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INDUSTRIAL PROJECT EVALUATION AND THE ENGINEER

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I. Introduction

The purpose of this paper is to outline certain practices and procedures in the evaluation of industrial projects which have been found essential from the standpoint of the engineer or technical expert. A proposed industrial project is usually evaluated for technical, economic and financial feasibility. It follows that the evaluation process usually involves the services of an engineer, an economist and a financial expert.

There is a tendency in many quarters to neatly draw a line between the responsibilities of the engineer and those of the economist and the financial expert in the evaluation process. Experience has shown however, that the training, experience and capabilities of the average engineer may well be employed in many aspects of the economic and financial evaluation as well as in the purely technical evaluation of industrial projects. This integration of capabilities and of responsibilities can, of course, work both ways, with the economist or financial expert being well versed in the relative importance of technical decisions and developments.

The complexities of the average industrial project automatically bring about an integration of responsibilities and functions in the evaluation process, which strongly involves the engineer, yet is of considerable concern to the economist and the financial expert. As an example, let us consider the questions of capital cost, profitability and management of an industrial project. The principal elements of the capital cost of a project are usually buildings, infrastructure and equipment. These are elements with which the engineer is vitally concerned. His first consideration with respect to them is whether the buildings are of the proper design and size, and reasonably costed; transportation facilities, housing and utilities are adequately provided for; and the equipment lists are reasonably complete, adequately specified and costed. These considerations make it mandatory that the capital cost of any industrial project become a prime concern of the engineer.

In the matter of profitability or benefit-cost ratio, the engineer is again vitally interested. Paralleling his concern regarding technical feasibility of the proposed process is his concern regarding the availability and cost of raw materials, labor, power,

water, operating supplies, and working capital. The anticipated demand and the price which can reasonably be expected for the final product are of equal interest to him.

Good management is, of course, vital to the success of any industrial project, and the engineer is among the first to recognize this fact. His first concern may be with the technical capabilities of the management organization; whether or not it includes engineers or technical experts who can determine the reasonableness of capital costs, the efficacy of a manufacturing process and the probable cost of production using that process. This does not mean that he will not also concern himself with the overall management organization, the chain of authority, the training and experience of key financial and sales personnel, as well as key technical personnel, for he is fully aware of the importance of a well-rounded management team.

The following outline of the evaluation process will place primary emphasis on the role of the engineer; however, as indicated above, this work will require the close cooperation and contributions of the economist and financial expert to produce a complete analysis. Because there can be a considerable range in practices and procedures in project evaluation, it is proposed that we examine the evaluation process from the standpoint of a developing country taking an ideal approach.

II Project Evaluation From the Standpoint of a Developing Country

Since any proposed industrial project must show evidence of economic, financial and technical soundness, the development of a viable project must begin with some form of feasibility study. The feasibility study is, therefore, a fundamental document in the project evaluation and approval process. The preliminary engineering contained in such studies must be adequate to show that the project is technically feasible and to form the basis from which a reasonably firm estimate of cost can be made. When combined with the results of economic, financial and other studies, it should constitute a clear-cut exposition of the reasons why, insofar as technical soundness, economic benefits and costs are concerned, the project is feasible.

A project can be considered technically sound if: (a) all pertinent technical aspects of the project have been taken into account in the analysis, (b) the planned construction or procurement conform to accepted engineering standards and practice, and (c) the estimated cost of the project is as low as any other reasonably available alternate which would produce the intended results.

The preliminary engineering plans should extend only as far as will give reasonable assurance that all foreseeable, excessively costly and time-consuming factors which may occur in the course of final design and construction have been eliminated. They should include:

(a) Preliminary investigations and surveys sufficient to identify all significant problems, establish the location, and fix those general criteria and standards of construction which will have a major effect on the final cost.

(b) A justification for the specific location, criteria and standards recommended, as compared with available alternatives.

(c) Preliminary designs in sufficient detail to permit a reasonably accurate estimate of work and equipment quantities and qualities.

(d) An analysis of the required construction and erection operations in sufficient detail to provide a sound basis for the cost estimate.

The preliminary cost estimate referred to in the preceding paragraph, as in the case of the preliminary engineering plans and designs, should be carried only to a point which will insure that all significant factors which will determine the total cost of the project have been taken into account. Construction in developing countries is subject to unforeseen delays and built-in impediments due to local customs, laws and regulations which affect the cost materially. All such contingencies should be evaluated as completely as possible, but to the extent that their probable effect on the project cost cannot be firmly established, they must be provided for in a contingency item. In addition to the cost of construction and equipment, the cost estimate should include the costs of working capital, final engineering, design, and supervision of construction, and any other costs for services in connection with management and training activities to be performed during construction and initial operation of the facility.

A major factor in judging the economic and technical soundness of a project is the completeness of the planning with respect to management and organization for operation and maintenance after completion of construction. With competent management a project may be successful despite inadequacies in the original concept. But no project, however, well conceived, can overcome the handicap of poor management. On the other hand no manager, however competent or experienced, can succeed without the necessary personnel, equipment and materials required for effective operation and maintenance. The feasibility study must show that these matters have been given thorough consideration.

If the project is of the public works type, to be operated by a government department or ministry, the feasibility study should give a description of the departmental organization and strength, its budget, and its experience in managing projects of the type in question. In particular, it should bring out in detail the suitability and adequacy of the field organization for handling the operation and maintenance of the specific project, with particular reference to maintenance equipment and personnel.

Of equal importance with the management and organizational structure is the planning of the manpower, materials, and equipment requirements for successful operation of the project. Manning tables should be submitted, showing types and degrees of skill required for both the operating and maintenance functions. The availability of local manpower to fill all key positions must be explored, and plans must be presented for the procurement and

training of all personnel lacking, either as to numbers or skills. An adequate supply of special tools and equipment, and particularly of repair parts, must be foreseen and provided for. Where the operation is dependent upon an uninterrupted flow of some vital material, all possible causes of interruption to the flow must be thoroughly analyzed and guarded against.

Projects which involve advanced technology or are new to the area will usually require operation over an extended period under the direction of qualified contract personnel in key positions. The overall cost estimate for the project should include realistic estimates of the cost of implementing the plans for handling problems of management, personnel training and maintenance.

The engineering aspects of the evaluation process, including essential financial aspects, are treated in detail hereunder. Information required is itemized under each numbered heading.

1. Nature, Size and Location of the Project

   a. A general description of the project, showing the specific nature of intermediate and final products and the daily and annual production target.

   b. Details of the site, including area, building locations, geographical relationship to raw material sources and to principal markets, availability and position of transportation facilities such as harbors, dock facilities, highways, railways and airlines A scaled location map would be the ideal means for illustrating details of the site.

2. Funding of Project

   a. The estimated total cost of the project

   b. Amount, cost and source of funds to be supplied by the owner for foreign procurement and/or local procurement.

   c. Loan terms and amount of funds to be supplied by international lending agencies for foreign procurement and for local procurement.

d. Amount, terms and source of funds to be supplied by others for foreign and/or local procurement.

e. Extent to which the government will waive or defer payment of taxes or import duties affecting construction and operating costs.

f. Nature and amount of any subsidies allowed.

g. Currency control regulations and effective rate of exchange.

3. Estimated Capital Cost

This section should include the following costs, broken down into foreign and local currency requirements:

a. Land, right-of-way, water rights, etc.

b. Site preparation, buildings, infrastructure.

d. Equipment, including installation.

d. Engineering costs.

e. Contingencies.

4. Working Capital Requirements

a. Amount required at startup of plant and at the end of the first, second and third years of operation to cover payrolls, maintenance, raw materials, spare parts, auxiliary materials and supplies, goods in process, finished inventories, accounts receivable and cash on hand.

b. Sources and availability of local and foreign currency requirements.

c. Occurrence of seasonal peaks in working capital requirements and method proposed to meet such requirements.

5. Production Costs - Including Distributing and Selling

This section should include the following items broken down into local currency and foreign exchange costs when appropriate:

a. Estimated direct cost of producing each of the major products and any intermediate products, supported by detailed calculations.

b. Adopted wage rates and production factors used in the cost analysis, taking into account legal wage and salary scales, including all fringe benefits such as social security, vacation pay, medical allowances, separation allowances and travel pay.

c Provisions for personnel facilities such as transportation, housing, subsistence, recreation, medical care, etc.

d. Number of shifts and days of operation per year used in calculations, and basis for determination.

e. Government allowances taken into account such as exemption from or deferment of any taxes on products, and corporate or local taxes, and any special depreciation allowances for tax purposes.

f. Estimated cost of distributing and selling the products including advertising and administrative expense.

6. Profitability (Economic factors of vital interest to the engineer).

a. The proposed selling prices in domestic and export markets based on careful technical and economic studies.

b. Analysis of predicted profit and loss and forecast of earnings, receipts and expenditures.

c. Estimated level of production and sales at the break-even point.

d. Estimate of net annual foreign exchange earnings from exports, if any.

e. General conclusions as to commercial profitability of the enterprise, including percentage of returns on total investment and on owner's equity.

7. Design and Engineering

a. Plant layout, including storage facilities for raw materials, goods in process and finished products, tie-in with transportation systems, and provision for possible expansion

b. Number, types and sizes of principal buildings and structures.

c. Number, types and sizes of major equipment items, explanation of the function of each and justification of the units and processes selected (Avoid both obsolescent and experimental technology).

d. Auxiliary capital equipment, including standby units, spare parts, transport and materials handling units.

e. Process flow sheet.

f. Patents and licenses involved, if any.

g. Designed capacity and planned build-up of output after startup.

8. Utilities Requirements

a. Power availability, cost, and requirement in peak KW demand and annual KWH consumption. Compare relative advantage of purchasing as opposed to in-plant production. Illustrate electrical system by single line diagram covering major power uses.

b Fuel for heat, steam and plant processes.

c. Water availability, cost and requirement Discuss problems relative to water treatment and disposal of effluents; including any which may be noxious or dangerous

9. **Raw Materials**

a. Quantity, specifications, source and availability of raw and intermediate materials. Detail reserves as in the case of minerals.

b. Estimated costs, possible cost variations, custom duties if any, and details of any contracts or agreements for major raw materials and supplies

10 Engineering and Construction Plans

a. Plan for obtaining necessary engineering services for final design, preparation of specifications, preparation of bid documents, evaluating bids, awarding contracts, and supervising construction, including expediting, inspecting, testing and reporting.

b. Preliminary plans for all construction work in sufficient detail to permit calculation of work quantities.

c. Preliminary specifications for equipment and construction, defining those standards of quality which will have a significant effect on the cost of construction, with specific justification for any unusual standards adopted to conform with local conditions.

d. Manpower requirements and availability, including skilled and unskilled labor, technical and supervisory personnel, and local subcontractors

e. Local availability of cement, steel, aggregates, water for concrete, building stone, lumber and other construction materials.

f. Types of construction equipment required for the work, indicating what is available locally and what must be imported.

g. Allowance for climatic conditions, especially time and length of wet and dry seasons as they affect construction schedules, equipment use and maintenance.

h. General plan for construction and execution of project, including work to be done and materials and equipment to be supplied by the owner, the equipment suppliers and the construction contractor.

i. Proposed methods of obtaining bids and contracting for construction if work is not to be done by force account (Owners work force)

j. Provisions for performance bond and nature of performance tests on completed plant

k. Nature of equipment and production guarantees to be required.

l. Planned engineering, funding, and construction schedules.

11. Organization and Management of Operations

a. Description of organization that will manage the business and supervise its operation, accompanied by organization charts.

b. Experience record, number, and qualifications of management and technical personnel available.

c. Number, qualifications and availability of operating personnel required.

d. Plans for recruiting and training.

III Problems Frequently Encountered in the Evaluation Process

The preceding outline for project evaluation from the standpoint of a developing country would largely satisfy information requirements of an international lending agency. The engineer's task in a lending agency is made simpler and his contribution made more effective when the projects presented to it have been studied as thoroughly and prescribed as completely as the resources of the prospective borrower permit. It is with this thought in mind that the foregoing outline is presented. There is no dearth of projects for which capital is required. There is a dearth of good projects, sufficiently developed to be worth further study and ultimate financing.

It is the purpose of this section III, to bring out some problems in the evaluation process which an international lending agency frequently encounters and must be prepared to meet. Among these are the following hypothetical cases:

1. A government agency or private firm which is otherwise well staffed, may not have the experience or knowhow for preparation of a complete feasibility study in support of an application for a loan. Nevertheless, it submits to the lending agency a study and application which may be partially responsive to the agency's requirements, but leaves a number of questions unanswered. The lending agency has three alternatives, namely; (1) point out the deficiencies in detail and request the applicant to supply the needed information, (2) request the applicant to engage a competent consulting engineering firm to supply a complete feasibility study, and (3) provide loan funds for financing a complete feasibility study. Each of these three procedures has advantages and disadvantages in terms of cost, financing and time. The first alternative is often unsatisfactory because of the lengthy correspondence involved and the incompleteness of the information submitted. It can be justified if the applicant has a competent staff with experience in such matters, and the scope of work does not warrant the cost of employing a consulting engineer. Either of the other two alternatives would be satisfactory but they can be justified only if the proposed project appears to be basically sound and potentially desirable

2. A government agency or private firm is inadequately staffed or lacks experience in evaluation work but is convinced that a proposed industrial project is basically sound or essential to the economy. Accordingly, it makes preliminary inquiries to a lending agency. The latter's investigations bring out the fact that the services of an experienced consultant is needed for preparing a satisfactory feasibility study. The solution lies in the engagement of a competent consulting engineering firm by the applicant to make a complete feasibility study in support of a formal loan application.

3. A private firm makes preliminary studies and investigations of a possible industrial venture and on the basis of the information obtained, approaches an international lending agency for financial assistance. The latter's engineer makes a preliminary analysis of the material submitted and finds not only that it is inadequate to establish feasibility of the project but also discloses a basic weakness in the whole scheme which precludes any possibility of success. Under these circumstances the applicant is advised of the findings and the application for financial assistance is declined.

Wherever possible, a prospective borrower should arrange for early discussions with the financing agency to determine the best approach to an investigation of the feasibility of a proposed project; what skills and experience are required, what points are to be covered; etc.

IV. General Limitations of this Paper

As the title and focus of this paper have indicated, it is concerned primarily with project evaluation from an engineering standpoint.

It should also be recognized that project evaluation should be undertaken at the post-completion stage to assure that the project meets its stated objectives. This, of course, is covered by another agenda item and will not be discussed here.

Finally, this paper has been prepared from the viewpoint of a developed country lending agency. Where the lending agency is a developing country government agency or development bank, there is always the opportunity for obtaining from the United Nations or the developed countries, when appropriate, specialized assistance in the performance of the project evaluation function.

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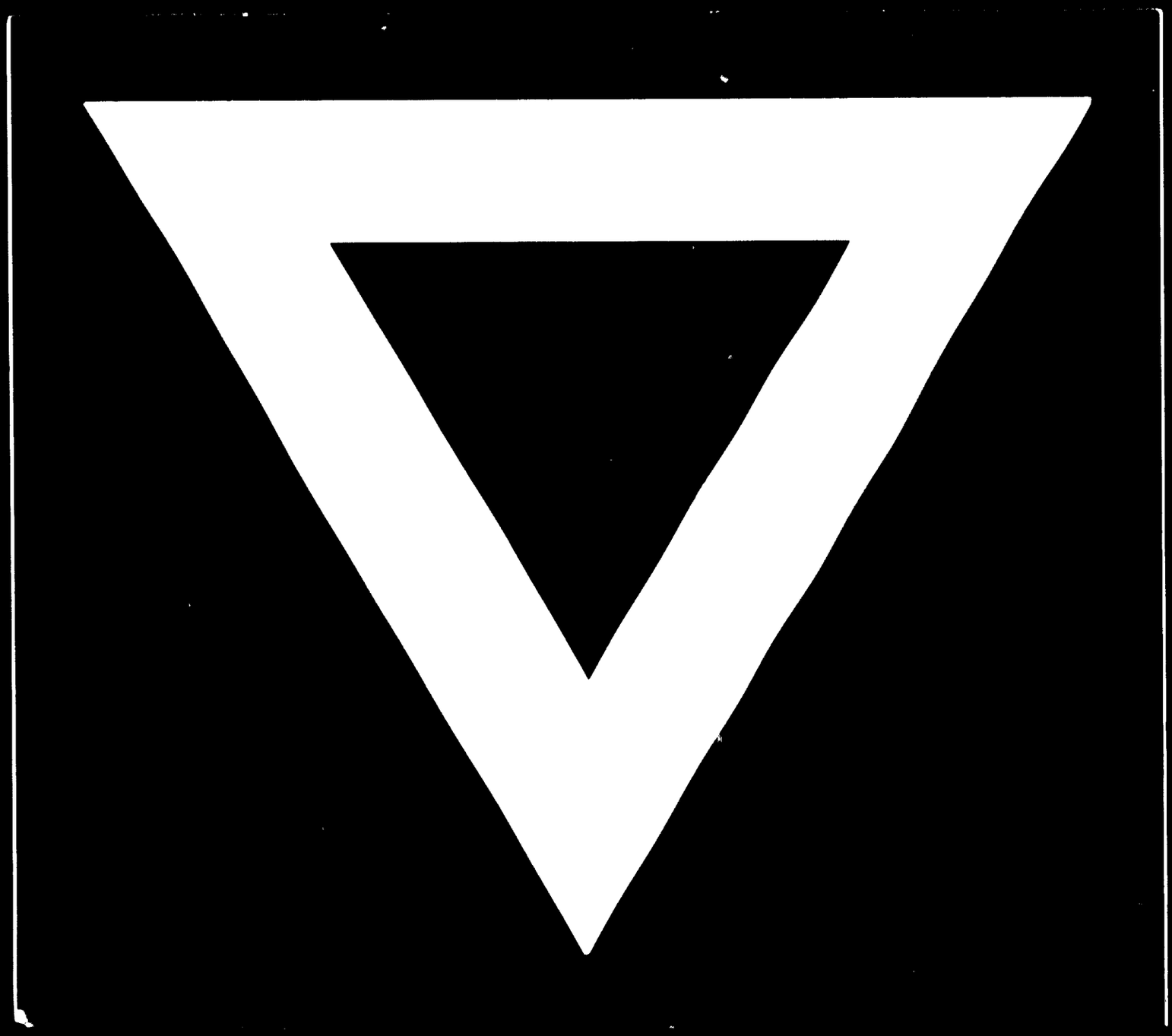

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