GCE 321: PART I ENGINEERING ECONOMICS

COURSE SYNOPSIS

1. What is Engineering economy?
2. Interest formulae
3. Cash flow, present worth, Discounting and Cost-benefit analysis
4. Cost-Volume-Profit (C-V-P) or Break-even analyses
5. Risk Analysis
6. Engineering economy in water resources development projects

1.0 Basic Concepts of Engineering Economy

Definition: Engineering economy is the application of economic techniques to the evaluation of design and engineering alternative. The role of engineering economics is to assess the appropriateness of a given project, estimate its value, and justify it from an engineering stand point or point of view.

Steps in economic analysis as a problem solving process.

(1) Formulation of the problem

(2) Analysis of the problem

(3) Search for alternative solutions to the problem

(4) Selection of the preference solution

(5) Specification of the preferred solution

- **Formulation of the problem**: Involves establishment of its boundaries starting from the original state to the desired state.

- **Analysis of the problem**: Detailed phrasing of the characteristics of the problem including restriction and criteria to be used in evaluating the alternatives (fact gathering is involved)

- **Search for alternative solutions to the problem**: Involves the use of engineering creativity in developing feasible solutions to the design problem.

- **Selection of the preferred solution**: measurement of the alternatives using the appropriate criteria.

- **Specification of the preferred solution**: consists of a detailed description of the solution to be implemented. Prediction of the performance characteristics of the solution to the problem are included in the specification

2.0 Interest Calculations

Interest is the money paid (fee that is charged) for the use of borrowed money or the return on invested capital. The size of the fee will depend upon the total amount of money borrowed and the length of time over which it is borrowed. The economic cost of construction, installation, ownership, or operation can be estimated correctly only by including a factor for the economic cost of money. i.e interest is the factor.

Example: An engineer wishes to borrow N20 000 in order to start his own business. A bank will lend him the money provided he agrees to repay N920 per month for two years. How much interest is he being charged?

Solution: The total amount of money that will be paid to the bank is 24 x N920 = N22 080. Since the original loan is only N20 000, the amount of interest is N22 080 - N20 000 = N2080.

Whenever money is borrowed or invested, one party acts as the lender and another party as the borrower. The lender is the owner of the money, and the borrower pays interest to the lender for the use of the lender's money. For example, when money is deposited in a savings account, the depositor is the lender and the bank is the borrower. The bank therefore pays interest for the use of the depositor's money. (The bank will then assume the role of the lender, by loaning this money to another borrower, at a higher interest rate).

2.1 Interest Rate

If a given amount of money is borrowed for a specified period of time (typically, one year), a certain percentage of the money is charged as interest. This percentage is called the interest rate.

Example (a) A student deposits N1000 in a savings account that pays interest at the rate of 6% per year. How much money will the student have after one year?

(b) An investor makes a loan of N5000, to be repaid in one lump sum at the end of one year. What annual interest rate corresponds to a lump-sum payment of N5425?

Solution

(a) The student will have his original N1000, plus an interest payment of 0.06 x N1000 = N60. Thus, the student

will have accumulated a total of N1060 after one year. (Notice that the interest rate is expressed as a decimal when carrying out the calculation.)

(b) The total amount of interest paid is N5425 - N5000 = N425. Hence the annual interest rate is

$$\frac{N425}{N5000} \times 100 = 8.5\%$$

Interest rates are usually influenced by the prevailing economic conditions, as well as the degree of risk associated with each particular loan.

2.2 Simple Interest: Simple interest is defined as a fixed percentage of the principal (the amount of money borrowed), multiplied by the life of the loan. This is given as

$F(1) = P+(P)(i) = P(1+i)$ i.e for one year

and

$F(N) = P + (N)(P)(i) = P(1+Ni)$ i.e for N years (1)

Where P = Present sum of money, F = Future sum of money

N = Number of interest periods, i=interest rate per period (%)

F(N) = Future sum of money after N periods

Example

If you have a sum of N 100 at 10 percent interest rate per year for 5 years yields

Using equation (1) we have

$F(5)=100[1+(5)(0.1)]$

$=100(1.5)$

$= N 150$

2.2 Compound interest

When interest is compounded, the total time period is subdivided into several interest periods (e.g., one year, three months, one month). Interest is credited at the end of each interest period, and is allowed to accumulate from one interest period to the next. During a given interest period, the current interest is determined as a percentage of the total amount owed (i.e., the principal plus the previously accumulated interest).

$F(1) = P + (P)(i) = P(1+i)$

It is the same as simple interest

$F(2) = F(1) + F(1)(i)$

Interest is applied to the new sum

$F(2) = (F)(1)(1+i) = P(1+i)^2$

$F(3) = F(2)(1+i) = P(1+i)^3$

and by mathematical induction,

$F(N) = P(1+i)^N$ (2)

Example

If you have N 100 at 10 percent interest rate per year for 5 years yields

$F(5) = 100(1+0.1)^5$

$= 100(1.1)^5$

= N 161.05

Which is over 7% greater than with simple interest

Example

In 1970 Daniel Company bought a workshop from Adedayo Company for N 50,000 at an average interest rate of 10 percent. What will be the present value in 2015 if both simple and compound interest approaches?

Solution

Given data

P= N 50,000 i=6%

N= 2015 – 1970 = 45 years

Simple interest (equation 1)

F(N) = P(1+Ni)

= 50,000 (1+45*0.06) = N 185,000

Compound interest (equation 2)

$F(N) = P(1+i)^N$

$= 50{,}000(1+0.06)^{45}$ = N688,231

The Time Value of Money

Time value of money is defined as the time dependent value of money stemming both from changes in the purchasing power of money (inflation or deflation) and from the real earning potential of alternative investments over time.

Since money has the ability to earn interest, its value increases with time. For instance, N100 today is equivalent to

$$F = N100\ (1+ 0.07)^5 = N140.26$$

five years from now if the interest rate is 7% per year, compounded annually. We say that the future worth of N100 is N140.26 if i = 7% (per year) and n = 5 (years). Since money increases in value as we move from the present to the future, it must decrease in value as we move from the future to the present. Thus, the present worth of N140.26 is N100 if i = 7% (per year) and n = 5 (years).

Example: A student who will inherit N5000 in three years has a savings account that pays 5% per year, compounded annually. What is the present worth of the student's inheritance?

$$P = \frac{F}{(1+i)^n} = \frac{N5000}{(1+0.05)^3} = N4319.19$$

The present worth of N5000 is N4319.19 if i = 5%, compounded annually, and n = 3.

Inflation

National economies frequently experience inflation, in which the cost of goods and services increases from one year to the next. Normally, inflationary increases are expressed in terms of percentages which are compounded annually. Thus, if the present cost of a commodity is PC, its future cost, FC, will be

$$FC = PC\ (l + A)^n \qquad (1.4)$$

where A = annual inflation rate (expressed as a decimal)

n = number of years

Example: An economy is experiencing inflation at the rate of 6% per year. An item presently costs N100. If the 6% inflation rate continues, what will be the price of this item in five years?

By (1.4), FC = N100 (1+ 0.06)' = N133.82.

In an inflationary economy, the value (buying power) of money decreases as costs increase.

$$F = \frac{P}{(1+A)^n} \qquad (1.5)$$

where F is the future worth, measured in today's naira, of a present amount P.

Example: An economy is experiencing inflation at an annual rate of 6%. If this continues, what will N100 be worth five years from now, in terms of today's naira?

From (1.5),

$$F = \frac{N100}{(1+0.06)^5} = N74.73$$

Thus N100 in five years will be worth only N74.73 in terms of today's dollars. Stated differently, in five years N100 will be required to purchase the same commodity that can now be purchased for N74.73.

2.3 Discounting

The inverse of compounding is determination of a present amount which will yield a specified future sum. This process is referred to as discounting. The equation for discounting is found readily by using the compounding equation to solve for P in terms of F.

$$P=F(1+i)^{-N} \qquad (3)$$

Example

What present sum will yield N1000 in 5 year at 10 percent?

Using equation (3)

$P = F(1+i)^{-N}$

$=1000(1+0.1)^{-5}$

$= 1000(0.62092) =$ N620.92

3.0 Cash-Flow-Concept

3.1 Definition: A cash flow is the difference between total cash receipts (inflows) and total cash disbursements (outflows) for a given period of time (typically, one year). Cash flows are very important in engineering economics because they form the basis for evaluating projects, equipment, and investment alternatives.

The easiest way to visualize a cash flow is through a cash flow diagram, in which the individual cash flows are represented as vertical arrows along a horizontal time scale. Positive cash flows (net inflows) are represented by upward-pointing arrows, and negative cash flows (net outflows) by downward-pointing arrows; the length of an arrow is proportional to the magnitude of the corresponding cash flow. Each cash flow is assumed to occur at the end of the respective time period.

3.2 Cash-Flow Diagrams

The easiest way to approach problems in economic analysis is to draw a picture. The picture should show three things:

1. A time interval divided into an appropriate number of equal periods
2. All cash outflows (withdrawals, expenditures etc.) in each period
3. All cash inflows (deposits, income, etc) for each period

Figure 1 is a cash-flow diagram showing an outflow or disbursement of N1,000 at the beginning of year 1 and an inflow or return of N2,000 at the end of year 5.

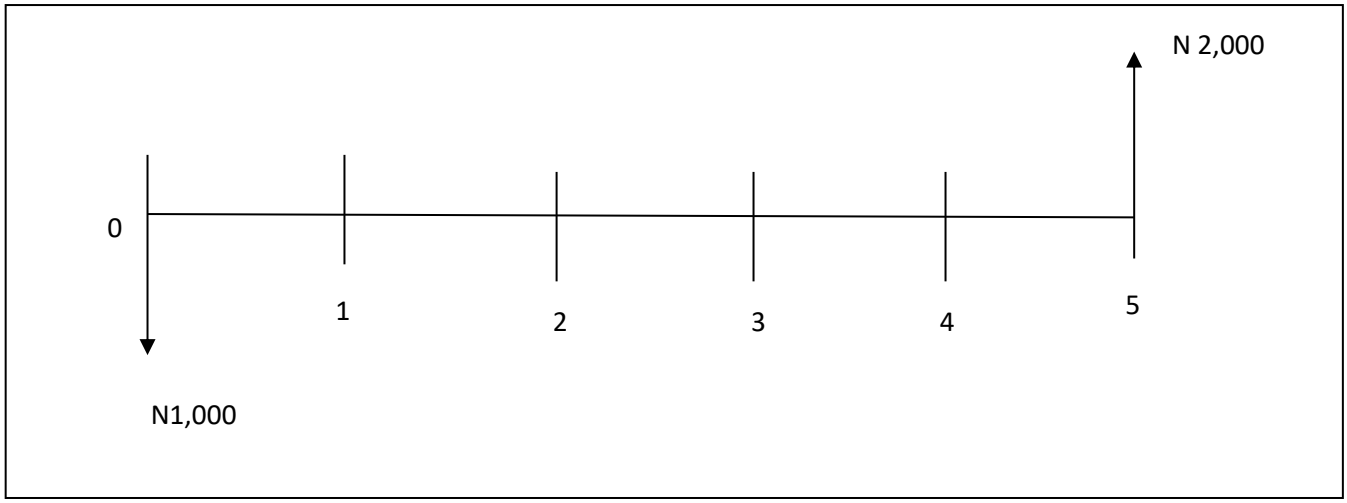

Figure 1 Cash-flow diagram

3.3 Benefit-Cost Analysis

Benefit-cost analysis, also referred to as cost-benefit analysis, is a method of comparison in which the consequences of an investment are evaluated in monetary terms and divided into the separate categories of benefits and costs. The amounts are then converted to annual equivalents or present worth for comparison. The important steps of a benefit-cost analysis are:

1. Identification of relevant benefits and costs

2. Measurement of these benefits and costs
3. Selection of the best alternative
4. Treatment of uncertainty

3.4 Present Worth

Present worth is the value found by discounting future cash flows to the present or base time.

4.0 Cost- Volume- Profit (C-V-P)

Cost – Volume – Profit (CVP) analysis is an analytical technique for studying the relationship between volume, costs (fix and variable), prices and profits. It is a device used to determine the sales volume required to achieve a specified profit level. usefulness of the profit planning process of the firm.

CVP is useful in the following

- It helps to determine the minimum sale volume to avoid loss and the sales volume that can produce profit.
- It helps management to seek the most profitable combination of cost and volumes.
- It is used to predict and evaluate the implication of short- decisions about fixed costs, variable costs, volume, selling price for the profit plan on a continuous basis.

4.2 Assumptions for Cost-Volume-Profit (C-V-P) analysis

(1) All costs can be resolved into fixed and variable elements

(2) Fixed cost will remain constant and variable costs varies proportionately with activity

(3) Costs and revenues behave in a linear fashion over the activity range being considered.

(4) That the only factor affecting costs and revenues is volume

(5) Technology, production methods and efficiency remain unchanged

(6) The analysis relates to one product only or to a constant product mix.

(7) Stocks are valued at marginal costs without stock level charges

4.3 Break – Even – Analysis

Break –even analysis is a specific way of presenting and studying the inter-relationship between costs, volume and profit. Break-Even Analysis is a subset of C-V-P analysis which focuses on how selling price, sales volume, variable costs, fixed costs and the mix of product sold affects profit. The usefulness of Break-Even-Analysis are stated as follows:

- It provides information to management in most lucid & precise manner.
- It is an effective and efficient reporting system
- Establishes a relationship between revenues and cost with respect to volume
- It indicates the level of sales at which costs and revenues are in equilibrium.

4.4 Analysis

$$\begin{matrix} Sales Volume \\ (to\ earn\ desired\ \ profit) \end{matrix} = \frac{Fixed\ \cos t(FC) - Desired\ \Pr ofit}{\Pr ice\ to\ volume(p/v)\ or\ Contribution\ ratio}$$

$$= \frac{FC + \dfrac{Desired\ after\ tax\ profit}{1 - tax\ rate}}{Contribution\ ratio(p/v)}$$

Profit margin = P/V ratio x margin of safety ratio

$$\text{P/V ratio} = \frac{\Pr ofit\ \ m\arg in}{m\arg in\ of\ \ safety\ ratio} \quad \text{or} \quad 1 - \frac{Variable Cost}{Sales}$$

$$\text{Margin of safety ratio} = \frac{\Pr ofit\ \ m\arg in}{(p/v)\ ratio}$$

Note: p/v ratio = Profit volume ratio

4.5 Limitations of Cost – Volume - Profit or Break - Even - Analysis

1. It is difficult to separate costs into fixed and variable costs

2. It is not correct to assume that fixed cost would remain unchanged over the entire activity period.

3. The assumptions of constant selling price and unit variable costs is not valid.

4. It is difficult to use break-even analysis for multipurpose firm

5. The break-even analysis is short run concept and has limited use for long term range planning

6. The break-even analysis is a static tool

7. Some costs are difficult to determine e.g. depreciation (methods of calculating it)

8. Some costs mixed, semi fixed, semi-variable are difficult to separate

Example

QUESTION 1

A firm has the following budget data for the year ending, 31, December, 2017

Budgeted sales		-	500,000
Budgeted variable costs	-	-	300,000
Budgeted fixed costs	-	100,000	
Margin of safety	-	100,000	

(i) Calculate the BEP (ii) What is the profit volume (P/V) ratio?

(iii) Suppose the firm wants to earn an after-tax profit of 54,000 and that the income tax rate is 30%, what will be the sales volume?

Solution

(i) $$BEP = \frac{margin\ of\ safety}{1 - \frac{budgeted\ variable\ cost}{budgeted\ sales}}$$ or $$BEP = \frac{Fixed\ Cost}{(p/v)\ ratio}$$

$$BEP = \frac{100,000}{1 - \frac{300,000}{500,000}} = 250,000$$

(ii) profit volume ratio $= \frac{Profit\ margin}{Margin\ of\ safety\ ratio}$

$$= 1 - \frac{Variable\ Cost}{Sales}$$

$$= 1 - \frac{300}{500} = 0.4$$

(iii) Sales volume $= \frac{margin\ of\ safety + \frac{after\ tax\ profit}{1 - tax\ rate}}{p/v\ or\ contribution\ ratio}$

$$= \frac{100,000 + \frac{54,000}{1 - 0.30}}{0.4} = 442,857$$

Assignment 1

QUESTION

The following information is extracted from the book of a Manufacturing company by a financial analysis:

Sales	-	1,000.000
Variable costs	-	800,000
Fixed costs	-	100,000

Compute: (a) P/V ratio

(b) BEP

(c) If fixed cost (FC) is increased by 10000 with variable costs and sales constant.

Calculate the new BEP?

5.0 RISK ANALYSIS

Definition: Risk analysis can be defined as the process of developing probability distributions for some measure of merit for an investment proposal. Risk exists because of the inability of the decision maker to make perfect forecasts since future event which they depend on is uncertain.

In investment evaluation, since we cannot anticipate the occurrence of the possible future events with certainty and consequently cannot make any correct prediction about the cash flow sequence.

Factors that can lead to uncertainty

- Economic conditions (internal and external),
- Business activities,
- Political situation,
- Government monetary and fiscal policies,
- Social conditions,
- Industrial relations,
- Change in material costs,
- Change in management in the company,
- Natural disaster such as flood, fire etc.

Risk associated with a project may be defined as the variability that is likely to occur in the future returns from the project e.g. purchasing a share in the company, can't product be demanded in return?

The most common measure of risk is standard deviation and coefficient of variation including normal distribution and beta distribution

Techniques to Handle Risk

(1) Payback Period

Very simple way, it focuses attention on the near term future and emphasis on liquidity of the firm through recovery of capital. It also favours short term project over a riskier long term project.

(2) Risk Adjusted Discount Rate;

The preference for money is estimated by discounting future cash flows at some risk free rate to show present value, to allow for this risk, "a risk premium rate" is added to the risk free discount rate. The adjusted discount rate is expressed as:

Net present value (NPV) = $\sum_{t=1}^{n} \frac{A_t}{(1+k)^t}$

where

k = risk adjusted discount rate ($i+\phi$) and can be varied at will

i= risk free rate

ϕ = risk premium

NB: A high rate for riskier project and lower rate for less risky one.

Advantages

1. appeal to risk average business man
2. attitude towards uncertainly

Disadvantages

1. The risk adjusted discount rate is difficult to derive
2. It assumes that investors are risk – average

(3) Statistical techniques to handle risk

(a) Probability Distributions;

Is a measure of someone's opinion about the likelihood that an event will occur. If an event is certain to occur its probability is 1, if it is not likely or certain not to occur, the probability is zero therefore, all probability of an event occurring or not is between zero and one. The most method commonly used is the normal distribution and beta distribution.

The monetary value is obtained from:

$$\overline{A}_t = \sum_{j}^{n} A_{ji} P_{ji}$$

where A_t = expected cash flow or return for a period

A_{ji} = the cash flow for the j^{th} event in time period t

P_{ji} = the probability of the cash flow for j^{th} event in time period t

N.B: The project with highest monetary value is preferred.

Example 1

Calculate the expected monetary value for each of the project x, y given the possible cash flows of the project and their associated probabilities as shown below for one year time period. Which project is preferable?

Possible event	Project X		Project Y	
	Cash flow (CF)	Probability	Cash flow (CF)	Probability
A	4000	0.10	12,000	0.1
B	5000	0.20	10,000	0.15
C	6000	0.40	8,000	0.50
D	7000	0.20	6,000	0.15
E	8000	0.10	4,000	0.10

Solution

Possible event (n)	Project X			Project Y		
	C.F (Aji)	(Pji)	Expected value Aji * Pji	C.F (Aji)	(Pji)	Expected value Aji * Pji
A	4000	0.10	400	12,000	0.1	1200
B	5000	0.20	1000	10,000	0.15	1500
C	6000	0.40	2400	8,000	0.50	4000
D	7000	0.20	1400	6,000	0.15	900
E	8000	0.10	800	4,000	0.10	400
		Total	6000		Total	8000

Project Y has a higher monetary value, therefore is preferable

(b) Standard Deviation

Standard deviation is an absolute measure of risk. It measures the deviation and variance about the expected cash flow of each of the possible cash flows. The result can be used to decide the level of risk.

N.B: The project with highest value of standard deviation has high risk.

Standard deviation $$\sigma = \sqrt{\sum_{j=1}^{n} \left(A_{ji} - \overline{A}_t\right)^2 P_{ji}}$$

Example 2

Consider the data given in Example 1. Calculate the standard deviation for the cash flow for project X and Y. Determine the project with high risk?

Possible event	Project X		Project Y	
	Cash flow (CF) (Aji)	Probability	Cash flow (CF) (Aji)	Probability
A	4000	0.10	12,000	0.1
B	5000	0.20	10,000	0.15
C	6000	0.40	8,000	0.50
D	7000	0.20	6,000	0.15

E	8000	0.10	4,000	0.10
Mean value ($\overline{A_t}$)	6000		8000	

Solution

(Calculation of Standard Deviation)

Project X			Project Y		
$(A_{ji} - \overline{A_t})$	$(A_{ji} - \overline{A_t})^2$	$(A_{ji} - \overline{A_t})^2 * P_{ji}$	$(A_{ji} - \overline{A_t})$	$(A_{ji} - \overline{A_t})^2$	$(A_{ji} - \overline{A_t})^2 * P_{ji}$
-2000	4000000	400000	4000	16000000	1600000
-1000	1000000	200000	2000	4000000	600000
0	0	0	0	0	0
1000	1000000	200000	-2000	4000000	600000
2000	4000000	400000	-4000	16000000	1600000

Standard deviation $\sigma = \sqrt{\sum_{j=1}^{n} \left(A_{ji} - \overline{A}_t\right)^2 P_{ji}}$

Project X	Project Y
$\sigma = \sqrt{1200000}$ =1095.45	$\sigma = \sqrt{4400000}$ = 2097.62

Y is riskier since it has higher standard deviation (σ). If the monetary value of the projects are the same, project X would have been preferred.

(c) Coefficient of variation

A relative way of risk is defined as the standard deviation of the probability distribution divided by its expected value. Useful when company project which has:

- Same standard deviation but different expected value
- Different standard deviation but same expected value
- Different standard deviation & different expected value

Example:

Project Y has a high expected value & high standard deviation, thus more risky

Coefficient of variation for X = 1095.45/6000 = 0.1825

for Y = 2097.62/8000=0.2688

NB: Which of the project to be acceptable will depend on the attitude of the business to risk?

Tutorial Questions / Assignments

Question1

(a)(i) What do you understand by Engineering Economic?

(ii) Outline five ways by which the Economic analysis can be used to solve problem

(iii) Define the following (a) Discounting (b) Benefit cost analysis (c) Time value of money

(b) In 1980 Daniel Company bought a workshop from Adelaja Company for N 100,000 at an average interest rate of 10 percent. What will be the present value in 2014? Use both simple and compound interest approaches

Question 2

(a)(i) What do you understand by Cost-Volume-Profit analysis and enumerate its usefulness

(ii) Enumerate five assumptions for Cost-Volume-Profit analysis

(iii) Enumerate five limitations of Cost-Volume-Profit analysis

(b) The following information is extracted from the book of a Manufacturing company by a financial analysis:

Sales	-	1,000.000
Variable costs	-	800,000
Fixed costs	-	100,000

Compute: (a) P/V ratio (b) BEP

(c) If fixed cost (FC) is increased by 10000 with variable costs and sales constant. What is the BEP

Question 3

(a) (i) What do you understand by risk analysis?

(ii) Outline ten factors that can lead to uncertainty

(b) The possible cash flows and their associated probabilities for each of the project x, y for one year time period are as presented in Table below.

Possible event	Project X		Project Y	
	Cash flow (CF)	Probability	Cash flow (CF)	Probability
A	4000	0.10	12,000	0.1
B	5000	0.20	10,000	0.15
C	6000	0.40	8,000	0.50
D	7000	0.20	6,000	0.15
E	8000	0.10	4,000	0.10

(i) Calculate the expected monetary value for each project

(ii) Calculate the standard deviation for each project

(iii) Which of the project has highest monetary value and standard deviation?

(iv) Which of the project is preferable?

6.0 Engineering Economy in water resources development projects

(e.g Development of electric power system)

Most projects involve a few major sets of alternatives, and each alternatives may include a number of subordinate sets. The most suitable alternatives and subordinate alternatives are usually selected on economic grounds.

For example, let us consider the case of an electric power system. We may have two alternatives, namely: Hydropower and Thermal power , if hydropower is cheaper, it should be selected. Even in hydropower, there may be a number of subordinate alternatives. For example, there may be different sites for the project. Even for a particular sites, there may be different alternative

designs for a dam, size of pen stocks, number and types of turbines, generators etc. Each subordinate alternative may have its further sub-sub alternatives. Thus at every stage of planning, it is important to consider relative economy of different alternatives to make a rational choice while selecting the most favourable overall design.

6.1 Steps involves in the economic study of a water resources development project

(i) Identify and clearly define each alternative design in physical terms

(ii) Prepare the preliminary estimates of cost of each alternative design

(iii) Determine the benefits likely to be accrued from each alternatives.

(iv) Compare the cost and benefits.

(v) Determine the benefit cost ratio (B/C ratio) of the various alternatives

(vi) Adopt the best design for construction

6.2 Estimation of Benefit-Cost Ratio

For estimation of benefit-cost ratio, it is the usual practice to convert all capital costs into annual costs that they can be compared with annual benefits for the determination of the benefit-cost ratio.

1. **Annual costs**: the total cost of the project is usually divided into two categories.

   (i) Capital cost: this is the expenditre done at the time of construction. It is also called initial cost

   (ii) Recurring cost: this is the expenditure during the life of the project on maintenance and operation. This is usually expressed as annual recurring cost.

Total annual cost = Equivalent annual recovery cost + annual recurring cost (6.1)

The equivalent annual recovery cost is estimated by converting the capital cost.

Equivalent annual recovery cost = CRF * Capital investment (6.2)

$$CRF = \frac{i(1+i)^N}{\left[(1+i)^N - 1\right]} \quad (6.3)$$

Where CRF =Capital Recovery Factor, i=interest rate per annum,

N=estimate life of the project (year)

2. **Annual benefits**: Benefits that are likely to accrue by the construction of a project

3. **Benefit-cost ratio**: the benefit cost ratio (B/C ratio) is the ratio of the annual benefits to the annual costs. Thus

$$B/C\ ratio = \frac{Total\ annual\ benefits}{Total\ annual\ costs} \qquad (6.4)$$

The project which gives a B/C ratio of greater than unity is economically viable.

Example 1:

Determine whether the hydro-power project with the following particulars is economically visible. Given data

Capital cost = N1.50 million

Annual maintenance cost = N25,000.00

Interest rate = 6% per annum

Useful life of project = 100 years

Power potential =200 kw

Power rate = N 0.10 per kwh

Solution

$$CRF = \frac{i(1+i)^N}{\left[(1+i)^N - 1\right]} = \frac{0.06(1+0.06)^{100}}{\left[(1+0.06)^{100} - 1\right]} = 0.06018$$

eqn(6.3)

Equivalent annual recovery cost = CRF * Capital investment

eqn(6.2)

$$=0.06018 * 1.5*10^6$$

$$=90270.00$$

Total annual cost = Equivalent annual recovery cost + annual recurring cost

eqn(6.1)

$$=90270.00 + 25{,}000.00 = 115270.00$$

Annual benefits = (Power potential *No of days in a year*No of hrs per day)* power rate

$$=200*365*24*0.1=175200.00$$

$$B/C\ ratio = \frac{Total\ annual\ benefits}{Total\ annual\ costs} \qquad (6.4)$$

$$B/C\ ratio = \frac{175200.00}{115270.00} = 1.52 > 1.0$$

The project is economically viable

Example 2:

A 100 kw hydropower project has the following two alternatives for conveyance of water from the reservoir to the power house. Which of the alternatives is more economical?. Take annual interest rate as 6%.

I. Alternative, a lined tunnel

Initial cost of tunnel = N 1.0 million

Useful life = 100 years

Annual maintenance cost = N 15,000.00

II. Alternatives, a power channel and penstocks

(i) Cost of power channel = N 400,000.00

Useful life = 100 year

(ii) Cost of lining = N 100,000.00

Useful life = 50 years

Annual maintenance cost = N 6000.00

(iii) Cost of penstocks = N 200,000.00

Useful life = 50 years

Annual maintenance cost = N 7000.00

Solution

Determine the total annual costs of the two alternatives

(a) I- Alternative $CRF = \frac{i(1+i)^N}{[(1+i)^N - 1]} = \frac{0.06(1+0.06)^{100}}{[(1+0.06)^{100} - 1]} = 0.06018$

Annual capital recovery cost = 0.06018 * 1,000,000 = 60180.00

Annual maintenance cost =15000.00

Total annual cost = 60180 + 15000 = 75180.00

(b) II Alternative (i) power channel $CRF = \frac{i(1+i)^N}{[(1+i)^N - 1]} = \frac{0.06(1+0.06)^{100}}{[(1+0.06)^{100} - 1]} = 0.06018$

Annual capital recovery cost = 0.06018 * 400,000 = 24072.00

(ii) Lining $CRF = \frac{i(1+i)^N}{[(1+i)^N - 1]} = \frac{0.06(1+0.06)^{50}}{[(1+0.06)^{50} - 1]} = 0.06344$

Annual capital recovery cost = 0.06344 * 100,000 = 6344.00

Total annual cost = 6344.00 + 6000.00 = 12344.00

(iii) Penstocks $CRF = \frac{i(1+i)^N}{[(1+i)^N - 1]} = \frac{0.06(1+0.06)^{50}}{[(1+0.06)^{50} - 1]} = 0.06344$

Annual capital recovery cost = 0.06344 * 200,000 = 12688.00

Annual maintenance cost = 7000.00

Total annual cost = 12688.00 + 7000.00 = 19688.00

Total annual cost of II alternative = 24072.00+12344.00+19688.00 =

= 56104.00

As the total annual cost of II alternative is less than that of I alternative, the former is more economical.