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SOME SUGGESTIONS FOR REDUCING INVESTMENT COSTS AND MOBILIZING SOURCES OF FINANCING FOR FERTILIZER PLANTS - EXPERIENCE OF ROMANIA IN THIS FIELD*

by

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* The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been translated from an unedited original.

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During the last three decades, Romania has developed a strong fertilizer industry, both to satisfy the requirements of its agricultural sector and to create an export capacity.

While it has followed international technological progress and purchased a number of plants and technologies, Romania has also developed its own technical base in terms of research, engineering consultancy and the construction of fertilizer units and has registered a series of original licences; as a result, the country has in its turn succeeded in becoming an exporter of such units.

The activity developed in this field has led to the accumulation of a wealth of experience concerning the construction of fertilizer plants where one of the basic and permanent objectives has been the steady reduction of investment outlay.

The economic efficiency of a production operation must be evaluated by an overall economic analysis, encompassing investment and operating costs, which should ultimately ensure as high as possible a rate of return on capital (constant and variable).

A further question which must be borne in mind in establishing a fertilizer industry is whether the raw materials are available in the country or whether materials can be imported on convenient terms, without forgetting that some intermediate products, such as sulphuric acid, are of great importance to the economy of any country, or indeed that fertilizer production itself is of vital importance.

These factors mean that individual countries have to adopt their own approaches to the development of the fertilizer industry and the adoption of technical solutions.

The adoption of technical solutions involving minimum investment outlay is particularly important at the present time, since the price of fertilizer units has increased considerably during recent years. Thus in Europe, between 1970 and 1976, the price index increased by 69 per cent for ammonia plants and by 78 per cent for sulphuric acid plants; for urea plants, fixed capital increased by 20 per cent within 12 months (1974-1975) (1) (2).

1. Choice of technology

The choice of technology is determined first and foremost by the nature and quality of the raw materials available - a factor which sometimes strongly influences investment costs. Let us take as an example of this sulphuric acid, which can be produced from native sulphur, pyrites, gas from the production of non-ferrous metals, gypsum or phosphogypsum; the investment costs vary considerably depending on which of these is used.

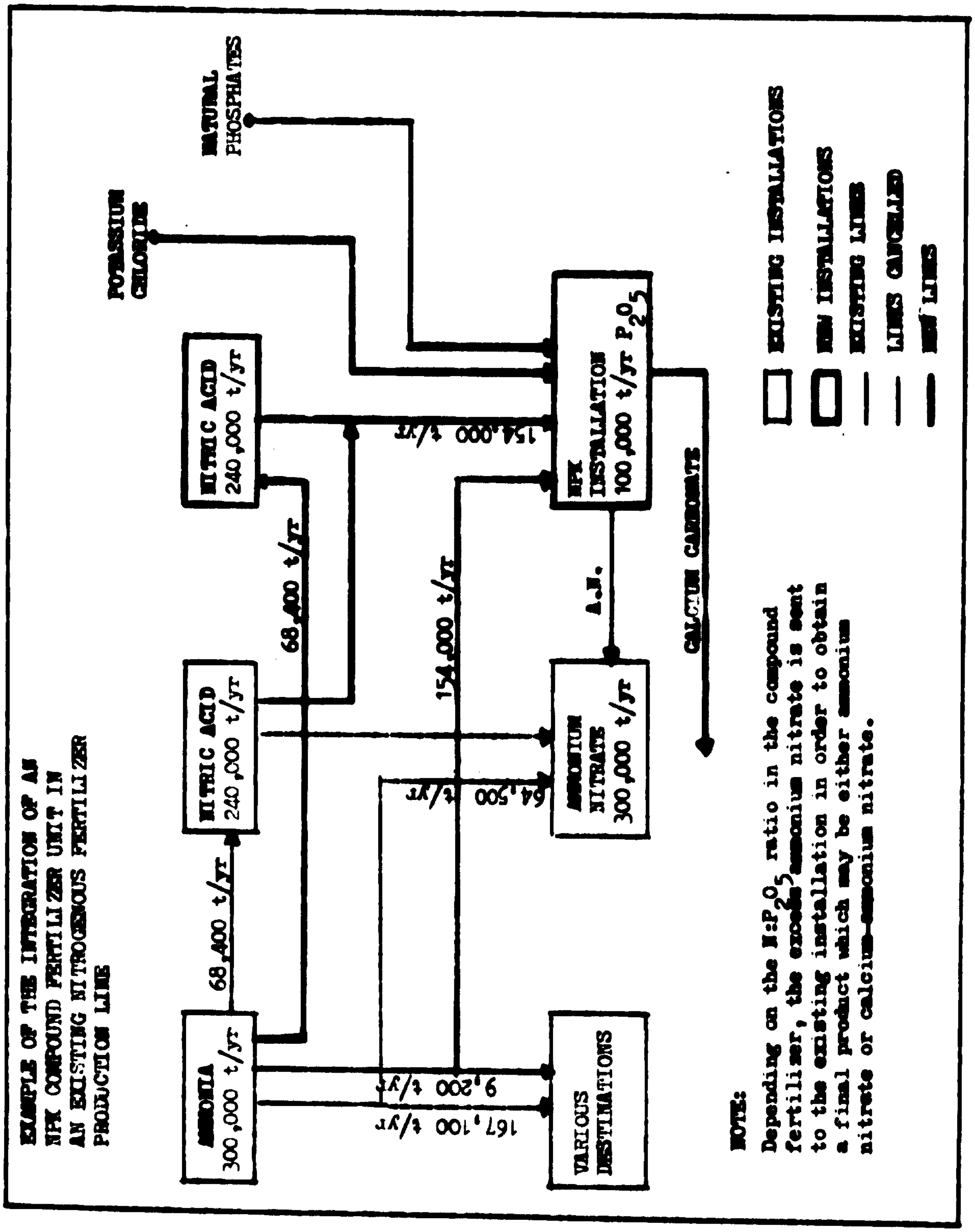
In Romania, sulphuric acid used to be produced mainly from pyrites and gases from non-ferrous metal production, which were at the time the only sources available, although the investment required is higher than if native sulphur is used. Thanks to the recent discovery of sources of native sulphur, it has been possible to construct plants for the production of sulphuric acid from this source.

The same is true for the production of ammonia, the raw materials for which may be natural gas, petroleum derivatives and, quite recently, coal; these different sources result in substantial variations in capital investment, the smallest outlay being required by the use of methane.

With regard to the production of complex fertilizers, the development of the production of nitrophosphate-based complex fertilizers could be considered, provided that outlets are also available for the sale of calcium and ammonium nitrate. In this regard, Romania has carried out a large-scale experiment by building four nitrophosphate plants with a total capacity of approximately 3.5 million tonnes per year.

Taking into account current prices of equipment and materials for complex fertilizer plants, an equivalence has been reached between the capital required for a particular fertilizer production process using the phosphoric acid and the nitric acid method.

If a large ammonium nitrate plant is already available, a complex nitrophosphate fertilizer plant can be constructed with lower investment, by integrating this plant in the production process - between the nitric acid and the ammonium nitrate plant - as has been done in Romania in the case of three nitrogenous fertilizer plants (see diagram).


EXAMPLE OF THE INTEGRATION OF AN NPK COMPOUND FERTILIZER UNIT IN AN EXISTING NITROGENOUS FERTILIZER PRODUCTION LINE
AMMONIA 300,000 t/yr
68,400 t/yr
NITRIC ACID 240,000 t/yr
68,400 t/yr
NITRIC ACID 240,000 t/yr
154,000 t/yr
154,000 t/yr
NPK INSTALLATION 100,000 t/yr P_2O_5
POTASSIUM CHLORIDE
NATURAL PHOSPHATES
A.N.
AMMONIUM NITRATE 300,000 t/yr
64,500 t/yr
9,200 t/yr
167,100 t/yr
VARIOUS DESTINATIONS
CALCIUM CARBONATE
EXISTING INSTALLATIONS
NEW INSTALLATIONS
EXISTING LINES
LINES CANCELLED
NEW LINES
NOTE:
Depending on the $N:P_2O_5$ ratio in the compound fertilizer, the excess ammonium nitrate is sent to the existing installation in order to obtain a final product which may be either ammonium nitrate or calcium-ammonium nitrate.

Apart from the advantage of smaller outlays, in specific cases where an ammonium nitrate plant already exists the construction of a nitrophosphate plant has the following advantages: it requires no consumption of sulphur and sulphur-based raw materials; the yield of phosphorus contained in the phosphates is 3 per cent higher than with the method using phosphoric acid as an intermediate, while the formation of massive phosphogypsum dumps is eliminated. The calcium carbonate produced as a waste product is successfully used in agriculture as an ameliorator.

It is obvious that capital outlays vary also according to the various technologies developed at the world level (comparing those which use the same raw materials), depending on their technical level, the production engineering used, the degree of mechanization and automation, the performance of the basic equipment provided for in the plants, etc. Thus, all these factors must be taken into account in an analysis before a decision is taken as to the technology to be acquired.

2. Location

Bearing in mind that location can considerably affect investment costs, close attention should be given to this factor. The optimum location will have to be selected following a comparative study which takes into account both investment costs and the resultant operating costs, such as the cost of transporting raw materials and finished products, utility costs, etc.

The size of the investment is influenced by the nature of the site, the costs of civil engineering (mainly required for foundations) and of developing the site, and costs for providing utilities.

In addition, account must be taken of the need for an infrastructure sufficiently developed to enable a fertilizer plant to operate or, if this does not exist, the need to finance it from other sources, since a fertilizer plant cannot support on its own the expenditure involved in a costly infrastructure.

3. Capacity of the units

It is well known that, on the basis of progress in technology and production engineering techniques, a break-even point can be reached for each unit from the capacity point of view and that, generally speaking, the specific investment decreases with the increase in the capacity of a production line according to a certain exponential curve.

There are, of course, constraints of a constructional nature, or related to operating problems or losses resulting from possible technical defects (in other words, the useful life of the units), which limit the tendency of the capacities of a production line to increase.

Some specific figures can be given as examples in this connexion (3):

Installation	Capacity of one production line t/year	Tonnage of equipment Total	Tonnage of equipment t/year / t equipment	Labour productivity t/year / employee
1	2	3	4	5
Ammonia, using methane	300	2,000	50	800
	900	3,500	86	3,500
Urea - conventional process	930	670	209	4,000
- stripping process	1,300	1,300	323	6,000

In order to benefit from the advantage of a suitable specific investment in a country where domestic fertilizer consumption is for the moment still limited, consideration could be given to increased production with the expectation of exporting the surplus in the first instance; reasonable production capacities above the acceptable break-even point could then be chosen.

4. Standardization of installations

The standardization of fertilizer units is one of the best ways of reducing capital investment.

Under a global plan for the development of the fertilizer industry, spread out over 15-20 years in each country, certain units should be designed which would subsequently be repeated several times. In smaller countries where the programme for the development of the fertilizer industry allows for the construction of only one or two similar units, agreement could be reached with neighbouring countries to construct units of the same type.

The standardization of units offers many advantages, among which the following should be noted:

The cost of the licence decreases progressively with each new unit constructed and in general is cancelled out after the third or fourth;

Consultant engineering costs are paid only once;

It is possible gradually to increase national participation in the construction of the units, thereby reducing the drain on foreign currency;

The money allocated for the acquisition of spare parts, which blocks substantial funds, particularly foreign currency, is considerably reduced;

The experience acquired during the construction and operation of the first units will make it possible to reduce foreign technical assistance as well as the time required to build similar units at a later date.

Production and maintenance staff for later units can be trained efficiently and at minimum cost in the first unit started up, thus eliminating the cost and problems of training such staff abroad.

In Romania, an ambitious programme has been adopted for the standardization of fertilizer units, the major ones being listed in the following table:

Installation	Specific raw material	Capacity t/day	Licence	Specifications
1	2	3	4	5
Ammonia	Methane gas	900	Kellogg	
Nitric acid		840	Iprochim	Combustion 4 atm (abs.), NO-NO_2 oxidation 11 atm (abs.), absorption 11 atm (abs.)
Urea		900	Stamicarbon	
Sulphuric acid	Pyrites	300 600	Lurgi	
	Sulphur	300 600	Iprochim	Double absorption
Phosphoric acid	Phosphates	180 P_2O_5	Iprochim	Dihydrate
	Sulphuric acid	360 P_2O_5	Iprochim	Dihydrate
Complex nitro-phosphate fertilizers	Phosphates HNO_3	2,300	Norsk-Hydro	Conversion of $Ca(NO_3)$ to NH_4NO_3
TSP		600 1,200	Iprochim	

Standardization involves equipping installations so far as possible with the same type of equipment, without this, however, impeding technical progress. When there has been an important advance in the world in the manufacturing technology of a product, the efficacy of introducing new elements should be weighed against the advantage of repeating installations already constructed.

It should, however, be borne in mind that technological progress in the fertilizer industry has occurred at fairly infrequent intervals, thus ensuring a certain stability, from the point of view of structural changes, although it has led to the introduction of new techniques and processes of the following types:

- Application of roasting techniques in fluidized beds for the calcination of pyrites in sulphuric acid plants;
- Introduction of double catalysis for the conversion of S_2 to S_3;
- Ammonia combustion and nitric oxide absorption under pressure for the manufacture of HNO_3;
- Introduction of centrifugal compressors in ammonia-urea synthesis;
- Utilization of the stripping process for the production of urea.

5. **Participation by nationals in the construction of fertilizer manufacturing installations**

This is one of the more effective ways to reduce the costs of fertilizer manufacturing installations, particularly the foreign exchange required.

Romania's experience in this field shows that national engineering consultancy bureaux of enterprises must first be set up which will specialize in the preparation of studies for fertilizer manufacturing installations, drawing initially on assistance from countries that have made progress in the field, or specialized international organizations such as UNIDO.

For the smaller countries, these types of consultancy bureaux could be set up in association with neighbouring countries or within economic associations or organizations. While this approach is certainly easier to follow in the more advanced developing countries, with the help of other countries it can and should also be adopted in any country that has a broad forward-looking programme for the creation of a national fertilizer industry.

Once a national consultancy organization has been set up, it can start with civil engineering studies and then take part in the preparation of studies for the process installations, with the eventual aim of doing all the engineering so that imports will be limited to the licence only and possibly the basic engineering.

In Romania, for example, complex nitrophosphate fertilizer installations have been built with only part of the basic engineering being purchased. We are now building the first urea installation, which will use the stripping process and have a capacity of 1,300 tonnes/day, under the same conditions. In that way it has been possible to save large amounts of foreign exchange, since the price of engineering studies has increased greatly in recent years. The participation of a consultancy bureau of the buyer's country in the design work for fertilizer plants provides, besides the reduction in the cost of the installations, many advantages such as:

- Acquisition of equipment directly from the manufacturers without the intermediary of the foreign engineering firm, at prices reduced by 15-20 per cent, with the ability to choose equipment not only for price but also above all for quality.
- The use in engineering studies made by bureaux of the buyer's country of techniques suited to specific local conditions or to material available on the local market. It is also possible to work more effectively with local building and equipment assembly enterprises and to make greater use of the national potential of the country in the construction of equipment.
- By carrying out engineering studies, the national bureau can subsequently provide some of the technical assistance, replacing the foreign supplier in the commissioning of the installations. This produces large foreign exchange savings, given the exorbitant prices asked at present for this type of service.

For example, Romania drew on foreign technical assistance only for its first Kellogg ammonia installation; subsequent installations were built and commissioned exclusively by Romanian technicians.

The same happened with the complex nitrophosphate fertilizer installations, which were built and commissioned by Romanian technical personnel, with only a small quantity of foreign technical assistance, and that for the first installation only. The foreign company provided a limited quantity of the basic engineering. The foreign personnel did not participate at all in the other three similar complex fertilizer installations, and this led to considerable foreign exchange savings and a reduction in investment costs.

Another advantage of nationals participating in the preparation of studies for fertilizer factories is the training of national specialized technicians, which facilitates the transfer of technology and know-how to the developing country - a basic requirement today.

This procedure naturally implies greater responsibility for the buyer, and risks that he must share with the seller.

In Romania's experience over the past 15 years since the firm adoption of such a direction for the development of the fertilizer industry, the conclusion to be drawn is that the procedure usually works out to the benefit of the buyer.

The construction of fertilizer installations under these conditions has led to a considerable reduction in foreign exchange expenditure and has given results that are entirely satisfactory, and in some cases even superior, in respect of performance and operational safety, compared with the situation where the engineering was provided entirely by the seller.

In comparison with an installation with a capacity of 900 tonnes/day of ammonia which was almost entirely imported, for example, the foreign exchange expenditure was reduced by 30 per cent (in current prices) for an installation built in Romania under the conditions outlined above (4).

6. Participation in technical progress

The participation by a country itself in the establishment of its fertilizer industry, as was mentioned in section 5, also offers the great advantage that the transfer of technology from the developed to the developing countries takes place more rapidly and more thoroughly, while the buyer is able to contribute to the development of his industry and to technological progress in general. The following example is taken from Romanian experience:

The process and equipment used for the technology of manufacturing nitric acid, which was acquired a few years ago from a foreign firm, was improved in Romania. The result was a reduction in the cost of the installation and an improvement in the technical performance indicators, as can be seen from the following table:

Indicator	Unit	Initial installation	Improved installation
Capacity	tonnes/day	750	820
Weight of equipment	tonnes	1,045	835
Including: stainless steel	tonnes	817	600
Acid concentration	%	58	60
NO_x content of final gas	ppm	300	200
Power consumption	kWh/tonne	10	5

Because of the large quantity of stainless steel used in nitric acid installations, which are usually imported by all the developing countries, the reduction in the weight of the equipment implies a reduction in the cost of the installations and in the foreign exchange required.

7. Rational choices regarding the degree of automation of installations

The degree of automation of installations must be treated differently from one installation to another, depending on the technology. It is to be decided mainly in the light of considerations concerning the safety of the installations - particularly in the case of ammonia, nitric acid and urea installations - and the means required for proper control of the process.

The reduction in operating personnel made possible by a higher degree of automation of installations as a result of the introduction of sophisticated techniques inevitably leads to an increase in the cost of the installation. When a reduction in personnel is being considered, allowance must be made for local conditions and certain social factors, etc.

It must also be borne in mind that a higher degree of automation of installations than is strictly required by the process presupposes the existence of staff qualified to operate and maintain the installations, and also personnel highly specialized in the operation and maintenance of the automatic systems. Otherwise, the additional expenditure for the systems will have been useless, and the automated operations will soon be abandoned by the operators.

8. The choice of the best way to ensure a satisfactory degree of environmental protection

The possibility of environmental deterioration caused by fertilizer plants is a serious, and in some areas of the world even alarming, problem. In recent years, the problem has been the subject of numerous studies and much research, and has resulted in a series of restrictive measures stipulated by national legislation (8).

The size of the problem has been stressed by UNIDO, which organized an Expert Group Meeting on Minimizing Pollution from Fertilizer Plants at Helsinki in 1974.

Measures to protect the environment from pollution by fertilizer plants often involve high investment costs and must be chosen carefully (7).

To reduce SO_2 emissions into the atmosphere from sulphuric acid plants, for example, double catalysis may be used, which requires an additional investment of some 10-12 per cent. For fertilizer plants, where the ammonium sulphate or phosphate can be put to profitable use, ammonia absorption of the tail gas containing SO_2, followed by acid decomposition of the ammonium sulphite-bisulphite solution, is a competitive technique (5) (6), and, under certain conditions, the investment costs are lower than those incurred in using double catalysis.

Another example is the recirculation of the contaminated cooling water of a nitrophosphate-based complex fertilizer plant where the discharge of harmful substances in the effluent, or the danger of infecting the soil or ground water, must be avoided. Comparison of two methods used in Romania - the use of a 30 ha cooling pond, and the use of cooling towers with a smaller pond for the fluorine salts - shows that the first method costs 50 per cent more than the second (3) (9).

Another factor that may influence greatly the reduction of environmental protection costs is the setting of reasonable limits on the content of harmful substances in gases released into the atmosphere and effluents (7) (8): a very high but unnecessary degree of purification can be extremely expensive.

The storage of enormous quantities of phosphogypsum is another problem of concern to the manufacturers of phosphoric acid (wet process). According to numerous studies made in Romania, at the present level of technological development the question whether full use can be made of this waste product under satisfactory economic conditions has not been answered. Neutralized phosphogypsum may be used in limited quantities for the improvement of arid land. Deposits of phosphogypsum can be used as an underlay for a layer of soil 0.5-0.6 m thick and subsequently used for agriculture, this being the cheapest way at present of disposing of this particular waste.

9. <u>Sources of finance for the construction of fertilizer plants</u>

One way of providing sources of finance is the attraction of foreign capital, in the form of joint companies with less than 50 per cent foreign capital so that decisions are governed by the local partner.

In Romania, the possibilities and conditions for the creation and operation of joint companies are the subject of legislation.

For this type of economic activity to be possible, conditions that favour and are suitable for the operation of joint companies must be created. In such companies, the developing country may receive the nominal capital from the foreign partner in the form of a transfer of technology and engineering services for the construction of the fertiliser plant.

In Romania, a decree of 1972 governs the conditions for the formation, organisation and operation of joint companies, and the legal status of and facilities available to such companies (10).

Another possible source of finance for the construction of fertilizer plants is the procurement of credits from firms or countries that have technologies and are able to build such plants under conditions where the credits are paid off in raw materials, intermediate products (NH_3, H_3PO_4, MAP) or in end products manufactured in the plant for which the credit was granted. This is one way of increasing the seller's responsibility to the buyer by interesting the seller in the satisfactory performance of the installation built, so that the credit granted will be repaid more rapidly.

The requirement in this regard which became evident at the meeting of the Working Group on Contracts and Insurance for Fertilizer Plants (Vienna, 14-17 February 1978) could be met in this way.

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