**Unit 8:Financial analyses of energy systems**

In the process of energy management, at times, for reducing the energy consumption of a process or utility, investment would be required for modifications/retrofitting and for incorporating new technology. It is simple, both in concept and application. A shorter payback means an attractive investment. It does not use tedious calculations. It favours projects, which generate substantial cash inflows in earlier years, and discriminates against projects, which bring substantial cash inflows in later years but not in earlier years.

**8.1 Financial analysis techniques**

Various financial techniques are discussed accordingly.

**8.1.1 Simple Pay Back Period**

It represents the time (number of years) required to recover the initial investment (First Cost), considering only the Net Annual Saving.

Simple payback period (SPP) =

Problem1: Simple payback period for a continuous Deodorizer that costs Rs.60 lakhs to purchase and install, Rs.1.5 lakhs per year on an average to operate and maintain and is expected to save Rs. 20 lakhs by reducing steam consumption (as compared to batch deodorizers) .

SPP==3Yrs 3 months

**8.1.2 Return on Investment (ROI)**

ROI expresses the "annual return" from the project as a percentage of capital cost. The annual return takes into account the cash flows over the project life and the discount rate by converting the total present value of ongoing cash flows to an equivalent annual amount over the life of the project, which can then be compared to the capital cost. ROI does not require similar project life or capital cost for comparison. But it has limitation because it does not take into account the time value of money and it does not account for the variable nature of annual net cash inflows

This is a broad indicator of the annual return expected from initial capital investment, expressed as a percentage

ROI=×100

**8.1.3 Net Present Value**

The difference between the present value of benefits and the costs resulting from an investment is the Net Present Value (NPV) of the investment. A positive NPV means a positive surplus indicating that the financial position of the investor will be improved by undertaking the project. Obviously, a negative NPV would indicate a financial loss. An NPV of zero would mean that the present value of all benefits over the useful lifetime is equal to the present value of all the costs. In mathematical terms,

NPV=

Where,

Bj=Benefits at the end of period j

Cj= Cost at the end of period j

n= Useful life period

i=Interest rate

It often happens that (Bj-Cj) is constant for all j’s except for j=0. In such a case

NPV= (B0-C0) + NPV=

Since Bo, the benefits in the 0th year, are invariably zero and (Bj-Cj) is constant (=B-C) for j=1 to n,

NPV=-C0+ (B-C)= NPV=-C0+ (B-C) []

Problem2. A small windmill for water pumping costs Rs 10,000 to purchase and install on the field of a farmer. It is expected to save Rs 800 worth of diesel annually to the farmer and its annual maintenance cost is estimated at Rs 200. Calculate the NPV of the instrument of the windmill if the useful life of the windmill is 10 years and the interest rate is 12 %.

Solution: Net annual benefits of using a windmill=800-200=Rs 600.

Since the amount of net annual benefits is constant over the useful life of the windmill

NPV=-C0+ (B-C) [] =-10000+ (600)] =-6,610

Therefore, the investment is not financially viable for the farmer.

Problem3. To illustrate the calculation of net present value, consider a project, which has the following cash flow stream. The cost of capital, κ, for the firm is 10 per cent.

|  |  |  |
| --- | --- | --- |
| Investment | |  | | --- | | Rs. 1,000,000) | |
| |  | | --- | | Saving in Year | | |  | | --- | | Cash Flow | |
| 1 | |  | | --- | | 200,000 | |
| 2 | |  | | --- | | 200,000 | |
| 3 | |  | | --- | | 300,000 | |
| 4 | |  | | --- | | 300,000 | |
| 5 | |  | | --- | | 350,000 | |

Solution: NPV= -=5,273

The net present value represents the net benefit over and above the compensation for time and risk.

Hence the decision rule associated with the net present value criterion is: Accept the project if the net present values are positive and reject the project if the net present value is negative.

**8.1.4 Internal rate of return**

The Internal Rate of Return (IRR) is a widely accepted discounted measure of investment worth and is used as an index of profitability appraisal of projects. The IRR is defined as the rate of interests that equates the present value of a series of cash flows to zero. In other words, it is the interest rate at which the NPV of an investment is zero. Mathematically, the internal rate of return is the interest rate i that satisfies the equation

NPV==0

IRR is widely used in the appraisal of projects because (i) the IRR on a project is its expected rate of return, (ii) it employs a percentage rate of return as the decision variable which suits the banking company, and (iii) for situations in which IRR exceeds the cost of the funds used to finance the project – a surplus would remain after paying for capital.

In economic terms the IRR represents the percentage rate of interest earned on the unrecovered balance of an investment. The unrecovered balance of an investment is the portion of the initial investment that remains to be recovered after interest payments have been added and receipts have been deducted up to the desired point in time.

**8.1.4.1 Computation of IRR**

Computation of IRR can be done using an iterative procedure or using Newton’s approximation to the solution of a polynomial.

1. Make a guest at a trial rate of interest.

2. using the guessed rate of interest, calculate the NPV of all disbursements and receipts.

3. If the calculated value of NPV is positive then receipts from the investments are worth more than the disbursements of the investment and the actual value of IRR would be more than the trial rate. On the other hand if NPV is negative the actual value of IRR would less than the trial rate of interest. Adjust the estimate of trial rate of return accordingly.

4. Proceed with steps 2 and 3 again until one value of i (=i1) is found that results in a positive (+) NPV and next higher value of i (=i2) is found with a negative NPV.

5. Solve for the value of IRR by interpolation using the values of i1 and i2 as obtained in step 4.

IRR=i1+ (

Problem4. Calculate the internal rate of return for investment in a heat exchanger which will cost Rs 5, 00,000 to purchase and install, will last 10 yrs and will result in fuel savings of Rs 1, 45,000 per year. Also assume that the salvage value of the heat exchange at end of 10 yrs is negligible.

Solution: Let the first guess at the value of IRR is 25%

NPV at 25% = 1, 45,000[] -5, 00,000= Rs 17,722

Since the NPV at 25% is positive, the IRR shall be greater than 25 %. If the next trial value is chosen at 30 %, then,

NPV at 30% =1, 45,000[] -5, 00,000=Rs -51,724

Obviously, the true IRR lies between 25 % and 30 %. By Interpolating between the two, the IRR can be estimated as

IRR=0.25+=0.26275

IRR=26.275%

A better estimate of the true IRR may be obtained by using smaller incremental changes in the interest rate.

Problem5. Installation of an Rs 50, 00,000 energy management system in an industry is expected to result in a 25% reduction in electricity use and a 40% saving in process heating costs. This translates to net yearly savings of Rs 6, 00,000 and Rs 7, 50,000 respectively. If the energy management system has expected useful life of 20 years, determine the internal rate of return on the investment.

Solution: Total annual benefits= Rs 6, 00,000+ Rs 7, 50,000=Rs 13, 50,000

NPV of the investment =-50, 00,000+ 13, 50,000[]

NPV at i=0.27=-50, 00,000+ 13, 50,000[] =-41,965

NPV at i=0.26==-50, 00,000+ 13, 50,000[] =1, 41,263

Thus the IRR can be obtained by interpolating between i=0.26 and i=0.27 in the following manner

IRR =0.26 +=0.2677

The IRR is 26.77%

Problem5. Calculate the internal rate of return for an economizer that will cost Rs.500, 000, will last 10 years, and will result in fuel savings of Rs.150, 000 each year. Find i that will equate the following Rs.500, 000 = 150,000 x PV (A = 10 years, i =?)

Solution: To do this, the net present value (NPV) for various i values, are selected by visual inspection;

NPV 25%= Rs.150, 000 × 3.571 – Rs.500, 000=Rs.35, 650

NPV 30% = Rs.150, 000 × 3.092 – Rs. 500,000=-Rs. 36,200

For i = 25 per cent, net present value is positive; i = 30 per cent, net present value is negative. Thus, for some discount rate between 25 and 30 per cent, present value benefits are equated to present value costs. To find the rate more exactly, one can interpolate between the two rates as follows

i=0.25 + (0.30-0.25) × 35650 / (35650 + 36200) = 0.275, or 27.5%

**8.1.4.2 Advantages of IRR**

A popular discounted cash flow method, the internal rate of return criterion has several advantages

1. It takes into account the time value of money.

2. It considers the cash flow stream in its entirety.

3. It makes sense to businessmen who prefer to think in terms of rate of return and find an absolute quantity, like net present value, somewhat difficult to work with.

**8.2 Financing options, energy performance contracts and role of ESCOs**

**8.2.1 Energy Performance Contracting (EPC)**

EPC is a turnkey service, sometimes compared to design/build construction contracting which provides customers with a comprehensive set of energy efficiency, renewable energy and distributed generation measures and often is accompanied with guarantees that the savings produced by a project will be sufficient to finance the full cost of the project. A typical EPC project is delivered by an Energy Service Company (ESCO) and consists of the following elements:

Turnkey Service: The ESCO provides all of the services required to design and implement a comprehensive project at the customer facility, from the initial energy audit through long-term Monitoring and Verification (M&V) of project savings.

Comprehensive Measures: The ESCO tailors a comprehensive set of measures to fit the needs of a particular facility, and can include energy efficiency, renewable, distributed generation, water conservation and sustainable materials and operations.

Project financing**:** The ESCO arranges for long-term project financing that is provided by a third-party financing company. Financing is typically in the form of an operating lease or municipal lease.

Project Savings Guarantee: The ESCO provides a guarantee that the savings produced by the project will be sufficient to cover the cost of project financing for the life of the project.

**8.2.2 Financing options in EPC**

EPC projects today are typically financed by third-party financial institutions using a set of financing vehicles that are tailored to the requirements of an individual project, not by ESCOs.

**8.2.3 Financing Marketplace**

EPC projects are financed by large institutional lenders that offer very competitive rates and terms, and have made billions of dollars of financing available.

**8.2.4 Financing Vehicles**

EPC project financiers offer a variety of financing vehicles, including:

**8.2.5 Tax-Exempt Lease Purchase Agreements**

It is also called Municipal Leases which allow the customer to finance an EPC project without carrying a liability on its balance sheet.

**8.2.6 State or Local Government Leasing Pools**

It issometimes called Master Leases, which allow individual projects to lower their financing costs by participating in a larger aggregated financing.

**8.2.7 State or Local Government Bonds,**

These can offer slightly lower interest rates than Municipal Leases, but are time-consuming to execute and often require voter approval.

**8.2.8 Revolving Loan Pools:**

Theseoffer subsidized interest rates, but have multi-year waiting lists.

**8.2.9 Power Purchase Agreements (PPAs)**

By these, the customer buys the output (*e.g.,* kWh or pounds of steam) of a distributed generation project, rather than the actual project.

**8.3 The role of ESCO**

An energy service company is a commercial business providing a broad range of comprehensive energy solutions including designs and implementation of energy savings projects, [energy conservation](file:///\\wiki\Energy_conservation), energy infrastructure outsourcing, power generation and energy supply, and risk management.

One of the foremost activities of an ESCO is the installation of energy conservation measures in industry. After installing energy conservation measures (ECMs), ESCOs often determine the energy savings resulting from the project and present the savings results to their customers. A common way to calculate energy savings is to measure the flows of energy associated with the ECM, and then to apply spreadsheet calculations to determine savings

The energy savings project often begins with the development of ideas that would generate energy savings, and in turn, cost savings. This task is usually the responsibility of the ESCO. The ESCO often approaches a potential client with a proposal of an energy savings project and a [performance contract](file:///\\w\index.php?title=Performance_contract&action=edit&redlink=1). During the initial period of research and investigation, an energy auditor from the ESCO surveys the site and reviews the project's systems to determine areas where cost savings are feasible, usually free of charge to the client. This is the [energy audit](file:///\\wiki\Energy_audit), and the phase is often referred to as the [feasibility study](file:///\\wiki\Feasibility_study). A hypothesis of the potential project is developed by the client and the auditor, and then the ESCO’s engineering development team expands upon and compiles solutions.

This next phase is referred to as the engineering and design phase, which further defines the project and can provide more firm cost and savings estimates. The engineers are responsible for creating cost-effective measures to obtain the highest potential of energy savings. These measures can range from highly efficient lighting and heating/air conditioning upgrades, to more productive motors with [variable speed drives](file:///\\wiki\Variable_speed_drives) and centralized [energy management systems](file:///\\wiki\Energy_management_systems). There is a wide array of measures that can produce large energy savings.

Once the project has been developed, the implementation phase begins. Following the completion of this phase, the monitoring and maintenance or [Measurement and Verification](file:///\\wiki\Measurement_and_Verification) (M & V) phase begins. This phase is the verification of the pre-construction calculations and is used to determine the actual cost savings.

**8.4 Project definition and scope, Technical design and Financing**

Project management is concerned with the overall planning and co-ordination of a project from conception to completion aimed at meeting the stated requirements and ensuring completion on time, within cost and to required quality standards. Project management is normally reserved for focused, non-repetitive, time-limited activities with some degree of risk and that are beyond the usual scope of operational activities for which the organization is responsible.

**8.4.1 Steps in Project Management**

The various steps in a project management are:

1. Project Definition and Scope

2. Technical Design

3. Financing

4. Contracting

5. Implementation

6. Performance Monitoring

**8.4.2 Project Definition and Scope**

A project is a temporary endeavor undertaken to create a unique product or service. A project is temporary in that there is a defined start (the decision to proceed) and a defined end (the achievement of the goals and objectives). Ongoing business or maintenance operations are not projects. Energy conservation projects and process improvement efforts that result in better business processes or more efficient operations can be defined as projects. Projects usually include constraints and risks regarding cost, schedule or performance outcome.

**8.4.3 Four Basic Elements of Project Management**

A successful Project Manager must simultaneously manage the four basic elements of a project resources, time, cost, and scope. Each element must be managed effectively. All these elements are interrelated and must be managed together if the project, and the project manager, is to be a success.

**8.4.3 Managing Resources**

A successful Project Manager must effectively manage the resources assigned to the project.This includes the labor hours of the project team. It also includes managing labor subcontracts and vendors. Managing the people resources means having the right people, with the right skills and the proper tools, in the right quantity at the right time. However, managing project resources frequently involves more than people management. The project manager must also manage the equipment (cranes, trucks and other heavy equipment) used for the project and the material (pipe, insulation, computers, manuals) assigned to the project.

**8.4.4 Managing Time and Schedule**

Time management is a critical skill for any successful project manager. The most common cause of bloated project budgets is lack of schedule management. Fortunately there is a lot of software on the market today to help you manage your project schedule or timeline. Any project can be broken down into a number of tasks that have to be performed. To prepare the project schedule, the project manager has to figure out what the tasks are, how long they will take, what resources they require, and in what order they should be done.

**8.4.5 Managing Costs**

Often a Project Manager is evaluated on his or her ability to complete a project within budget. The costs include estimated cost, actual cost and variability. Contingency cost takes into account influence of weather, suppliers and design allowances.

**8.4.6 Technical Design**

For a project to be taken up for investment, its proponent must present a sound technical feasibility study that identifies the following components:

1. The proposed new technologies, process modifications, equipment replacements and other measures included in the project.

2. Product/technology/material supply chain (e.g., locally available, imported, reliability of supply)

3. Commercial viability of the complete package of measures (internal rate of return, net present value, cash flow, average payback).

4. Any special technical complexities (installation, maintenance, repair), associated skills required.

5. Preliminary designs, including schematics, for all major equipment needed, along with design requirements, manufacturer's name and contact details, and capital cost estimate.

6. Organizational and management plan for implementation, including timetable, personnel requirements, staff training, project engineering, and other logistical issues.

**8.4.7 Financing**

When considering a new project, it should be remembered that other departments in the organization would be competing for capital for their projects. However, it is also important to realize that energy efficiency is a major consideration in all types of projects, whether they are:

1. Projects designed to improve energy efficiency

2. Projects where energy efficiency is not the main objective, but still plays a vital role. The funding for project is often outside the control of the project manager. However, it is important that you understand the principles behind the provision of scarce funds. Project funds can be obtained from either internal or external sources.

Internal sources include:

• Direct cash provision from company reserves

• From revenue budget (if payback is less than one year)

• New share capital

Funding can become an issue when energy efficiency projects have previously been given a lower priority than other projects. It is worth remembering that while the prioritization of projects may not be under our control, the quality of the project submission is.

External sources of funds include:

• Bank loans

• Leasing arrangement

• Payment by savings i.e. A deal arranged with equipment supplier

• Energy services contract

• Private finance initiative

The availability of external funds depends on the nature of organization. The finance charges on the borrowed money will have a bearing on the validity of the project.

**8.5 Project planning and management**

Project planning and management are the crucial component of energy management. It has certain tools by which we can manage projects without much of hassle. These are discussed below one by one.

**8.5.1Grant chart**

Grant chart is used for scheduling of the tasks and tracking of the progress of energy arrangement project.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Months | | | | | | | | | | | |
| Task | Duration | J | F | M | A | M | J | Ju | A | S | O | N | D |
| 1 | 2 Months |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 2 Months |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | 2 Months |  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | 2 Months |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 | 2 Months |  |  |  |  |  |  |  |  |  |  |  |  |

Horizontal axis of the chart is the time scale in the above table. The time duration depends on the project. Generally, it is expressed in terms of weeks or months. Rows in the chart show the beginning and ending duration of individual task in projects.

**8.5.2 CPM or Critical path method**

This method was developed by Dupont in 1957 to address the challenges of shutting down chemical plants for maintenance. The characteristics of method are discussed one by one

1. Provides the graphical view of the project.

2. Depicts the interrelationships among various tasks or activities.

3. Predicts the time required to complete projects.

4. Shows which activities are critical to maintaining the schedule and which are not.

F

3 wk

E

2wk

D

2 wk

C

1wk

B

4 wk

A

3wk

Finish

Start

CPM diagram

Steps of drawing a CPM diagram

1. Specify the individual activities.

2. Determines the sequence or inter relationships of the activities.

3. Draw the network diagram.

4. Estimate the completion time for each activity.

5. Identify the critical path.

6. Update the CPM diagram as the project program.

The critical path can be identified

ES (Earliest Start Time): The earliest time at which the activity can start given that its precedent activities must be completed first.

EF (Earliest finish Time): Equal to earliest start time the activity thus the time required to compute the activity.

LF (Latest Finish time): The latest finish time at which the activity can be completed without delaying the project.

LS (Latest Start Time): Equal to the latest first time minus the time required to complete the activity.

Problem: The following data corresponds to the replacement of a boiler with an energy efficient one

|  |  |  |  |
| --- | --- | --- | --- |
| Activity code | Activity | Time duration |  |
| A | Preparation technical inspection | 10 | - |
| B | Tender Processing | 25 | A |
| C | Release of Work | 3 | B |
| D | Supply of boiler equipment | 60 | C |
| E | Supply of auxiliary | 20 | C |
| F | Supply of Pipes | 10 | C |
| G | Civil works | 15 | C |
| H | Inspection | 5 | E,F,G |
| I | Others | 10 | D,H |
| J | Miscellaneous | 2 | I |

Solution: Critical path is A-B-C-I-J

10

60

3

2

20

25

10

10

15

PERT or Program Evaluation and Review Technique: It uses three time estimates optimistic, pessimistic and most likely. One of the important characteristic of this method is that it helps establishing the probability of completion of a project. It has potential to reduce the time and cost.

PERT planning

1. Identify the specific activities and milestones.

2. Determine inter dependable and proper sequencing of the activities.

3. Construct a network diagram.

4. Estimate the time (Three time estimates if the problems are to be compared) required for each activities.

5. Determine the critical path.

6. Update the PERT chart as project programming.

Benefits of PERT

1. Expected project completion time

2. Probability of completion before the specified date.

3. Critical path activities that directly impact the completion time.

Questions

1. Cost of an heat exchanger is Rs.1.00 lakhs .Calculate simple pay back period considering annual saving potential of Rs.60,000/- and annual operating cost of Rs.15,000/- .

2. What is the main draw back of simple pay back method?

3. Calculate simple pay back period for a boiler that cost Rs.75.00 lakhs to purchase and Rs.5 lakhs per year on an average to operate and maintain and is expected to annually save Rs.30 lakhs.

4. What do you understand by the term “present value of money"?

5. Define ROI.

6. Investment for an energy proposal is Rs.10.00 lakhs. Annual savings for the first three years is 150,000, 200,000 & 300,000. Considering cost of capital as 10%, what is the net present value of the proposal?

7. What are the advantages of net present value?

8. Internal rate of return of a project is the discount rate which makes its net present value equal to zero. Explain.

9. What is role of an ESCO?

10. What is performance contracting?

11. What are the criteria for screening of projects?

12. What are the aspects to be considered in the management of contract?

13. Make a Gantt chart for your preparation of energy manager/energy auditor examination. Split into to as many components as possible.

14. Explain the importance of performance monitoring.

15. Describe briefly the use of PERT in project managements.

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