

ENGINEERING ECONOMICS**JGS 210-120-1-06E**

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1. SCOPE

- (1) This standard practice provides the economic evaluation procedure of feasibility study and design selection phases in refineries, petrochemical plants and similar plants.
- (2) This standard practice is intended to discuss the selection technique from mutually exclusive alternatives from the economic viewpoint.
- (3) Depreciation, tax and interest charge are not considered in this analysis phase.
- (4) Cost estimation methodology is outside the scope of this standard practice.

2. WORK PROCEDURE**2.1 Input to the Evaluation**

The data to be used for the economic evaluation should include the followings;

- (1) Fixed Capital Cost
- (2) Working Capital Cost
- (3) Revenue
- (4) Expense
- (5) Discount Rate, if necessary

2.2 Output from the Calculation

The output from the calculation for the economic evaluation should include the followings;

- (1) Evaluation Criteria, as required
 - Payback Period
 - Return on Investment
 - Discounted Payback Period
 - Net Present Value
 - Internal Rate of Return
- (2) Summary of Cash flow
- (3) Selected alternative from case study

2.3 Work Steps

The economic evaluation should be conducted as follows;

- (1) Selection of applicable criteria
- (2) Preparation of input data
- (3) Calculation of Cash flow and applicable criteria
- (4) Selection of economic alternative

2.4 Computer Programs

Computer programs, details of which are described in relevant manuals, available to assist economic study applying the discounted cash flow method are as follows:

System	: A493
Description	: Discounted Cash Flow Program

NPV or IRR can be obtained using functions in spread sheet type applications such as Lotus 1-2-3, or Microsoft Excel.

3. DESIGN

3.1 General

- (1) The basic concept of Engineering Economics is to consider cash flow as one of the principal elements affecting the profitability of the project.
- (2) It is important to estimate investment cost, revenues, and expenses by adequate estimation procedure and latest unit cost data.
- (3) If no unit cost data is available from clients, data in the case of similar plants should be used.

3.2 Evaluation Method

3.2.1 Calculation Formula

- (1) Calculation Formula of Applicable Criteria are summarized in Table-1.
- (2) Net Present Value method shall be applied in economic evaluation, unless specified by clients. Discount rate to be used for calculation shall be determined by clients. If discount rate is not specified by clients, apply 6-8% for the domestic project and 10-15% for the developing countries' project as discount rate.
- (3) Payback Period shall be useful for rough screening of modification or revamp project. It is also suggestive when cash flow from the investment is constant. Acceptable Payback Period is 2-3 years for rough screening of modification or revamp project.

Table-1 Calculation Formula of Applicable Criteria

Method	Criteria	Mathematical Formula	
		B_i : variable	B: constant
Undiscounted Method	Payback Period (PP)	$I - \sum_{i=1}^{PP} B_i = 0$	$PP = \frac{I}{B}$
	Return on Investment (ROI)	$ROI = \frac{B}{I}$	$ROI = \frac{B}{I}$
Discounted Method	Discounted Payback Period (DPP)	$I - \sum_{i=1}^{DPP} \frac{B_i}{(1+r)^i} = 0$	$DPP = \frac{\log \frac{B}{(B-rI)}}{\log(1+r)}$
	Net Present Value (NPV)	$NPV = -I + \sum_{i=1}^n \frac{B_i}{(1+r)^i}$	$NPV = -I + B \times \frac{(1+r)^n - 1}{r(1+r)^n}$
	Internal Rate of Return (IRR)	$0 = -I + \sum_{i=1}^n \frac{B_i}{(1+IRR)^i}$	$0 = -I + B \times \frac{(1+IRR)^n - 1}{IRR(1+IRR)^n}$

Note : See chapter 5 for abbreviations.

3.2.2 Evaluation Criteria

(1) Evaluation Criteria are summarized in Table-2.

Table-2 Summary of Evaluation Criteria

Method	Criteria	Evaluation Criteria	Note
Undiscounted Method	Payback Period (PP)	$PP < \text{Acceptable PP}$	Acceptable PP : 2~3 years for modification or revamp project
	Return on Investment (ROI)	$ROI > \text{Acceptable ROI}$	Not adequate criteria for engineering economics
Discounted Method	Discounted Payback Period (DPP)	$DPP < \text{Acceptable DPP}$	Acceptable DPP: 3~5 years for modification or revamp project
	Net Present Value (NPV)	$NPV > 0$	Discount Rate: - 6-8% for the domestic project - 10-15% for the developing countries' project
	Internal Rate of Return (IRR)	$IRR > \text{Acceptable IRR}$	Acceptable IRR(Cut-off Rate): - 6-8% for the domestic project - 10-15% for the developing countries' project

3.3 Investment Cost

3.3.1 Fixed Capital Cost

The fixed capital is the capital required to provide all the facilities needed for a project regardless of how remote they might be from manufacturing operations. The latest data shall be collected to estimate fixed capital costs, as price level of equipment and bulk material fluctuates widely. Fixed capital cost item should be estimated based on the FWBS code.

Factors which have large effects on major equipment cost are shown in Table-3.

Table-3 Cost Affecting Factors in Major Equipment

Equipment Category	Tower	Vessel	Heat exchanger	Tank
Factors	Shell material	Shell material	TEAM Type	Type
	Diameter	Diameter	Shell material	Shell material
	Height	Length	Tube material	Capacity
	Tray number or packing volume	Design pressure	Heat transfer area	
	Design pressure	Design temperature	Design pressure	
	Design temperature		Design temperature	

Equipment Category	Furnace	Stack	Pump	Compressor
Factors	Tube material	Material	Type	Type
	Heat absorption	Diameter	Capacity	Capacity
	Design pressure	Height	Material	Material
	Design temperature		Head	Suction pressure
			Design temperature	Discharge pressure
				Inlet temperature

3.3.2 Working Capital Cost

Working capital is the capital frozen in the project that will be recovered in full at the end of the project.

Working capital costs include the following items.

- (1) Raw materials for plant start-up
- (2) Raw materials, intermediate and finished-product inventories

3.4 Revenue

Revenues include the following items.

- (1) Increased production
- (2) Quality improvement

3.5 Expense**3.5.1 Operating Cost**

The operating costs are the costs required to produce final products and which occur annually. Operating costs include the following items.

- (1) Raw materials costs
- (2) Utilities costs
- (3) Labor costs
- (4) Maintenance costs
- (5) Fixed overhead costs

The purpose of the investment in revamp or modification project is to reduce operating costs such as utilities cost and maintenance cost.

The utilities cost can vary widely with location, with the size of the service required, with the national and local economy, and even with the season. Utilities must be examined closely on a local basis, especially if they form a major part of operating costs. Order of magnitude for each utility cost is shown in APPENDIX-1. Order of magnitude for the maintenance cost in a petroleum refinery is about 5% of the investment per year.

3.6 Sensitivity Analysis

Whatever method or combination of methods is used, projections necessarily involve various assumptions and probabilities. The objective of sensitivity analysis is to determine their impact on the various cash flow items. In making sensitivity analysis, it is common to measure the effect of a single change in the range of 20% to 30%.

3.7 Data Sources

The following data sources are available for cost estimation.

Investment Cost

- (1) Syoki-Keikaku Cost Data Syuu, 1992, Project Gourika Iinkai

Raw Materials and Utilities Cost

- (1) World Petrochemicals Price Update, SRI International, Tokyo
- (2) PEP Yearbook International, SRI International, Tokyo
- (3) Petroleum Times Energy Report, Nexus Media Ltd., England
- (4) IEA Oil Market Report, Denryoku Shinposya, Tokyo
- (5) Oil & Gas Journal, A Pennwell Publication, Oklahoma