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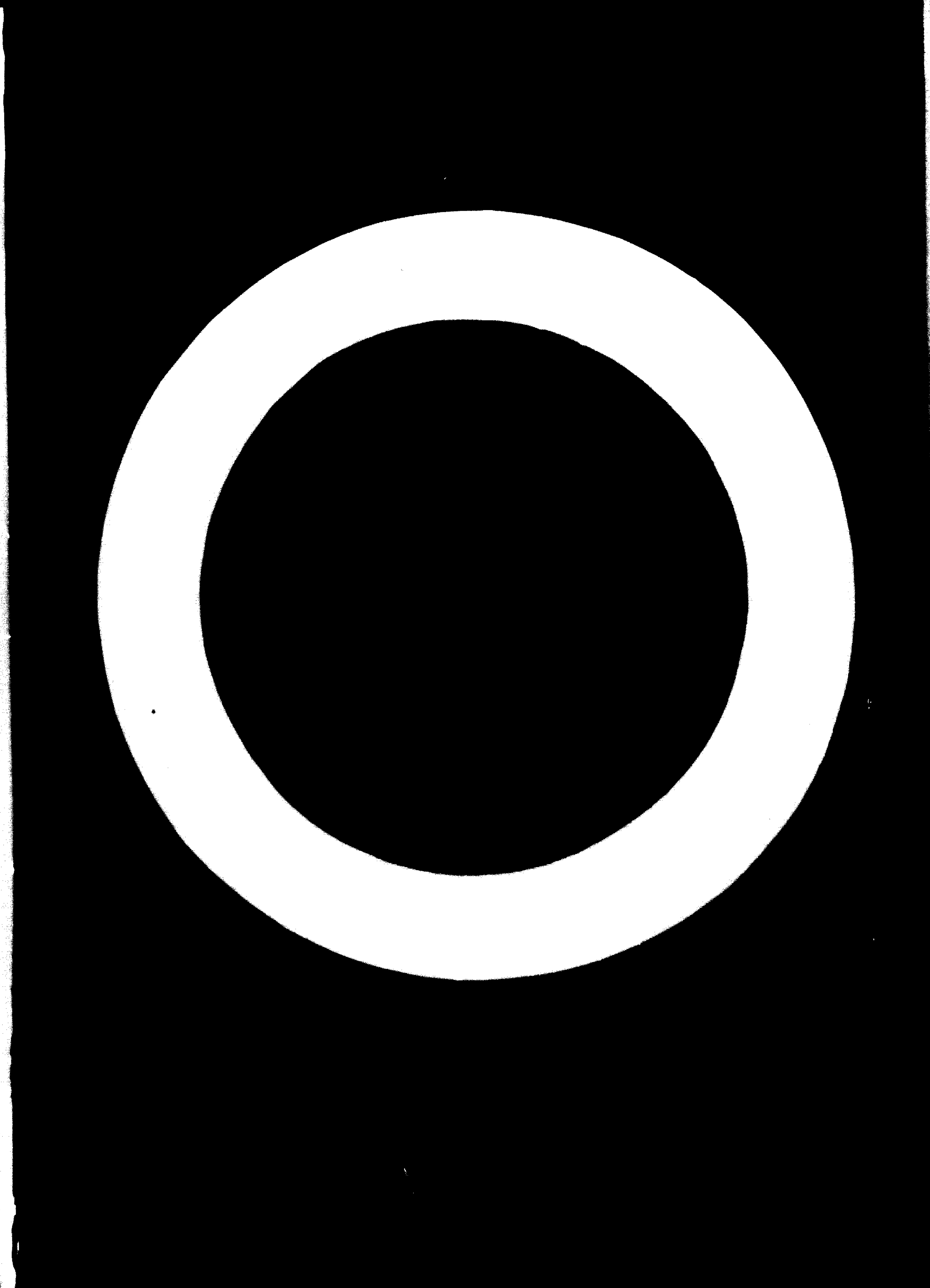

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# *Problems often encountered in implementing industrial projects in developing countries**

This article analyses some of the problems most frequently encountered in the implementation of industrial projects in developing countries. It has been said repeatedly that, although industrial development planning is generally well done these days, plan implementation is generally not. Yet, the industrial development literature is crowded with books and articles on planning, and quite lacking in guidance on implementation.

Before implementation begins, it can be assumed that the decision to invest has been made; the product, general process, scale, market, financing method and general location have been decided upon; government approval has been obtained, at least in principle; and the investment funds, including foreign exchange, are allocated and available. At this point the implementation process then normally begins. It usually includes site selection, detailed design of project to accommodate it to the site and to final engineering changes, bidding, contracting and procurement, construction and finally start-up.

The problems of implementation do not greatly differ between private and public projects. Private projects may, on the one hand, experience greater difficulty in obtaining approvals and allocations, especially of foreign exchange; but public projects may, on the other hand, suffer more from organizational confusion and delays in decisions. All in all, the problems of projects in both sectors are perhaps about equally burdensome. This article includes both public and private projects without distinction, except in detail, as noted from time to time.

Most of the problems discussed here are those encountered by large-scale industrial projects of the size that stand out individually in national economic planning. These are the projects whose delay can upset a development programme or whose costs, when excessive, can disturb a national budget. They also represent the most visible sector of industry, and the most politically dangerous if mishandled. The whole world can see a half-built steel mill, to the embarrassment of those responsible. The medium- and small-scale projects, although no less important to national development when taken together, individually present fewer implementation problems than do large-scale projects. They rely less on foreign exchange and imported technology, tie up less capital during construction and are less likely to attract criticism and interference. Nevertheless, some problems of this sector will be discussed and suggestions made for their solution.

Although the problems discussed here differ somewhat from country to country, they are more marked by their general applicability to all developing countries. This is because the origins of the problems are the same and are to be found in the very definition of "developing country". The scarcity of means and skills, the lack of foreign exchange, the accompanying dependence on foreign equipment and technology and the absence of an industrial base—these are at the source of implementation problems, and they are common characteristics of practically all new countries. Hence, in the analysis of problems that follows, no distinction has been made on the basis of country. Some common problems that cause delay are first discussed and then the cost of these delays is analysed.

## Sources of delay

The implementation work of an industrial project divides, roughly, into three phases: *(a)* project planning, including site selection, detailed engineering design and cost estimating; *(b)* the bidding, contracting and procurement cycle; and *(c)* construction and start-up. These are highly interrelated activities. Oversights in project planning can cause delays in construction.

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Poor contracting procedures may lead to inefficient and costly start-up. In view of this interrelatedness, the three-phase division of work can be used as the principle for organizing the great variety of problems encountered in the implementation of industrial projects in developing countries.

### *Project planning*

Much thought has been given in recent years as to how developing countries can achieve the most efficient allocation of their scarce resources, and considerable skills have been developed in the selection of the potentially most profitable projects from among an array of alternatives; but in the planning of individual projects, the wise and frugal use of capital, especially foreign exchange, is sometimes not given adequate attention. This oversight, when it occurs, may be a source of problems that bedevil the project throughout its implementation phase.

Overcapitalization is, perhaps, the most frequent of these errors. Local costs of labour and capital are not realistically appraised before mechanized systems and other capital-intensive production methods are imported from abroad. Economies of scale are not well understood; some products are economically produced only for vast markets and are better imported until the market grows. Imbalance of production facilities can lead to the perpetual under-use of parts of a plant. Failure to estimate the market correctly may lead to overcapacity or undercapacity. The economic consequences of locating the project in a less-than-the-most-convenient place are frequently not defined and measured. Sometimes, inadequate attention is given to ensure that the manufacturing process employed is technically stable, and yet not in danger of obsolescence.

Hackney makes the point forcefully when he writes:

> "The success of a capital investment is irrevocably determined during the relatively short and usually hectic period between its inception and initial productive use. During this period its value is established. The location of the facility, the products it is capable of making, the process it uses, the type and quality of equipment, the efficiency of layout these and similar project decisions will strongly affect operating costs and income throughout the facility's potential working life of ten to fifteen and more years. It is therefore important to ensure, as far as may be possible, the correctness of capital investment project decisions."[1]

An illustration of the quality and intensity of planning that is required if subsequent implementation problems are to be avoided is provided by the procedure of a Dutch company[2] that has established several plants in developing countries. Factories are adjusted both in product and manufacture to the economic scale, labour supply and skill of the host country. A pilot operation in Utrecht simulates the manufacturing methods to be used in the subsidiary; manufacturing methods are designed to suit the local situation, sometimes with the result that methods, previously thought antiquated, are used. Plants can be put into operation on location with amazing rapidity; the Congo plant was built in a week and put into operation four days later.

Inadequate estimating procedures are another prime source of errors in the planning phase. Cost estimating for capital projects is a complex and difficult process. Failure to adjust cost elements to the local conditions of developing countries and to consider the relationship of project costs to delays in implementation perhaps accounts for most estimating errors.

A full discussion of estimating procedures is beyond the scope of this article, but the following items suggest potential sources of underestimation:

- *(a)* Additional costs of remote site, including power source, other utilities, construction colony, freight costs and roads;
- *(b)* Higher cost of first-time effort because of the learning effect;
- *(c)* Difficulty of anticipating at the time of the estimate all of the installations and features required to accomplish the purpose of the project;
- *(d)* Labour estimates not adjusted to local productivity and manning patterns;
- *(e)* Strikes and other work stoppages;
- *(f)* Cost of ancillary construction and services not included in plant cost (such as housing colony, auxiliary power source, fire protection and security);
- *(g)* Insufficient allowance for price escalation (published price indexes suffer from reporting-time lag and lack of sensitivity);
- *(h)* Possibility of devaluation;
- *(i)* Adverse climatic conditions; interruptions caused by monsoons etc.;
- *(j)* Difficult maintenance conditions for construction equipment; need for spares inventory;
- *(k)* Cost of delays caused by need to import equipment including customs clearance;
- *(l)* Customs duties for imported equipment;
- *(m)* Need for a general contingency allowance;
- *(n)* Need for a restricted reserve fund.

Few projects reach completion without meeting unforeseen difficulties, and the estimates must include sufficient allowances for such contingencies as changes in design and unexpected construction problems. In this regard, Hackney has the following advice:

> "The cost in lost time, confusion, mistakes, and inefficiency produced by changes in scope must be

[1] John W. Hackney (1965) *Control and Management of Capital Products*, John Wiley and Sons, New York, p. 4.

[2] Anon. (1967) "Old-Fashioned Technology in Developing Lands", *Business International*, Feb. 10, p. 47.

considered. A project in midcareer has tremendous momentum. It takes a substantial expenditure of money and time to change its direction. Sometimes the cost of disrupting the work to make changes will be found to outweigh the real but lesser benefits to be derived. In some cases it is best to complete the project as planned, making the necessary modifications at a later date and as a separate operation."[3]

Attention should also be given to the source of cost estimates. The natural optimism of project planners has to be discounted by others.

*Bidding, contracting and procurement*

The phase of bidding, contracting and procurement includes: *(a)* sending out bid requests to qualified contractors or vendors; *(b)* analysis of bids; *(c)* comparison of the best bid with cost estimates; *(d)* contracting or placing orders with the lowest qualified bidders; *(e)* follow-up on contractor performance. There are well-established procedures and generally accepted conventions on bidding and contracting that should not be violated without very good cause. These are beyond the scope of this article, but certain mistakes to be particularly avoided by developing countries should be pointed out.

There is a rather common tendency to solicit bids from sources with which there is no real intention of placing the contract or order. This may be done, for example, to satisfy legal or political requirements for world-wide bidding, when in fact the development funds are a loan tied to a source of supply. Or it may result from simple curiosity about a variety of sources, or the desire to get additional cost data, although a preferred source is already in mind. Whatever the reason, this is poor practice and is self-defeating in the long run.

There is also a tendency in developing countries to accept the lowest bid without reference to the qualifications of the bidder and his ability to provide goods and services at the required time, and of the required amount and quality. At this point, a consultant may be necessary, not only to assist in preparing the specifications and invitations to bid, but also to advise the bidder as to whom the contract should be awarded. Hackney warns against these mistakes in the following words:

"Whether work is performed on a cost-plus, fixed-price, or any other basis, the owner must take precautions against getting the wrong contractor for the job at hand. This calls for pre-selection of contractors so that the low bidder will be acceptable. Inclusion of bidders on the list who will not be accepted by the owner, even if they submit the low bid, is indefensible.

"Contractors should not only be experienced in the type of work to be performed, but the size of the project should be of the order of magnitude to which they are geared. An organization which ordinarily handles very large projects may be ineffective in building small units unless it sets up a special part of its organization for this work. Similarly, a small contractor may get into difficulties if he attempts work which is too large for his organization at its current stage of development."[4]

Contracting methods vary from the turn-key contract, including start-up, at the one extreme, to contracting for delivery of equipment only, at the other. The variations and combinations of approaches are almost limitless, and the appropriate method depends on the specific conditions, including: previous experience in the kind of project involved; availability of managerial and technical personnel; need for specialized equipment that a contractor may provide; time pressures; desire for training of local managers and technicians; technical complexities of the project; and political considerations.

John P. Lewis points out that a balance must be struck between meeting time schedules and having the project provide a meaningful learning experience for the developing country's personnel:

"The basic object lesson I know of on this can be drawn from the comparative experiences of the three Second-Plan public-sector steel mills, one built under Western German contracts at Rourkela in Orissa State, a second under a Soviet contract at Bhilai in Madya Pradesh, and the third by a consortium of British firms at Durgapur in the Damodar Valley region of West Bengal. These all are large steel-making units with initial-designed capacities of about a million tons of ingot a year. Although they will produce different product lines by significantly different processes, . . . they are all designed to turn out satisfactory grades of steel with modern equipment and methods; and while each fell behind its original schedule . . . and each encountered some unexpected technical difficulties . . ., one gathers that all sooner or later will work.

"Yet these three steel projects received radically different ratings as to their success from most Indian and foreign observers . . . The differences are not due to any inherent differences among the German, British and Russian nationalities, or between Soviet and Western economic systems. They were largely the predictable result of the widely different contractual arrangements into which the government of India entered in the three cases.

"At Rourkela, the first of the three projects to be undertaken, separate government-of-India contracts were signed with as many as thirty-five individual German firms, and the entire burden of co-ordinating the project fell on the Indian management . . . The end result of the Rourkela project will be a substantial success; but the distressingly awkward manner in which the work was organized probably can be blamed for some of the technical fumbles and certainly is responsible for un-

[3] Hackney, op. cit., p. 16.

[4] Ibid, p. 268.

necessary delays, unexpectedly high costs, and a certain amount of bad feeling.

"At Durgapur, the last of the three projects to be started, contractual arrangements were carried to an opposite extreme; the government of India entered into a single contract with an *ad hoc* consortium of a dozen British firms (which in turn did considerable sub-contracting) for a finished, operable steel plant. Durgapur, in other words, was a turn-key job; full responsibility for co-operating all aspects of the construction lay with the consortium. The latter, evidently thoroughly mindful of the need for a unitary operation, was carrying forward its work efficiently . . . But the Indians on the scene, compared with their colleagues at the other two sites, scarcely felt like participants. Lacking responsible involvement in the construction as such, they found that the latter gave them little preparation for the problems of operation.

"What struck me most forcefully at Bhilai, having come directly from the other mills, . . . was the extraordinarily high morale of the Indian participants in the project. They were not only enormously proud of the relatively good record that the work at Bhilai had made; they were completely convinced that this was substantially *their* accomplishment. Sharing fully, as they saw it, in each step of the work, they had gained so much in-service training and experience during the project's planning and construction phases that they were thoroughly confident of their ability to move to an entirely Indian operation of the plant in very short order.

". . . The procedural success of Bhilai was essentially the result of faithful execution of an astutely drawn contract a single contract in which the Soviet government undertook to provide all required imports and foreign personnel in timely fashion, to provide training for Indian operators, and to supply all of the technical guidance necessary for building a plant of the specified capabilities; but, at the same time, the contract stipulated that all line decision making, as to design and construction as well as to subsequent operations, was to be the exclusive prerogative of Indian project personnel . . .

"Superficially this was a curious contract in that each party obligated itself unilaterally to responsibilities that it could not in fact perform without the co-operation of the other; but precisely this, of course, was its particular strength: the contract *forced* detailed partnership, explicit binational co-operation and agreement at every stage of the project. It was this characteristic of the arrangement that, as widely reported, was mirrored at all levels of the project organization by the dual posting of Russian and Indian counterparts to most supervisory and technical positions. Each pair was required to work as partners, formally always with the Russian in the advisory, the Indian in the decision-making capacity, actually with the Indian assuming more and more of the joint initiative as the work proceeded."[5]

[5] John P. Lewis (1964) *Quiet Crisis in India*, The Brookings Institution, Washington, D.C., pp. 295–298.

### *Construction and start-up*

Two aspects of the construction and start-up phase provide the source of most of the problems that occur during this last stage of project implementation. These are the general management and organization of construction, and the scheduling and control procedures.

The first essential condition for effective management of construction is unity of command in a single person, the project manager. He should be as close to the scene as possible, in the early stages at the engineering office and later at the construction site. Remote control of projects in the implementation stage does not work.

The shortage of managers capable of assuming full responsibility for project implementation is one of the main difficulties in the way of industrial development. It is sometimes compounded either by an unwillingness to employ foreigners in management or by the scarcity of suitable foreign personnel. There are various contracting and consulting arrangements for getting around this shortage, and although most may appear costly on first sight, they usually pay for themselves in time savings and the avoidance of costly mistakes.

The following account from Korea tells how a capable contracting firm, in spite of a series of staggering problems, managed to bring its project to timely completion through skilful project management.

"In April, Korea's Ministry of Commerce and Industry commissioned Universal Oil Products Company to conduct a preliminary engineering study for the proposed refinery. This study was completed in July, and negotiations began to select a firm to build the refinery.

"A corporation, with worldwide experience in engineering and construction of grass-roots refineries such as the one planned near Ulsan, guaranteed completion of the project within 16 months, and on October 17 won the contract for the project.

"The firm's overseas experience enabled it to foresee most problems associated with projects in other countries, but it faced additional obstacles unique to this Korean job-site; roads leading to it were poor; no communications network was available; lumber was practically non-existent; and sand and rock sources had to be developed.

"In addition, the contractor had to provide power for construction, establish security and fire protection services, furnish housing for personnel – in effect, make the site self-sufficient. Recruiting and training a native work-force (which eventually numbered nearly 1,200) was another responsibility of the contracting company.

"After establishing a liaison in Seoul, word was sent immediately to the contractor's home office, where engineering work began within 10 days and procurement of equipment began within a month.

"Arrival of the general superintendent at the job-site in December helped in planning site preparation. Engineering and procurement, meanwhile, continued on schedule in the home office. By mid-February, construction equipment was on hand, temporary buildings had been constructed and the first supervisors had arrived to help organize the many construction activities and train workers.

"Problems in site preparation caused the company to miss its intended start-up date of March 1 by nearly two weeks, and construction did not begin until March 12.

"Korea's rainy climate, taken into consideration during original scheduling, surprised the company and Koreans alike. Still striving to regain the two lost weeks, the workers encountered more delays when unusually heavy spring rains—the heaviest in Korean history—fell on the job-site in April and continued through May. The rains not only hampered all construction activity, but actually caused a cessation of work on several occasions.

"For example, four inches of rain fell during a 10-hour period on April 18, completely flooding the project, burying materials under mud and causing excavations to cave in. By the end of May, the company was 30 days behind schedule.

"In June, still a month behind, 13 inches of rain fell over a five-day period and the project was completely flooded again. Good working weather did not arrive until August, though the industrious Koreans—willing to work and capable of working in adverse weather conditions—had helped the company regain some of the lost time during July.

"By September, the peak work-force of craftsmen was at work on the refinery. Aiding this effort were a minimum of design changes, co-operative vendors who supplied equipment on time and a lack of major shipping delays.

"Shipping of equipment across national borders, often a major obstacle in construction progress of overseas projects, was expedited through an agreement with the Korean government for passing construction materials directly through customs unopened. This was the first time Korea worked out such an arrangement with a private firm.

"Meanwhile, the urgency of completing the task had been relayed to the workers and to the sub-contractors responsible for offshore facilities, tankage and pipelines. Their response and a lack of major delays contributed to the amazing speed with which the job continued. Near the end of October, work was nearly 85 per cent complete.

"On Dec. 21—58 days earlier than the contract called for—the contractor placed control of the refinery in the hands of Korea Oil Corporation."[6]

Many construction projects fall behind because of deficient scheduling and control precedures. Progress reporting from projects under construction is frequently inadequate. A typical procedure is a report in two parts, one a narrative section describing physical progress, frequently in general terms and sometimes without reference to specific targets, and the other an expenditure-to-date section that shows how fast the project is managing to spend money, without reference to the efficiency of economic timing of that expenditure. Although planning charts of the bar type, showing the sequence of activities to be accomplished by given future dates, are frequently prepared in the planning stage, they are far less frequently employed as control charts in the construction phase. In a later part of this article presenting suggestions for improved practice, the network scheduling system is recommended and described. This system is not new; it is widely used elsewhere and has become the prevalent scheduling and control system for tbe construction industry in the developed countries.

Start-up problems are somewhat different from those of construction and require special consideration. Most important is to have the right people available in the right numbers. One way to train the key technical, production and maintenance staff is to have them work for a time in an operating plant of the same kind. A start-up manager should be on hand, apart from the project manager and the future works manager. As a specialist in the start-up phase, who has been through it repeatedly before, he will be prepared to react quickly and correctly in the event of trouble.

The start-up of a plant using second-hand equipment and machinery is a particularly risky and difficult undertaking. Under some circumstances the purchase of second-hand equipment is obviously a good idea. When the technology in a given field has made great advances, for example, the displaced machinery can possibly be put to profitable use in a developing country. Used machinery can be delivered more quickly than new machinery. Most manufacturers require from six months to two years to supply new machines, whereas used machines can usually be acquired immediately and installed quickly. Used machinery generally costs from one quarter to one third as much as new machinery of most recent design. Used machinery, however, is no bargain if it does not produce satisfactorily. Unless the product it produces is competitive in quality with other available products, the machinery is a poor investment.

When second-hand plant and machinery are to be used in an industrial project, certain precautions can be taken to prevent difficulties and delays from occurring at the time of installation and start-up. As a general rule, it is well for the buyer not to try to "go it alone". He can follow three courses of action in seeking help. First, he can engage managers or consultants from abroad who will help him buy and install the second-hand machinery. A second method, and perhaps the safest of all, is through a joint business

[6] Walter L. Russler (1964) "An Economic Renaissance Occurs in Korea", *Korean Report*, Vol. IV, No. 3, April—June.

venture with the firm that is selling the second-hand equipment. This has been done on many occasions with considerable success. If neither of these alternatives is possible, the buyer should engage an independent expert to examine the machinery he is considering buying. There are some companies that do this as a regular service.

No matter what precautions the buyer takes to avoid purchasing unusable machinery, there are still dangers in buying second-hand equipment. A machine that appears to be in good condition must be tested under power and in operating conditions to make sure that it works properly. The purchaser must also find out whether the machine has all the necessary attachments and accessories. Many machines sold "as is" are not useful unless the accessories can be found. There is also the problem of dismantling, packing, shipping and reassembling the equipment. Many pieces of equipment may operate in their old location, but can never be put together to operate successfully elsewhere. For these reasons, it is well for the buyer to have some resources or control over the seller until the machines have been put into production.

## THE COST OF DELAYS

Although much has been said and written about the costs of delays in project implementation—the tied-up capital, the loss of earning opportunity and the immobilizing of scarce foreign exchange—few data exist on the magnitude of these costs or their relation to various rates of time discount. A study[7] recently completed in India provides the first organized information on this subject. The study points out that developing countries should use high rates of time discount in calculating the present value of committed funds.

> "The low rate of substitution of future for present consumption . . ., the relative over-supply of labour and also the political determination to accelerate economic growth by rapid increases in the level of investment, all tend to determine high rates of time discount. These high rates emphasize the importance of obtaining maximal returns from investments, and put a heavy weight on the returns obtainable during the first few years of project life. Yet, in . . . many . . . developing countries, one encounters large sums tied up in projects with extended gestation periods, widespread and considerable lags in project completion, and substantial under-utilization of both new and existing facilities. These represent a large loss to the nation in potential income and potential savings for reinvestment."[8]

[7] This section draws heavily upon the doctoral dissertation of Robert C. Repetto (1967) *Temporal Elements of Indian Development*, Department of Economics, Harvard University, Cambridge, Mass., October

[8] Ibid., p. II-1

Table 1 gives the length of time from approval in principle to full production for 41 public-sector capital projects in India. The data are necessarily crude; in some cases they are based on estimates. They serve, however, to provide a sense of dimension. The public sector is used for this illustration, not because the private sector has necessarily fared any better in keeping its projects to schedule, but because the accounting procedures of the public sector provide open information on this subject. Also, it must be emphasized that the Indian case is used not because it represents either poor practice or good practice, but because it is the only case available.

The average lag from initially scheduled production start for these 41 projects is about one and one quarter years. The total average time from the first project approval to full capacity operations ranged from seven and one quarter years for thermal power projects to ten and three quarter years for nitrogen fertilizer plants. Frequently, the funds, both foreign and domestic, for these projects were committed—and immobilized—at the time of project approval. The cost of these underutilized resources is a major source of inadequate returns to investment.

Table 2 presents the results of discounted cash flow calculations which show the effects of more rapid project completion and attainment of full-capacity production on the net worth of individual projects. Two sets of alternative assumptions about financing methods are made:

Assumption 1: The capital is committed at the time of each investment outlay. The effect of this "pay-as-you-go" assumption is to minimize the cost of lags in the construction period, since such lags defer both benefits and costs. This assumption is usually invalid, particularly for the foreign capital component of investment, which is typically allocated before the project is undertaken and is thereafter unavailable for other projects.

Assumption 2: One half of the capital is committed at the time of project approval; the rest is "pay-as-you-go".

The production life of all projects is assumed to be fifteen years, with no subsequent scrap value. The start of production is assumed to occur after 75 per cent of the total investment is disbursed—a conservative assumption. Discount rates of 7 per cent and 15 per cent have been used.

The results, as shown in table 2, although roughly drawn, show that delays in reaching full capacity have a particularly strong impact on the net value of projects at both high and low rates of discount. Under assumption 2, the cost of delay in reaching full-capacity production is about the same for both discount rates, since the higher operating margins and higher discount rates tend to cancel each other out.

*Table 1*

**Length of period, in years, from approval to full operation: forty-one capital projects in India[a]**

| *Industry* | *Approval in principle to receipt of detailed project report* | *Detailed project report to final government approval* | *Final approval to start of construction* | *Construction start to commercial production start* | *Lag from initially scheduled production start* | *Commercial production start to full capacity operations* | *Average total time* |
|---|---|---|---|---|---|---|---|
| 1. Five nitrogen fertilizer projects | 2 (3) | $\frac{1}{4}$ (3) | $2\frac{1}{4}$ (5) | $3\frac{3}{4}$ (5) | $2\frac{1}{2}$ (5) | $2\frac{1}{2}$ (2) | $10\frac{3}{4}$ |
| 2. Four refinery projects | | | | $2\frac{3}{4}$ (3) | 1 (4) | 1 (2) | |
| 3. Ten thermal power projects | $1\frac{1}{2}$ (2) | 1 (8) | $\frac{3}{4}$ (8) | $3\frac{3}{4}$ (10) | $1\frac{1}{4}$ (10) | $\frac{3}{4}$ (6) | $7\frac{1}{4}$ |
| 4. Twelve engineering and machinery projects | $1\frac{1}{4}$ (8) | $\frac{1}{2}$ (8) | $\frac{3}{4}$ (9) | 2 (11) | 1 (6) | $5\frac{1}{4}$ (12)[b] | $9\frac{3}{4}$ |
| 5. Five coal washeries[c] | 2 (4) | $1\frac{1}{2}$ (4) | | $2\frac{3}{4}$ (5)[d] | 1 (4) | 4 (2) | $10\frac{1}{4}$ |
| 6. Five steel projects | 1 (5) | $\frac{3}{4}$ (5) | $\frac{1}{2}$ (4) | $2\frac{1}{2}$ (4)[e] | $\frac{3}{4}$ (5)[e] | 3 (3)[e] | $7\frac{3}{4}$ |

Note: () The number of projects included in the average is given in parentheses.

Sources: Data were collected from various annual reports on public-sector enterprises, and Planning Commission documents.

[a] Robert C. Repetto, (1967) p. II-3.
[b] Mostly estimated.
[c] Including two expansions.
[d] Contract award to production start.
[e] Refers to finished steel.

*Table 2*

**Percentage reduction in total net worth of a project owing to delays[a]**

| | 7% Discount rate | | | 15% Discount rate | | |
|---|---|---|---|---|---|---|
| | *Lag in project completion* | | | | | |
| Assumption 1 | 1 year | 2 years | 3 years | 1 year | 2 years | 3 years |
| | 1.5% | 3% | 4.5% | 3% | 6% | 9% |
| | *Delay in reaching full capacity* | | | | | |
| | 1 year | 2 years | 3 years | 1 year | 2 years | 3 years |
| | 7% | 12% | 16% | 10% | 17% | 20% |
| | *Lag in project completion* | | | | | |
| Assumption 2 | 1 year | 2 years | 3 years | 1 year | 2 years | 3 years |
| | 4% | 7% | 10% | 8% | 13% | 18% |
| | *Delay in reaching full capacity* | | | | | |
| | 1 year | 2 years | 3 years | 1 year | 2 years | 3 years |
| | 10% | 16% | 22% | 12% | 19% | 24% |

[a] Net worth is expressed as a percentage of the capital employed. A capital/output ratio of 2 : 1 is assumed.

Table 2 shows, for example, that under assumption 2, at a 15 per cent discount rate, a one-year lag in project completion can reduce the net worth of an industrial project by about 8 per cent, and a delay of one year in reaching full capacity can reduce the net worth of the same project by another 12 per cent. If one puts these figures together, it appears that the combined effect of more economical financing methods, accelerating completion by one year, and attaining full capacity one year earlier would save an amount equal to roughly 15 to 17 per cent of investment at a 7 per cent discount rate, and about 22 to 24 per cent of investment at a 15 per cent discount rate. This comparison shows the substantial difference efficient management can make in the utilization of scarce capital. This difference is at least as great as differences in costs arising from locational factors, economies of scale and labour productivity.

### Some ways of avoiding implementation problems

As indicated previously in this article, the best way to avoid problems and delays in implementing industrial projects is through meticulous project planning and continuous attention to the cost of time. Most of the kinds of problems itemized and discussed here are avoidable if they are properly anticipated. As developing countries gain repeated experience in project planning and implementation, they learn to avoid these problems, and the quality of performance improves.

Perhaps the greatest single opportunity for improved practice in implementing industrial projects is in the area of project scheduling and control methods. Powerful techniques are available that have not yet been broadly applied in developing countries. Among these is "critical-path scheduling".

#### *Improved scheduling and control*

Critical-path scheduling is based on the concept of discovering, and paying particular attention to, the longest time-path through a network of activities. The system is not new; it is widely used in developed countries and has become the prevalent scheduling and control system for the construction industry in these countries. Although computers are usually used when the method is applied, they are not essential. A paper-and-pencil adaptation can be worked out, which is appropriate to the needs of developing countries.

The basis of critical-path scheduling is the application of network analysis to the planning and control of time schedules. This network analysis is similar to that used in communications and electronics. Planning a project as a network of activities allows the application of precise techniques to the problem of planning and the time schedules and the cost schedule of the project. The planning of performance is the planning of the physical activities and sequence of operations necessary to achieve the project objectives. The planning of time schedules is the correlation of the performance plan to calendar dates in order to ensure that deadlines will be met.

The first step in the planning of operations begins with the definition of the project's objectives and its scope. The project is then analysed in terms of the activities required. The activities should be broken down into the smallest unit that has to be scheduled and controlled.

The important data needed are the activities, their estimated times, and some way of showing efficiently the sequence of activities required. The logical analysis required to draw up the lists of activities and to establish their sequence relationships provides, in itself, an advantage of the system. Exhibit 1 shows the major activities required to build a house. This list is greatly simplified as compared with the list of activities a building contractor would want to use; however, the

*Exhibit 1*

Sequence and time requirements of jobs in building a house

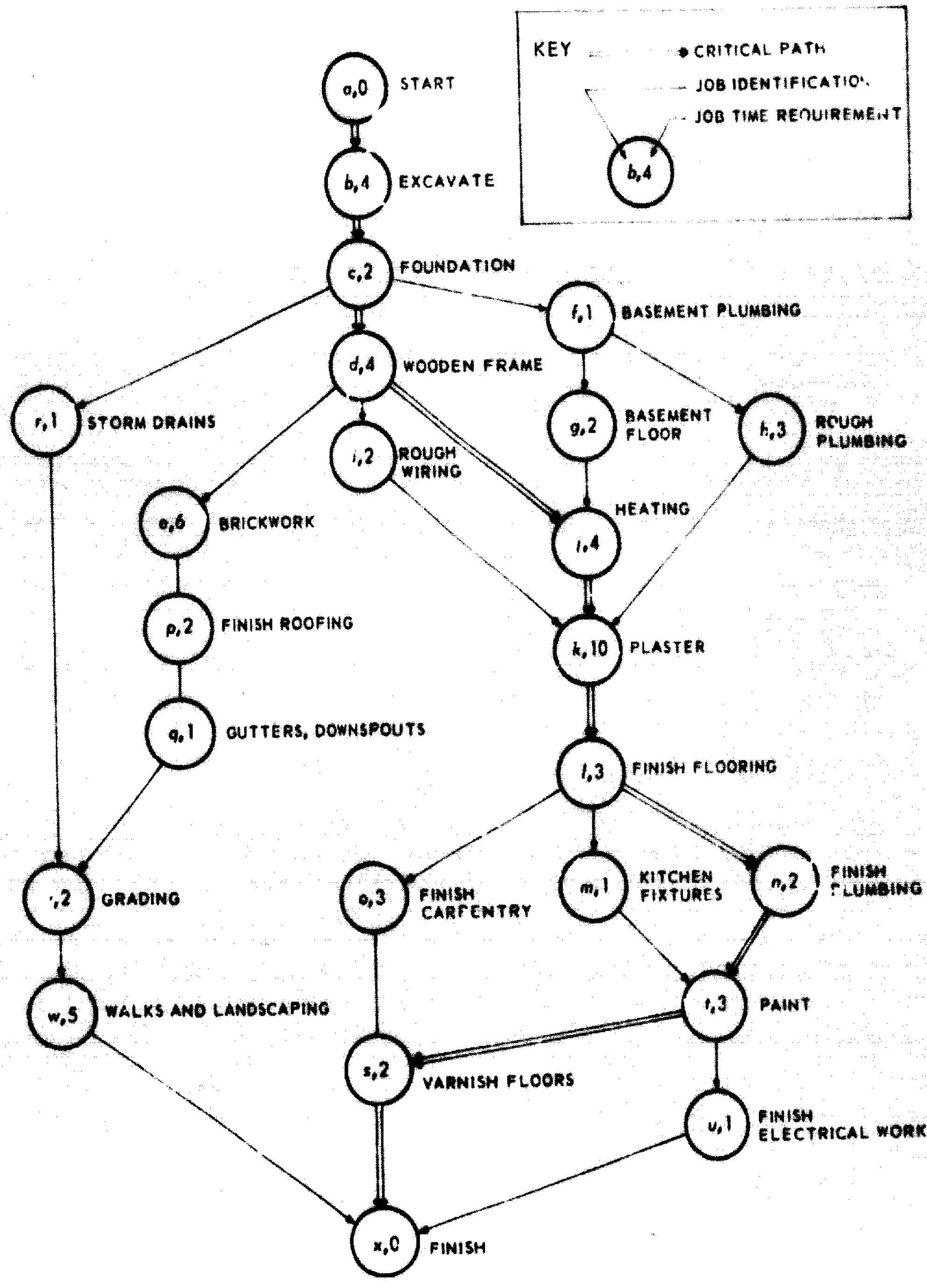
| *Job* | *Description* | *Immediate predecessors* | *Normal time (days)* |
|---|---|---|---|
| *a* | Start | | 0 |
| *b* | Excavate and pour footers | *a* | 4 |
| *c* | Pour concrete foundation | *b* | 2 |
| *d* | Erect wooden frame including rough roof | *c* | 4 |
| *e* | Lay brickwork | *d* | 6 |
| *f* | Install basement drains and plumbing | *c* | 1 |
| *g* | Pour basement floor | *f* | 2 |
| *h* | Install rough plumbing | *f* | 3 |
| *i* | Install rough wiring | *d* | 2 |
| *j* | Install heating and ventilating | *d, g* | 4 |
| *k* | Fasten plaster board and plaster (including drying) | *i, j, h* | 10 |
| *l* | Lay finish flooring | *k* | 3 |
| *m* | Install kitchen fixtures | *l* | 1 |
| *n* | Install, finish plumbing | *l* | 2 |
| *o* | Finish carpentry | *l* | 3 |
| *p* | Finish roofing and flashing | *e* | 2 |
| *q* | Fasten gutters and downspouts | *p* | 1 |
| *r* | Lay storm drains for rainwater | *c* | 1 |
| *s* | Sand and varnish flooring | *o, t* | 2 |
| *t* | Paint | *m, n* | 3 |
| *u* | Finish electrical work | *t* | 1 |
| *v* | Finish grading | *q, r* | 2 |
| *w* | Pour walks and complete landscaping | *v* | 5 |
| *x* | Finish | *s, u, w* | 0 |

simplified listing of activities is more appropriate for explanation here. Exhibit 1 shows, in addition to a listing of the activities, the sequence of activities required and an estimate of the normal time for completion of each activity in days. These sequences are imposed by the technological requirements of the activities. For example, one cannot pour the foundations before excavation.

On the basis of exhibit 1, the arrow diagram, or project graph, shown in exhibit 2, can now be prepared. In this exhibit, the circles represent activities and the arrows represent sequences of activities required to carry through the project. The rules for constructing the project graph are simple. Arrows indicate the direction of flow, and activities connected by an arrow indicate that the second in the sequence must be preceded by the first. If it is possible to trace a circular path through the maze at any point, some mistake has been made in determining the order of relationships, or in preparing the diagram.

*Exhibit 2*

PROJECT GRAPH



Twenty-two unique paths from start to finish can be traced on the diagram. The shortest path requires 14 days by the sequence in *a-b-c-r-v-w-x*. The longest path through the system requires 34 days, through the activity sequence *a-b-c-d-j-k-l-n-t-s-x*. The latter is the critical path. It determines the over-all minimum project time and indicates which activities are critical in meeting this minimum time schedule. If the contractor attempts to complete the house in less than 34 days, he will somehow have to shorten the time requirements for one or more of the activities along the critical path. It would be useless to shorten the time requirements for the jobs not on the critical path.

Determining the critical path for a project graph as simple as that of exhibit 2 is neither difficult nor time-consuming, since it is necessary only to compare time requirements in the various branches to determine which path takes maximum time. For the complex projects for which critical-path scheduling is designed, however, the critical path is not obvious; and it usually requires some calculation to discover it.

Although network analysis provides a highly systematized and logical method of planning, it does not relieve management of the responsibility for control. Network analysis does not provide automatic control or automatic planning. It does provide a highly efficient tool for planning and control.

The first point at which control has to be exercised by management is in the definition of the project objectives, and this should occur in the planning phase, before the list of the component activities of the project is drawn up. The list of activities should be agreed upon by everyone involved in the particular project. The prevalent custom seems to be to delay approval of the list of activities until an arrow diagram has already been prepared, since the development of the arrow diagram itself helps to verify the list of activities. Approval of the arrow diagram is probably the key control function in the planning phase. This approval really means approval of a detailed plan of action. If modifications or changes are introduced later, they can always be related to the original diagram.

A series of reports may be generated during the course of the project to control performance. With the basic data provided in the schedule (earliest and latest start and finish times, and critical path), many variations of these data may be obtained by sorting and tabulation. The strategic factor in controlling performance is maintaining the schedule. An information system can be set up so that revised schedules produced periodically will reflect the latest revisions in time estimates and the latest actual times for activities completed. This type of updating procedure fulfils the needs of project management. In addition, the head office should be told exactly how each revised schedule departs from the original plan. Especially at the end of the project, a comparison of the original and the final schedule actually accomplished is desirable in order to determine what should be modified in the next project so that mistakes will not be repeated.

*Simplified engineering and design*

Once the process to be employed has been adapted to local conditions, the next task is the engineering design of the plant facilities. Individual plant design is difficult and expensive, amounting to an estimated 15 per cent of the total project cost, and it provides unlimited opportunities for mistakes, delays and overruns on construction costs. Detailed engineering and construction drawings, specifications, and lists of equipment and materials needed, all phased in the proper order for delivery on the site, are required for the processing equipment, the foundations and building, and any auxiliary services needed.

Normally, this work is handled by a consulting engineering firm, which must have experience and particular competence in the industrial process and thorough integrity in dealing with the numerous suppliers of machinery and construction services. Well and properly done, individual plant design results in satisfactory construction and operation, but the number of firms qualified to undertake it is limited. The alternative is standardized plant design. The advantage of standardization is that, when once constructed and operated at one location, the same plans and procedures, corrected and improved where necessary, can be employed at known costs and with known results in other areas. These known costs and results can be transposed to make the planning of other projects of the same type immeasurably easier and the implementation much more certain. The difficulties with standardized plant design are connected with the site requirements and variations requested in production volume, but floating concrete slab foundations are generally usable on all sites, regardless of soil conditions, and modular design can usually offer definite steps in planned production output.

One company, for example, has designed six sizes of standard package petroleum refineries specifically for sale to less developed regions. These are self-sufficient units, built to generate their own power and supply their own steam and water-treatment facilities so that they may operate at sites removed from centres of industry. The company provides a detailed proposal for the refinery, with guaranteed volume and quality specifications for the output, on-site construction, and even supervision in operation and maintenance, if desired. This very complete "turn-key" approach removes the burdens of organizational and administrative responsibilities usually borne by the purchaser in multiple-contract bidding, and permits the contractor to accept wide responsibility and penalty clauses in regard to performance without charging a wide margin for uncertainties. The cost and time savings to the purchaser of standardized design can thus be very substantial.

The construction of process facilities on-site in the less developed countries is awkward and time-consuming. Construction material may well be of uncertain quality and difficult to obtain on schedule, if at all. These material problems, willing but unskilled labour, unusual climatic conditions and difficult transport in a remote area combine to delay projects and overrun costs.

As local contractors may be unqualified for industrial projects, which require a considerable measure of experience and managerial organization, the use of international construction companies has become common. These firms accept the responsibility, often with penalty clauses, for performance to standard specifications and schedules; they provide the material, the supervisory personnel and the construction machinery required to build the plant on the site, but even experienced and well-equipped firms find the work demanding.

An alternative to on-site construction is prefabrication, a new industrial technique. Prefabricated plants can be built complete, at considerably reduced cost, in an industrialized country, with skilled labour and fabrication, with more readily available machining and handling equipment, and using experienced engineers and cost and quality supervision. Prefabrication may be either in the form of a completely self-contained unit that is shipped disassembled, but requires no skilled labour for assembly, or a component package of parts ready for assembly with some skilled labour, but no local material.

The recent installation of a petroleum refinery at Port Brega, Libya, is an example of the prefabrication technique. This refinery, with a capacity of 8,000 barrels per day, which meets Libyan requirements for kerosene, gasoline, diesel and fuel oil, was built with modular design on a concrete barge at the shipyards at Antwerp, and then towed 3,000 miles to the site. The barge was then set in a dredged inlet, with the concrete base forming the permanent foundation, and linked by pipeline to the storage facilities on the shore. Delivered on time, it was ready for operation three days later. The project was considered so successful that several other standard and prefabricated refineries are planned, and a barge-mounted power station, with two turbine generators of 12,500-kW capacity, has been ordered for Port Brega, to be installed next to the refinery.

### *Industrial estates and prepared sites*

Another way in which developing countries can avoid problems in implementing industrial projects, especially medium-sized and smaller projects, is through the establishment of industrial estates or prepared sites.

An industrial estate is a tract of land that is subdivided and developed for the use of industry. Provisions are normally made for streets and roads, transport facilities and the necessary utilities. In some industrial estates, factory buildings are erected in advance of sale or lease to the occupants. In other industrial estates, only the land is subdivided and prepared for industry. Although all sizes of enterprise benefit from locating in industrial estates, the benefits appear to be greatest and most obvious for small- and medium-scale factories. Larger industrial enterprises often have the financial and managerial resources to develop the property themselves.

Industrial estates assist in many ways to prevent or overcome the problems of project implementation. First, they save the time and cost normally needed for selecting a site and purchasing land. Problems of industrial zoning and local taxes are completely eliminated. Progress need not be delayed while the basic utilities are being provided. Water, electricity and sewage disposal frequently present a major problem in the preparation of a plant site in developing countries. Many estates provide training services to prepare the work force for employment before the factory is completed. This eliminates the necessity for in-plant training, which frequently slows down the rate at which the factory is brought into full production. When the estate provides both land and the buildings on a lease basis, the financing of industries is considerably easier.

The development of an industrial estate is in itself the implementation of an industrial project, and all that has been said above about the importance of time applies equally well to the industrial estate. The most important cost element is speed in constructing the project and having it fully occupied by industrial plants. The sooner development funds are recovered the more quickly they can be used for other things; conversely, slow development of the estate retards the income stream from the investment and endangers the financial success of the project.

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