

CHAPTER V

ECONOMIC EVALUATION

Economic evaluation evaluate the projects or alternatives meeting the company's profit target or not. It shows the net profit which is the sale revenue subtracted by the total costs--including fixed and variable costs--, depreciation, and taxes [19].

1. Fixed costs (do not depend on the production rate) include

- Capital costs
- Routine maintenance
- Overhead (safety, service, laboratories, personal facilities, administrative services, etc.)
- Local taxes
- Labor
- Insurance, etc.

2. Variable costs (depend on the production rate) include

- Raw materials
- Chemical and catalysts consumed in manufacturing other than raw materials
- Utilities (fuel, steam, electricity, cooling water, process water, compressed air, inert gases, etc.)
- Maintenance costs incurred by operation
- Royalties
- Transport costs
- Quality control, etc.

The total costs include all of the fixed and variable costs for the new design case. But, this work, the debottlenecking case, is the modification

of the existing process to handle higher capacity; thus, the total costs refer to the incremental or marginal costs [24]. They consist of two main parts:

1. Marginal fixed cost is
 - Capital costs
2. Marginal variable costs include
 - Raw materials
 - Utilities (fuel, steam, electricity, etc.)



The other items exclude in the marginal costs because they are fixed. For example, the overhead, maintenance, and insurance costs paid for the higher capacity equal for the existing capacity. The case study unit, topping unit, is not the reaction process; thus, the chemical and catalyst costs are discarded.

Marginal Fixed Costs

To estimate the marginal fixed (or capital) cost, the capital cost must be divided into direct cost, indirect cost, and contingency.

A) Direct cost

- Procurement (P) include
 1. Purchased equipment
 2. Piping (15% of 1)
 3. Instrument and electrical (15% of 1)
 4. Others (15% of 1)
- Engineer and supervision (20% of A)
- Construction (30% of A)

B) Indirect cost (20% of A)

C) Contingency (20% of (A+B))

Start at (1) the purchased cost of equipment which is the accumulative cost of the main equipment in debottlenecking. The main equipment include distillation column, heat exchanger for heating or cooling, furnace, and pump. Those costs are shown as follows:

Distillation column costs have two costs:

- Expanding in height equals 4 k\$/m.
- Packing cost equates 3.09 k\$/cu.m. (based on 2 inch Pall Rings (stainless steel)) [25]

Heat exchanger cost[26] estimates from

$$\bullet \text{ Cost}(\$) = (30,800 + 750A^{0.81}) \left(\frac{CI_{1994}}{CI_{1992}} \right)$$

Furnace cost[20] estimates from

$$\bullet \text{ Cost}(\$) = (5.52 \times 10^3) Q^{0.85} (2.27) \left(\frac{CI_{1994}}{CI_{1989}} \right)$$

| | | | | |
|---|------|------|------|------|
| A = shell/tube exchanger area (m ²) (carbon steel) | | | | |
| CI = Marshall & Swift Equipment Cost Index [27] | | | | |
| Year | 1969 | 1979 | 1992 | 1994 |
| CI | 280 | 569 | 943 | 1048 |
| Q = absorbed duty (MBtu/h), 20 < Q < 30 1 Watt = 3.412 Btu/h | | | | |

Pump cost estimates from the pump-cost curve [28]

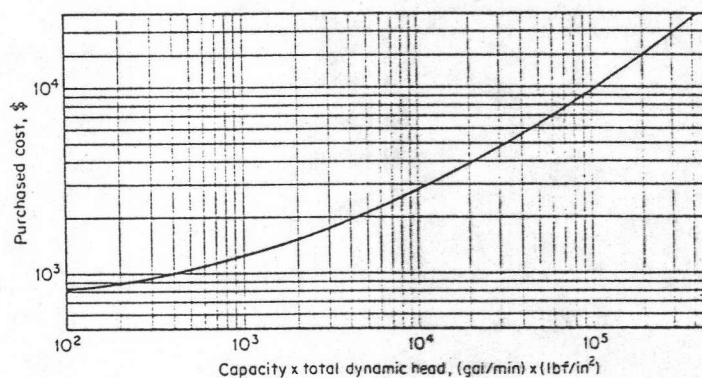


Figure 5.1 Pump-cost curve [28]

Because of the lack of local costs, the purchased costs based on the published data are chosen to evaluate this work. After accumulate those purchased costs, the other costs can be calculate from the percentage of their costs to the total purchased cost (1). For instance, the piping equals 15% of 1 as the same as instrument and electrical and others. The procurement cost (P) is the sum of 1,2,3 and 4. The direct cost is the sum of procurement, engineer and supervision, and construction costs. Similarly, the total cost is the sum of (A) direct cost , (B) indirect cost, and (C) contingency. Those percentages are recommended from the BCP's experts who have the experience of plant modification. For example, the engineer and construction costs are very high to 50% of A because the debottlenecking requires many workers to modify the existing unit, but add only a little of new equipment.

Marginal Variable Costs

To estimate the marginal variable costs, the raw materials and marginal expenses (mainly, utilities) are accumulated. Unfortunately, those costs varied with time are difficult to estimate accurately. However, this estimation can be simplified by two factors:

1. Gross margin equals 2.7 US\$/BBL (is the product sale minus the raw material (crude) cost)
2. Marginal expenses equal 0.5 US\$/BBL (with 4% inflation/year)

Those values are used to plan the BCP's budgets for the next 15 years.

Depreciation and Taxes

Depreciation is the decrease in the value of property with time, since it can be considered from a cost viewpoint, and can be subtracted from the revenue. To calculate the depreciation, the service life of the property and the calculating method must be determined. For this work, the service life is 15 years, and the straight-line method is used with zero salvage value.

Tax is levied to supply funds to meet the public needs of a government; thus, it likes a cost which must subtract from revenue. For this work, the tax is refer to the income tax based on gross earnings, which subtract the fixed (exclude the capital costs) and variable costs and depreciation from the revenue.

Economic Indexes

Economic indexes usually used to evaluate projects consist of three indexes: payback period, net present value (NPV), and discount cash-flow rate of return (or internal rate of return; IRR).

1. **Payback period** is the time required to recover the capital costs[29]--called the break-even point which equates the accumulative cash flows to the total costs.
2. **NPV** is the sum of the present values of each individual cash flow, shown in Figure 5.2.
3. **IRR** is the discount rate which equates the total of discounted (to the present value) annual profits to the capital costs, shown in Figure 5.3. It means the project profit rate, and must not be less than the company's profit target rate--called the hurdle rate which consists of the Bank interest rate and the inflation rate. If IRR is less than the hurdle rate (15 % in this work), the project is rejected because the Bank interest profit is higher than this project profit[29]. Therefore, IRR indicates the investment efficiency by comparing with the Bank interest rate.

To compare between NPV and IRR[19], NPV measures profit but does not indicate how efficiently capital is being used. In contrast, IRR measures the investment efficiency but gives no indication of how large the profits will be.

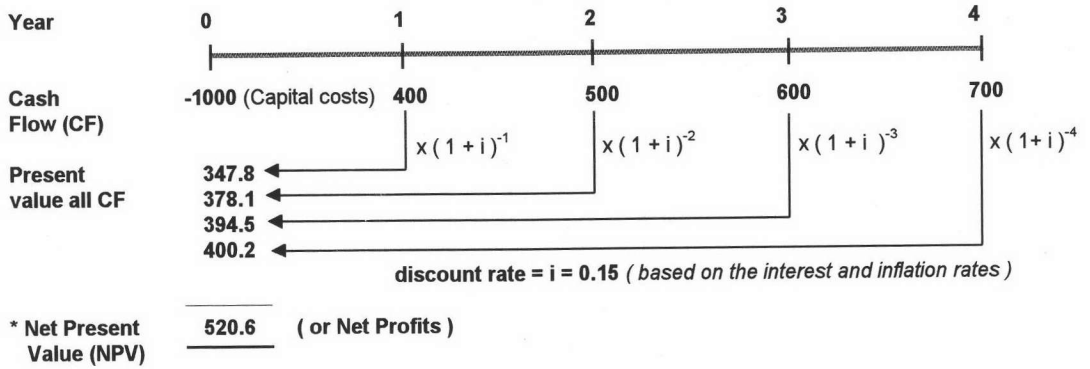


Figure 5.2 Net Present Value (NPV)

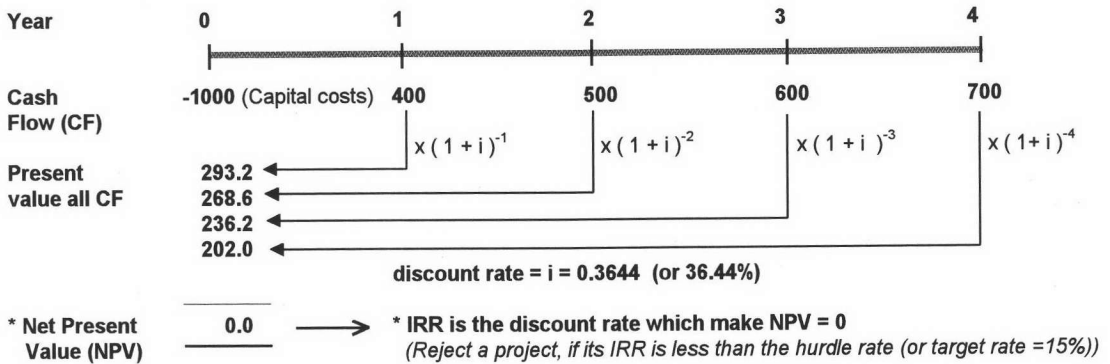


Figure 5.3 Internal Rate of Return (IRR)

Summarize the basis of this debottlenecking project shown as follows:

1. Project life 15 years
2. Operating days per year 340 days
3. Gross margin 2.7 US\$/BBL
4. Marginal expense (mainly, Utilities) 0.5 US\$/BBL with 4% inflation/year
5. Income tax 35 % of gross earnings
6. Capital cost estimation based on the published data