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WAYS AND MEANS TO REDUCE THE COST OF FERTILIZER PLANTS TO BE BUILT IN DEVELOPING COUNTRIES*

by

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I. SUMMARY

There is a pressing need for establishing fertiliser industries in developing countries. During the last decade the plant capacities have gone up. The investment cost of fertiliser plants have also shot up unprecedently due to several influences. This situation calls for a thorough examination of every step in its execution, so that the huge amount of capital outlay involved in the project shall be wisely spent ensuring safety of the good return on capital, satisfactory execution and speedy completion of the project.

With the above objective the paper examines certain important aspects in the implementation of a fertiliser project, like, capital structure, feasibility study, project specification, bidding and evaluation, project delays etc. with a view to locate areas of cost reduction.

II. INTRODUCTION

The period after 1963 witnessed a major breakthrough in fertiliser technologies and consequent enhancement in plant sizes. Large size single stream plants, using simplified design, large size vessels, sophisticated machinery and instrumentation came into existence. For example the installed capacities of modern Ammonia plants are 600 TE, 900 TE, 1350 TE and 1500 TE of ammonia per day.

In step with the above changes in technology, the capital involved in establishing fertiliser plants also grew by leaps and bounds. Added to this, the world inflationery trends, rising cost of labour and materials, increased transportation costs, appretiated land costs, upward trend in taxes and duties levied by governments for imported materials and raw materials, sales, capital expenditures etc., contributed in no small measure in boosting up capital cost of fertiliser plants and making it unpredictable regarding price rise pattern. Influence of all the above factors resulted in the prohibitively high cost of fertilisers in developing countries, at a time, when the world is confronted with the pressing problem of acute shortage of food. In the above circumstances, expansion of fertiliser industry and means of reducing the associated cost of fertiliser plants are of paramount importance to the developing countries. This paper is an attempt at assistance in this regard.

III. COST RISE IN FERTILISER PLANTS SINCE 1970 AND INFLUENCE ON INFRASTRUCTURE.

(a) The cost indices listed below, roughly arrived at by compiling the data in two separate cases, show the trend of price rise since 1970. The cost of an ammonia plant installed in 1970 is shown as 100.

Cost indices - Ammonia plants

Year	Case A	Case B
1970	100	100
1973	124	--
1975	161.5	173
1976	169.5	200
1980	*200	*230

*Anticipated cost (approximate).

On the basis of the above indices shown under Case A, approximate cost of an ammonia plant installed in 1977 for various feed stocks and sizes is shown along with the corresponding cost in 1970, in order to have a factual appreciation of the capital involved and its variation.

Exclusions

1. Boiler feed water treatment
2. Steam Boilers
3. Cooling towers
4. Instrument and plant air supply
5. Transformer station
6. Product storage

Installed cost of ammonia plant (in MM dollars)

Product capacity of ammonia.	Feed stock and year									
	Natural gas		Naphtha		H. Fuel oil		Coal Pres Gasification		Coal powder Gasification	
	1970	1977	1970	1977	1970	1977	1970	1977	1970	1977
300 TE/Day	18.75	33.16	19.79	35.40	27.00	47.95	31.80	56.45	37.00	65.79
600 TE/Day	28.30	50.16	29.58	52.37	40.40	71.54	45.80	81.16	53.30	94.50
1000 TE/Day	38.30	68.08	40.00	70.83	53.30	94.41	60.40	107.00	70.30	124.70
1500 TE/Day	50.00	88.54	52.08	92.20	66.60	118.04	75.00	132.83	87.30	154.83

NOTE:

1. In fuel oil and coal gasification plants, investment cost includes cost of oxygen plant, but not coal handling facility.
2. Cost covers engineering and license free.
3. Cost of equipment and materials F.O.B. Europort.
4. Civil and erection works included.
5. Cost is in million (MM) American dollars.
6. Cost approximate, escalated from 1970 price and approximate indices.
7. Cost is for a battery limit plant.
8. Location of plant Western Europe.

7. Mobile equipment
8. Spares

(b) Along with Ammonia plant capital cost rise, significant rise has been experienced in Phosphatic fertiliser plants also. The following table illustrates the above point.

Cost Indices - Phosphatic fertiliser plants.

Year	Indices
1970	100.00
1975	132.70
1977	147.00
1980	*175.00

*Anticipated

(c) The installed cost of Ammonia plant varies according to the feed stock used for the processes because of the different process technology adopted for each feed stock. The following indices illustrate this point. Cost index for an Ammonia plant with natural gas as feed stock is taken as 100.

Feed stocks (All sizes & years)	Indices	Remarks
Natural Gas	100	Cost of battery limit plant.
Naphtha	110	"
Fuel oil	150	"
Coal	180	Doesn't include coal handling.

(d) The installed cost of an Ammonia plant goes up as the size of the plant increases according to the following approximate indices. It is assumed that the cost of Naphtha/Natural gas based Ammonia plant having 1000 MT/Day capacity as 100.

Plant capacities		Indices (All years)
1000 MT/Day	...	100
1350 MT/Day	...	125
1800 MT/Day	...	165

(e) For establishing primary fertiliser plants, a reliable and well developed infrastructure is required. This includes transportation, power and water, skilled labour, general service facility, availability of land at reasonable prices etc. Since installed cost of the plant and its continued economic operation is very sensitive to changes or interruptions in the above factors, it is needless to emphasise on its stability, reliability and dependability. In developing countries, fluctuations are very often influenced by governmental policies.

In general, industries having a high material index and which are weight losing in character are located towards raw material and fuel sources whereas industries having a low material index and which are not weight losing are, to an appreciable degree, located near the area of consumption. Primary fertiliser plants belong to the former category while secondary producers like bulk blenders etc., are clubbed in the latter. Naphtha consuming fertiliser plants are generally located at port or refinery sites for achieving the same objective.

In developing countries, in view of the essential nature of the industries, assistance from the government is usually available for improving railway and port facilities as well as road transport. Wherever possible plants are located at places where the same railway wagons, used for transporting materials to harbour for export are made available at concessional rates for distribution of fertilisers, on their way back. By fixing consumer prices of fertilisers, government subsidises producers who have to use long distance transport. Since, in certain countries, fertiliser is listed as an essential commodity, government allots the distribution of fertilisers in such a way that no manufacturer has to transport his product over unduly long distances.

Though, generally, public power is made available by government agencies, in certain locations it may be preferable to have the plant totally independent of outside power due to reasons of lower energy cost and greater reliability. Power plants also can be integrated with process, using extracted steam after power recovery as process steam and/or steam for driving process machinery. Though ammonia plant can be designed with no power requirements practically, usually about 600 KW per tonnes of ammonia made is expended in driving some essential and standby machinery. Steam driven machinery should be preferred to electrically driven machinery, if found cheaper, since in the writer's experience machinery using by-product steam are equally if not more reliable.

Without adequate supply of water for process, cooling requirements, power and other purposes, primary fertiliser plants can neither be conceived nor operated. About 380 MT of circulating cooling water per tonne of ammonia made is a normal figure. Developing sweat water sources itself is a capital intensive project. Generally governments assist in meeting water requirements by making public water systems cater to the needs of the plants. In places where such facilities are not available, alternate methods like using sea water for cooling, air cooling etc., will have to be resorted to, which of course will involve additional investment cost to the project.

Land costs, especially near big cities, have skyrocketed in recent times. Now due to fear of pollution or perhaps the governmental desire to develop rural areas, there is already a tendency to locate big factories in such places. In cases like this land cost will appreciably come down. In either case, government assistance is generally available in view of the essential nature of industry, for acquiring land at normal prices and making it available for the factory. This assistance helps in reducing capital cost of the plant.

In a developing country like India, skilled labour for setting up and operating factories are generally available at most locations. Wherever such facilities are not available people can be trained to the required standards without excessive expenditure. Government also provides assistance in making general services available at no cost to the project.

From the point of view of reduced capital outlay of a project the ideal location for setting up a fertiliser project will be one which is already served by railways, highways, water canal systems and good harbour facilities so that transport of raw materials as well as finished products can be made by any of the above modes. Cost of the services and facilities required for the plant can be nearly halved by locating the plants at such places when compared to setting up a grass roots plant at a different location. Even working capital can be reduced as there is likely to be well organised marketing facilities for finished products at such locations.

IV. CAPITAL STRUCTURE - FERTILISER PLANT

The vital components of capital structure of a fertiliser plant include erected cost of plants, cost of services and facilities, cost of land and its development and working capital.

Plant costs: Cost of plant and allied equipment under review include its F.O.F/F.O.R cost plus transit insurance and freight. Customs duty for imported components varies from country to country and for developing countries it has varied from 27½% on c.i.f. cost to 50% during the last decade. The other important constituents which come under plant costs are license fees, engineering and procurement (Annexure-A).

Services and facilities: This is also a major component of the cost structure and it includes cost of water, power, services, transport, office equipments and furniture and miscellaneous expenses covering preliminary expenses of the project, pre-operative expenses, interest charges during construction, contingencies etc.(Annexure-A).

Cost of land and its development: Investment under this head consists of cost of land where plant is located as well as the land for building factory's township. Cost of development of above land, building roads, construction of dwelling houses, shopping centre and other amenities to employees come under this head (Annexure - A).

Working capital: Cost of inventories, like raw materials, fuel oil, products etc., for a reasonable period of time fall in this category. Other components of working capital include cost of operating supplies, spares etc., as well as goods in process (Annexure-A).

Modern fertiliser plants are capital intensive. Considerable study and analysis are needed to find the best way of providing the required fixed and working capital in order that they are kept to a minimum and the greatest possible returns on the total investment is obtained. If the project is augmented by a realistic and well presented feasibility study, which also indicates a favourable profit margin after taxes, there will be different sources through which capital funds may be obtained. However, financial problems might still arise, owing to currency restrictions, doubts regarding security of capital earnings etc. In developing countries guarantee from governmental agencies helps in overcoming such difficulties.

A practical way of surmounting foreign exchange limitations as well as raising of large funds is to borrow money from one or more of the international lending agencies or banks specialising in these services like International Finance Corporation, The International Bank for reconstruction and development also known as World Bank, International Development Association Agency for International Development etc. Several countries have also set up development corporations to encourage investment in the country through the provision of long term loans and equity participation. In India, Industrial Finance Corporation and Industrial Credit and Investment Corporation of India are two such organisations. For financing a fertiliser project a normal practice is to adopt a debt-equity of the ratio 2:1 in the total capital outlay. At times, certain developed countries also offer suppliers' credit on favourable terms, which will help in securing foreign exchange and imported equipments.

Tabulations listed as Annexure - A to this paper include detailed analysis of capital structure showing approximate percentage cost of each item on total capital outlay for an Ammonia - Urea facility. The statement showing production cost of Ammonia also illustrates how fixed and variable cost influences cost of the product.

The Statement listed as Annexure - D includes breakdown of investment cost for an Ammonia/urea facility constructed on the basis of a turn-key contract. Cost given for individual items are, as percentages of the total investment, so that it will give an overall appreciation of the work involved. It may also throw some light on where reduction in cost can be attempted and is worthwhile. Percentages given are approximate and in some cases they are estimated.

V. FEASIBILITY STUDY - CHOICE OF LOCATION

However inspired the conception of a fertiliser plant may be, to ensure beyond a shadow of doubt that the huge amount of capital outlay involved shall be wisely spent, it is imperative to justify it, as regards to fertiliser demands both present and future, choice of process, local needs, material availability, location, sales, marketing, distribution and the envisaged financial return. This calls for a thorough feasibility study which must be absolutely objective and impartial as well as accurate in its findings and recommendations. Failure to anticipate possible bottlenecks or a tendency to underrate financial requirements or to overestimate potential sales and resultant profit may lead to disastrous situations in the future. Hence, a thoroughly competent and objective study team with clear ideas about the scope, depth, purpose and time schedules for the work to be undertaken is a prerequisite for ensuring success of the project.

When fertiliser projects are contemplated by government authorities, either independently or in conjunction with private investors, valuable assistance can also be rendered by industrial specialists in marketing, shipping, financing, agronomy, fertiliser statics and other pertinent fields.

It is the normal practice to choose, as the first step, a region or even a country on the basis of fertiliser demand, raw material availability, shipping facilities, financing and marketing provisions and then select a site on the basis of more tangible factors like soil characteristics, process water, power, local labour, transport, infrastructure and so on.

The feasibility reports must include among other things, capital structure, financial and economic analysis, cash flow and profitability statements. Annexure - B shows the nature of a financial and economic analysis of the project.

The demand for fertilisers in the region have to be worked out on the basis of agricultural land available and the per hectare need of fertilisers in those regions, details of which will normally be available in government agricultural establishments. While selecting the process, although advantage of modern process and improved technology is desirable, the adoption of untried new process, equipments and methods should be avoided for projects in developing countries in the interest of dependability and reliability of the process employed. The product pattern is to be accepted only after a complete and exhaustive agronomic survey.

<u>Factors to be considered in location selection</u>: The objective of proper selection of site is to curtail the delivery price of the fertiliser produced. Failure

to select an optimum location will usually result in aggravated costs, which no amount of commercial or technical skill will be able to nullify.

Relationship between major economic factors and optimum location of a plant has to be established on the basis of theoretical analysis as well as a practical study based on check lists and detailed field work meant to cross check each other. In the search for an optimum plant location, theoretical analysis tends to become less generalised and more specific. Simultaneously computer techniques have advanced so much that it permits numerous input variables to be handled more easily than it was possible a few years back.

Primary fertiliser plant location is strongly influenced by the raw material availability factor because of the weight losing nature of most processes in this category and the relatively high transportation costs. Raw material availability thus plays a major role in the selection of an optimum site, either directly in the case of a plant adjacent to the source of material or indirectly by choosing a location linked by sea transport, if in a far off place. To prevent transportation cost from becoming prohibitive phosphate minerals are invariably upgraded at the mines before use. Petroleum products such as naphtha and refinery gas also act as location-influencing factors for Ammonia plants, which are often built near a refinery or a port capable of handling bulk shipments.

Fertiliser plants are, in most cases, sensitive to the transportation factor, especially regarding raw material supplies and to a lesser extent to the delivered cost of products to distributors. Thus, experience in securing the lowest transportation cost, improvements in bulk shipping and cargo handling are no less important than skill in production and developments in process technology. Changes in overseas and inland transportation rates can shatter the economic viability of a plant location. Therefore, it becomes imperative for fertiliser producers to reduce and stabilise transportation cost variables to the greatest possible degree, by making appropriate agreements with suppliers and shippers and by being continually on the look out for new ways of reducing charges.

Transportation factors regarding finished goods are also of considerable significance in determining the optimum location of a primary fertiliser plant unless freight equalisation is predominant in the market area. The influence of low delivered cost to the consumers, on the part of competitors, makes it imperative to select a location which permits minimum cost deliveries with additional emphasis on reliability and efficiency. Availability of alternate transportation eg., road and or rail, barge or two competing rail roads etc. are very advantageous for transport cost reduction and assured delivery to consumers.

Availability of power is not a major factor in deciding upon the location of a primary fertiliser plant, since a self-contained generating unit driven by steam either separately or integrated with the process can be installed.

Though availability of water is a key factor in influencing plant locations considerable flexibility exists regarding water requirements. If not present at preferred site it can usually be drawn in via pipelines, provided it exists or can be located in the region. In many locations water can also be obtained by sinking wells at appropriate places in the vicinity of plant. When fresh water supply is inadequate, sea water, if available, is often used for cooling purpose. Alternatively air cooled heat exchangers are also sometimes installed.

When solid or liquid fuels are used for feed stock, heat and energy requirements in Ammonia plants, location near the source of fuel permits appreciable savings in transportation costs. When such fuels are to be transported over long distances they are normally brought in by the same transport services used to ship the product i.e., water, road or rail. Fuel requirements therefore, do not normally exercise any influence in site selection.

Waste disposal can be another major factor in choosing the location of a primary fertiliser plant, especially those producing phosphates. Wet process phosphoric acid plants generate substantial volumes of waste gypsum, of of the order of 2 tonnes per ton of rock used which creates disposal problems, especially in built up industrial areas. Similarly the disposal of acidic effluents containining flourides may not be permitted. Fumes from sulphuric acid, nitric acid and phosacid plants may be subject to rigid local bylaws. Stacks from prill tower of urea plants have to be de-dusted before let into atmosphere. All the above potential pollution problems necessitate selection of appropriate plant site.

Capital costs and operating expenses may be considerably increased by adverse site conditions, which in extreme cases may compel the selection of more favourable locations. Major factors to be checked include possibility and chances of survival in the event of natural catastrophes like floods, earthquakes, cyclones etc., soil bearing conditions, right of way, titles expansion provisions and numerous other items for which check lists are available. In short any feature which may prove to be of significant importance must be dealt with in detail before a final decision is arrived at regarding the site.

The problems encountered in plant construction are often severe. They include transportation and site difficulties, weather hazards and labour recruitment. However, these are matters which an experienced contractor can easily overcome. Locating a plant at a place where good infrastructure is already available will reduce the cost for services and facilities by nearly 45 per cent.

There are other equally important factors which have major influence on plant location in terms of capital investment and profit protection. These are political, corporate and other factors like taxation etc. A prerequisite for establishing a large fertiliser plant overseas is a stable political situation, free from threats of revolution, devaluation, expropriation etc. Insurance against such possibilities can be obtained only from government agencies. Relation between the respective countries in which raw material suppliers, processors, consumers and plant owners are stationed is also an important aspect.

Another significant factor on plant location is taxation, which may be applied to raw material supplies, capital expenditures, earnings and sales etc. The modest rate of return generated by many fertiliser operations can be reduced to unreasonable proportions by the numerous taxes levied by certain countries and states. Hence every possible effect of taxation for several alternate locations should be anticipated, studied and compared by experts in taxation laws and checked by government authorities prior to making a final decision on location.

Some countries stipulate or restrict participation of foreign capital to less than 50 per cent, majority holding being retained by local public, private or government interest.

It's evident from the above that influence and effect of fundamental corporate, fiscal and financial considerations on plant location can be even more decisive than complaiance with economic theory or site requirements Therefore, a thorough study of these items for different possible locations by experts on this subject is unavoidable before irrevocable decisions regarding site selection are made.

VI. COMPREHENSIVE AND CLEAR BID SPECIFICATIONS

Having established through feasibility study that the project is viable economically and that the government, owner and the lending institutions are fully confident about the success of the project, the next important step is to prepare a clear, precise and comprehensive specification for the plant explaining clearly how it should be built. This is the initial step in the preparation for inviting tenders. Building a large fertiliser complex is a specialised business and hence in the preparation of the above documents, experts specialised in this field should be made to participate. Many of the difficulties encountered in the construction of a fertiliser project can be eliminated or at least minimised, if one can secure the services of a reliable contractor and he can be made to enter into a good contract, the implications of which are understood both by the owner and the contractor. For achieving the above objective a clear and precise project specification is a prerequisite.

There are various ways of preparing these specifications. Whatever way is finally adopted, it should describe the type of plant required, its capacity, the details of products, the infrastructure requirements, the nature of raw materials, safety standards during construction, the provision of spares, the nature of guarantees required on raw materials and efficiencies, climatic donditions, the site, availability of utilities, general requirements etc.

On the basis of the above, project specifications can be divided into two major heads namely, (1) technical specifications and (2) commercial specifications. The technical specifications should describe the scope of the factory, design basis including site conditions, climatic data, raw materials and utility conditions for the factory, basis of engineering, spare parts lists, process performance of each unit etc.

Similarly the commercial specifications should include among others, test and inspection of contract equipments, spare parts, commissioning, trial and guarantee test runs of factory, performance guarantee, procurement and delivery, training of owner's staff, general and comprehensive insurance, equipment guarantee, liquidated damages for non-performance guarantees, delay, taxes and duties, Force majeure, supervision of erection, patent rights etc. etc.

<u>Technical Specifications</u>

This should comprise of

(A) <u>Scope of the factory</u>: Scope of the factory should clearly explain the following:

(1) The main manufacturing plants to be put up, their daily production capacities, feed stock to be used and the process to be adopted.

(2) Utility facilities required for the flexible operation of the whole factory consisting of:

(a) main sub station, power and steam generation and emergency power generation facilities.

(b) cooling water facility consisting of cooling towers and chemical treatment,

(c) water treatment facility

(d) Inert gas generation facility if necessary.

(e) dehumidified air generation facility.

(f) yard piping

(g) raw water reservoir.

(3) Storage, handling and transportation facilities required like:

(a) raw material storage and transportation.

(b) intermediate storage and transportation like ammonia and phosacid storage.

(c) product storage, bagging and transportation.

(4) Auxilliary facilities normally consisting of:

(a) administration office, factory office, general laboratory, canteen and change-room facilities, maint, shop, gate house, store house, garage and fire house etc.

(b) maintenance shop equipment

(c) general laboratory equipment

(d) effluent water treatment

(e) roads, sewerage and fencing

(f) intercommunication system

(g) drinking water, safety equipments, sanitation system.

(h) fire fighting facility

(i) training equipment and process simulation.

(B) Design basis: This should enumerate the conditions to be followed for designing and constructing the factory and should consist of sections detailing (1) (2) raw material and utility conditions for factory and finally (3) basis of engineering.

Site condition

(1) Climatic condition: Performance guarantee has to be achieved regardless of climatic condition.

(2) Geological conditions: The following details are to be provided:

(a) material stratum ground underlayer upto 10 M below ground level

(b) ground water level

(c) seismic coefficient

(d) site levelling--site has to be cleared and levelled in preparation for commencement of civil works.

(e) available authentic data on soil bearing, spot levels, contour maps, meterological data etc.

(3) Particular condition for inland transportation. Since large equipments and materials have to be transported to plant site from harbour or rail road p oint, investigation in this regard have to be done in advance. Strengthening of roads, bridges, wharf etc. have to be completed wherever necessary.

(C) Raw materials and utility conditions for the factory: Performance guarantee regarding production capacity, product quality, raw material and utility requirement of each plant, will depend upon the specification of raw materials and utilities. Hence, details furnished in this regard should be clear, complete and should not be a cause for misunderstanding at a later stage.

Following are some details on the subject:

(a) Naphtha: Specifications required are type, carbon/hydrogen ratio, specific gravity, compositions showing contents of olefins, aromatic, sulphur and lead, initial and final boiling points, vapour pressure, net heating value and residue on evaporation etc.

(b) Coke and coal: Specifications required are carbon, hydrogen, oxygen, sulphur, nitrogen, initial deformations, softening temperature, moisture, volatile matter, fixed carbon, size range and heating value.

(c) Heavy fuel oil: Specifications required are sulphur, net heating value and viscosity.

(d) Filtered water: Specifications required are pH, total suspended matter, total dissolved solids, silica, iron, calcium oxide, magnesium oxide, chloride, sulphate and total hardness.

(e) Electric power: For low and high voltages the following details are to be furnished:

> Voltage, frequency, phase and voltage fluctuations. Geherally government electricity rules applicable are to be followed for all electrical installations.

(f) Empty bags: Capacity and type of fabric required are to be specified.

(g) Intermediate products for further processing: Specifications required are for (1) Ammonia -- purity, water and oil content, and (2) Urea -- Nitrogen content , moisture, Buiret, size and iron content.

(D) Basis of Engineering

This is the most important section among all the specifications. For want of scope and space it has not been possible to give a full text of such comprehensive specifications for a complete fertiliser plant facility. However, some important aspects are highlighted and some specific points of interest are included in Appendix-C.

The plant should be designed taking into consideration the maximum ease and economy of operation, minimum maintenance, interchangeability of parts, long operating life and safety of operating and maintenance personnel. All aspects of engineering should conform to some international and or the respective country's applicable standards and they should be spelt out clearly in the technical specifications.

Necessary additional equipments as standby should be installed to maintain the high on stream efficiency of the plant. The equipment, piping and all other mechanical items are designed according to the advanced engineering standards considering the special requirement of the project and should be of heavy duty type designed for continuous service.

Material of construction of parts, particularly of those used for pressure service should be sufficiently resistant to corrosion. Corrosion allowance of pressure holding parts should be at least 3 mm for carbon steel and low alloy steel. Corrosion allowance is not required for high allow steel unless otherwise specified.

All piping, vessels, heat exchangers coming in contact with process fluids in Ammonia plant shall be made of such material equivalent to or better than recommended in Nelson Chart. Also heat exchanger tubes must be of standard diameter and length.

The spare parts required for the plant for the period of two years have to be and should be made available to the contractor for bidding. A comprehensive list can be made for the whole factory, grouping the various equipments in different categories and mentioning the spares required against them. Convenient groupings may be catalysts, centrifugal compressors and turbines (large size), reciprocating pump (large size), centrifugal pump, small size reciprocating pump, small size steam turbines, centrifuges, heat exchangers, control valves, panel instrument and transmitter, analysers etc. etc. It is imperative that in large size fertiliser plants certain spare parts are always maintained as insurance spares. They include one spare set of catalysts, a spare rotor assembly for every large size centrifugal compressor, 15 per cent of the reformer tubes etc.

Process performance of each production unit should clearly specify guarantee production capacity, product quality and raw material and utility consumption.

Commercial Specifications: Described elsewhere under the head "General condition of contract".

VII. BIDDING AND EVALUATION

Careful selection of reputed contractors, adoption of proven process technologies and ensuring that the contracts contain appropriate performance guarantee clauses are important aspects that contribute to the successful implementation of a fertiliser project. Contract procedures which are legal and technical in concept should be prepared by specialists.

There is a wide range in type of contracts, as explained below each one having its merits and demerits.

(a) 'Turnkey' contract (Lumpsum Contract).

In this type of contract all responsibility for adherence to the guaranteed plant performance, keeping to schedules and specifications etc. rests with the contractor. This avoids dual resp onsibility between contractor and owner. 'Lump-sum' along with 'Bonus-penalty' contract offers incentives to shorten the construction period.

(b) Cost plus percentage fee or fixed contract.

This type of contract tends to lengthen time og rtrvyion and increase total cost. A compromise is to use, 'A fixed fee plus guaranteed maximum cost" type of contract, which may offer some protection to both contractor and owner when unknown factors are anticipated.

(c) Negotiated contract.

This is a contract made between experienced contractors and knowledgeable owners on the basis of actual negotiations. This type of contract eliminates the time otherwise spent in soliciting and scrutinising competitive bids. It might also lead to some significant reduction in plant costs.

(d) Partly reimbursable and partly lumpsum contract.

In this type of contract, provision of some goods and or services is provided by lump-sum payment while others are paid on a reimbursable basis. Various items coming in this category include engineering, procurement, construction testing and inspection, process know-how etc. etc.

Before the finalisation of contract, there are two steps of critical importance to be gone through, which define precisely the work to be done under the contract and the responsibilities of the two main parties. They are the preparation of tender documents and the assessment of the tenders.

Preparation of tender documents.

Tender documents are generally prepared under four heads namely (1) General informations (2) Instructions to tenderers (3) Technical specifications, and (4) General conditions of contract.

(1) General informations.

This section gives definition of terms used in the contract, the informations required for tenderers' personnel, the correspondence procedure to be followed, the type of contract the tenderer is expected to submit, language to be used, general intentions and requirements of the owner etc.

(2) Instructions to the tenderers.

This section explains the following for the benefit of the tenderer so that he fully understands how the tender must be prepared and how the documents must be presented. The tenderer is expected to satisfy himself as to the nature and location of factory site, applicable laws, agreements and regulations, the general and local conditions particularly those pertaining to transportation, disposal, handling and storage of materials, availability of labour, water, electrical power etc. etc. He is expected to inspect the site and satisfy himself about adequacy of site preparation done by owner and assume its full responsibility. He also should make sure that he has fully examined the technical specifications.

The break-up of the individual parts of the tender is described and the procedure for pricing of each is given in detail in this section.

The procedure for opening of tender as well as the details of two stage tendering proposed is explained. The contractor is expected to give his quotation in two envelopes sealed and superscribed 'technical tender' and 'priced tender' respectively. On the first day, in the presence of tenderers, only the technical tenders are opened. This evaluation is to ensure that the technical tenders comply with the requirements of the invitation to bid.

During evaluation of above tender, owner calls for additions or deletions, if any, so as to harmonise all tenders. At this point each tenderer is invited to prepare a supplementary priced tender, if called for, relating only to the agreed changes in technical aspects. Tender bond will be altered accordingly. On the day of opening of the priced tenders, the corresponding supplementary tenders also are scrutinised.

Each tenderer is expected to provide a tender bond to ensure that he will not withdraw on receipt or after the acceptance of offer. This should be executed in the form of 'On demand bonds' by banks in favour of the owner for a total value of about 2 per cent of the tender value. Tender bonds will be returned to the unsuccessful tenderers. It will be replaced by an appropriate performance bond by the tenderer who has been offered the contract. One of the main virtues of tender bonds and performance bonds are that they weed out contractors who in the eyes of the bank and surety companies are not fit enough to fulfil the contract. Tenderers, in order to be considered for the work should have sufficient experience and competence in building large size fertiliser plants. He should also produce documentary evidences in support of his credentials and financial standing.

(3) Technical Specifications.

Details are already explained elsewhere.

(4) General conditions of contract.

These conditions, also termed as commercial specifications describe the specific financial requirements, restrictions on currency, general contractual terms and conditions and owners' intent with respect to such items as insurance, taxes, import duties etc. Following are some of the salient points highlighted in this section.

The contractor should guarantee the mechanical completion of the factory within the stipulated period, in accordance with the construction schedule. (Normally a large size Ammonia plant takes upto a maximum of 30 months for completion). In the event of delay in mechanical completion, contractor has to pay liquidated damages for the period of delay. This will be normally about 0.25 per cent of the total contract value for each week of delay. Sometimes contract also provides for bonus which will be about half the value of penalty for the corresponding period of delay. There will also be liquidated damages for not achieving production target and raw materials and utilities consumption. While fixing penalties and liquidated damages one should ensure that these are not being overdone since all these tend to increase contract price or at times scare the contractors away.

Contractor has to provide within contract price and maintain in force, until the date of acceptance of factory, the builders' erection risk insurance including fire and extended peril with provision for settlement of claims to be paid in U. S. dollars or other convertible currency in such proportions as may be required for replacement or repair of non-indegenous equipment or spare parts. Contractor should also maintain insurance cover against third party liability and workmens'compensation liability.

If within one year after owner's acceptance of each plant of the factory, the contract equipment is found defective, contractor is obliged to repair or replace such defective equipments.

General conditions of contract should clearly explain procedure for demonstration of performance guarantee and evaluation of datas collected in this regard. Prior to commencement of guarantee test run, the factory should have operated continuously and successfully for 21 days at an average of 95 per cent installed capacity. The guarantee test run shall be performed for about 120 hours non stop for Ammonia, urea and compound fertiliser plants. Average results for any continuous operation of 72 hours shall be taken for determining plants' capacity for meeting guaranteed performance.

Commercial specifications should also mention as to who will pay taxes, duties, excise, assessments or any other charges of various kinds, whether present or future, levied on Contractor by governmental bodies.

Contractor shall obtain for owner all fully paid up licenses to operate the factory according to the specifications laid down in contract. Force majeure conditions preventing contractor from performing his contractual obligations due to reasons beyond his control should be detailed.

Arbitration rule should be clarified. Any disputes which are not amicably settled by mutual negotiations between parties shall be submitted to arbitration in Paris pursuant to the rules of conciliation and arbitration of the International Chamber of Commerce for settlement by one or more arbitrators appointed in accordance with the rules.

The contractor should undertake training of owner's staff as necessary with respect to the operation and maintenance of the factory.

The contractor should ensure that he shall perform the design and detailed engineering for the factory as well as standards and codes as set forth in the technical specification.

Assessment of Tender

The merits and demerits of all technical tenders are assessed and a consolidated tabulated statement is made showing prices for comparative study. It is not obligatory to finalise contracts on lowest tender, but it will be a sound business ethic to indicate the genuine reasons for rejecting a tender in fairness to all concerned. Such a contract finalisation will not only be correct but also appear correct. The choice of the contractor will however, be done only on merits, the main objective being overall success of the factory. The chosen contractor is given written notice of his appointment.

VIII. PROJECT DELAYS AND HOW TO AVOID THEM.

(1) Preparing feasibility reports and getting the approval for the project take unduly long time in developing countries. An extended pre-financing or pre-construction period not only deprives the concerned of the resultant benefit but may also increase investment needs, owing to the continental rise in engineering, equipment and labour cost. A well presented feasibility study, backed by detailed information sufficient to answer anticipated questions and requests for further data would most probably save valuable time and money and thus expedite the entire project to a considerable degree.

Feasibility study has to be read by specialists in different fields. To pass such a series of close examination, the feasibility study must be encouraging, yet at the same time accurate. The following features should be emphasised and demonstrated wherever possible.

(a) Basic need of the project
(b) Direct and indirect benefits to the community
(c) Answers of markets and sales
(d) Assurance of raw material supplies
(e) Suitability of process and performance guarantees
(f) Competence of proposed senior management
(g) Detailed financial analysis, projected earnings and cash flow.

Feasibility report, if possible, should be supported by letters of intent from prospective customers and raw material suppliers as well as guaranteed maximum prices from contractors, licensors and others. An attractive format without being showy will evoke a favourable response.

(2) Fertiliser projects being capital intensive in nature, difficulty will be experienced in securing the interest of potential investors who might wish to subscribe a large part of the required capital. Financing problems might also rise owing to currency restrictions and doubts concerning the security of capital and earnings. A practical way of surmounting foreign exchange limitations, as well as raising large funds required, might be to borrow money from one or more of the international lending agencies. Government interest in the project also can save considerable time and effort.

The foreign exchange component in a fertiliser plant can be in millions of dollars, which is needed for buying specialised items like stainless steel vessels, complex machinery, sophisticated instruments etc. Time in arranging such finance can be saved perhaps if we make use of suppliers' credit occassionally offered by developed countries.

(3) Preparation of tender documents, invitation of competitive bids and finalisation of contract is another item that can be time consuming. This can be minimised by choosing the proper type of contract that takes minimum time for finalisation.

There is a mistaken notion that when governmental agencies are involved in a particular project, the contract should be awarded to the lowest tenderer for fear of government disapproval if otherwise offered. Generally, government does not question technical decisions and it is only fair that when a lowest tender is rejected the reasons for rejection are clearly mentioned. Tender recommendations should be prepared by knowledgeable and competent persons and they should be fair, convincing and should speak for its genuineness.

(4) Complexities of the problems involved in a fertiliser project are enormous. Lack of understanding of this aspect and inadequate planning have caused considerable delays in the execution of projects.

One of the best ways to avoid this delay is to assemble an experienced planning group, which could develop an overall plan and break it down into manageable components. A 'critical path technique' or 'PERT' could then be applied to ensure that the project is completed on a specified time schedule with minimum of delay to provide co-operation among all the contributors to the plan.

In a 'turn key' type of project the entire responsibility for the project rests with the contractor. However, it would be advisable for the owner to appoint one or two of his planning men to follow the progress of the project in close conjunction with the contractors' personnel.

Occasionally, plants are built by several contractors and sub-contractors under the coordination of the owners' engineering department. In such cases extremely close control must be kept on construction schedule to prevent the total time and cost of the project increasing alarmingly, since overall resp onsibility rests with the owner.

(5) Orders for a large number of equipments, parts, services etc. are placed with different vendors both inside the country where the project is built as well as abroad. If any contractor fails to deliver the goods or gets into legal complications, project can be unduly delayed. To avoid this a vendors' list should be made which is approved by both owner and contractor as a result of their experience and or study. Orders will be placed only with the approved vendors.

(6) There is sufficiently large fabrication capacity for heavy vessels and equipments available in developing countries. However, special alloy steels or stainless steel raw materials for above mentioned fabrication may sometimes be in short supply indegenously or vendors may not be able to get them in time from indegenous sources to meet the tight construction schedules. This can cause considerable delay. There have been several instances when projects were delayed due to delay in delivery of indegenous equipment.

Above difficulties are overcome by importing necessary raw materials sufficiently in advance of their requirements or owners assisting contractor to expedite indegenous raw material deliveries.

(7) Inland transportation of contract equipments arriving by sea or at railway heads is an important item since many a times special arrangements like strengthening of roads/bridges/culverts have to be made for the transportation to construction site. Sometimes special trailers/bargesh have to be procured for the transportation of complex and gigantic equipments. This needs proper planning, coordination with government departments etc. and if not carefully planned can upset the construction schedule.

(8) Large size ammonia plants of 1500 TE/Day capacity are quite common in recent times. Plant capacity

is restricted by the size of the equipments. For example, a single stream 1500 TE/Day Ammonia plant may require a converter weighing about 500 TE. Handling and erection of such vessels is complicated and costly. Under such situations there is no disadvantage in duplicating such vessels and making them operate in parallel. This saves time and cost in erection and at the same time operating in parallel will have absolutely no adverse reactions.

(9) Construction time can be shortened considerably by assisting contractor with such items like temporary utility supplies, transportation, housing, local labour and guidance in local government regulations as well as customs clearances and similar sources of potential delay.

(10) The complexities of problems and the minute coordination required between the contractors and their sub-Contractors of equipments can be illustrated by the following example.

A large size single stream ammonia plant was designed to have a two barrel centrifugal compressor for synthesis gas. The driver steam turbine was located in the centre with the high and low pressure barrels of the Compressor located on either end of the turbine. When the trial run of the machine was taken, it was found that though turbine was running in proper direction, the compressors were rotating in the wrong direction. The mistake was identified in time and was corrected by interchanging compressor barrels. This obviously resulted in delay and enormous cost to rework all pipelines completed earlier.

Normally the compressor vendor is responsible for giving design of matching coupling and diection of rotation to the vendor supplying the driver equipment. A lack of coordination between the vendors resulted in the above mix up. Such a problem could have delayed a project by several months, though in the reviewed case due to fortunate circumstances delay was restricted to eight weeks.

(11) Improper testing of lines and vessels, cleaning of pipelines and testing of safety valves have been resp onsible for considerable delays in the commissioning of the plant.

These can be avoided by establishing an inspection team to follow up and co-ordinate construction activities, precommissioning tests and clearing contractors work for quality.

(12) Abnormally tall vessels with 180 to 200 feet height are sometimes used in the CO_2 regeneration process. If these are to be fabricated in the vendors' shop and transported to site in one piece, they might

involve considerable costs. Also this could result in unnecessary delay. In such cases possibilities of transporting such vessels to site in sections and assembling them at site should be explored.

(13) Spare parts for two year normal operation of the plant and the insurance spares mentioned elsewhere in this paper should be available at site when plant is commissioned. Failure to provide them could cause delay in the event of any emergency.

(14) Selection of a reputed contractor, who has (a) reliable experience in building fertiliser plants, (b) engineering, construction inspection and procurement personnel under him, (c) a large skilled labour force readily available (d) the construction aids and equipments under his custody etc. goes a long way in the successful expedition of the project. This is a most important pre-requisite for avoiding delays and misunderstandings between owner and contractor due to lack of coordination.

IX. STANDARDISATION - AMMONIA PLANTS

Feed stock availability generally dictates the process technologies to be adopted for the manufacture of synthesis gas. Steam reforming of light hydrocarbons operating at a pressure between 28 - 35 Kgs/Cm^2 is the process used for feed stocks, Naphtha and Natural gas. For heavy liquid petroleum feed stocks like fuel oil, partial-oxidation route is followed with the gasifiers operating at pressures ranging between 60 and 85 Kgs/Cm^2 using two separate patented processes. Gassification of coal, which is achieved by blowing oxygen and steam to a bed of coal is classified into two categories namely (1) process where fuel is retained in a fixed bed, and (2) process where fuel is suspended in a gas. The former gassification operates at a pressure of about 25 Km/Cm^2 while the latter operates at atmospheric pressure. It is obvious from above that there may not be any scope for standardisation of processes for manufacture of synthesis gas. However, there may be a possibility of standardisation in plant capacities.

Ammonia synthesis, has not gone through any major changes over the years. Most of the synthesis loops operate at a pressure of 300 - 350 Kg/Cm^2, whereas a small number of loops operate at low pressures ranging between 150 and 250 Kg/Cm^2. Low pressure loop has the disadvantage of plant size for higher capacities. There appears to be a sound justification for standardisation on high pressure process for synthesis loop especially in plants of higher capacities. The only other standardisation that might be applicable to Ammonia plant (including gasification and synthesis) is in the plant capacity. Three plant capacities suggested for standardisation for large size single stream ammonia plants are 600 TE/Day, 1000 TE/Day and 1500 TE/Day.

Phosphatic fertiliser plants which adopt basically similar processes may also be able to bring in capacity standardisations for large plants in one or two capacity ranges.

Equipments that can be standardised following capacity standardisation in Ammonia plant are reformer furnace, gasifiers, ammonia convertors, Centrifugal Compressors for synthesis gas, air, ammonia etc.

Process flow for the suggested methods being practically the same layout of the plant also can be standardised.

Advantages that can be expected out of standardisation are:

(a) Reduction in engineering cost

(b) Easy availability of spare parts especially for centrifugal compressors

(c) Reduction in cost of manufacture of pressure vessels.

(d) Reduction in overall cost of fertiliser plant.

(e) Shortening the period of completion of project.

X. GREATER UTILISATION-MACHINERY/EQUIPMENT-DEVELOPING COUNTRIES.

To build a large size modern Ammonia plant in a developing country, a minimum of about 25 per cent of the investment is in terms of foreign exchange. This tends to go up in the absence, within the country of fabrication capacity of pressure vessels, equipment manufacturing facilities, engineering expertise and so on. In addition to the scarcity of foreign exchange, imports of equipments and machinery takes inordinate long lead time for procurement, not to speak of the complicated formalities to be gone through. A fertiliser plant with sophisticated imported machinery has also to depend upon imported spare parts until such time that these can be substituted with indegenous ones.

Taking all these into consideration, there is unquestioned advantage in making full use of the availability of indegenous goods and services. Countries which could make available above services in surplus of their own requirements could also export them to the needy countries thereby earning considerable foreign exchange in the process.

Some of the above facilities now available in certain developing countries are listed below:

(1) There are competent design organisations which can successfully undertake the complete design and engineering of fertiliser plants. They possess engineering license from internationally known process owners. This facility is also available for export.

(2) The complete power plant machinery including high pressure boilers, power generators, fuel burning equipments etc. are available.

(3) Centrifugal compressors in modern ammonia plant driven by extremely high horse power steam turbines are very delicate but at the same time highly dependable. These are now manufactured in developing countries with technical collaboration from well known manufacturers.

(4) Modern fertiliser plants use different catalysts in large volumes. All of them which were being imported till the recent past are now available through indegenous sources. Some are being manufactured under license from reputed process owners while some others are being developed with indegenously available knowhow, the raw materials for some catalysts like nickel being, of course, imported.

(5) Large number of pressure vessels of intricate design, heat exchangers etc. made of stainless and special alloy steels are used in fertiliser plants. All such vessels excepting very few can now be manufactured in certain developing countries. It is found that on certain occasions raw materials like stainless or special alloy steel may have to be imported.

(6) Reformer tubes centrifugaly cast out of high chrome-nickel alloy are used for steam reforming of light hydrocarbons. This highly sophisticated reformer tubes are now manufactured in certain developing countries.

Fertiliser technology and associated services are so much advanced in certain developing countries that foreign exchange component in investment of a fertiliser plant, which was 70 per cent a decade back has plummeted down to less than 35 per cent. This is a major development which augurs well for fertiliser plant growth in developing countries.

XI. INFLUENCE OF TAX ON INVESTMENT COST AND SCOPE FOR ITS REDUCTION.

Customs duty on imported equipments forms a substantial portion of the investment capital of a fertiliser plant. Its value has varied from 27½ per cent to 50 per cent on the C.I.F cost, during the past decade. The quantum of imported components differs from country to country depending on the development of indegenous fertiliser technology in it.

In an ammonia/urea facility where the ratio of cost of imported machinery to indegenous ones is about 2 : 1. About 7.5 per cent of the investment cost of the project goes for customs duty when its rate applicable is about 27½ per cent on C.I.F.cost. This will go up to 15 per cent when the duty is doubled (Refer Annexure-A).

Normally a 5 per cent sales tax is levied on cost of indegenous equipments. Its influence on investment cost may go up to one per cent in proportion to the rate of tax applicable in the country.

Impact of customs duty on investment cost of a Fertiliser Plant is clear from above. Any relief given to the above aspect can help considerably in capital formation. Customs duties are generally levied by governments as a measure to encourage local industries by protecting it from imported goods and as a governmental policy. In view of the essential and capital intensive nature of a fertiliser project, there is a justifiable need to review the tax structure. This aspect should also draw the attention of international bodies that assists in economic and industrial growth of the developing countries.

XII. BARGE MOUNTED FERTILISER PLANTS.

Skid mounted chemical and fertiliser plants were in existence for over twenty years, their main attractions being shortening the construction time of the unit and their ready made state, avoiding adverse local conditions that may not favour building grass roots plants.

In developing countries, longer completion time and excessive over run of budget were often inevitable in setting up a fertiliser plant. Plants therefore, tend to become uneconomical thereby retarding the growth of fertiliser plants to a considerable extent.

In a developed country like U. S. A., more than sixty per cent of the nitrogen supplied to the soil is in the form of Anhydrous Ammonia. Considerable portion of the other fertiliser needs of phospherous and potash in required proportions came from buck blending plants. Portable fertiliser plants of above type can save cost of long haulage of fertilisers in certain locations.

Skid or barge-mounted fertiliser plants appeared and became popular in developing and developed countries in the above background. They have the following special characteristics that makes it more favourable than conventional plants wherever such conditions exist.

(i) It can serve the need of remote agricultural areas, having access to limited or small reserves of feed stock (Natural gas/Naphtha).

(ii) It can serve locations where infrastructure for erection of plants are poor.

(iii) In case feed stocks are depleted, the plants can easily move to another site where feed stock supply is available.

(iv) Because of its ready made state, it is possible to get lumpsum bid.

(v) Easier to obtain finance to set up plants and they can be installed on fixed and short completion schedules.

(vi) Long fertiliser hauls can be avoided in certain locations.

(vii) In a developing country it is specially attractive, because plants can be fabricated, assembled and tested in vendors shop, simultaneously to ground preparation in owners site. Work at site is simplified and reduced to just coupling up pieces. These enables completion of the project in time and within the budget.

Smaller fertiliser plants of upto 100 TE/Day Ammonia capacity were in existance long back. At present capacities upto 1000 TE/Day and over are being actively considered. In large barge-mounted units utilities like power and water have to be produced in the unit itself, the former by power generation and the later by desalination of water.

Large barge-mounted units necessitates fabrication of plants in large sections, which needs special hauling and lifting facilities to move them to site and lift them to positions. The same applies to large skid mounted plants erected on builtup platform. All the above units are mainly considered only for reasons explained earlier and for application mostly in developing countries.

I. FINANCIAL STRUCTURE

FOR FERTILISER PLANT-AMMONIA/UREA FACILITY
SHARE CAPITAL
(DEBT-EQUITY RATIO - 2: 1)

(a) Total investment cost of project - A Dollars

(b) Deduct: Suppliers credit from developed countries. - B Dollars

A -B Dollars

(c) Funds to be provided.

(i) Equity capital - $\frac{A}{3}$ Dollars

(ii) Loan capital - (2/3 A-B) Dollars

TOTAL A - B Dollars

II. CAPITAL STRUCTURE

FOR AN AMMONIA/UREA FACILITY

(a) Ammonia plant cost

CAPACITY-TONNES PER DAY

ANNUAL PRODUCTION-TONNES

			Cost shown as percentage of total investment.
1.	Plant and equipment F.O.B/F.O.R cost.	...	22.04 %
2.	Freight and Insurance.	...	1.43 %
3.	Customs duty (assuming 27½% on C.I.F cost.	...	4.92 %
4.	Inland handling.	...	0.179%
5.	Sales Tax (for local items only)	...	0.493%
6.	Cooling towers.	...	0.59 %
7.	License fee.	...	0.578%
8.	Engineering and procurement.	...	3.54 %
9.	Civil construction.	...	1.80 %
10.	Erection.	...	2.98 %
	TOTAL	...	39.6 %

(Values given are approximate indication only)

(b) UREA PLANT COST

CAPACITY-TONNES PER DAY

ANNUAL PRODUCTION-TONNES

			Cost shown as percentage of total investment.
1.	Plant and equipment F.O.B/F.O.R. cost.	...	10.92 %
2.	Freight and Insurance.	...	0.72 %
3.	Customs duty at 27½% on C.I.F. cost.	...	2.41 %
4.	Inland handling.	...	0.122 %
5.	Sales tax.	...	0.263 %
6.	Cooling tower.	...	0.635 %
7.	Product handling and bagging including Silo.	...	1.973 %
8.	License fee.	...	0.835 %
9.	Engineering and procurement.	...	1.50 %
10.	Civil Construction.	...	1.28 %
11.	Erection.	...	1.614 %
	TOTAL	...	22.29 %

(Values given are approximate indicators only)

(c) COST OF TOWNSHIP

		Cost shown as percentage of total investment.
1. Land and land development.	...	2.74 %
2. Cost of land inside township.	...	0.43 %
3. Cost of township with 500 dwelling houses, shoping centre and other general amenities.	...	2.19 %
TOTAL	...	5.36 %

(d) COST OF SERVICES AND FACILITIES

		Cost shown as percentage of total investment.
I. WATER		
a) Water storage and pumping.	...	-
b) Overhead Reservoir.	...	-
c) Sanitary water for township.	...	-
		1.75 %
II. POWER		
a) H. T. Switch yard and main Receiving station.	...	-
b) Steam Generation.	...	-
c) Emergency power.	...	-
d) Temp. power supply to site.	...	-
e) Earthing-Lighting Protectors and Factory Lighting.	...	-
f) Power wiring of building.	...	-
g) Air Conditioning.	...	-
h) Utilities.	...	-
		6.677 %
III. SERVICES		
a) Water treatment plant.	...	-
b) Yard piping.	...	-
c) Effluent disposal.	...	-
d) Workshop building and equipment.	...	-
e) Electrical and Instrument shop.	...	-

		Cost shown as percentage of total investment.
f) Laboratory building and equipment.	...	-
g) Fire Engine and safety equipment.	...	-
h) Communications.	...	-
i) Hospital services.	...	-
j) Tech. Office.	...	-
k) Training Centre.	...	-
l) Fencing and compound wall for factory.	...	-
m) Weigh scale.	...	-
n) Roads inside factory.	...	-
o) General and Infl. Stores.	...	-
p) Plant Main office.	...	-
q) Time office and pay roll.	...	-
r) Administrative Building.	...	-
s) City office.	...	-
t) Start up of plants.	...	-
u) Product weighment-Lorry weigh scale.	...	-
v) Safety equipments.	...	-
		5.17 %
IV. TRANSPORT		
a) Railway siding and Marshalling yard with Locomotive.	...	-
b) Construction equipment.	...	-
c) Transport vehicles.	...	-
		5.85 %

			Cost shown as percentage of total investment.
V.	OFFICE FURNITURE AND EQUIPMENT		
	a) Drawing office and Survey equipment.	...	-
	b) Office furniture.	...	-
			0.21 %
VI.	MISCELLANEOUS		
	a) Preliminary expense.	...	-
	b) Pre-operating expense.	...	-
	c) Interest during construction and credit insurance charges.	...	-
	d) Foreign training of Indian personnel.	...	-
	e) Contingencies.	...	-
			10.70 %
	GRAND TOTAL	...	28.3 %

(e) WORKING CAPITAL

FOR NORMAL OPERATION 100 %

	Cost shown as percentage of total investment.
1. Accounts receivable (1 month sale of product at selling price).	-
2. Inventories.	
(a) Raw materials	
(i) Naphtha for 15 days operation.	-
(ii) Fuel oil for 15 days operation.	-
(b) Product	-
Urea 3 months production at cost price.	-
3. Operating supplies.	
Bags - 1 month.	
Consumable stores chemicals etc.	-
Spares at 4% on plants cost.	-
4. Goods in process	
Ammonia 5 days production at cost price.	-
5. Cash in hand	-
TOTAL ...	13.06 % (approx.)
Less	
6. Accounts payable	-
7. Bank Borrowings and international resources.	-
8. Net for capital outlay	-
	4.38 (approx.)

(f) SUMMARY OF CAPITAL OUTLAY

			Total percentage of total investment.
1.	Ammonia plant	...	39.57 %
2.	Urea plant	...	22.29 %
3.	Capital outlay for services and other facilities.	...	28.37 %
4.	Land and township.	...	5.37 %
5.	Working capital.	...	4.38 %
	TOTAL	...	100 %

(g) PRORATA COSTS OF SERVICES AND OTHER FACILITIES PLANTWISE.

	Plant cost	Prorata allocation of cost of services.	Prorata allocation of land and township.	Prorata allocation of working capital.	Prorata allocation of working capital (Margin provided in capital.
1. Ammonia plant	39.57	18.15	3.43	5.219	2.80
2. Urea plant	22.29	10.21	1.93	2.93	1.57
TOTAL ...	61.86	28.36	5.36	8.149	4.37

(h) COST OF PRODUCTION PER TONNE OF AMMONIA

Annual production ... Tonnes (MM dollars.

I. INVESTMENTS

(a) Plant cost.

(b) Proportionate cost of services.

(c) Proportionate cost of township.

(d) Working capital (Margin).

(e) Working capital.

II. DIRECT OPERATION COST

	Quantity per tonne of ammonia.	Unit	Unit rate.	Cost per tonne of ammonia.	Cost as percentage of ammonia Cost per ton.
1. Raw material					
Naphtha	-	tonne	-	-	-
2. Utilities					
(a) Power	-	KWH	-	-	-
(b) Cooling water	-	M^3	-	-	-
(c) Process water	-	"	-	-	-
(d) Steam	-	tonne	-	-	-
3. Operating supplies.					
4. Labour and overheads.					
Total direct cost					36.51%
FIXED COST.					
5. Maintenance cost at 3.5% on cost of plant and services (Ia + Ib)					

6. a) Depreciation at 10% on cost of plant and services (Ia + Ib).	
b) " at 5% on township (Ic).	
7. Insurance at 0.5% on cost of plant and services (Ia + Ie).	
8. Interest at 9% on working capital (Ie).	
9. Interest at 7% on 2/3 of (Ia + Ib + Ic + Id)	
TOTAL FIXED COST	65.5 %
TOTAL COST	100 %
	(Percentages approximate and indicative only)

FINANCIAL AND ECONOMIC ANALYSIS

A. PLANT CAPACITY

1. Ammonia production	Tonnes/year
2. Nitrogen equivalent	Tonnes/year
3. Urea for sale	Tonnes/year

B. PLANT INVESTMENT

	MM (dollars)	Approximate percentage of total investment.
1. Total erected plant cost		61.87 %
2. Cost of services and other facilities.		28.37 %
3. Cost of township including land.		5.38 %
4. Initial working capital.		4.38 %
TOTAL INVESTMENT ...		100 %

C. FINANCING

1. Equity capital. – $\frac{A}{3}$ MM dollars.
2. Loan capital –($\frac{2}{3}$ A) MM dollars

D. ANNUAL EARNINGS AND EXPENSES.

	in MM dollars
1. Sales income	
2. Cost of sales (a) Variable cost.	–
(b) Fixed cost	–
3. Annual depreciation	–
4. Interest on Longterm loans and credits.	–
5. Profit/loss before taxes.	–
6. Net profit after taxes.	–

E. ECONOMIC EVALUATION

1. Investment per tonne of nitrogen B5/A2. – – Dollars.

2.	Process investment ratio B1/B5	...	- ratio
3.	Capital output ratio D1/B5	...	- ratio
4.	Profit ratio on sales D6/D1.	...	- %
5.	Percentage of net profit on equity capital D6/C1.	...	- %
6.	Percentage of gross profit before interest and taxes on total investment D4 + D5/B5.	...	- %
7.	Pay back period	...	- years
8.	Break even point : a) turn over	...	- MM dollars.
	b) capacity	...	- %
9.	Cost of sales to sales income D2/D1.	...	- Ratio.

GENERAL DESIGN CODES FOR BUILDING FERTILISER PLANTS

The following codes applies generally to fertiliser plants and ammonia/urea facility in particular.

(1) The design, manufacture, testing and construction of the factory shall be in accordance with generally accepted standards for the safety of ammonia/urea plants built in the United States of America. Comparable other standards may be substituted provided recognition is given to differences in rating, allowable stress, and dimensions of ammonia plants. Besides, it should also comply with all laws and regulations applicable to the industry in the country where the factory is being built.

(2) Mechanical

Centrifugal pumps	..	API - 610
Mechanical drive steam turbines.	..	API - 615
Centrifugal compressors	..	API - 617
Reciprocating compressors	..	API - 618

(3) Pressure vessels

ASME Code section VIII for design and section II and IX for materials and welding.

(4) Exchangers

ASME Code Sections I or VIII as applicable and the standards of Tubular Exchanger Manufacturers Association TEMA).

(5) Boilers

American Society for Mechanical Engineers (ASME) Boiler and Pressure vessel code Section 1 for design, Section II for materials and Section IX for welding.

(6) Burner tubes

American Petroleum Institute (API) "Recommended practice for calculation of heater Tube thickness in petroleum refineries", API RP 530 for establishing allowable stresses for pressure parts outside the furnace and for all the tube fabrication.

USA Standards (USAS) are issued by American Standards Institution, series A refers to Civil Engineering and Series B to Mechanical Engineering.

(7) Piping

USAS B 31-3 and the standards listed therein for bolting, fittings, values, flanges, gaskets, piping, tubes and threads. These standards cover dimensions for interchangeability pressure- temperature ratings and manufacturing and testing requirements.

(8) Ammonia storage tanks

API Standard 650 with appendix-R_2 for refrigerated products when pressure is below 1 Kg/Cm^2 and ASME Code, Section VIII for over 1 Kg/Cm^2 Pressure.

(9) Safety

USAS-A12 for wall openings. USAS A14-3 for fixed ladders. API-RP 500 for limits of hazardous areas. API-RP-520 as design and lay out guide for pressure relieving systems. API RP 2000 for tank venting guide.

(10) Electrical

National Electrical Code (NEC as modified for local conditions. Electrical equipments located in hazardous area are of proper type of construction for the area classification. Hazardous area classification is given in NEC.

(11) Concrete design

American Concrete Institute (ACI) Publication ACI 318 "Building code requir ments for reinforced concrete" with details conforming to ACI-315 "Manual of Standard Practice for detailing reinforced concrete structures".

(12) Structural Steel-Furnace Steel and Stacks.

American Institute of Steel Construction (AISC) "Specification for the design, fabrication and erection of structural steel for buildings". Welded stack details are in accordance with the American Welding Society (AWS). Standard Specifications for Welded Highway and Railway Bridges D_2.O.

(13) Buildings

In accordance with local codes.

(14) Wind and earthquake

USAS. A58.1 for Wind Load Uniform building code for earthquakes.

(15) Plumbing

USAS A40.8 Plumbing Code.

(16) Heating, Ventilating and Airconditioning.

Generally in accordance with the guide of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

(17) Effluent disposal

The liquid effluents should conform to the standard specification applicable to the country in which plant is built. Gaseous effluents will conform to air pollution legislation and Standards applicable for similar industries in the country in which the plant is built.

BREAK DOWN OF INVESTMENT COSTS FOR AN AMMONIA/UREA FACILITY

1000 TE/Day - Ammonia - 1650 TE/Day Urea
Feed stock - Naphtha

Location of plant - India, Bangladesh, Srilanka.

Contract - 'Turn-Key'

	I. EQUIPMENT PROCUREMENT		Cost given as percentage of total investment cost.
(a)	C.I.F Cost of imported contract equipments at Indian Port (Approximate freight and Insurance cost)	-	21.3 %
(b)	Customs duty at 27½ per cent of C.I.F cost of imported equipments.	-	5.8 %
(c)	C.I.F cost of indigenous contract equipments.	-	10.9 %
(d)	Sales tax at 3 per cent of I(c)	-	0.33%
(e)	C.I.F. Cost of imported spares including one charge of catalysts.	-	2.01 %
(f)	Customs duty at 50% of I(e)	-	1.005 %
(g)	C.I.F. Cost of indegenous spares	-	0.5 %
(h)	Sales tax at 3 per cent of I (h)	-	0.014 %
(i)	Transportation from Rail head or Port to job site of all contract equipments and spare parts.	-	1.34 %
(j)	Paid up License and know-how fees	-	2.258 %
	TOTAL	-	45.45 %

(Total cost of customs duty and sales tax alone at above rate comes to 7.14 per cent of investment cost).

II. ENGINEERING INCLUDING:

(a) Process flow diagrams -

(b) Process P & I Flow diagrams -

(c) Utility P & I Flow diagrams -

(d) Plot plan and layout drawings - with foundations.

(e) General materials and utilities - balance diagram.

(f) Engineering specification for tanks, vessels, heat exchangers, compressors, pumps, fans, furnaces, piping, Instrumentation, electricals buildings, structure, civil, Instrumentation and painting.

(g) Individual Data sheets for major equipments.

(h) Instrument Schedule.

(i) Engineering, drawings for major Vessels and towers.

(j) Route drawing for instrument wiring and piping.

(k) Instrument panel layout.

(l) Electrical single line diagram.

(m) List and specification of Motors and electrical equipment.

(n) Layout drawing and yard lighting.

(o) Route drawing of electrical wiring.

(p) Piping arrangement drawing.

(q) Piping line schedule.

(r) Piping specification.

(s) Outline drawing of main structure and main pipe rack.

(t) Planning drawing of jetty road-fence etc.

(u) Vendors assembly drawing of major equipment.

(v) Vendors catalogue and other pertinent documents for major equipments.

(w) Inspection and testing record.

(x) Instruction for operation and maintenance of all plants.

(y) Mechanical specification manual.

(z) Instruction for necessary supplies including, catalysts, operating chemicals, lubricant, supplies etc.

TOTAL ... 7.0 %

III. CIVIL CONSTRUCTION AND MECHANICAL ERECTION

Direct Construction costs

(1)	Civil works	...	- 8.41%
(2)	Erection works	...	- 3.70 %
(3)	Piping works	...	- 1.34 %

INDIRECT CONSTRUCTION COSTS

(1)	Temporary construction	...	- 0.33 %
(2)	Contractors Construction aids	...	- 0.83 %
(3)	General site office cost.	...	- 0.433 %
(4)	Insurance cover for construction and erection-duration till factory take over.		- 0.40 %

SUPERVISION COST

Local as well as foreign ... - 2.38 %

TOTAL ... - 17.82 %

IV. CONTRACTORS COST FOR CONTRACT

Equipment inspection, Home office establishment etc. - 3.96 %

V. WORKING CAPITAL - 4.5 %

VI. Procurement and development of land. - 5.37 %

Procurement of licenses, arrangement for water, electricity etc. - 1.00

VII. MISCELLANEOUS INCLUDING:

(1)	Training of owners staff	-
(2)	Preliminary expenses like Project report, feasibility study, financial analysis.	-
(3)	Preparation of bid specifications, and contract finalisation.	-
(4)	Cost of financing	-
(5)	Pre-operating expenses.	-
(6)	Contingencies.	-
	TOTAL	13.9

NOTE:

1. Cost upto item IV excluding customs duty and sales tax are included in contract price.
2. All other expenses are to the owners account.
3. In the turn key contract, prices are inclusive of the following:

   a) Product storage - Bulk storage - 45.000 TE
   Bagged storage - 6.000 TE
   Bagging capacity- For bagging entire product.
   Empty bag storage- For one month.

   b) Intermediate storage-Liquid ammonia storage tank system.
   6000 TE capacity at 4.5 Kg/Cm^2

   c) Raw material storage-Raw Naphtha tank-10.000 TE x 2 Nos.
   Sweet Naphtha tank-5000 TE x 1 No.
   Heavy oil storage tank-10000 TE x 1 No.

   d) Loading facility -

   e) Dehumidified air facility-

   f) Power water cooling tower.

(g) <u>Auxiliary facility including</u>:

1) Administration office.
2) Factory office
3) General laboratory
4) Canteen and change room
5) Maintenance shop
6) Gate House
7) Store House
8) Garmage and fire house.
9) Hospital

(h) Maintenance shop equipment:

(i) General Lab equipment.

(j) Effluent water treatment facility

(k) Road, sewage and fencing

(l) Inter communication

(m) Drinking water, safety equipment, sanitary.

(n) Fire fighting facility.

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