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INSTALLATION OF A PETROCHEMICAL INDUSTRY IN A DEVELOPING COUNTRY

by

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Scope

Determination of the correct unit size is one of the key elements in the study of the installation of a petrochemical industry. This capacity must not be inferior to a certain value called "the minimum economic size", under which the production cost of the product becomes prohibitive.

The market of developing countries is often such that the required capacity is situated below this minimum size. The solution, which consists in increasing this capacity whilst exporting a portion of the overall production, faces several objections. A solution based on an exchange system has been envisaged in order to avoid some of these obstacles. The conditions necessary for these exchanges to take place have been specified and a typical example is given as a demonstration.

In order to assist in the selection of worth-while projects, certain criteria have been suggested which will permit the evaluation of a project's feasibility.

I. Introduction

Petrochemicals are the object of world-wide interest, which originates primarily in the tremendous possibilities of oil as a raw material. The ease with which oil may be transported by pipeline or tankers and above all its low cost are contributory factors to the rapid growths of the petrochemical industry.

Petroleum-derived chemicals (or "petrochemical products") were developed for one two essential reasons:

1. They can be produced cheaper than by other routes.
2. They satisfy raw material needs which cannot wholly be met by existing suppliers: the coal tar, wood distillation and fermentation industries.

Very often, petrochemicals fulfilled both these conditions.

Thus oil or natural gas will in many instances be the preferred raw material when the need arises to create or develop a chemical industry in a country wishing to expand its industrial potential, augment its wealth, increase its standard of living and save foreign currencies by reducing imports. However, the problems inherent in the production of petrochemicals are not simple ones. The raw materials used are not as a rule pure compounds and the chemical reactions are rarely selective.

Very seldom will the production of a petrochemical compound result in a single, desired end product. Almost invariably, there will be a simultaneous production of one or more by-products. For the production cost of the main product to be reasonable, it will be necessary to credit the by-products, and this entails having sufficient quantities of the latter.

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For instance, the cost of ethylene, everything else being equal, may vary between 5 and 10 cents per pound depending on whether or not the by-products are valorized.

Furthermore, the complexity of petrochemical installations often results in relatively high capital investments which are not in direct proportion with the capacity of the unit (an average power factor of 0.5-0.7 is commonly used) and which penalise heavily the smaller units. Thus, if a 10 000 tons/annum ammonia unit costs about \$ 2 280 000, a 50 000 t/a unit will cost only \$ 6 700 000 - i.e. roughly 3 times more for a five-fold increase in size, thus notably decreasing that part of the production cost which is tied with the capital cost.

This leads us to two important aspects of the petrochemical industry:

- the integrated complex.
- the minimum economic size.

IFP underlined the salient points of these aspects in a previous paper^{1/} and discussed the technical and economic factors entering into the production cost of a petrochemical product.

Whether a project is feasible or not depends to a great extent on economic aspects entering into the selling price. Certain elements constituting the production cost are, nevertheless, independent: raw material cost, operating costs (utilities, labour, maintenance, etc. ...). The difference arises from interest rates, amortization policy, desired profit, etc. ...

Developing countries often suffer from narrow markets, resulting in small-sized projected installations. The latter's profitability may, in certain cases be justified through an economic system benefiting in some degree from State intervention (low interest rates, long amortization period, absence of profit taxes, etc. ...). Nevertheless, in spite of such a favourable set of conditions, production costs are often marginally competitive if not too high. Possible solutions to this problem are envisaged hereunder.

II. Basis of the problem

One of the most important factors in a project feasibility survey is determination of the optimum size of the unit(s). The local market's needs are often limited at least in the first stages of a developing country's expansion. Consequently, the projected capacity is likely to be below the minimum economic size.

^{1/} United Nations. Inter-Regional Seminar on Techniques of Petroleum Development, New York 23rd January - 21st February, 1962. Paper No. 23 - "The Petrochemical Industry" by Pierre Leprince.

It is frequently suggested, in such a case, to increase the capacity over and above this minimum whilst exporting a more or less important part of the production. Should this increase be justified, it would indeed permit production at a rate resulting in lower unit costs. Examination of this suggestion in greater detail, however, leads to several objections. It would be truistic to state that for one country to export, another or others must import. There can be no question today, except perhaps in particular cases, of exporting petrochemicals to the highly industrialised countries of America and Europe. The other countries in the process of industrialization generally consider themselves as special cases and avoid importations for a variety of reasons. Some of these are economic, since they believe that their own production will be cheaper. Others are political, since they wish to be independent relative to such basic products as synthetic rubber and are sometimes obliged to protect certain local raw materials such as alcohol (from the fermentation industry) or coal.

Furthermore, regional groups within a State, who are conscious of the benefit to be derived from a petrochemical industry, exert great energy to ensure that their particular region will be endowed with at least one petrochemical installation.

Lastly, but by no means least, one faces in the export markets the competition of the well-established selling organizations of the giant American and European chemical companies, who dispose of large technical services applicable to market research and customer assistance, and may even at times resort to unforeseen price cuts.

Economic unions, common markets and other remedies have been suggested to counter these difficulties. The scope of this paper does not permit examination of these questions but it is proposed to discuss a less ambitious solution based on an exchange system.

III. I.F.P.'s position

The French Institute of Petroleum owes its birth to the problems facing French industry at the end of World War II. It was created with the purpose of furnishing personnel and technical know-how and in general of helping industry in technical matters. It contributed to resolve for and with the French industry, analogous problems to those met today in the industrial development of several countries. IFP is actually engaged in simultaneous, though distinct, studies on the development of the refining and petrochemical industries in several countries in Asia: Ceylon, India, Iran, Pakistan and Turkey.

One meets the same fundamental problems in all these surveys, in spite of the variety in local conditions. Each State believes to some extent that its neighbours will form an outlet for national products and that its industry will be capable of producing at the international price level, or even below it, thanks to its privileged position (availability, for instance, of raw materials such as oil or gas).

This is rarely the case, however, and but few productions can meet world prices. There is no doubt that raw material availability helps but this item often plays a smaller role in the establishment of the production cost than those linked with capital investment. The minimum economic size criterion is thus only slightly modified. This is illustrated below giving production costs of ammonia (from naphtha) as a function of capacity and raw material cost.

Ammonia product cost - \$/metric ton

Capacity (tons/annum)	50 000	25 000	10 000
Naphtha at \$ 14/ton	66.8	78.2	106.6
\$ 7/ton	61.5	73.0	101.3
\$ 0/ton	56.2	66.7	95.5

Whereas the necessity to export remains vital, the outlets appear hypothetical.

Backed by our experience in these regional studies, we will attempt to define the conditions necessary for export and to underline the importance for various countries of complementing their oil and petrochemical resources.

IV. General conditions required by developing countries to export

Planning. Each country should formulate its own development plan to ascertain what it can produce independently, how much it will cost and how far it can reasonably proceed along certain selected lines. This is an essential prerequisite to enable each and every one to determine:

- The volume of and advantages to be gained in imports and exchanges.
- The selling price for products likely to be exported.

Mutual advantages. Bilateral exports or exchanges must be beneficial to both parties and their interruption as harmful to one as to the other of the partners.

Exchanges. These should proceed along the lines of barter between equals - for instance: natural gas, crude oil L.P.G., or fertilizers against plastics, synthetic rubber or fibres.

Prices. These should be based on effective world prices, augmented by transportation costs.

V. Typical application

Consider, for the purpose of our discussion, the hypothetical case of two countries labelled X and Y. Whereas this example is of necessity theoretical, several actual cases could be cited.

/1. X's position

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X has available large quantities of natural gas and crude oil. Its market, at least in the first stage of development, is limited.

Demand does not exceed about 7 500 t/a polyethylene and 6 000 t/a synthetic rubber.

Effective world prices are around 20¢/lb for polyethylene and 12¢/lb for butadiene.

In the context of X's development plan, studies have shown that polyethylene could not be produced at under 30¢/lb and butadiene under 18¢/lb.

These costs could be reduced to 25¢/lb and 15¢/lb respectively by assuming an economic structure, which in the limit would allow a 10-years payout period with 10 years amortization for process units and 20 years for offsites, together with a long term low interest loan.

In spite of very attractive economic conditions, such anticipated costs present little interest. Besides, long term, low interest loans are not easily obtained and it may well be thought preferable to use them in electricity or steel production rather than invest them in an unprofitable petrochemical complex.

X's plan also indicates that fertilizer production based on 7 500 t/a of ammonia will result in an ammonium nitrate price of \$72/ton. In spite of the fact that the potential market could absorb the whole production, 4 years will elapse before this is achieved, assuming rational utilisation of fertilizers and strict adherence to distribution and development programmes.

Simultaneously, natural gas consumption is lagging and large quantities of it are wasted whilst X is facing difficulties in disposing of its crude oil on the international market without granting important discounts. X's governmental petroleum company cannot absorb the share in crude oil to which it is entitled.

2. Y's position

On the other hand, Y has a relatively large market but lacks crude oil for its refineries. Y is short of foreign currencies. It is unlikely that large units forecast in its plan could operate at full capacity for several years to come.

Y's studies indicate that it would be possible to produce polyethylene at 19¢/lb and butadiene at 11¢/lb. It would be difficult for Y to produce the fertilizers required to cover its needs because of the shortage of adequate raw materials.

/Y cannot

Y cannot obtain significant discounts on crude oil imports because of foreign currency problems.

3. It would seem logical for X and Y to resort to exchanges, with X providing crude oil and fertilizers and Y supplying in return polyethylene and butadiene at the international price levels, the balance of payments between X and Y being settled by cash payments or by bartering other goods. The advantages of such an arrangement are evident:

- (a) Currency payments are reduced to a minimum.
- (b) Each country can satisfy its needs through a supply obtained at a reasonable cost: effective international price plus transport over a short distance.
- (c) Each country can operate its units at full capacity and consequently supply its own market with cheaper products.
- (d) The countries deal with these exchanges as equals and are in fact independent. This constitutes a safeguard against any sudden and unilateral interruption in supplies for political or economic reasons.
- (e) Whilst these exchanges are proceeding, the market can develop and reach the minimum economic level which will allow a new step forward in the process of industrialisation.

This system, which makes available sufficient quantities of products for consumption, is likely to stimulate a much more rapid development than that expected from the usual import schemes which, owing to foreign currency problems, often result in paralysing the market's potential growth.

VI. Criteria governing a project's feasibility

All along our discussion so far, we have assumed that serious market surveys and production cost studies have been made, and that we have selected the manufacture of a certain product which presents interest.

Certain reference points are necessary for the critical evaluation of a project's feasibility. The establishment of such criteria is a delicate matter and involves technical, economic and also political problems. Since general criteria do not exist, the following points could usefully be considered:

It is generally recognised that it is advisable to produce at or near effective world prices. It is equally sound to consider as unfeasible those projects which lead to 2 or 3 times these prices.

There exists a debatable range between these well defined limits. We believe that experience has shown that a production resulting in over 115 per cent of international prices would present little interest. Above this value, it is undesirable to develop an industry on a basis which would constitute an expensive way of saving foreign currency.

/We realise

We realise that this point is controversial: a Government short of foreign currencies and simultaneously spending large sums on the country's development (creating employment, training skilled labour etc. ...) could conceivably decide it worthwhile to support an industry and thus allow it to maintain itself while producing at 115 to 130 per cent of world prices.

It must be stressed that a country may well afford certain uneconomic productions for reasons linked with national defence, foreign currency saving, regional development, etc.; but it cannot afford to develop an entire industry on this basis.

Another argument, which is commonly met, is that delivered prices (i.e. international prices plus transport) are often of the same order and even in certain instances higher.

This criterion has dangerous facets. Whereas freight may not be a major problem for products transportable in bulk form, it may become considerable for hazardous chemicals which must of necessity be transported in relatively small packages. In the latter case, it is dangerous for developing countries to think in terms of this parity. For in the final analysis, their standard of living in the world will depend on effective prices at the level of the consumer.

Taking these arguments into account, we believe that, as a general rule (and as such, it could suffer certain exceptions), the price at consumption centre should be kept under 130 per cent of effective world prices plus transport from the nearest national port to the centre of consumption.

Likewise, no agreement for imports or exchanges with a neighbouring country should be considered which would result in a c.i.f. price (national port) greater than 130 per cent of world prices. Sooner or later, it will be necessary to be competitive with world prices if the standard of living is to be raised effectively. The establishment of an industry without consideration of these factors will increasingly handicap the country's future development.

It appears highly advisable, under these conditions, to concentrate one's efforts on producing a limited number of products at prices below the limits defined above, part of which could be exported to or more likely exchanged with neighbouring countries. During this period, local demand for products not manufactured at home could be created or at least stimulated by placing on the national market those products obtained through exchanges. An accelerated market growth should thus be obtained, which will in turn speed up attainment of the minimum capacity level justifying the construction of economic units.

VII. Conclusion

Establishment of a profitable petrochemical industry in developing countries is hindered, if not blocked, by their markets which are as yet often limited.

Serious difficulties lie in the path of exports, and exporting as such, does not appear a satisfactory way out of the problem.

Examination of the principal problems met suggests a somewhat different solution - that of a mutual exports, approaching an exchange system.

The main advantage of this solution lies in the fact that the exchanges would proceed between equals and would create a certain interdependence, which would constitute a safeguard against unilateral interruptions in supplies for political or economic reasons.

In a first stage of development, each country would limit itself to the establishment of the most profitable projects and would develop its own market by means of exchanges, thus preventing outflows of currencies for the purchase of those necessary products which could not economically be manufactured locally.

A production cost inferior to 130 per cent of effective world prices may be considered as a sine qua non for the feasibility of a project.

For such a programme to be implemented, it should be noted that every country must of necessity rely on an industrial development plan which would state:

- how much it would cost to produce locally if it was decided not to import.
- what prices would be charged if it chose to export.

This would permit serious negotiations on precise topics resulting in mutual supplies agreements through exchanges, as opposed to discussions which, often hinging on ill-defined bases, lead to misunderstandings and deadlocks and seldom materialise.

Such a procedure would result in a more rational use of investments and in accelerated local market growths.

We hope that the ideas we have submitted may serve as a basis of discussion and fruitful thought, which will stimulate those countries which do not as yet dispose of a petrochemical industry to develop it on sound technical and financial grounds.