UNIT – 6

Economic Analysis

- Important Repeated Questions

6.1 Introduction

6.2 Initial and annual cost

6.3 Present worth calculations

6.4 Example

6.5 Clean Development mechanism

Important Repeated Questions:

1. **Explain time value of money / present worth calculations.**
    - Appeared in: W25 (Q5a OR, 03 marks), S24 (Q5b, 04 marks), W23 (Q5a OR, 03 marks)
2. **Explain payback period method and its limitations.**
    - Appeared in: W23 (Q5b, 04 marks), S22 (Q5b, 04 marks), S25 (Q5b, 04 marks)
3. **Explain Clean Development Mechanism (CDM).**
    - Appeared in: W24 (Q5c, 07 marks), S24 (Q4c, 07 marks), S23 (Q5c, 07 marks), S25 (Q5c, 07 marks)
4. **Define: NPV, IRR, ROI, Life Cycle Cost Analysis, Cumulative Savings.**
    - Appeared in: W23 (Q5a, 03 marks), S25 (Q5b, 04 marks), S24 (Q5a, 03 marks), S23 (Q5a OR, 03 marks)
5. **Explain economic analysis of solar system.**
    - Appeared in: W25 (Q5c, 07 marks), S24 (Q5c, 07 marks)
6. **Explain annual savings, cumulative savings, payback period.**
    - Appeared in: S24 (Q5a, 03 marks), S23 (Q5a OR, 03 marks)

Legends: W- Winter, S- Summer, Q- Question and 03/04/07- Marks of Question

INTRODUCTION

Life Cycle Costing

Engineering economy is the application of economic factors and criteria to evaluate alternatives, considering the time value of money. The engineering economy study involves computing a specific economic measure of worth for estimated cash flows over a specific period of time.

The terms interest, interest period and interest rate are useful in calculating equivalent sums of money for an interest period. Interest is the manifestation of the time value of money. It is the difference between an ending amount of money and the beginning amount over an interest period. For more than one interest period, the terms simple interest and compound interest become important.

6.1 Simple Interest:

Simple interest is calculated using the principal only, ignoring any interest accrued in preceding interest periods. The total simple interest over several periods is computed as: *Simple Interest = (Principal) x (Number of Periods) x (Interest Rate)*

Here the interest rate is expressed in decimal form. The total sum accrued at the end of n interest periods is given by:

$S = P(1 + n * i)$ .... *(1)*

S = Sum accrued at the end of interest periods (also called Future Worth) P

= Principal (also called Present Worth)

n = Number of interest periods (normally one year is taken as one interest period) i =

Interest rate (normally annual interest rate)

6.2 Compound Interest:

For compound interest, the interest accrued for each interest period is calculated on the principal plus the total amount of interest accumulated in all previous periods. Compound interest reflects the effect of the time value of money on the interest also. The interest for one period is calculated as:

Compound Interest = (Principal + All accrued Interest) x (Interest Rate)

We can see from the above two expressions that the sum accrued at the end of first year would be same for both simple interest and compound interest calculations. However,
for interest periods greater than one year, the sum accrued for compound interest would be larger.

What happens if the interest is compounded more than once in a year?

1.3. Inflation:

In all the above equations, we had assumed that there is no inflation. Inflation is an increase in the amount of money necessary to obtain the same amount of product before the inflated price was present. Inflation occurs due to downward change in the value of the currency. If ‘C’ is the cash in hand today for buying a product, f is the inflation rate, then the amount we need to pay for the same product after n years would be $C(1 + f)^n$, assuming uniform inflation over the years.

Life Cycle Cost:

Life cycle costing or LCC is an important factor for comparing the alternatives and deciding on a particular process for completing a project. The different components taken into account for calculating LCC are:

LCC = Capital + Replacement cost + Maintenance cost + Energy cost - Salvage

Here, Capital is the present worth. Replacement cost that may occur at a later years need to converted to present worth. Maintenance cost is annual maintenance cost and needs to be converted to present worth and so is the energy cost. Salvage is the money that is obtained while disposing the machinery at the end of life cycle period. Even this amount has to be converted to present worth for calculating LCC. Once we have the LCC value, we can easily find the Annual Life Cycle Costing using the following equation: These equations would be clearer once we do some problems

Example – 1

Assume that opportunity A generates benefits equal to 100, 150, and 200 at the end of years 1, 2, and 3, respectively. Assume that opportunity B yields benefits of 225 in year 2 and 225 in year 3. Therefore over 3 years, both opportunities A and B yield benefits of 450. However, the timing of the benefits received is different in each case. By using the present- worth technique, their two benefit flows can be viewed in terms of today's dollar value

ANS:-

Compute the present-worth factor PWF using Eq. (12.3). With an interest rate of 10 percent, the calculation of present-worth factors is as follows:

$$year1 = \frac{1}{(1+i)^n} = \frac{1}{(1+0.1)^1} = 0.9091$$

$$year2 = \frac{1}{(1+i)^n} = \frac{1}{(1+0.1)^2} = 0.8264$$

$$year3 = \frac{1}{(1+i)^n} = \frac{1}{(1+0.1)^3} = 0.7513$$

Compute the present worth of each opportunity benefit flow by multiplying the present- worth factor by the annual benefit amount

		Annual benefit		Present worth	
year	Present worth factor	A	B	A	B
1	0.9091	100	0	90.91	0
2	0.8264	150	225	123.96	185.94

3	0.7513	200	225	150.26	169.04
Total		450	450	**365.13**	354.98

Example – 2
A community has 500 people. The source of water to the community is from the bore- wells and the supply of water from the bore-wells is by hand-pumps. Six hand-pumps are installed to meet the water requirement of the community. Per-capita water consumption of the community is 40 liters/day. Bore-well depth is 20 meters. The cost of each hand-pump is Rs.5,000.00. Cost of digging of each bore-well is at the rate of Rs.250.00 per meter. Life of the hand-pump is 10 years. Annual maintenance cost per pump is Rs. 1250.00. If the rate of interest is 10%, what is the unit water cost for the life cycle period of 20 years?
Example – 3
A PV array of 500 watts has been installed to pump water from a bore-well of 2 meters deep using a submergible motor and pump system to an over-head tank. The length of pipe required to pump the water is 30 meters. Following are the costs involved for the sub-systems and their life spans:

PV Array : $8/peak watt; Life span - 15 years

Motor and pump: $2/watt; Life span - 7.5 years Pipe

cost: $8/meter; Life span - 5 years

Cost of digging the bore-well: $20/meter

Maintenance cost: $80/year Miscellaneous

cost: $3.5/watt

If the interest rate is 10%, calculate the Life Cycle Cost of the water for a period of 15 years and also water cost per year (ALCC).
Example - 4
A micro-hydel plant of lkW power capacity has been installed. Following are the cost involved in installation of the whole system:

Installation cost of the plant = Rs. 16000 Cost of mains transmission = Rs. 16000 Cost of

distribution transformer = Rs.2500 Cost of 11 kV line per Kilometer = Rs.4000
Life span of the plant is 25 years. If the rate of interest is 12%, find the unit cost per Kilometer.

Comparison of Alternative Energy Systems using Life Cycle Cost Analysis
Electricity is a major secondary energy carrier and is predominantly produced from fossil fuels. Challenging concerns of the fossil fuel based power generation are depletion of fossil fuels and global warming caused by greenhouse gases (GHG) from the combustion of fossil fuels. To achieve the goal of environmental sustainability in the power sector, a major action would be to reduce the high reliance on fossil fuels by resorting to the use of clean/renewable sources and efficient generation/use of electricity. Because of the existence of number of alternative energy systems, there is a need of comparing their economic aspects in producing electricity. In order to consider the long-term implications of power generation, a life cycle concept is adopted, which is a cradle-to-grave approach to

analyse an energy system in its entire life cycle. Life cycle assessment (LCA) is an effective tool to pinpoint the environmental implications. Life cycle cost analysis (LCCA) provides effective evaluation to pinpoint cost effective alternatives. LCA and LCCA should be combined to identify cost effective power generation alternative scheme. In this paper, for a given energy requirement, a sample comparison was done between solar PV, solar thermal, microhydel, wind, wave and biomass system using the life cycle costing (LCCA) approach.

Example – 5 MICRO HYDEL PLANT

These plants are used for power requirements less than 100KW.

The costs of all major components are specified in the table, the costs of civil works and permits are not included.

1. Approximate Micro Hydel system Costs (Battery based):

Component	100W (flow rate 41ps and head at 5m.	lifetime
Penstock	Rs 32500	10 years
Turbine-generator	Rs 125000	
Controller	Rs 20000	
Batteries	Rs 26000	5 years
Inverter	Rs 60000	
Power house	Rs 10000	
Miscellaneous	Rs 10000	
Maintenance	Rs 2000per year	

Estimates provided by Energy Alternatives Ltd.

Example – 6 BIOMASS PLANT

The major components of Biogas plant are listed as follows.

1. Gassifier
2. Piping
3. Sand fdter
4. Diesel engine
5. Electric Generator

The costs of different components of Biogas plant are specified in the following table.

Item	Cost in Rs.for 5KW plant	Life period
Biogas plant	127700	20 years
Piping	8300	10 years
Sand filter	4150	10 years
7hp diesel engine	37700	15 years
5 KVA generator	78150	15 years
Accessories, Tools	20750	10 years
Engine room	16550	20 years