on project development in this area and on other potential exporters in Developing Countries will probably inhibit this trend.

On the other hand, the move to vertical integration in the phosphate industry seems likely to accelerate as rock producers seek to exploit its economic advantages and dominate the industry.

There will be no significant change in structure in the Potash Industry with Canada and Russia consolidating their position as leaders.

The earlier years of the 1980's have not been good for the international fertilizer industry, but hopefully the second half of the decade will turn out to be a period of development and prosperity.

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