OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

07735

Distr.
LIMITED

UNIDO/IOD.120
21 October 1977

ENGLISH

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

FAI - IFDC
Fertilizer Seminar 1977 on
Trends in Consumption and Production
New Delhi, 1 - 3 December 1977

ISSUES FACING THE WORLD FERTILIZER INDUSTRY 1/

by

M.C. Verghese
Head
Chemical Industries Section
Industrial Operations Division

(Paper presented under key-note addresses for the above seminar)

1/ This document has been reproduced without formal editing.

id.77-7567

CONTENTS

INTRODUCTION

1. The United Nations Industrial Development Organization (UNIDO) is the co-ordinating agency in the United Nations system for industrial development. UNIDO's primary function in connexion with fertilizers as with other sectors of industry is to assist member countries to develop and particularly to increase existing output and plan for future production. The Food and Agriculture Organization's (FAO) primary function in connexion with fertilizers is then its efficient use fro crop production. The World Bank finances viable fertilizer projects and the United Nations Environmental Programme (UNEP) places stress on preventing pollution from production and use of fertilizers. UNIDO, FAO and the World Bank are working together through the UNIDO/FAO/World Bank Working Group to reduce duplication of efforts and in co-operation with industry and other institutions to forecast supply and demand positions in the short run for assisting countries in planned development. All these organizations are also involved in marketing, distribution, storage credit facilities and assistance to farmers.

2. The Second General Conference of UNIDO in March 1975 in Lima, Peru, solemnly declared (ref. 1) "that, in view of the low percentage share of the developing countries in total world industrial production, recalling General Assembly resolution 3306 (XXIX), of 14 December 1974, and taking into account the policy guidelines and qualitative recommendations made in the present Declaration, their share should be increased to the maximum possible extent and as far as possible to at least 25 per cent of total world industrial production by the year 2000, while making every endeavour to ensure that the industrial growth so achieved is distributed among the developing countries as evenly as possible. This implies that the developing countries should increase their industrial growth at a rate considerably higher than the 8 per cent recommended in the International Development Strategy for the Second United Nations Development Decade".

3. To carry out the above mandate UNIDO convened a worldwide consultation meeting on the fertilizer industry in January 1977 to discuss ways and means of reaching the Lima target or more, and to consider the issues facing the industry.

4. This paper presents the issues facing the world fertilizer industry as identified and discussed in the consultation meeting and in other forums.

SUMMARY

5. The Lima Declaration and Plan of Action formulated at the Second General Conference of UNIDO in 1975 in Lima, Peru, has stated that the share of the developing countries in the world industrial production should be increased to the maximum possible extent as far as possible to at least 25 per cent of total of the world industrial production by the year 2000. UNIDO is taking steps to assist developing countries to reach the Lima target and the worldwide consultation meeting on the fertilizer industry was convened to discuss ways and means of reaching the Lima target.

6. In 1975 the developing countries,although they consumed about 30 per cent of N and 22 per cent of P_2O_5 nutrient supplied by the world fertilizer industry, they produced only 18 per cent of world production of N and lesser percentage of P_2O_5 fertilizers. Even if the developing countries do not get a large share in the world export market,in order to become self-sufficient,their share of world production of N and P_2O_5 fertilizers will have to reach 33 per cent by 1985 and 40 per cent by the year 2000. More investment and more production in the field of fertilizers are necessary in the coming years. Most efficient use of fertilizer in agriculture should be made so that increased agricultural output can feed the expanding populations and improve the nutritional standards.

7. In building up the fertilizer industry, the developing countries will face difficulties with regard to infrastructure in following areas: transport, utilities, raw materials, marketing, agricultural extension, human resources and policy guidance. The consultation meeting convened within this framework by UNIDO discussed these problems and recommended that for the fertilizer projects the governments and others concerned should equally take part in financing and developing infrastructure.

8. Delays in construction and bringing into production of fertilizer projects in developing countries have been posing a major problem. Whereas in developed countries from conception to the execution of projects it may only take two to three years, in developing countries it takes double this period of time. The concept of floating plants whereby equipment can be assembled in developed countrieson barges and towed to developing countries, has been studied extensively. Although such a project may cost 15 to 20 per cent more than a land based plant in a developing country, the time saved in bringing into production is the major advantage.

9. To fully utilize existing capacities in developing countries various solutions have been suggested by studies, technical assistance missions and financial institutions. The average utilization of existing capacities in developing countries today seems to be about 70 per cent which can be improved considerably if the problems are attacked in a vigorous manner. Many projects have suffered due to inadequate supply of water and electric power. Particularly the problem of cooling, process and boiler feed water needs special attention.

10. To help in clearly defining responsibilities for reducing capital cost and thereby production cost, improvement in existing contract procedures have been recently discussed. The proposals for compensating consequential losses in a project involving outlays as large as $ 200 million is worthwhile for serious consideration.

11. The capital costs of fertilizer projects rapidly increased from $90 million for a 1000 tons/day ammonia plant and a 1,650 tons/day urea plant to $180 million today and it is predicted that costs will go up to $240 million by 1980. One of the important ways of reducing capital costs is to build large facilities either in existing locations or adjacent to them. A reduction of about 20 per cent of capital investment costs can be achieved.

12. Although credit worthy countries and viable projects have always been able to find financing through bilateral and multilateral sources there are a number of countries who are not so well placed. In addition, the internal markets are small and their raw material resources are limited. There is a large scope for assistance to

such countries for development of smaller size projects than those which are coneidered economically viable now, and which can use alternate raw materials.

13. The cyclical nature of world fertiliser prices has been a deterrent in the full utilization of existing capacities in developed countries. Some system to stabilize the world prices and availability of fertilizer is essential. In addition to proposals of buffer stocks and price stabilization funds, UNIDO has proposed an "option scheme" which is discussed in detail in the paper. In view of the predicted levelling off of prices of agricultural products in developed countries and in view of the fact that in developing countries the prices of food grains cannot be radically raised due to the low purchasing power of population, it is essential to keep equitable fertilizer prices and most efficient use of fertilizers as targets of the world fertilizer development.

14. Use of alternate raw materials other than natural gas and naphtha are attracting attention in many countries of the world. This is particularly so because of the non-renewable energy source situation. In this connexion, nuclear energy and energy from magneto hydrodynamic converters (MHD) and the use of difference in temperature between the top and bottom layers of sea water in certain locations seem attractive.

15. A case can be made for developing countries where already a large number of projects exist to build central "jumbo" units either raw material oriented or market oriented to feed "satellite" units and "stabilize" production from existing units. A case in point is in India when the "Bombay high gas" is conveyed to the main land by pipeline, large ammonia/urea facilities could be built. Also consideration has been given in the past for building or expanding existing units in the East and West Coasts of India.

16. The environmental considerations which should be strictly adhered to in planning, building and operating fertiliser plants are well-known

The processes selected must be so designed so as to ensure safety and health of workers and projects should avoid discharging polluting or harmful effluents, gaseous, liquids or solids into the atmosphere, land, or water.

17. Appropriate technology and transfer of "know-how" in the fertilizer industry between developed and developing countries and also between developing countries are of the utmost importance. The developing countries who have experience in many facets of the fertilizer industry should transfer their experience and "know-how" to the developing countries which are starting building fertilizer projects.

18. Regional and sub-regional co-operation in the field of fertilizer development has been discussed by the World Consultation Meeting on the Fertilizer Industry and recommendations have been made to establish Regional Development Centres to assist regional co-operative efforts and to encourage bi-lateral, international technical and financial assistance o., a regional basis.

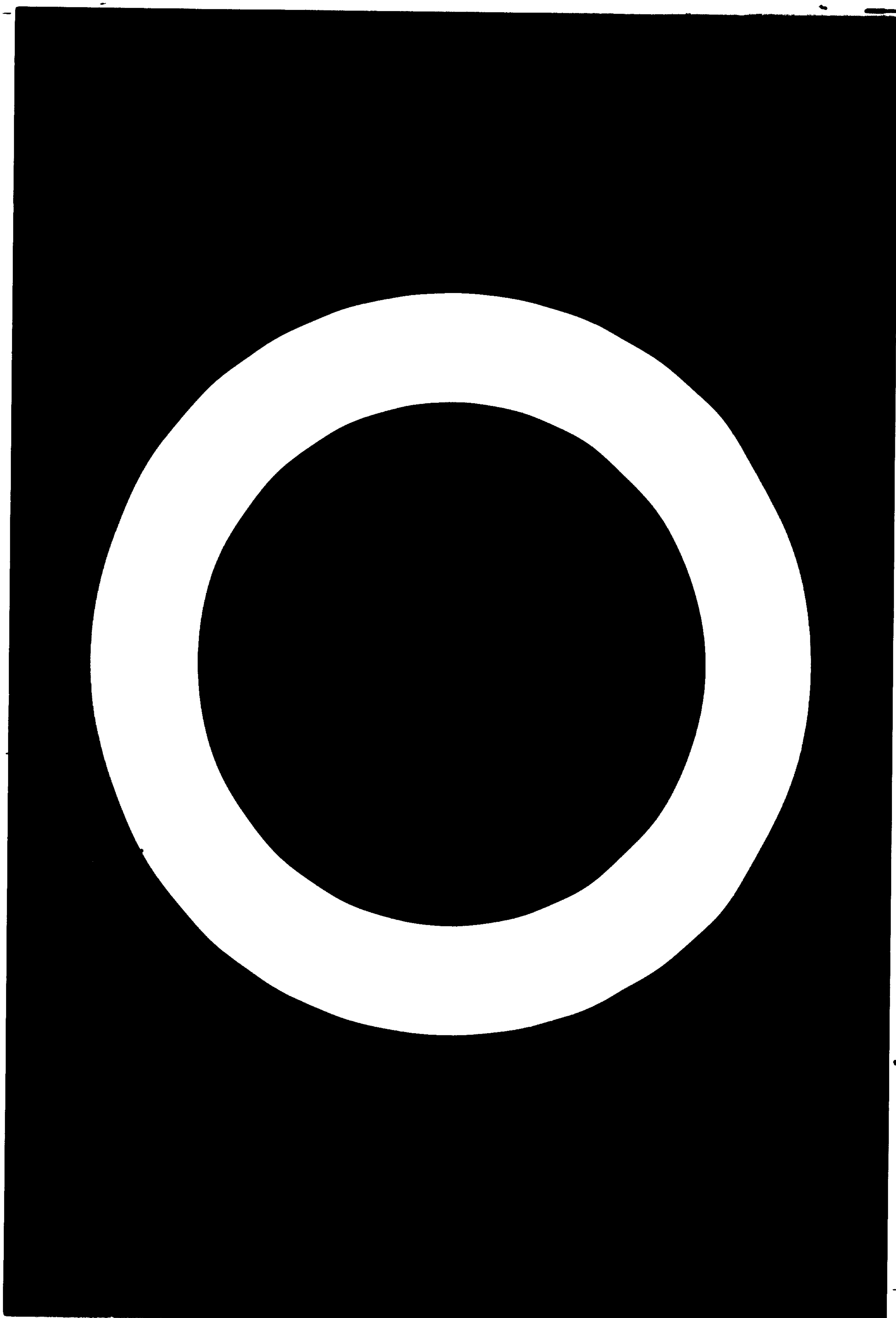


Table 2

PROJECTIONS OF WORLD FERTILIZER CONSUMPTION

(million metric tons nutrient)

REGION	N			P_2O_5			K_2O		
	1985/86	1985	2000	1985/86	1985	2000	1985/86	1985	2000
	UNIDO/FAO/IBRD	Ewell	Ewell	UNIDO/FAO IBRD	Ewell	Ewell	UNIDO/FAO IBRD	Ewell	Ewell
North America	14,4	15,5	27,5	7,2	7,3	10,6	7,6	7,5	12,4
West Europe	11,7	12,4	21,0	6,6	8,6	12,9	6,8	7,5	11,2
Oceania	0,4	0,4	0,8	1,5	1,4	1,6	0,5	0,4	0,7
Other developed	1,5	0,8	0,8	1,3	1,1	1,6	1,0	0,7	0,8
TOTAL DEVELOPED	28,0	29,1	50,1	16,6	18,4	26,7	15,9	16,1	25,1
Revised totals		47,6 *	85,1 *		26,7 *	40,6 *		27,8 *	45,8 *
Africa	1,4	2,4	5,1	0,9	1,6	3,2	0,5	0,6	1,1
Latin America	4,5	4,1	9,0	3,4	3,6	8,3	2,5	2,4	5,5
Near East	3,1 }	12,7	29,3	1,7 }	4,8	11,6	0,1 }	2,4	5,6
Far East	10,0 }			3,1 }			1,8 }		
Total developing	19,0	19,2 25,4 *	43,4 54,5 *	9,1	10,0 10,8 *	23,1 23,3 *	4,9	5,4 6,3 *	12,2 14,4 *
Centrally planned									
Asia	10,0	9,3	20,2	3,3	3,3	7,3	0,9	1,4	3,7
Europe	21,0	23,6	50,5	12,8	10,3	19,5	14,5	13,2	25,4
Total centrally planned	31,0	32,9	70,7	16,1	13,6	26,8	15,4	14,6	29,1
World total	78,0	81,2	164,2	41,8	42,0	76,6	36,2	36,1	66,4
Revised totals		73,0	139,6		37,5	63,9		34,1	60,2

Table 2 (page 2)

NOTE: 1. Projections for 1985/86 were compiled and agreed upon at the 14th Meeting of the UNIDO/FAO/IBRD Working Group on Fertiliser, Rome, June 1977. The figures are considered as very rough tentative estimate based on the result of projections presented by various organizations who have applied different methods of projecting future consumption or effective demand.

2. Projections for 1985 and 2000 are those produced by Prof. R.Ewell and published by UNIDO in the Draft World-wide Study of the Fertiliser Industry 1975 - 2000 (December 1976).

3. Revised projections (regional totals only are based on Prof. Ewell's corrections and modifications as requested by the Panel Meeting of Experts (November 1976).

4. Prof. Ewell's revised regional totals for developing countries include the PR China.

6. Nitrogen. Projections for 1985/86 are very rough estimates. Various compilations and projections were reviewed. Figures listed are basically those presented by the World Bank. Also considered were TVA straight line projections, Gompertz equation, least square root method, Box-Jenkins, FAO projections, Nitrex, Centre D'Etude Del'Azote.

7. Phosphate. Projections for 1985/86 are basically those of ISMA and the World Bank.

8. Potash. Projections based on figures presented by Mr. Rüping (medium level forecasts).

Table 3

New projections of fertilizer demand based on 1964/65 to 1974/75 and on the Joint Working Group estimates for 1979/80

(Classification of countries is UN standard classification)

Nitrogen demand

	1980	1985	1990	1995	2000
Developed countries	37.5	47.6	58.9	71.4	85.1
Developing countries	18.1	25.4	33.9	43.6	54.5
World	55.6	73.0	92.8	115.0	139.6

P_2O_5 demand

	1980	1985	1990	1995	2000
Developed countries	22.8	26.7	31.0	35.6	40.6
Developing countries	7.6	10.8	14.4	18.6	23.3
World	30.4	37.5	45.4	54.2	63.9

K_2O demand

	1980	1985	1990	1995	2000
Developed countries	22.8	27.8	33.3	39.3	45.8
Developing countries	4.3	6.3	8.6	11.3	14.4
World	27.1	34.1	41.9	50.6	60.2

NPK demand

	1980	1985	1990	1995	2000
Developed countries	83.1	102.1	123.2	146.3	171.5
Developing countries	30.0	42.5	56.9	73.5	92.2
World	113.1	144.6	180.1	219.8	263.7

23. By 1985, the preliminary estimate suggests that the developing countries will consume about 34 per cent of N and about 31 per cent of P_2O_5 nutrients consumed in the world; ~~and by the~~ year 2000 about 39 per cent of both N and P_2O_5 nutrients. Therefore if developing countries are to be self-sufficient, their share of world production of N and P_2O_5 fertilizers will have to reach 33 per cent by 1985 and 40 per cent by the year 2000.

24. A revision of the above forecasts (ref. 7) in consultation with industry as given in **Table 3** shows that the total NPK demand in the world may be only 264 million tons compared tothe earlier forecast of 307 million tons - a reduction of about 14% in the year 2000.

25. From the above discussions whether a forecast of a higher or lower figure is taken for world demand for NPK in the year 2000, the increased need to produce and use more fertilizer is evident. **These demands come into the proper prospective if we look at the population and agricultural production prospects by the year 2000. (Table 4)**

Table 4

(ref. Prof.Ewell's draft study)

1. World Grain Production (acutal and projected) (million tons of grain)

	Average 1970-74	1980	1985	1990	2000
Developing countries	619	735	809	884	1,032
Developed countries	685	840	936	1,030	1,221
World:	1,304	1,575	1,745	1,914	2,235

2. World Populations (actual and projected) (in million of persons)

	1975	1980	1985	1990	2000
Developed countries	1,097	1,145	1,192	1,237	1,317
Developing countries	2,869	3,229	3,624	4,043	4,936
World:	3,966	4,374	4,816	5,280	6,253

3. India

		1975	1980	1985	1990	2000
Population (in million of persons)		614	694	783	876	1,059
Grain production (million tons)		125	130	141	152	175
Fertilizer needed (million tons)	N	2.00	3.60	5.24	7.19	12.0
	P_2O_5	0.45	1.30	1.90	2.60	4.5
	K_2O	0.30	0.70	1.00	1.40	2.4
$N + P_2O_5 + K_2O$		2.75	5.60	8.14	11.19	18.9

Cultivated area 125 million hectares) 1975
Irrigated area 35 millionhectares)

II. Infrastructure difficulties

26. This issue facing the world fertilizer industry particularly in developing countries was discussed in detail during the UNIDO's First Consultation Meeting on the fertilizer industry. The consensus reached is reflected in the following paragraphs (ref.2)

" The Consultation Meeting recognized that the major programme of construction of fertilizer plants in developing countries that has already started would necessitate the building up of an adequate infrastructure. The Consultation Meeting considered various aspects of infrastructure planning. They included:

(a) Transportation infrastructure (roads, railways, port facilities, railway rolling stock and ships);

(b) Utilities infrastructure (power supply, water supply and a drainage and sewage system);

(c) Raw materials infrastructure (critical raw material inputs, particularly feedstocks);

(d) Marketing infrastructure (storage facilities and a distribution network that would make it possible for the product to reach the farms);

(e) Infrastructure of agricultural extension services and modern agronomic practices;

(f) Human infrastructure (entrepreneurial skills, managerial skills, and maintenance and operation skills);

(g) Policy infrastructure (the broad framework of government planning, laws, and pricing and economic policies).

The Consultation Meeting felt that the construction of fertilizer plants would be greatly facilitated if there was a composite infrastructure including the types described above. In locating fertilizer plants in developing countries, it would therefore be desirable to place them in areas where infrastructural facilities already existed. When the specific location of plants within individual developing countries was being considered, local infrastructure should be taken into account.

Although the Consultation Meeting emphasized the need for a composite infrastructure, it appreciated that the creation of an infrastructure could not be related solely to fertilizer plants. The infrastructure would be part of over-all internal planning and development and would be required to support a variety of industries within the regional and national plans.

The Meeting recognized that the absence of an infrastructure should not be allowed to inhibit decisions to set up plants. On the other hand, the Meeting felt that the setting up of plants would assist in the over-all economic development of less developed areas and would stimulate the creation of an infrastructure.

Considering the costs involved in establishing an infrastructure and the need to produce fertilizers cheaply so that they would be within the reach of the farmer, the Consultation Meeting was of the view that it would not be correct to expect fertilizer projects to bear the total costs of infrastructure.

There was a need to define and demarcate clearly those items of infrastructure that should fall within the responsibility of the State and public authority and that should consequently be financed from the public exchequer, and items of infrastructure which were directly associated with fertilizer projects.

The Meeting recognized that the conditions and practices in different developing countries would not be identical and that the demarcation of the State's and project's areas of responsibility would therefore have to be adjusted to local conditions. It was generally felt, however, that the public authority should assume responsibility for the basic physical, transportation and utilities infrastructures up to the site boundary. The projects should assume responsibility for the marketing infrastructure and the environmental infrastructure, including the disposal of effluents. There would be joint responsibility for the building up of the human infrastructure: the State would provide the basic facilities for training and development, and the projects would assume responsibility for the specialized skills required for fertilizer plants.

The Consultation Meeting felt that the demarcation must be so arranged as to reduce, as far as possible, capital costs in fertilizer projects and, consequently, total production costs.

The Consultation Meeting emphasized the need for a clearly defined policy infrastructure and suggested that developing countries should work out a scheme of laws, regulations, and economic and planning policies that would facilitate the growth of the fertilizer industry.

The Consultation Meeting recognized that the development of human skills was most important. It suggested that managers and workers should participate at all stages of project conception, planning and implementation. The Consultation Meeting also suggested that measures should also be included for the health and safety of workers and the protection of the environment, and that the relevant ILO conventions should be duly observed."

27. The main recommendations were that efforts must be made to reduce infrastructure costs (please see also Section VI) by apportioning the infrastructure costs between fertilizer projects, state and public authorities. We shall discuss advantages and cost reduction by building centrally located large fertilizer plants to supply satellite units and to add new capacities to existing projects than to start "grass-roots" plants in "green fields" later in the paper (Section III and VI).

III. Delays in construction and bringing into production of fertilizer projects

28. Great deal of study, research and development have taken place in the last few years of ways to reduce delays in construction and bringing into production at full capcity new fertilizer projects. Experience shows that the time lag from the date that finances are obtained and orders placed to the date production starts in a project involving a 1000 tons/day ammonia plant and 1,650 tons/day urea plant is two years in a developed country whereas it is about four years in a developing country. The time lag between feasibility studies, issues and analyses of tenders, preparation of a bankable project submission, assessment of the economic and social returns to the time finances are obtained and orders placed is anywhere between 1 - 3 years. Thus on an average minimum of 5 years elapse between the feasibility study and first starting of trial production. The experience in developing countries of many projects based on naphtha let alone coal is that during first year of operation the target itself is only 60 per cent of designed or "name-plate" capacity, 70 per cent in the second year and so on. It is very rare to see a project in developing countries which comes to 100% of the designed or "name-plate" capcity in the first year of production itself, whereas in developed countries the projects attain 100% capacity in the first year of operation itself. Of course in developed countries this is governed by the market prices and demand of fertilizers. Various attempts and measures have been suggested to reduce the time lag in developing countries and thereby avoid the losses due to not only the blocking up of capital but also production losses

which will most of the times entail loss from quantities to be exported or in countries with large demand drain on foreign exchange balances for importing fertilizers if prices are reasonable and quantities of fertilizer are available in the world market.

29. The concept of floating plants which can be anchored or barge mounted plants which can be towed to site and permanently settled have some advantages in reducing time lags. A few floating plants have been built, small oil refineries, pulp and paper plants and an ammonia plant for Indonesia which has been designed, partly built and then abandoned. Barge mounted plants have been designed by various consortia such as:

Humphreys and Glasgow (UK);
Götaverken/Topsøe (Sweden);
Uhde (FRG);
Coppée-Rust SA (Belgium);
Mitsubishi (Japan).

30. It is claimed that barge mounted plants can be assembled in a developed country and towed to a site in a developing country and permanently grounded in three years from the time orders are placed. Against this advantage a balance has to be struck in gaining experience in a developing country in construction and erection of a plant. We shall discuss the capital cost differences between conventional and barge mounted plants for a developing country in a later section which is estimated to be only 15 per cent.more for barge mounted plants.

31. Other reasons claimed for the delays in developing countries are the delays in supply of local equipment and availability of trained manpower, supply of electric power, water and raw materials. Transportation bottlenecks and other infrastructure problems are serious in "grass-roots" or remote locations.

32. It is therefore logical to ask the question in countries where few fertilizer projects are already in existence whether the time lag in construction and erection can considerably be reduced if the existing units with infrastructure and trained personnel are allowed to expand or allowed to build additional parallel units. We shall examine this

problem from the cost point of view in Section VI. In any case, "grass-roots" plants are estimated to cost in the order of 40% more compared to other plants, if exapansion or parallel capacities are built in existing plant locations. A case in point is Indonesia Pusri I, II, III, IV and perhaps V and Trombay.

IV. Full utilization of existing capacities

33. One of the most important issues facing fertilizer projects in developing countries is under utilization of existing capacities. It has been estimated that if the existing projects fully utilized their capacities, the ESCAP region would be self-sufficient in nitrogen fertiliesrs.

34. There are various reasons why an ammonia and associated urea plant using modern technology are unable to attain and sustain 100 per cent of the designed or "name-plate" capacity. There are internal and external reasons.

The internal ressons are:

a) Probleme arising from faults in plant design and inadequacies of equipment; (ref.2)

" One of the major precautions to be taken when setting up fertiliser plants would be to design them on the basis of a careful analysis of basic data. A wrongly conceived or faultily designed plant would experience problems of operation. The need to prepare feasibility studies and project reports so as to ensure that viable and efficient fertilizer plante were installed was emphasized. Studies and reports should be followed by the selection of reputed contractors, the adoption of proved technologies, and the careful drawing up of bid documents and proper contracts.

b) Problems caused by faulty maintenance (ref.2)

The Consultation Meeting noted that one of the keys to fuller utilization of capacity and higher operational effioienoy was a regular eystem of preventive maintenance backed by trained manpower and a regular flow of spare parts. The Meeting was of the view that contractors and consulting engineers should assist buyers to draw up scheudles of maintenance and should provide lists of critical spare parts that should be carried in stock. Because of difficulties in obtaining spare parts, developing countries should, with the assistance of contractors, ensure that their workshops were so equipped that spare parts could be manufactured locally wherever possible. The developing countries should also shorten the procedures for importing urgently required spare parts.

c) Problems caused by not suitably trained operation and maintenance personnel:

The Consultation Meeting recognized that the development of skilled manpower was essential, if fertilizer plants were to operate efficiently. The manpower would include plant management staff, plant operators and maintenance staff. It would be necessary to train personnel well in advance of the commissioning of plants. There was also a need for a continuous process of training.

d) Inadequate supply and high prices of raw materials and spare parts.

The external reasons are:

a) Market constraints (ref.2):

The Meeting noted that capacity could be underutilized if no adequate arrengements were made for the local, regional or international marketing of the product. The problem was of special significance in developing countries that were installing capacity mainly for export."

b) Inadequate infrastructure:

The most import factors affecting high utilization of capacity in many countries are transport and storage bottlenecks, insufficient and fluctuatingsupply of electric power and most importantly supply of good quality water. It has been reported that even demineralized water used for boiler feed and closed circuit cooling are reducing efficiencies of turbines and heat exchangers. It is a policy in the right direction that may developing countries are allowing captive power units with fertilizer projects.

c) Cyclical and unequitable prices of fertilizers:
In developing countries with large internal demand, unless grain prices give a reasonable return to farmers using fertilizers and unless fertilizers reach the large number of subsistent level farmers who now seldom use or use inadequately or inefficiently and at an equitable price, demand will not grow. In most developed countries 100 per cent capacity utilization is possible if after meeting internal demand (30 per cent or so of capacity) the world prices are attractive enough to push capacity to maximum possible extent.

Example of India (ref. 12) - see Table 5, p.19

Example of FRG (ref. 6)

Figure 1 (ref.6)

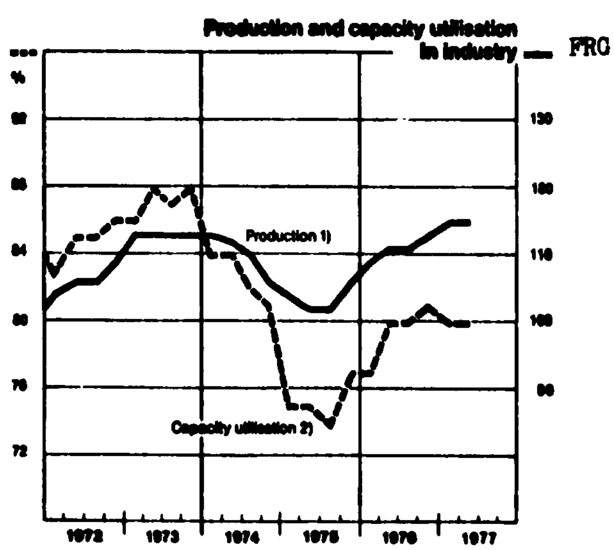


Table 5 Example of India (ref.12)

Percentage utilization of all installed capacity in India for N and P_2O_5

(i.e. $\frac{\text{production} \times 100}{\text{capacity}}$)

	Actual					Estimated						
	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
N	70	54	n.a.	56.35	64.46	64.62	62.46	69.60	76.27	76.97	79.48	80.03
P_2O_5	n.a.	n.a.	n.a.	43.42	49.29	57.57	63.55	69.61	70.64	70.64	68.09	69.47

N.B. However if you consider some of the large sized ammonia plants based on naphtha built after 1965 such as 1) SCI, Kota, 2) IEL, Kanpur, 3) GSFC, Baroda, 4) MFL, Madras, 5) ZACL, Goa and others, the percentage utilization of capacity in 1976 and 1977 are reported to be 85% to 100%.

ref. 12

ref. 5

V. <u>Contracting procedures</u>

35. The recent Technical Seminar on Contracting Methods and Insurance Schemes for Fertilizer and Chemical Process Industries, Lahore, Pakistan, 26 - 29 November 1977, highlighted contract procedures intended to ensure the successful construction and operation of fertilizer plants. Many countries entering the field for construction of fertilizer plants do not fully know how to protect their interests. Although guarantees, penalties, bonuses and liabilities for machinery breakdown during the first year of operation and arbitration procedures are well known to countries having long experience, it is necessary to bring the drawbacks if any of international contracting procedures and correct them at an early stage. It has been mentioned that even few experienced countries realize that legally they are entitled to scrutinize sub-contracts entered into by main contractors, nor is it widely known that total liability of a main contractor can be up to 20 per cent of total value of contract and not up to 10 per cent as is now accepted.

36. The most important question being considered by the UNIDO and other UN agencies is how to compensate a large fertilizer project costing say 200 million dollars from consequential losses. Consequential losses for whatever may be the reason by insurance in which the buyer, the seller, the countries involved and the financing institutions can take part. Although commercial insurance companies will hesitate to enter the field and quote premiums unless the exact reason and responsibility for losses can be identified. The premiums are also bound to be high and fixing reason and responsibility for consequential losses are difficult and time consuming. There is existing insurance against machinery breakdown, and production losses in many countries like USA and India.

37. Another approach which has been suggested, is to create a fund supervised by one or other international agency and to which all fertilizer projects being built in the world will pay a premium. The fund will then compensate any project which suffers consequential losses due to buyers, sellers or any others' faults. It is not an easy approach but it is well worth considering. It is important that while developed countries cover the investments and loans their contractors [illegible] developing countries, the buyers in developing countries [illegible] guarantee that the large sums they invest will produce goods [illegible] and returns as foreseen. From this angle, protection from consequential losses is also a responsibility and should be an aim of supplier countries and financial institutions which will ensure the productive use of their money and services.

VI. Rising capital and raw material costs

38. Five to ten years ago a 1,000 tons/day ammonia plant and a 1,650 tons/day urea plant could be installed in a developing country for about 90 - 100 million US dollars. The present costs are about 180 million US dollars.

It is predicted that the costs will go up to 240 million US dollars by 1980. This is for a site which is not remote and has reasonable infrastructure. For a remote location, forecasts indicate a total investment of 335 million US dollars.

39. Mr. William Sheldrick (ref. 8) of the fertilizer unit of the World Bank has analyzed the factors affecting capital and production costs for N and P fertilizers. In his draft paper to the FAO fertilizer commission, he estimates the cost involving the "site factor" as follows:

Plant in developed country	site factor	1.10
Plant in developing country	" "	1.25
Plant in developed country (remote location)	" "	1.35

40. For those developing countries who have already built large fertilizer projects, one of the most important ways to reduce total investments in new fertilizer production capcity is to build the capacities parallel to or adjoining existing facilities. These existing units have already got trained manpower, infrastructure, marketing and storage experience, raw material availability and above all trained and well informed management. A 10 to 20 million US dollar investment can be saved in a 200 million US dollar project if facilities are built in existing projects or close to them rather than going to "remote" or "green field sites". The costs reduction involved in building large **"jumbo" central plants will be discussed** in Section X.

41. Mr. Sheldrick's analyses of investment costs and prodcuction costs are quoted below:

" Investment cost estimates for an ammonia/urea complex to produce 1,650 tons/day based on natural gas in different locations are given in Table 6. In some cases, where it is felt that a specific location does not quite fit into one of the categories, capital costs may be assumed by interpolation. This could apply to aplants in developing countries being erected on partially developed sites.

Comparative Production Costs

42. The production costs for urea are presented in Tables 7, 8 and 9. In Table 8, the information is given in the form of a "cost envelope" to show the effect on production costs of factors such as gas price, investment cost and operating rate for a 1,650 tons/day ammonia/urea complex. These costs contain depreciation but no interest charges.

43. Specific production costs are given for various sites in Table 7. In addition, this Table contains the ex-factory realization price per ton of urea necessary to achieve various returns on investment. Although gas prices are assumed which which are believed to be most likely for the cases considered, adjustment in cost and realization price can be made easily as indicated in the tables.

Discussion of Results

44. The results in Tables 8 and 9 demonstrate the importance of the three main variables, feedstock cost, investment cost and operating rate, on production and realization prices for urea. All factors are equally important, and the advantages of cheap natural gas currently available as flared gas in remote locations, can soon be outweighed by higher investment costs and lower operating rates.

45. The results show that the cost of producing urea and the realization prices to give reasonable returns on investment could vary considerably from site to site and even for each site itself depending on the parameters assumed.

46. In order to facilitate comparison of the data for various locations, a simple return on investment has been assumed. This has been based on the average realization price required over the project life although, in fact, prices will vary considerably during this period due to inflation and cyclical supply/demand imbalances. Although an ROI(return on investment) of 10 per cent has been assumed for some calculations, this has been done mainly to establish the minimum realization price necessary to cover adequate servicing of capital, particularly at the beginning of the project life. A commercial company, however, would normally require at least 15% pre-tax return to provide adequate profit to justify the project. Exceptions to this case might occur in the energy-rich developing countries who have capital available and may be prepared to accept a lower ROI.

47. On the basis of a urea plant contracted today, assuming an operating rate of 90 per cent, it is estimated that the average realization price for the various locations considered would have to fall within the range of US$175-200 per ton of urea in order to achieve a 15 per cent return on invesiment. These prices are in constant 1977 dollars.

TABLE 6

INVESTMENT COST ESTIMATES FOR AMMONIA/UREA PLANTS 1,650 TPD BASED ON NATURAL GAS
($ Million)

Item	Developed Country	Developing Country	Developing Country (Remote Location)	Barge[1/] Mounted Plant
1. Land, Site Preparation & Civil Works, including Roads, Drains Workshops, Buildings, etc.	4	12	14	-
2. Machinery, Equipment and Spares	83	90	98	83
3. Freight and Insurance	3	12	20	11
4. Engineering Charges including Design, Erection, Licence Fees, etc.	30	40	50	59
5. Offsites and Other Expenses including Start-Up Fees, Housing Amenities, etc.	16	30	55	9
6. Barges	-	-	-	53
7. Mooring Buoy	-	-	-	12
	136	184	237	227
Price, Physical & Site Contingency	14	46	83	23
Plant Investment	150	230	320	250
Working Capital	7	10	15	15
Total Investment	157	240	335	265

1/ Based only on preliminary investment cost estimates.

TABLE 7

ESTIMATED PRODUCTION COSTS FOR UREA
($ Metric Ton)

Basis : 1,650 tpd bagged product
Capacity Utilization : 90%
Production : 330 days/year
544,500 tons urea/year

Site	Developed Site	Developing Site (Some Existing Infrastructure)	Developing Site (Remote Location)	Barge-Mounted Plant (Remote Location)
Plant Investment US$	US$150 Million	US$230 Million	US$320 Million	US$250 Million
Working Capital US$	US$7 Million	US$10 Million	US$15 Million	US$15 Million
Total Investment US$	US$157 Million	US$240 Million	US$335 Million	US$265 Million
Raw Materials	Gas @ $2.0/M scft	Gas @ $0.6/M scft	Gas @ $0.3/M scft	Gas @ $0.3/M scft
Natural Gas including Fuel and Gas for Steam and Power Generation	70.00	21.00	10.50	10.50
Other Variable Costs US$/Ton	11.87	11.87	11.87	11.87
Fixed Costs US$/Ton	45.96	62.82	80.69	67.04
Production Costs US$/Ton	127.83	95.69	103.06	89.41
Profit (15% ROI) US$/Ton	48.06	73.50	102.54	81.09
Realization Price US$/Ton (ex-factory)	175.89	169.19	205.63	170.50

Note: An increase in gas prices of US$0.1/M scft will increase the production cost and realization price of urea by US$3.5/ton of urea.

TABLE 8

PRODUCTION COSTS FOR UREA 1/

$/Ton

INVESTMENT COST

($ Million)

Operating Rate	Gas Price $/M Scft	100	200	300	400	500	600
100% of Design	0	43.74	62.72	81.70	100.67	119.65	138.63
	0.5	61.24	80.22	99.20	118.17	137.15	156.13
	1.0	78.74	97.72	116.70	135.67	154.65	173.63
	2.0	113.74	132.72	151.70	170.67	189.65	208.63
	4.0	183.74	202.72	[illegible]	240.67	259.65	278.63
90% of Design	0	47.28	68.37	89.46	110.54	131.63	152.72
	0.5	64.78	85.87	106.95	128.04	149.13	170.22
	1.0	82.28	103.37	124.46	145.54	166.63	187.72
	2.0	117.28	138.37	159.46	180.54	201.63	222.72
	4.0	187.28	208.37	229.46	250.54	271.63	292.72
80% of Design	0	51.71	75.43	99.15	122.88	146.60	170.32
	0.5	69.21	92.93	116.65	140.38	164.10	187.82
	1.0	86.71	110.43	134.15	157.88	181.60	205.32
	2.0	121.71	145.43	169.15	192.88	216.60	240.32
	4.0	191.71	215.43	239.15	262.88	286.60	310.32
70% of Design	0	57.40	84.51	111.62	138.74	165.85	192.96
	0.5	74.90	102.01	129.12	156.24	183.35	210.46
	1.0	92.40	119.51	146.62	173.74	200.85	227.96
	2.0	127.40	154.51	181.62	208.74	235.85	262.96
	4.0	197.40	224.51	251.62	278.74	305.85	332.96
60% of Design	0	64.99	96.62	128.25	159.88	191.51	223.14
	0.5	82.49	114.12	145.75	177.38	209.01	240.64
	1.0	99.99	131.16	163.25	194.88	226.51	258.14
	2.0	134.99	166.62	198.25	229.88	261.51	293.14
	4.0	204.99	236.62	268.25	299.88	331.51	363.14

1/ Contains depreciation but no charge for interest or return on investment.

REALIZATION PRICES VERSUS RETURN ON INVESTMENT FOR UREA

	Developed Country				
Gas Price	US$2.0/M scft				
Plant Investment	US$150 Million				
Working Capital	US$7 Million				
Total Investment	US$157 Million				
	100	90	80	70	60
Operating Cost $/Ton	123.23	127.93	133.57	140.96	150.80
Return on Investment $/Ton					
@ 5%	14.42	16.02	18.02	20.60	24.03
@ 10%	28.84	32.04	36.04	41.20	48.06
@ 15%	43.26	48.06	54.06	61.80	72.09
@ 20%	57.68	64.08	72.08	82.40	96.12
@ 25%	72.10	80.10	90.10	103.00	120.15
Realization Price $/Ton at Various Returns on Investment		↓			
@ 5%	137.65	143.95	151.59	161.56	174.93
@ 10%	152.07	159.87	169.61	182.16	198.86
@ 15%	166.49	175.89	187.63	202.76	222.89
@ 20%	180.91	191.91	205.65	223.36	246.92
@ 25%	195.33	207.93	223.67	243.96	270.95

	Developing Country South East Asia				
Gas Price	US$0.60/M scft				
Plant Investment	US$230 Million				
Working Capital	US$10 Million				
Total Investment	US$240 Million				
	100	90	80	70	60
Operating Cost $/Ton	89.41	95.69	103.55	113.65	122.11
Return on Investment $/Ton					
@ 5%	22.05	24.50	27.56	31.50	36.75
@ 10%	44.10	49.00	55.12	63.00	73.50
@ 15%	66.15	73.50	82.68	94.50	110.25
@ 20%	88.20	98.00	110.24	126.20	147.00
@ 25%	110.25	122.50	137.80	157.50	183.75
Realization Price $/Ton at Various Returns on Investment					
@ 5%	111.46	120.19	131.11	145.15	163.86
@ 10%	133.51	144.69	159.67	176.65	202.61
@ 15%	155.56	169.19	186.23	208.15	237.36
@ 20%	177.61	193.69	213.79	239.65	274.11
@ 25%	199.66	218.19	241.35	271.15	310.86

	Saudi Arabia Land Based Plant				
Gas Price	US$0.30/M scft				
Plant Investment	US$320 Million				
Working Capital	US$15 Million				
Total Investment	US$335 Million				
	100	90	80	70	[illegible]
Operating Cost $/Ton	95.00	103.05	113.15	125.72	143.41
Return on Investment $/Ton					
@ 5%	30.75	34.18	38.44	43.93	[illegible]
@ 10%	61.50	68.36	76.88	87.86	[illegible]
@ 15%	92.25	102.54	115.32	131.79	[illegible]
@ 20%	123.00	136.72	153.76	175.72	[illegible]
@ 25%	153.75	170.90	192.20	219.65	[illegible]
Realization Price $/Ton at Various Returns on Investment					
@ 5%	125.75	137.24	151.59	170.05	[illegible]
@ 10%	155.50	171.42	190.03	213.93	[illegible]
@ 15%	187.25	205.60	228.47	257.91	[illegible]
@ 20%	[illegible]	239.78	266.91	301.84	[illegible]
@ 25%	248.75	273.96	305.35	345.77	[illegible]

	Saudi Arabia Barge Mounted Plant				
Gas Price	US$0.30/M scft				
Plant Investment	US$250 Million				
Working Capital	US$15 Million				
Total Investment	US$265 Million				
	100	90	[illegible]	[illegible]	60
Operating Cost $/Ton	82.71	89.41	[illegible]	102.57	[illegible]
Return on Investment $/Ton					
@ 5%	24.33	27.03	30.41	34.75	40.55
@ 10%	48.66	54.05	[illegible]	69.50	81.10
@ 15%	72.99	81.09	91.23	104.25	121.65
@ 20%	97.32	[illegible]	121.64	[illegible]	162.20
@ 25%	121.65	135.15	152.55	173.75	202.75
Realization Price $/Ton at Various Returns on Investment					
@ 5%	107.04	116.44	128.21	143.32	163.49
@ 10%	131.37	143.47	[illegible]	[illegible]	[illegible]
@ 15%	155.70	170.50	[illegible]	212.42	[illegible]
@ 20%	[illegible]	197.53	219.44	[illegible]	[illegible]
@ 25%	204.36	[illegible]	245.65	[illegible]	[illegible]

Note: An increase in gas prices of US$0.1/M scft will increase the production cost and realization price of urea by US$3.5/ton of urea.

TABLE 9

VII. Financing

48. It has been often stated that a well conceived, viable fertilizer project either export oriented or internal market oriented, **had no problem materialising** due to lack of bilateral, multilateral or international financing. This is well brought out by financing statements by the World Bank, Asian Dvelopment Bank, the German Kreditanstalt für Wiederaufbε and others.

49. An analysis of the World Bank investments in fertilizer projects for the fiscal year 1976-77 showed the following:

World Bank Annual Report 1977 (ref.9);

Table 10

World Bank investments in fertilizer projects 1976-77 (US$ million)

		World Bank
Brazil	Fertilizer and chemicals	64.0
Brazil	Fertilizer and chemicals	82.0
Pakistan	Fertilizer and chemicals	55.0
Romania	Fertilizer and chemicals	18.3
	Total:	219.3

50. A summary of projects financed by the World Bank and IDA in the years 1974, 1975 and 1976 shows the following (World Bank Annual Report 1974, 1975 and 1976 (ref.13)) - **see Tables 11 and 12.**

Table 11

Investments made by	World Bank	IDA	Total	in industrial projects
in 1974	309.1	109.7	418.8	
in 1975	665.3	125.0	790.3	
in 1976	501.0	105.0	606.0	
total	1,475.4	339.7	1,815.1	

(all in US $ million)

Investments made by	World Bank	IDA	Total	in fertilizer plants
	(all in US $ million)			
in 1974	95.0	70.4	165.4	
in 1975	292.0	125.0	417.0	
in 1976	120.0	105.0	225.0	
total	507.0	300.4	807.4	

Table 1[illegible]

[illegible] fertilizer projects in the years 1974, 1975, 1976:

Country	Project	Date of approval of loan	Principal amount	Lending Agency
EGYPT	Nile delta urea fertilizer plant	13 Nov. 1973	400.000	IDA
EGYPT	Talkha urea fertilizer project	18 June 1974	20,000.000	IDA
INDIA	Bombay fertilizer plant	18 June 1974	50,000.000	IDA
PAKISTAN	Multan fertilizer project	7 May 1974	35,000.000	IBRD
ROMANIA	Fertilizer plant	27 June 1974	60,000.000	IBRD
		sub-total for 1974	165,400.000	
BANGLADESH	Dacca fertilizer plant	28 Jan. 1975	33,000.000	IDA
INDIA	IFFCO project	7 Jan. 1975	109,000.000	IBRD
INDIA	Sindri fertilizer project	26 Nov. 1974	91,000.000	IDA
INDONESIA	Fertilizer project	25 Feb. 1975	115,000.000	IBRD
JORDAN	Potash engineering project	19 June 1975	1,000.000	IDA
MEXICO	Guanomex fertilizer project	22 May 1975	50,000.000	IBRD
TURKEY	supplement to the IGSAS project	15 April 1975	18,000.000	IBRD
		sub-total for 1975	417,000.000	
BRAZIL	[illegible] project	11 May 1976	50,000.000	IBRD
INDIA	Fertilizer project	16 Dec. 1975	105,000.000	IDA
INDONESIA	PUSRI fertilizer project III	11 May 1976	70,000.000	IBRD
		sub-total for 1976	225,000.000	
		Grand total	807,400.000	

51. It is therefore safe to say that for "credit worthy countries" building large viable fertilizer projects, financing is not a constraint. But this is not true in case of so-called "non-credit worthy countries" or countries which are land locked or island countries and which have neither cheap raw materials,"know-how,nor large internal demand. Such countries want to build ammonia plants of capacities from 100 tons/day to 300 tons/day using fuel oil coal or electric power as raw materials. They find it difficult to locate finances at reasonable rates and also engineering and constructing firms willing to undertake and build such projects. Those who are willing to help, seek high rates of return and the costs to such countries is disproportionally higher. These are the countries which need, regional, interregional and international assistance. e.g.

Asia and Middle East

1. Afghanistan
2. Brunei
3. Cyprus
4. Jordan
5. Malaysia
6. Nepal
7. The Philippines
8. Singapore
9. Thailand

Africa

1. Cameroon
2. Congo, People's Republic of
3. Ethiopia
4. Gabon
5. Ghana
6. Madagascar
7. Malawi
8. Mali
9. Mozambique
10. Liberia
11. Nigeria
12. Senegal
13. Sudan
14. Tanzania
15. Togo
16. Zaïre
17. Zambia

Latin America

1. Argentina
2. Bolivia
3. Central American countries
4. Colombia
5. Chile
6. Ecuador
7. Peru

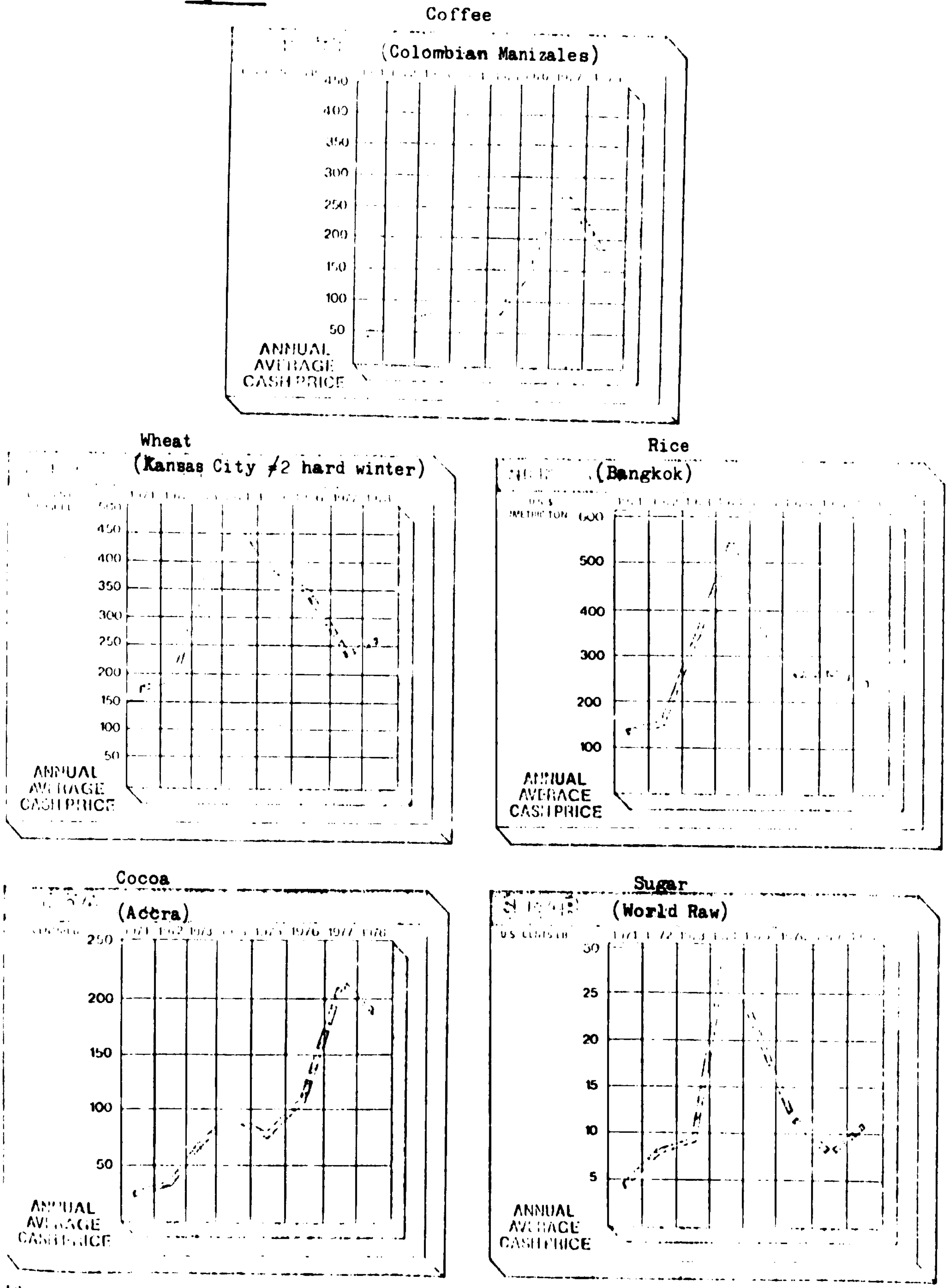
VIII. Cyclical nature of world fertilizer prices

52. We are all aware of this phenomenon. Many experts are predicting we are going through such a cycle right now. With the traumatic experiences of 1974 and 1975 when price of urea f.o.b. went up as high as $300 per ton and the supply position in the world deteriorated, both developed and developing countries wish that prices, as well as supply and demand will or could be maintained at equitable levels. Urea prices in 1977 has again shown a tendency to rise and the stabilization level does not seem to have reached.

53. It is necessary for the continued improvement of effective demand and use in developing countries of fertilizers, an advantageous price ratio between food grains and fertilizers be maintained. There is no way to increase food grain prices in many developing countries since the purchasing power of the vast majority of population is stagnant. Therefore, fertilizer prices have to be maintained suitably. Further, yield by use of agricultural inputs must be improved and a larger number of farmers must be economically induced to use inputs not only by credit, demonstrations, availability at reasonable prices but also by reasonable price of agricultural products.

54. The following charts show that there is a tendency in developed countries like USA of falling prices for agricultural products (ref.10).

Figure 2



12

Newsweek, September 26, 1977

55. UNIDO has suggested a new approach to reduce the cyclical nature of world fertilizer prices. As is well known, UNCTAD and FAO are discussing buffer stocks not only for agricultural products but also for agricultural inputs such as fertilizers. Price equalization or stabilization commodity funds are also an outcome of the North South negotiations in Paris recently.

56. The UNIDO's "option scheme" for fertilizer in a nutshell will work as follows. Every developed country or companies or organizations in such countries like Japan, USA and Europe pledges a certain percentage of their production to the "option scheme". These amounts will represent the excess over the internal demand. Developing countries will then call on these quantities pledged to the "option scheme" at prices to be negotiated on a long range basis but with mutual understanding for escalations. In such a scheme the developed countries may be able to run their plants even up to 110 per cent of their installed capacity but meeting their internal demand which may be met by 80 per cent capacity utilization. Thus they will be able to reduce production costs and developing countries will have a source to fall back upon with reasonable prices. Even in the forseeable future many developing countries do not seem to be at a stage to avoid imports. Let us look at the case of India.(Table 13)

Table 13

Estimated Capacity, Production and Consumption for N and P_2O_5 for the years 75-76 to 83-84 (Ref.5)
'000 tons

Years and Nutrient		Capacity	Production	Consumption	Gap
1975-76 -	N	2,676	1,508	2,031	- 523
	P_2O_5	737	320	453	- 133
1976-77 -	N	3,025	1,950	2,500	- 550
	P_2O_5	923	455	600	- 145
1977-78	N	3,748	2,422	2,826	- 404
	P_2O_5	1,068	730	740	- 10
1978-79	N	4,550	2,842	3,214	- 372
	P_2O_5	1,369	870	801	+ 69
1979-80	N	4,908	3,416	3,630	- 214
	P_2O_5	1,369	953	865	+ 88
1980-81	N	5,151	3,929	4,074	- 145
	P_2O_5	1,369	967	929	+ 38
1981-82	N	5,379	4,140	4,545	- 405
	P_2O_5	1,369	967	995	- 28
1982-83	N	5,379	4,275	5,044	- 769
	P_2O_5	1,451	988	1,063	- 75
1983-84	N	5,379	4,305	5,572	-1267
	P_2O_5	1,451	1,008	1,132	- 124

(ref. 5)

IX. Use of alternate raw materials and new approaches

57. For countries with extremely large populations and who should not depend on imports except for a small proportion of their fertilizer demand, fertilizers must be declared as a **"strategic"** commodity. If they have low cost clean liquid or gaseous feedstocks they are lucky. But recently questions have been raised whether liquid and gaseous feedstocks cannot be used for more "value added" products than fertilizers. Therefore, we come to the question of utilization of solid fuels like peat, lignite and coal and residual liquid fuels like fuel oil. The capital costs of plants using these raw materials are at least 50 to 100 per cent more than those using naphtha or gas. But in countries like India, it is a good policy to have a certain percentage of production on coal. The tendency in USA to build coal based fertilizer plants or to produce synthetic natural gas, fertilizers and petrochemicals have attracted **worldwide** attention.

58. The proposals put forward some time ago by the then US Atomic Energy Commission to build large multipurpose nuclear power plants in a region like the Sinai desert to produce electric power, desalinate water, produce hydrogen and then synthesise ammonia (electrolysis of water) and produce aluminium, magnesium and other metals,have attracted attention.2-3 mills electric power per KWH have been predicted.

59. The recent developments in USSR in the production of electric power by means of magneto hydrodynamic (MHD) converters was highlighted by Dr. R. Ramanna (Director of the **Bhabha** Atomic Research Centre, Bombay) in his article on this subject in the journal of the Indian Institution of Engineers. Comparison of generation costs are given in tables **14 and 15**. Further Dr. Ramanna states "The improved efficiency of combined MHD steam plants reflects in the reduction of waste heat pollution and lower consumption of cooling water. Further as potassium injected as seed substance can be fully recovered as potassium sulphate atmospheric pollution by sulphurous gases is also avoided. At the operating temperature it is possible to fix nitrogen and obtain raw materials for fertilizer industry." (ref.4)

Table 14

Comparison of Generation Costs

		Conventional steam*	MHD/steam**
Construction cost (steam section)	250 $/kW	5.86 mil/kWh	3.40 mil/kWh
Construction cost (MHD section)	250 $/kW	-	2.40
Gas cleaning	50 $/kW	1.18	-
Cooling towers	30 $/kW	0.71	0.41
Fuel cost	25 ¢/MBTU	2.40	1.[illegible]
Seed cost			0.20
		10.15 mil/kWh	[illegible] mil/kWh

* Based on steam plant efficiency of 40%

** Based on 22% net MHD enthalpy extraction, 38% net steam plant efficiency

Table 15

Requirement for Unit Energy Generation

	Conventional 100 MW	Conventional 200 MW	Conventional 500 MW	MHD 500 MW Stage I	MHD 500 MW Stage II
Coal requirement per kWh of energy generated, kg	0.60	0.53	0.50	0.37	0.30

60. It may also be remembered that the Indian Atomic Energy **Commission** [illegible] studies to utilise nuclear power for fertilizer production in the State [illegible] **Uttar** Pradesh **and others.**

61. The recent publication of a study **by** Johns Hopkins University (ref.11) [illegible] on the use of the temperature **differences** between top **layers** and bottom layers [illegible] 400 metres of sea water in certain locations deserve [illegible] serious attention. **Extracts from the study are quoted below:**

" General Summary

There are two primary options for using OTEC (Ocean Thermal Energy Conversion) power. One is to moor a plant near shore, e.g., in the Gulf Stream off the lower US East Coast, and deliver to shore either electricity via cables or high-pressure gaseous hydrogen. Development of a demonstration plant using this approach could offer greater visibility to [illegible] public than one in tropical oceans, and the potential exists to deliver a significant amount of energy to the southeastern states. However, plants in the Gulf Stream would have to be much more rugged to withstand hurricanes and large currents, and would have to operate with a much lower ocean temperature difference (ΔT, 30-34°F) than is available in oceans near the equator. These factors make such plants significantly more expensive per unit of electric power developed on board and conceptually riskier to deploy and operate. Two recent studies by Lockheed and TRW, funded by [illegible]/ERDA, provide comparative cost estimates of $2,450 and 1,[illegible] per kW_e, respectively, compared to [illegible] per kW_e for the APL-designed OTEC/ammonia tropical ocean plant-ship.

The other option, addressed in this report, is to base OTEC plants in selected tropical ocean sites where design winds, waves and currents are much smaller, and available temperature differences are much higher (ΔT, 40-43°F) and less subject to seasonal variation. The small surface and subsurface currents are particularly important to the design of the cold water pipe, which is both large in diameter and very long. The available ΔT is a powerful factor; plant cost varies inversely with ΔT to a power of 2 to 2.5 within the range of interest. The total energy potential from large siting areas in tropical oceans is also much greater.

The power generated by OTEC plants at tropical ocean sites must be used to make energy-intensive products (e.g., ammonia, aluminum, liquid hydrogen) which can be shipped to U.S. or foreign markets. Although this paper presents primarily the design concept and economic estimates for building OTEC/ammonia plant-ships, descriptions of the plants and costs for producing aluminum and liquid hydrogen are also included. At present ERDA is supporting other studies of ammonia and hydrogen production in OTEC plants and studies of ocean industrial complexes based on OTEC plants. The authors have received only interim progress reports from those studies. The reports have been related to earlier ERDA-funded plant concepts and do not reflect the advantages of our unique, low-cost plant-ship design.

The APL option for using OTEC power is designed to operate in tropical waters; is feasible to build in existing US shipyards; requires a minimum of risk; and can have a significant, favourable impact on US energy needs by 1985. The following unique features of the APL option are designed to reduce costs and provide a useful output:

- The optimum site for ocean thermal energy production is the 600 nautical mile area in the tropical South Atlantic Ocean (ATL-1) which has the highest temperature differential combined with the lowest waves, winds and currents.
- The heat exchanger configuration is engineered specifically for OTEC use and features low-cost construction integrated into the concrete ship support structure.
- Design of the ship uses standard methods of construction with a low-cost hull and dimensions which can be accommodated by existing US shipyards.
- State-of-the-art equipment is used for all basic OTEC components, for which quotes and delivery schedules are available.
- Manufacture and storage is included for a product which will be in short supply and is now using nearly 3 per cent of scarce US domestic natural gas, which can be conserved by use of the natural resources available at the OTEC site.

The result is a new plant-ship program which can be started now and have an economically attractive impact on the US maritime industry and on national energy needs. Further, the cold water brought up from the benthic depths 2,500 feet below the surface is filled with nutrients, the environmental impact of manufacture could actually be positive, in contrast

For the OTEC/ammonia plant-ship at site ATL-1, which we recommend be undertaken first by ERDA and the US Maritime Administration, detailed cost estimates have been made based on actual quotes of individual equipment items from vendors for most of the major components. They show that commercial OTEC/ammonia plant-ships, at 500 MW_e net power output and 1,700 short tons of ammonia per day, can be built for US$734 per kilowatt. At a production cost of US$96 delivered f.o.b. New Orleans, Louisiana and a sales price of US$180 per ton, we estimate that the plant-ship investment can be recovered in 5.5 years. This estimate is based on constant 1975 dollars. Government cost-sharing or support will be required for the earliest commercial plant-ships to produce ammonia at this cost.

Funding for an end-of-1978 tropical ocean pilot plant will require about $3-5 million from ERDA and $2-5 million from the Department of Commerce (US Maritime Administration) in each of fiscal years 1977 and 1978. Alternatively the $15 million estimated cost (1975 dollars) for the end-of-1978 tropical ocean pilot plant could be funded by ERDA. Assuming a prior, successful pilot plant, the following schedule for OTEC/ammonia plant-ship implementation is recommended:

End of 1980	Demonstration-size plant-ship (100 MW_e)
1981 - 1982	One commercial-size plant-ship (500 MW_e)
1982 - 1986	Twenty commercial-size plant-ships (500 MW_e)

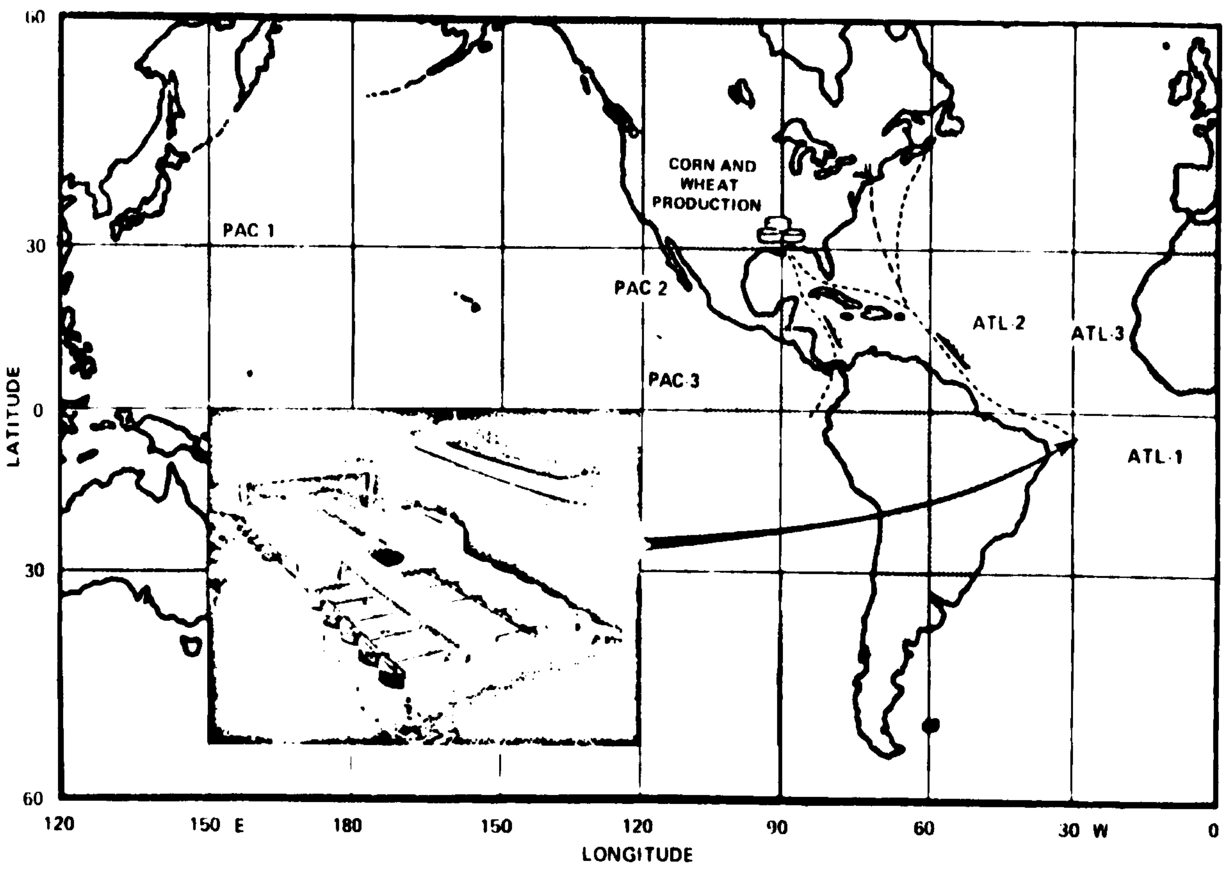
The benefits from a successful OTEC/ammonia program by 1986 would include:

- An annual savings of 0.5 trillion cubic feet of gas, about 3 per cent of the 1986 US natural gas supply. This would benefit each of the 32 million American households using natural gas.
- 101,000 new jobs in US shipyards.
- 1,600 new US flag shipping jobs.
- Additional jobs in the aluminum industry, in concrete, in steel, and in the industrial equipment sector of our economy.
- Farmers would benefit from the long-term fertilizer price improvement.
- Finally, there would be a net profit for the plant owners of the sixth and subsequent ships of about 50 per cent on equity/ship/year."

(Refer Figures 3, 4 and 5,and Tables 16 and 17)

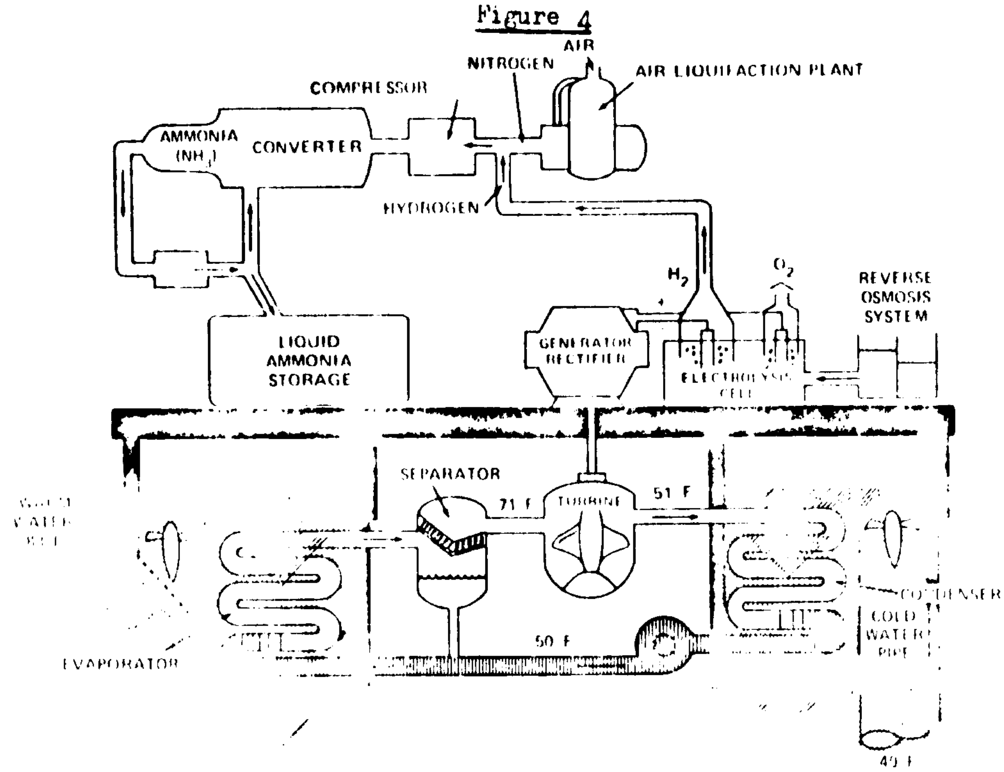
62. Another new appraoch relates to breeding new vegetable plants which has the ability to fix nitrogen from the atmosphere. Noteworthy accomplishments have been recorded by DuPont de Nemours, Co., USA. The United Nations is sponsoring research work in this direction through a co-operative programme with the Rockefeller Foundation in Mexico. Recent efforts to develop strains of wheat and rice which need minimum amounts of water and fertilizer and development of agriculture in the arid region of the world are also steps in the right direction.

Figure 3



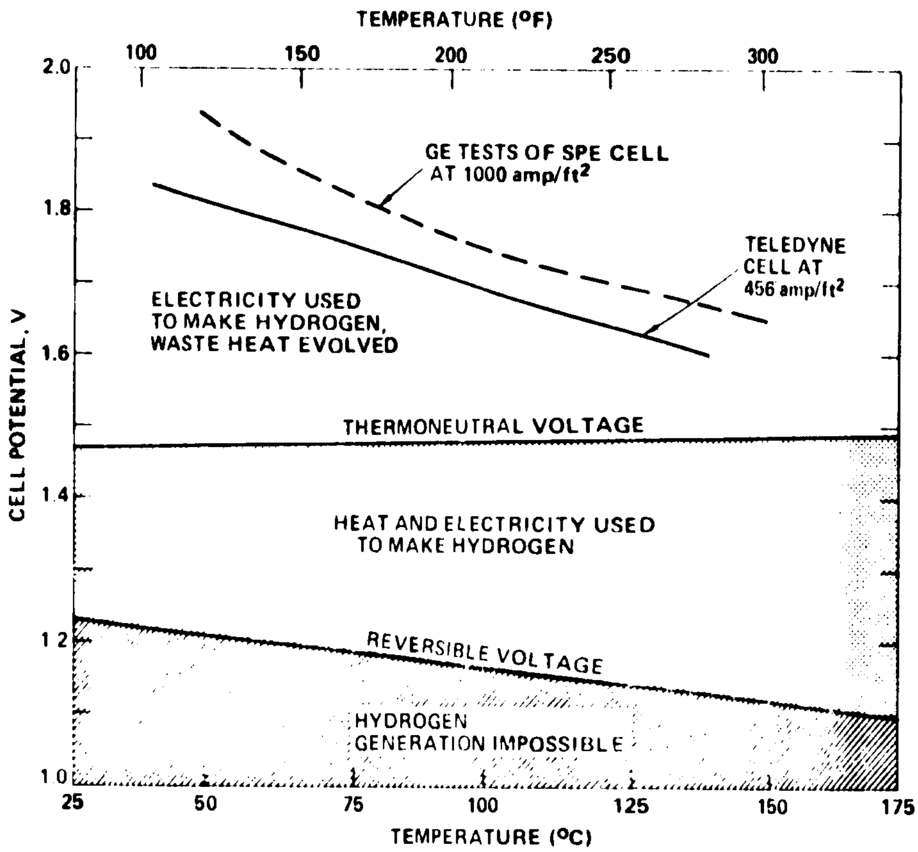
The Six Tropical Ocean Sites Selected for Deployment of OTEC Plant-Ships

Figure 4



OTEC/Ammonia Plant-Ship

Figure 5



Idealized Operating Conditions for Electrolysis and Temperature Effect

Table 16

Teledyne Electrolysis Plant Performance and Requirements
(16.14 MW Plant Unit Comprising Five Modules and Auxiliaries)

ITEM	MAXIMUM CAPACITY OR REQUIREMENT
Hydrogen output	149,500 SCF/H 776 lb/hr
Cell voltage	1.72 V
Power density	791 W/ft^2
Voltage efficiency	85.6%
Current efficiency	98.0%
Overall system efficiency	83.8%
Maximum operating pressure	100 lb/in.^{2}
Gas purity after water removal	98+%
Dew point (Reduced to NH_3 plant req't. in NH_3 plant)	180°F
Space requirement	25 ft x 25 ft x 15 ft high
Total weight	149,000 lb
Plant life	20 yr
Plant manning	
Operations: completely automatic with manual override; one man can start up, run, and shut down in manual mode	
Preventive maintenance: 183 man-hr, 1st year, 124 man-hr, 2nd through 20th years	

Services Required

Deionized water: 500,000 ohm/cm resistance (minimum)

Cooling: water must be available in NH_3 synthesis loop to cool KOH electrolyte to 165°F

Power: 3.2 MW_e per module, 440 V 3φ for pumps, remainder 220 V 3φ

Air: oil-free, 80 lb/in.^{2} minimum

Nitrogen: 700 SCF per startup; 20,000 SCF for emergency purge use

Inital KOH charge: 13,764 gal. of 25% wt. solution

Table 1[illegible]

Comparison of Estimated U.S. Production Costs for Ammonia from Various Sources

SOURCE	PRODUCTION COST ($/Ton)	ENVIRONMENTAL IMPACT
Natural gas	$ 64 - 91[a]	Moderate
Natural gas (residential rate)	100 - 104[b]	Moderate
OTEC/ammonia plant-ship	87 - 96[c]	Least (some aspects favorable)
Naphtha	108 - 122[a]	Moderate
Heavy fuel or crude oil	111 - 128[a]	Moderate
Coal	108 - 150[a]	Greatest

[a] Estimates from TVA National Fertilizer Research Center published data based on $0.80 to 1.50/MSCF gas cost, $80 to 95/ton naphtha cost, $11 to 14/bbl fuel oil cost and $22 to 42/ton coal cost.[37] Naphtha and fuel oil costs obtained from Platt's Oilgram.

[b] Production cost based on $1.75 to 1.86/MSCF rate being charged residential user by Washington Gas Light, Washington, D.C. for October 1975.

[c] OTEC/ammonia plant-ship cost is for ammonia delivered f.o.b. New Orleans, Louisiana.

X. Raw material oriented and market oriented production - Central "jumbo" units to feed "satellite" units and to "stabilize" existing units

. Some of the approaches discussed in Section IX are long term based. If we look at the natural gas and associated gases flared in oil producing countries, there is a short term step which oil and gas producing countries can adopt by building ammonia plants by using such flared gas. Many such projects have been started and ammonia trade by tankers is taking place to India and Europe and many other areas. By assigning a reasonably low level gas costs, ammonia can be produced at less than [illegible] per ton. If the countries putting up such facilities also invest in ammonia tankers and terminal facilities, the vicissitudes of transport costs and storage costs can be minimized.

2. Coming to countries with large demand such as India, Indonesia and others, question of building large (jumbo) ammonia and phosphoric acid plants either, raw material oriented or market oriented and attached to existing plants deserve careful study. For example with the "Bombay High Gas" coming to the mainland, there is a good chance for building a mammoth ammonia plant and distributing the ammonia to "satellite" plants and also to "stabilize" and reduce costs of production of older units. It is unfair that units based on solid fuels or high cost liquid and gaseous feedstocks should inherently get disadvantage over others more luckily placed with regard to feedstocks from a national point of view. Fertilizer prices in India being equalized at all points of consumption, it is only fair that such units which are at a disadvantage and all units for that matter are helped to reduce costs of production of fertilizers. Now that in India almost all

constituent states have their own fertilizer plants, it will be useful to consider locations for mammoth production centres for ammonia such as Kandla, Trombav, Goa, Mangalore, Cochin, Tuticorin, Madras, Kakinada Vizag, Pradip,Haldia etc. Each such centre can supply from the West and East Coasts of India to the central area which will not be more than 300 - 500 km from either coast. Ten such locations each producing 2,000 tons/day ammonia and 3,300 tons/day urea in two streams each or about 0.5 million tons of nitrogen per year or 5 million tons in total could be planned by the year 2,000. An outlay 5 billion dollars for identical mammoth plants will bring up the Indian installed capacity from 5.4 million tons of N planned by 1983 (ref.5) to 10.4 million tons of N in the year 2000. Similar approach to phosphoric acid production in Rajasthan and other centres where phosphate rock is available are worthy of consideration. Liquid sulphur imports coupled with phosphate rock imports to coastal locations to produce triplesuperphosphate (TSP) in single units of 1,000 tons/day P_2O_5 could be envisaged for 2.5 million tons of P_2O_5. The estimated capital cost will be 1 billion dollars. Thus 6 billion dollar investment in 17 years (1983-2000) works out to 350 million dollars per year which is quite a reasonable investment per year. Further the entire standardized ammonia, urea, sulphuric acid, phosphoric acid and TSP plants must be designed, engineered, fabricated and put up in India.

XI. Environmental considerations

65. To enhance the "quality" of life of the population all production centres for fertilizers should guard against pollution of environment, human beings,air, water and soil. Not only processes selected must have built in safeguards, but day to day operations must take care to prevent conditions affecting safety and health of workers, avoid discharging polluting or harmful effluents, gaseous,liquid or solids into the atmosphere, land or water. In case of captive sulphuric and phosphoric acid plants, ammonia plants using purification agents containing arsenic material discharges containing excessive amounts of sulphurous gases, arsenic and ammonia are to be carefully controlled. Byproduct gypsum from phosphoric acid plants although not a pollutant in itself has contaminated certain shore lines of North African region and the storage and disposal problems should be tackled by a technological approach. For example by-product gypsum or phosphogypsum could be converted to cement, clinker and sulphuric acid. (Cochin Phase II)

XII. <u>Technology and know-how transfer</u>

66. This brings us logically to the questions of technology and know-how transfer. Technologies must be appropriate and the recipient should be able to use and improve on technology. The subject is attracting great attention in UNCTAD, UNIDO, UN Science and Technology Programme and also in the Section of Multinational Corporations. Technology of fertilizer production is vital to many developing countries and the terms and conditions of such transfer should be equitable and urgent. UNIDO is starting a technical information and data bank and will benefit by the experience of FAO, IFDC and the World Bank. The ESCAP region is establishing an ESCAP/FAO/UNIDO Joint Asian Fertiliser Advisory Development and Information Service.

67. But the most important aspect of this subject is what can developing countries who are advanced in technologies do for other developing countries who are not so far advanced. Technology transfer among developing countries (TCDC) and Economic co-operation between developing countries (ECDC) are at present basic programmes of many UN agencies. A case in point is the production and use of catalysts. Countries like India and Mexico can help many other developing countries. Use of liquid fertilizer, "know-how" in fabrication of fertilizer plant equipment, transfer of experience in evaluating and using different technologies are available in India, Pakistan, Iran, Mexico and Brazil to mention a few countries only. The assistance given by FCI of India and FACT to countries like Philippines, Burma, Zambia, Sri Lanka, etc., need special mention.

XIII. <u>Regional and sub-regional co-operation</u>

68. The examples of such co-operation is evident in the ANDEAN Group, the ASEAN Group etc. The efforts of India to build or take part in building fertiliser projects in the Gulf area, in Sri Lanka and in Bangladesh, the efforts of co-operation between Phillipines and Indonesia whereby Philippines will concentrate on phosphoric acid and Indonesia on nitrogen are noteworthy.

The Consultation Meeting on Fertiliser Industry organised by UNIDO

stated as follows (ref.2):

"Regional co-operation

The Consultation Meeting recognized that the installation of fertilizer plants and the establishment of a marketing and distribution network would be easier in developing countries that had large fertilizer markets. In countries with smaller markets, it would be desirable to plan for regional co-operation and a combination of resources and skills. The opportunities for broader co-operation between all developing countries should also be pursued.

The Consultation Meeting reviewed the efforts that had already been made, including the regional co-operation arrangements of the Andean Group, the Latin American Association for the Development of Fertilizer Industry (ADIFAL), the Latin American Economic System (SELA), the Senegal River Development Organization (OMVS), the Mano River Union, the Arab Federation of Chemical Fertilizer Producers, the Industrial Development Centre for Arab States (IDCAS), the ASEAN group of countries, and the region served by the Economic and Social Commission for Asia and the Pacific (ESCAP).

The Consultation Meeting expressed its support for those efforts. It recommended that they should be intensified and that:

(a) High priority should be given in the programmes of those regional groups to the preparation of feasibility studies, the setting up of fertilizer plants, and the building up of a marketing and distribution network within each region;

(b) UNIDO should extend technical and professional assistance to those regional co-operative efforts and should provide consultancy services in response to requests, and should follow up the suggestions made at the Consultation Meeting;

(c) UNIDO should consider giving assistance to establish regional development centres for the fertilizer industry;

(d) International technical and financing assistance from bilateral and other sources should also be made available for such regional group efforts. "

69. In conclusion, it may be stated that to increase output from agriculture to feed the world population, the most important input to agriculture namely fertilizers must be produced and delivered even to the poorest farmers at the lowest possible price. We must help them to use fertilizers efficiently and increase yields. This will improve rural economy and raise hopefully the living conditions of those who are now left out of the development process.

References

1. Report adopted by the Second General Conference of UNIDO, Lima, Peru, 12 - 26 March 1975

2. Report of the First Consultation Meeting on the Fertilizer Industry, Vienna, Austria, 17 - 21 January 1977: ID/WG.242/8/Rev.1 dated 4 February 1977

3. Supporting information on eight issues which might be selected for consideration of the consultation meeting: ID/WG.236/2 dated 29 October 1976, Vienna 8 - 12 November 1976

4. MHD power generation - a technology of future by Dr. R. Ramanna, Director, Bhabha Atomic Research Centre, Bombay, India Journal Institution of Engineers, India, Vol 26, January 1977

5. Chemical Age of India 27th Anniversary Issue, pp. 139 - 148 "Indian Fertiliser Industry - Past, Present anf Future" by Dr. K.S. Chari, Fertilizer Association of India, New Delhi, India

6. Economic Quarterly No.54 - August 1977 Dresdner Bank, FRG, "The German Economy in Charts"

7. UNIDO, Draft Worldwide Study of the Fertilizer Industry 1975-2000 UNIDO/ICIS.22/Rev. 1 dated 28 December 1976

8. Investment and production costs for fertilizers by Mr. William Sheldrick, Fertilizer Unit, World Bank prepared for the FAO Commission on Fertilizers, 27 - 30 September 1977

9. World Bank Annual Report 1977, page 22

10. Newsweek, September 26, 1977 Newsweek - WEFA Forecasts, prepared in collaboration with the University of Pennsylvania's Wharton Econo-metric Forecasting Associates (WEFA)

11. Maritime and Construction Aspects of Ocean Thermal Energy Conversion (OTEC) Plant Ships - The Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Road, Laurel, Maryland 20810, USA

12. Production yearbook, FAI -1976

13. Summary data on fertilizer plants financed by the World Bank

C-673

78. 11.10