ENERGY AUIDT AND ENERGY ECONOMICS

Energy audit -need – types - benefits - methodology and barriers – role of energy managers – instruments for energy auditing; Energy economics – discount rate – depreciation cost - payback period – internal rate of return – net present value – life cycle costing – case study.

4.1 Definition and Objectives of Energy Management

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The definition of energy management is:

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions" (or)

"The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems"

The objectives of Energy Management include,

- ✓ To achieve and maintain optimum energy procurement and utilisation, throughout the organization
- ✓ To minimise energy costs / waste without affecting production and quality
- ✓ To minimise environmental effects.

"Energy Audit" means the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption.

4.3 Need for Energy Audit

In any industry, the three top operating costs are often found to be energy (both electrical and thermal), labour and materials. Among the three, energy has the highest potential for cost reduction. Energy audit will help to understand more about the ways energy is used in the industry, and help in identifying the areas where waste can occur and where scope for improvement exists. Such an audit programme will review variations in energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. In general, energy audit is the translation of conservation ideas into realities, by evolving technically feasible solutions with economic and other organizational considerations within a specified time.

4.4 Types of Energy Audit and Approach

The type of energy audit to be performed depends on the type of industry, the depth to which final audit is needed, and the potential and magnitude of cost reduction desired. Thus energy audit can be classified into the following types: Preliminary Audit, Targeted Energy Audits and Detailed Audit.

Preliminary Energy Audit

Preliminary energy audit, which is also known as Walk-Through Audit and Diagnostic Audit, is a relatively quick exercise and uses existing, or easily obtained data. The scope of preliminary energy audit is to:

- Establish energy consumption in the organization (sources: energy bills and invoices)
- Obtain related data such as production for relating with energy consumption
- Estimate the scope for energy savings
- Identify the most likely and the easiest areas for attention (e.g. unnecessary lighting, higher temperature settings, leakage etc.)
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set up a *baseline* or *reference point* for energy consumption
- Identify areas for more detailed study/measurement

Targeted Energy Audits

Targeted energy audits often results from preliminary audits. They provide data and detailed analysis on specified target projects. For example, an organization may target its lighting system or boiler system or steam system or compressed air system with a view of effecting energy savings. Targeted audits therefore involve detailed surveys of the target subjects and analysis of the energy flows and cost associated with the targets. Final outcome is the recommendations regarding actions to be taken.

Detailed Energy Audit

Detailed energy audit is a comprehensive audit and results in a detailed energy project implementation plan for a facility, since it accounts for the energy use of all major equipment. It considers the interactive effects of various projects and offers the most accurate estimate of energy savings and cost. It includes detailed energy cost saving calculations and project implementation costs.

One of the key elements in a detailed energy audit is the energy balance. This is based on an inventory of energy-using systems, assumptions of current operating conditions, measurements and calculations of energy use.

Detailed energy auditing is carried out in three phases: a) Pre Audit Phase b) Audit Phase and c) Post Audit Phase. A comprehensive ten-step methodology for conducting detailed energy audit is suggested as follows. However, methodology is flexible and can be adapted depending upon the industry concerned.

Ten Steps Methodology for Conducting Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
PHASE I –PRE AUDIT PHASE		
Step 1	• **Plan and Organise** • **Walk through Audit** • **Informal Interview** with Energy Manager, Production / Plant Manager	• Establish/organize a **Energy audit team** • Organize Instruments and time frame • Macro data collection (suitable to type of industry.) • Familiarization with process / plant activities • First hand observation and Assessment of current level of operation and practices
Step 2	• **Introductory Meeting** with all divisional heads and persons concerned with energy management (1-2 hrs.)	• To built up cooperation and rapport • Orientation, awareness creation • Issue questionnaire tailored for each department
PHASE II –AUDIT PHASE		
Step 3	• **Primary data gathering, Process Flow Diagram and Energy Utility Diagram**	• Historic data collection and analysis for setting up **Baseline energy consumption** • All service **utilities system diagram** (e.g. Single line power distribution diagram, water, and compressed air and steam distribution). • Prepare **process flow charts** • Design, operating data and schedule of operation • Annual Energy Bill and **energy consumption pattern** (Refer manual, logbook, name plate etc.)
Step 4	• **Conduct survey and monitoring**	• **Measurements** : Motor survey, Insulation, lighting survey etc. with portable instruments for operating data. Confirm and compare operating data with design data.
Step 5	• **Conduct of detailed trials /** tests for selected major energy equipment	• **Trials / Tests** - 24 hours power monitoring (MD, PF, kWH etc.). - Load variations trends in pumps, fan compressors etc. - Boiler Efficiency trials for (4-8 hours) - Furnace Efficiency trials - Equipments Performance tests etc

Step 6	• **Analysis of energy use**	• **Energy and Material balance** • **Energy loss/waste analysis**
Step 7	• **Identification and development of Energy Conservation (ENCON) opportunities**	• Conceive, develop and refine ideas • Review ideas suggested by unit personnel • Review ideas suggested in previous energy audit report if any • Use brainstorming and value analysis techniques • Contact vendors for new / efficient technology
Step 8	• **Cost benefit analysis**	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step 9	• **Reporting and Presentation** to the Top Management	• Documentation, draft Report Presentation to the top Management. • Final report preparation on feedback from unit
	PHASE II –POST AUDIT PHASE	
Step 10	• **Implementation and Follow-up**	**Implementation of ENCON recommendation measures** and Monitor the performance • Action plan, schedule for implementation • Monitoring and periodic review

Phase I – Pre Audit Phase

An initial study of the site should always be carried out as proper planning is a pre-requisite for an effective audit. An initial site visit should take only one day and gives the Energy Auditor an opportunity to meet the personnel concerned, to familiarize with the site and to assess the procedures necessary to carry out the energy audit.

The outcome of this visit should be:

- To finalise Energy Audit team
- To know the expectation of management from the audit
- To identify the main energy consuming areas/plant items to be surveyed during the audit.
- To identify existing instrumentation and additional metering required prior to audit e.g. for measurement of electricity, steam, oil or gas consumptions
- To plan for audit with time frame
- To collect macro data on plant energy resources, major energy consuming equipments
- To build up awareness and support for detailed energy audit

Phase II – Detailed Energy Audit Phase

Depending on the nature and complexity of the site, a detailed audit can take from several weeks to several months to complete. Detailed studies would involve investigation and establishment of material and energy balances for specific plant departments or process equipment. Whenever possible, checks of plant operations are carried out over extended periods of time, at night and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.

Energy audit team should ensure that the following baseline data are collected:

- ✓ Quantity and type of raw materials
- ✓ Technology, process used and equipment used
- ✓ Capacity utilization
- ✓ Efficiencies / yield
- ✓ Percentage rejection / reprocessing
- ✓ Quantity and types of wastes
- ✓ Consumption of fuel, water, steam, electricity, compressed air, cooling water, chilled water

Energy auditor must specially interview the supervisors and equipment operators as they have information related to the equipment. Maintenance manager is often the primary person to talk about types of lighting, lamps, sizes of motors, A/c plant and electrical load and related performance problems.

Identification of ENCON Opportunities

Fuel substitution: Identifying the appropriate fuel for efficient energy conversion

Energy Generation: Identifying efficiency opportunities in energy conversion equipment/utility such as feasibility for high efficient DG sets, optimal loading of DG sets, boiler optimization - minimum excess air combustion with boilers / thermic fluid heating, optimising existing efficiencies, efficient energy conversion equipment, biomass gasifiers, Cogeneration etc.

Energy Distribution: Identifying efficiency opportunities in electrical systems such as transformers, cables, switchgears and power factor improvement in electrical systems and chilled water, cooling water, hot water, compressed air, etc.

Energy Usage by Processes: This is where the major opportunity for improvement lies and many of them are hidden. Process analysis is a useful tool for process integration measures.

Technical and Economic Feasibility

The technical feasibility should address the following issues:

- Technology availability, space, skilled manpower etc
- The impact of energy efficiency measure on safety, quality, production or process.
- Reliability, service issues, maintenance requirements and spares availability

The Economic viability often becomes the key parameter for the management acceptance. The economic analysis can be conducted by using Pay back method, Internal Rate of Return method, Net Present Value method etc. For low investment short duration measures, which have attractive economic viability, payback method is sufficient. A sample worksheet for assessing economic feasibility is provided below:

Worksheet for Economic Feasibility

Name of the Energy Efficiency Measure		
1. Investment	2. Annual Operating costs	3. Annual Savings
1. Equipment 2. Civil works 3. Instrumentation 4. Auxiliaries	1. Cost of capital 2. Maintenance 3. Manpower 4. Energy 5. Depreciation	1. Thermal energy 2. Electrical energy 3. Raw materials 4. Waste disposal
Net Savings /year = Annual savings – Annual operating costs **Payback period in months = Investment / Net Savings /year x 12**		

Classification of ENCON Measures

The potential energy saving measures (ENCON) may be classified into three categories:

(a) Low cost – high return

(b) Medium cost – medium return

(c) High cost – high return

Table 4.1 Project Priority Guideline			
Priority	**Economical Feasibility**	**Technical Feasibility**	**Risk / Feasibility**
A- good	Well defined and attractive	Existing technology adequate	No Risk/ Highly feasible
B-May be	Well defined and only marginally acceptable	Existing technology may be updated, lack of confirmation	Minor operating risk/ May be feasible
C-Held	Poorly defined and marginally unacceptable	Existing technology is inadequate	Doubtful
D-No	Clearly not attractive	Need major breakthrough	Not feasible

Energy Audit Report

The length and detail of energy audit report will depend upon the facility audited. The report should begin with an executive summary that provides the management of the audited facility with brief synopsis of the total savings and highlight of each energy saving measure. Executive summary should be tailored to non-technical personnel. The reader who understands the report is more likely to implement the recommended ENCON measures.

Report on

DETAILED ENERGY AUDIT

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Table 4.2 Summary Of Energy Saving Recommendations					
S.No.	**Energy Saving Recommendations**	**Annual Energy (Fuel & Electricity) Savings (kWh/MT or kL/MT)**	**Annual Cost Savings (Rs. Lakhs)**	**Capital Investment (Rs. Lakhs)**	**Simple Payback Period**
1					
2					
3					
4					
Total					

Table 4.3 Types and Priority of Energy Saving Measures				
	Type of Energy Saving Options	**Annual Electricity / Fuel Savings**	**Annual Savings**	**Priority**
		kWh/MT or kJ/MT	**(Rs. Lakhs)**	
A	No Investment (Immediate) • Operational improvement • Housekeeping			
B	Low Investment (Short to Medium Term) • Controls • Equipment modification • Process change			
C	High Investment (Long Term) • Energy efficient devices • Product modification • Technology change			

Table 4.4 Reporting Format for Energy Conservation Recommendations		
A: Title of Recommendation	:	**Combine DG set cooling tower with main cooling tower**
B: Description of Existing System and its Operation	:	Main cooling tower is operating with 30% of its capacity. The rated cooling water flow is 5000 m3/hr. Two cooling water pumps are in operation continuously with 50% of its rated capacity. A separate cooling tower is also operating for DG set operation continuously.
C: Description of Proposed System and its Operation	:	The DG Set cooling water flow is only 240 m3/h. By adding this flow into the main cooling tower will eliminate the need for a separate cooling tower operation for DG set, besides improving the %loading of main cooling tower. It is suggested to stop the DG set cooling tower operation.
D: Energy Saving Calculations		
Capacity of main cooling tower	=	5000 m^3/ hr
Temp across cooling tower (design)	=	8 °C
Present capacity	=	3000 m^3/hr
Temperature across cooling tower (operating)	=	4 °C
% loading of main cooling tower	=	(3000 x 4) / (5000 x 8) = 30%
Capacity of DG Set cooling tower	=	240 m^3/hr
Temp across the tower	=	5 °C
Heat Load (240 x 1000 x 1 x 5)	=	1200,000 kcal/hr
Power drawn by the DG set cooling tower		
No of pumps and its rating	=	2 Nos x 7.5 kW
No of fans and its rating	=	2 Nos x 22 kW
Power consumption@ 80% load	=	(22 x2 +7.5 x2) x.80 = 47 kW
Additional power required for main cooling tower for additional water flow of 240m^3/h (66.67 l/s) with 6 kg/cm^2	=	(66.67 x 6) / (102 x 0.55) = 7 kW
Net Energy Savings	=	47 – 7 = 40 kW
E: Cost Benefits		
Annual Energy Saving Potential	=	40 kW x 8400 hr = 3,36,000 Units/Year
Annual Cost Savings	=	3,36,000 x Rs.4.00 = Rs.13.4 Lakh per year
Investment (only cost of piping)	=	Rs 1.5 Lakhs
Simple Payback Period	=	**Less than 2 months**

4.12 Instruments and Metering For Energy Audit

The requirement for an energy audit is to identify and quantify where energy is being used necessitates measurements. These measurements require the use of instruments. The basic instruments used in energy audit work are listed below. These instruments are portable, durable, easy to operate and relatively inexpensive.

Key Performance Parameters for Energy Audit

Basic Electrical Parameters in AC & DC systems – Voltage (V), Current (I), Power factor, Active power (kW), Maximum demand (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc.

Parameters of importance other than electrical such as Temperature and Heat Flow, Radiation , Air and Gas Flow, Liquid Flow, RPM , Air Velocity, Noise and Vibration, Dust Concentration, TDS, PH, Moisture Content, Relative Humidity, Flue Gas Analysis – CO_2, O_2, CO, SO_x, NO_x, Combustion Efficiency etc.

Electrical Measuring Instruments:

These are instruments for measuring major electrical parameters such as KVA, KW, PF, Hertz, KVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e. on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.

Some precautions and safety measures:

To avoid short circuits and potentially life-threatening hazards, never attach the clamp to a circuit that operates at more than the maximum rated voltage, or over bare conductors.

While using the instrument, use rubber hand gloves, boots, and a safety helmet, to avoid electrical shocks, and do not use the instrument when hands are wet.

Fyrite:

In this, a hand bellow pump draws the flue gas sample into the solution inside the fyrite. Thereafter, a chemical reaction changes the liquid volume that reveals the amount of gas percentage. Oxygen or CO_2 can be read from the scale. The FYRITE employs the well-known "Orsat method of volumetric analysis" using chemical absorption of a sample gas such as carbon dioxide or oxygen. The reagent used to absorb carbon dioxide (CO_2) is potassium hydroxide (dyed red), and chromous chloride (blue) is the absorbent for oxygen (O_2). The unique feature of the FYRITE is that the absorbing fluid is also used as the indicating fluid so that one vessel takes the place of both measuring burette and absorption pipette.

Fuel Efficiency Monitor:

This measures Oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

Combustion Gas Analyzer:

This instrument has in-built chemical cells which measure various gases such as CO_2, CO, NO_X, SO_X etc.

Gas analyzers are flexible in what must be measured depending on the requirements of the customer/user.

They have specific sensors sealed inside the equipment that can be changed to measure the different components in the gas. But because a maximum of two sensors can be connected, only two or three parameters can be measured at one time.

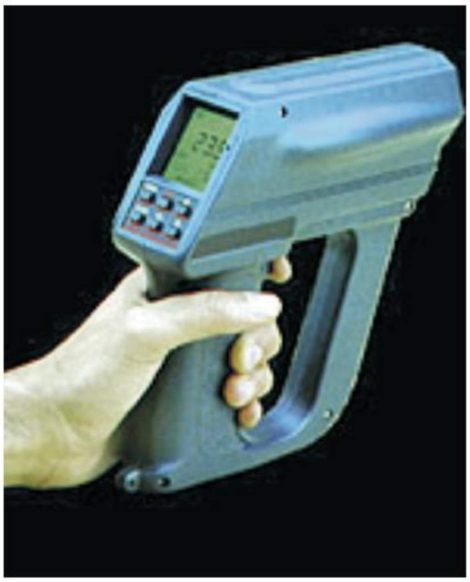
It is light and easier to handle compared to the fuel efficiency monitor.

 	**Manometer with Pitot Tube:** Digital flexible membrane manometer is used for measuring pressures in air ducts carrying exhaust flue gases (boiler, furnaces), or air from fans and blowers. • To measure pressure in air pipes, manometers must be used in combination with a pitot tube • Attach flexible rubber tubes to the inlet and outlet probes of the manometer. Tighten these to ensure that there is no leakage of air. • Attach these two tubes to the ends of the pitot tube • Make a 6-cm monitoring hole in the duct or pipeline • Insert the pitot tube into the monitoring hole

Contact Thermometer:

These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream.

For surface temperature a leaf type probe is used with the same instrument.



Non Contact Infrared Thermometer:

Infrared thermometers calculate the amount of thermal radiation (infrared radiation) emitted from the object. By knowing the emissivity of the object and the amount of infrared energy emitted by the object, the object's temperature can be determined. With the help of infrared thermometers, temperatures of the objects placed in hazardous or hard-to-reach places or other situations can be determined.

The most common design of a IR thermometer consists of a lens to focus the infrared energy on to a detector. The detector changes the energy to an electrical signal that can be shown in units of temperature after being corrected for ambient temperature variation.

Ultrasonic Flow Meter:

This is one of the popular means of non-contact flow measurement. There are two main types of ultrasonic flow meters: Transit time and Doppler. Transit time ultrasonic meters have both a sender and a receiver. They send two ultrasonic signals across a pipe: one traveling with the flow and one traveling against the flow.

The ultrasonic signal traveling with the flow travels faster than a signal traveling against the flow. The ultrasonic flow meter measures the transit time of both signals. The difference between these two timings is proportional to flow rate.

Transit time ultrasonic flow meters usually monitor clean liquids. Doppler ultrasonic flow meters measure dirty liquids. They compute flow rate based on a frequency shift that occurs when their ultrasonic signals reflect off particles in the flow stream.

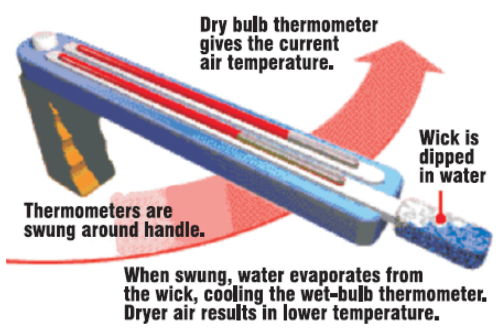
Tachometer

Stroboscope

Speed Measurements:

In any audit exercise speed measurements are critical as they may change with factors such as frequency, belt slip, loading, etc. A simple tachometer is a contact type instrument, which can be used where direct access is possible.

More sophisticated and safer ones are non contact instruments such as stroboscopes. A stroboscopic light source provides high-intensity flashes of light, which can be caused to occur at a precise frequency. When this light source is made to fall on an object with periodic motion it appears that the motion is slowed down, or stopped when both the frequencies bear a definite relationship. A stroboscope uses this principle for measurement of RPM.



Psychrometer:

A sling psychrometer - consists of two thermometers mounted together with a handle. One thermometer is ordinary and measures the dry bulb temperature. The other has a wet cloth wick, over its bulb and is called a wet-bulb thermometer. When a reading is to be taken the psychrometer is whirled around. The water evaporates from the wick, cooling the wet-bulb thermometer. Then the temperatures of both thermometers are read. If the surrounding air is dry, more moisture evaporates from the wick, cooling the wet-bulb thermometer more, so there is a greater difference between the temperatures of the two thermometers. By using these temperatures the humidity is computed.

Lux Meters:

A light sensitive cell measures the incident light (all light in the visible spectrum is measured) and evaluates that against the human daylight sensitivity curve. The resulting value is the measurement result in lux. This works well but it requires a different correction factor for every light spectrum.

The much more expensive lux meters with one cell are optimized and tuned with optical filters and lenses such that the sensitivity of this set of lenses and the cell itself directly matches the eye's light sensitivity curve (so only one correction value needed for light of any spectral content).

Smart Energy Meters

The term smart meter usually refers to electric meters which keep detailed statistics on usage, but it can be used for fuels or water applications as well performing the same job. The primary purpose of smart meters is to provide information on how end users use their electricity on a real-time basis. The smart energy meters use a wireless communication to help track the electricity consumption and thus save both electricity and money. It can be easily installed and gives an accurate reading of electricity consumption which can also be monitored / controlled through mobile or internet.

	**Thermography** Infra-red thermal monitoring and imaging (non-contact type) measures thermal energy radiation from hot/cold surfaces of an object and provides input for assessing health of equipment and predictive maintenance. The thermal camera unit converts electromagnetic thermal energy (IR) radiated from an object into electronic video signals. These signals are amplified and transmitted via interconnected cable to a display monitor where the resulting image is analysed and interpreted for hot/cold spots.

2.3.7. Certification of Energy Managers and Auditors:

A cadre of professionally qualified energy managers and auditors with expertise in policy analysis, project management, financing and implementation of energy efficiency projects would be developed through Certification and Accreditation programme. BEE has been designing training modules, and regularly conducting a National level examination for certification of energy managers and energy auditors.

Qualification for Accredited Energy Auditors and Maintenance of their list, Regulations, 2009

An Energy auditor shall be qualified to become an accredited energy auditor if he / she-

(a) is a certified energy manager and has passed the examination in "Energy Performance for Equipment and Utility Systems" conducted by Bureau

(b) has an experience of five years in energy audit out of which atleast three years shall be in any of energy intensive industries

(c) has been granted a certificate of accreditation by the Bureau of Energy Efficiency.

List of Acts, Rules & Regulations relevant to Energy Managers and Energy Auditors

No	Title
1.	THE ENERGY CONSERVATION ACT, 2001 [Act 52 of 2001, dt. 29-9-2001] [As amended by Act No. 28 of 2010, dt. 4-8-2010]
2.	THE ENERGY CONSERVATION (THE FORM AND MANNER FOR SUBMISSION OF REPORT ON THE STATUS OF ENERGY CONSUMPTION BY THE DESIGNATED CONSUMERS) RULES, 2007 [GSR 174(E), dt. 2-3-2007]
3.	THE ENERGY CONSERVATION (FORM AND MANNER AND TIME FOR FURNISHING INFORMATION WITH REGARD TO ENERGY CONSUMED AND ACTION TAKEN ON RECOMMENDATIONS OF ACCREDITED ENERGY AUDITOR) RULES, 2008 [GSR 486(E), dt. 26-6-2008]
4.	THE ENERGY CONSERVATION (INSPECTION) RULES, 2010 [GSR 645(E), dt. 27-7-2010, w.e.f. 30-7-2010]
5.	THE BUREAU OF ENERGY EFFICIENCY (QUALIFICATIONS FOR ACCREDITED ENERGY AUDITORS AND MAINTENANCE OF THEIR LIST) REGULATIONS, 2010 [Notification No. 02/11(7)/09-BEE, dt. 31.3.2010]
6.	THE BUREAU OF ENERGY EFFICIENCY (CERTIFICATION PROCEDURES FOR ENERGY MANAGERS) REGULATIONS, 2010 [Notification No. 2/11(2)/07-BEE, dt. 15-10-2010]
7.	THE BUREAU OF ENERGY EFFICIENCY (MANNER AND INTERVALS OF TIME FOR CONDUCT OF ENERGY AUDIT) REGULATIONS, 2010 [Noti. No. 02/11(6)/05-BEE, dt. 28-4-2010]
8.	ENERGY CONSUMPTION NORMS AND STANDARDS FOR DESIGNATED CONSUMERS, GSR 269 (E) dt 30th March, 2012
9.	ENERGY CONSERVATION (MINIMUM QUALIFICATION FOR ENERGY MANAGERS) RULES, 2006. G.S.R. 309 dt. 8th December, 2006

10.	ENERGY CONSERVATION (FORM AND MANNER AND TIME FOR FURNISHING INFORMATION WITH REGARD TO ENERGY CONSUMED AND ACTION TAKEN ON RECOMMENDATIONS OF ACCREDITED ENERGY AUDITOR) RULES, 2008. G.S.R. 486 (E) dt 26th June, 2008
11.	(ALTERED) LIST OF ENERGY INTENSIVE INDUSTRIES AND OTHER ESTABLISHMENTS SPECIFIED IN THE SCHEDULE TO THE SAID (EC) ACT S.O. 394 (E) dt 12th March, 2007
12.	APPELLATE TRIBUNAL FOR ENERGY CONSERVATION (PROCEDURE, FORM, FEE AND RECORD OF PROCEEDINGS) RULES, 2012 GS.R. 510(E) dt 28th June, 2012

The full references of these are available in the BEE website.

Appointment of Energy Manager

To develop and maintain vitality for the energy management program, a company must designate a person who has responsibility for coordinating the program. If no one has energy management as a specific part of his or her job assignment, management is likely to find that the energy management efforts are given a lower priority than other job responsibilities.

The energy manager should be strong, dynamic, goal oriented, and a good manager. Such a person should be supported by management with resources including staff. The energy manager should report as high as possible in the organization without losing line orientation. Energy Manager location can vary from one organization to another depending upon existing management structure. The location of Energy Management function in a typical textile mill is shown in Figure 6.3.

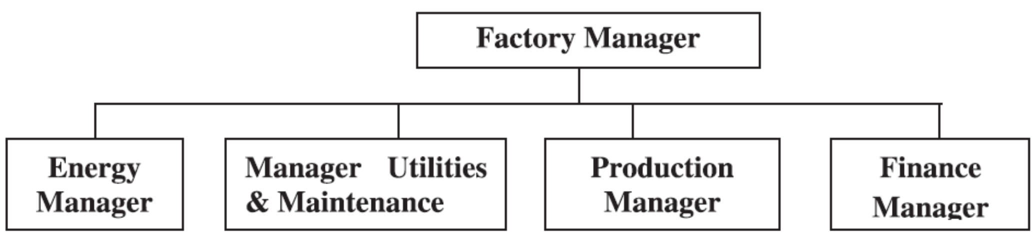


Figure 6.3 Energy Cell in a Typical Textile Mill

Responsibilities

1. Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs.
2. Establish an energy conservation cell within the firm and agree with management about the mandate and task of the cell.
3. Initiate activities to improve monitoring and process control to reduce energy costs.
4. Analyze equipment performance with respect to energy efficiency.
5. Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.

6. Prepare information material and conduct internal workshops about the topic for other staff.
7. Improve disseminating of energy consumption data down to shop level or profit center of a firm.
8. Establish a methodology to accurately calculate the specific energy consumption of various products/services or activity of the firm.
9. Develop and manage training programme for energy efficiency at operating levels.
10. Co-ordinate nomination of management personnel to external programs.
11. Create knowledge bank on sectorial, national and international development on energy efficiency technology and management system and information denomination.
12. Develop integrated system of energy efficiency and environmental up gradation.
13. Wide internal and external networking
14. Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
15. Establish and / or participate in information exchange with other energy managers of the same sector through association.

Duties of Energy Manager

1. Report to BEE and State level Designated Agency once a year. The information with regard to energy consumed and action taken in the recommendation of the accredited energy auditor, as per BEE – Format.
2. Establish an improved data recording, collection and analysis system to keep track of energy consumption.
3. Provide support to Accredited Energy Audit Firm retained by the company for the conduct of energy audit.
4. Provide information to BEE as demanded in the Act, and with respect to the tasks given by the mandate, and the job description.
5. Prepare a scheme for efficient use of energy and its conservation and implement such scheme keeping in view the economic stability of the investment in such firm and manner as may be provided in the regulations of the Energy Conservation Act.

7.3 Financial Analysis Techniques

In most respects, investment in energy efficiency is not different from any other area of financial management. So when the organization first decides to invest in increasing its energy efficiency, it should apply exactly the same criteria to reduce its energy consumption as it applies to all its other investments. A faster or more attractive rate of return on investment in energy efficiency should not be demanded.

The basic criteria for financial investment appraisal include:

- **Payback period –** is a measure of how long it will be before the investment recovers itself. This can determine how long the financing term needs to be there.
- **Net Present Value (NPV) and Cash Flow –** are measures that allow financial planning of the project taking into account streams of money inflow and outflow over a period of time. These measures provide the company with all the information needed to incorporate energy efficiency projects into the corporate financial system
- **Return on Investment (ROI) and Internal Rate of Return (IRR) –** are measures that allow comparison with other investment options

$$\textbf{Simple Payback period} = \frac{\textbf{Capital cost}}{\textbf{Annual net savings}}$$

A cogeneration system installation is expected to reduce a company's annual energy bill by Rs. 23 Lakhs. If the capital cost of the new cogeneration installation is Rs. 90 Lakhs, and the annual maintenance and operating costs are Rs. 5 Lakhs, what will be the expected payback period for the project?

$$\text{Simple payback period} = \frac{90}{23-5}$$

$$= 5 \text{ years}$$

Return on Investment (ROI)

ROI expresses the "annual return" expected from a project as a percentage of capital cost or initial investment. ROI is an inverse of payback period.

$$\textbf{ROI} = \frac{\textbf{Annual net cash flow}}{\textbf{Capital cost}} \times \textbf{100}$$

In comparing projects, ROI does not require similar project life or capital cost for comparison. ROI must always be higher than cost of money (interest rate) so as to make the project attractive; the greater the return on investment better is the investment.

An outlay of Rs.100,000 for equipment is expected to provide an after-tax cash flow of Rs. 25,000 over a period of six years, without significant annual fluctuations. What is the return on investment?

$$ROI = \frac{\text{Average annual operating cash flow}}{\text{Net investment}} = \frac{25,000}{100,000} \times 100$$

$$= 25\%$$

Time Value of Money

A project usually entails an investment for the initial cost of installation, called the capital cost, and a series of annual costs and/or cost savings (i.e. operating, energy, maintenance, etc.) throughout the life of the project. To assess project feasibility, all these present and future cash flows must be equated to a common basis. The problem with equating cash flows which occur at different times is that the value of money changes with time. The method by which these various cash flows are related is called ***discounting***, or the ***present value*** concept.

For example, if money can be deposited in the bank at 10% interest, then a Rs.100 deposit will be worth Rs.110 in one year's time. Thus the Rs.110 in one year is a future value equivalent to the Rs.100 present value.

In the same manner, Rs.100 received one year from now is only worth Rs.90.91 in today's money (i.e. Rs.90.91 plus 10% interest equals Rs.100). Thus Rs.90.91 represents the present value of Rs.100 cash flow occurring one year in the future. If the interest rate were something different than 10%, then the equivalent present value would also change. The relationship between present and future value is determined as follows:

$FV = NPV\ (1 + i)^n$ or $NPV = FV / (1+i)^n$

Where, *FV = Future value of the cash flow*
NPV= Net Present Value of the cash flow
i = Interest or discount rate
n = Number of years in the future

Net Present Value Method

The net present value method considers the time value of money. This is done by equating future cash flow to its current value today, or in other words by determining the *present value* of any future cash flow. The *present value* is determined by using an assumed interest rate, usually referred to as a discount rate. Discounting is the opposite process to compounding. Compounding determines the future value of present cash flows, whereas discounting determines the *present value* of future cash flows.

The *net present value* method calculates the *present value* of all the yearly cash flows (i.e. capital costs and net savings) incurred or accrued throughout the life of a project and summates them. As a matter of convention, costs are represented as negative values and savings as positive values. The sum of all the present values is known as the *net present value* (NPV). The higher the *net present value*, the more attractive is the proposed project.

The net present value (NPV) of a project is equal to the sum of the present values of all the cash flows associated with it. Symbolically,

$$NPV = -\frac{CF_0}{(1+\kappa)^0} + \frac{CF_1}{(1+\kappa)^1} + \cdots + \frac{CF_n}{(1+\kappa)^n} = \sum_{t=0}^{n} \frac{CF_t}{(1+\kappa)^t}$$

Where NPV = Net Present Value

CF_t = Cash flow occurring at the end of year 't' (t=0,1,….n). (As per our convention, net savings or inflows are represented by + sign and net costs or outflows are represented by – sign. Since capital investment is an outflow, it will be treated as negative (-) as per our convention.)

n = life of the project

k = Discount rate

The discount rate (k) employed for evaluating the present value of the expected future cash flows should reflect the risk of the project.

Hence the decision rule associated with the net present value criterion is: "Accept the project if the net present values is positive and reject the project if the net present value is negative". A negative net present value indicates that the project is not achieving the return standard and thus will cause an economic loss if implemented. A zero NPV is value neutral.

The net present value takes into account the time value of money and it considers the cash flow stream in entire project life.

Example 7.4: NPV

Using the *net present value* analysis technique, evaluate the financial merits of the two proposed projects shown in the table. The annual discount rate is 8% for each project.

	Project 1	Project 2
Capital cost (Rs.)	30000	30000
Year	**Net annual saving (Rs.)**	**Net annual saving (Rs.)**
1	+6000	+6600
2	+6000	+6600
3	+6000	+6300
4	+6000	+6300
5	+6000	+6000
6	+6000	+6000
7	+6000	+5700
8	+6000	+5700
9	+6000	+5400
10	+6000	+5400
Total net savings at end of 10^{th} year	**+60000**	**+60000**

For Project 1

$$\text{NPV} = -\frac{30000}{(1+0.08)^0} + \frac{6000}{(1+0.08)^1} + \frac{6000}{(1+0.08)^2} + \frac{6000}{(1+0.08)^3} + \frac{6000}{(1+0.08)^4}$$

$$+ \frac{6000}{(1+0.08)^5} + \frac{6000}{(1+0.08)^6} + \frac{6000}{(1+0.08)^7} + \frac{6000}{(1+0.08)^8} + \frac{6000}{(1+0.08)^9} + \frac{6000}{(1+0.08)^{10}}$$

$= \ - 30000 \times 1 + 6000 \times 0.926 + 6000 \times 0.857 + 6000 \times 0.794 + 6000 \times 0.735 + 6000 \times 0.681 + 6000 \times 0.630 + 6000 \times 0.583 + 6000 \times 0.540 + 6000 \times 0.500 + 6000 \times 0.463$

$= \ + 10254$

For Project 2

$$NPV = -\frac{30000}{(1+0.08)^0} + \frac{6600}{(1+0.08)^1} + \frac{6600}{(1+0.08)^2} + \frac{6300}{(1+0.08)^3} + \frac{6300}{(1+0.08)^4}$$

$$+ \frac{6000}{(1+0.08)^5} + \frac{6000}{(1+0.08)^6} + \frac{5700}{(1+0.08)^7} + \frac{5700}{(1+0.08)^8} + \frac{5400}{(1+0.08)^9} + \frac{5400}{(1+0.08)^{10}}$$

$= \ - 30000 \times 1 + 6600 \times 0.926 + 6600 \times 0.857 + 6300 \times 0.794 + 6300 \times 0.735 + 6000 \times 0.681 + 6000 \times 0.630 + 5700 \times 0.583 + 5700 \times 0.540 + 5400 \times 0.500 + 5400 \times 0.463$

$= \ + 10867$

For a 10-year life-span, the net present value for project 1 is Rs. 10,254, while for project 2 it is Rs. 10867 Therefore project 2 is preferential proposal.

Internal Rate of Return Method

By setting the net present value of an investment to zero (the minimum value that would make the investment worthwhile), the discount rate can be computed. The internal rate of return (IRR) of a project is the discount rate, which makes its net present value (NPV) equal to zero. It is the discount rate in the equation:

$$0 = -\frac{CF_0}{(1+k)^0} + \frac{CF_1}{(1+k)^1} + \cdots + \frac{CF_n}{(1+k)^n} = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t}$$

Where, CF_t = cash flow at the end of year "t"

k = discount rate

n = life of the project.

CFt value will be negative if it is expenditure and positive if it is savings.

Example 7.5: IRR (Example of iterative procedure to estimate the IRR)

A proposed project requires an initial capital investment of Rs. 20,000. The cash flows generated by the project are shown in the table below:

Investment	Rs. 20,000
Saving in Year	Cash flow
1	6000
2	5500
3	5000
4	4500
5	4000
6	4000

The cost of capital (discount rate), κ, for the firm is 8 per cent.

The net present value of the proposal is:

$$NPV = -\frac{20000}{(1+0.08)^0} + \frac{6000}{(1+0.08)^1} + \frac{5500}{(1+0.08)^2} + \frac{5000}{(1+0.08)^3} + \frac{4500}{(1+0.08)^4} + \frac{4000}{(1+0.08)^5} + \frac{4000}{(1+0.08)^6}$$

= - 20000 x 1 + 6000 x 0.926 +5500 x 0.857 + 5000 x 0.794 + 4500 x 0.735 + 4000 x 0.681 + 4000 x 0.630

= 2791

The discount rate has to be increased to bring NPV to zero.

Increasing the discount rate to 12%,

$$NPV = -\frac{20000}{(1+0.12)^0} + \frac{6000}{(1+0.12)^1} + \frac{5500}{(1+0.12)^2} + \frac{5000}{(1+0.12)^3} + \frac{4500}{(1+0.12)^4} + \frac{4000}{(1+0.12)^5} + \frac{4000}{(1+0.12)^6}$$

= - 20000 x 1 + 6000 x 0.893 +5500 x 0.797 + 5000 x 0.712 + 4500 x 0.636 + 4000 x 0.567 + 4000 x 0.507

= 495

Further increasing the discount rate to 16%

$$NPV = -\frac{20000}{(1+0.16)^0} + \frac{6000}{(1+0.16)^1} + \frac{5500}{(1+0.16)^2} + \frac{5000}{(1+0.16)^3} + \frac{4500}{(1+0.16)^4} + \frac{4000}{(1+0.16)^5} + \frac{4000}{(1+0.16)^6}$$

= - 20000 x 1 + 6000 x 0.862 +5500 x 0.743 + 5000 x 0.641 + 4500 x 0.552 + 4000 x 0.476 + 4000 x 0.410

= -1508.5

For a discount rate of 13%

$$NPV = -\frac{20000}{(1+0.13)^0} + \frac{6000}{(1+0.13)^1} + \frac{5500}{(1+0.13)^2} + \frac{5000}{(1+0.13)^3} + \frac{4500}{(1+0.13)^4} + \frac{4000}{(1+0.13)^5} + \frac{4000}{(1+0.13)^6}$$

= - 20000 x 1 + 6000 x 0.885 +5500 x 0.783 + 5000 x 0.693 + 4500 x 0.613 + 4000 x 0.543 + 4000 x 0.480

= - 65

It can be clearly seen that the discount rate which results in the net present value being zero lies somewhere between 12% and 13%. It is closer to 13%.

The exact internal rate of return can be found by interpolation or plotting the net present value on a graph as shown in Figure 7.1.

By interpolation Method

NPV at 13% = -65

NPV at 12% = +495

$$IRR = \text{Lower rate} + \frac{\text{NPV at lower rate x (Higher rate-lower rate)}}{\text{(NPV at lower rate – NPV at higher rate)}}$$

$$IRR = 12 + \frac{495 \text{ x } (13-12)}{495-(-65)}$$

= 12.88 %

By Graphical Method

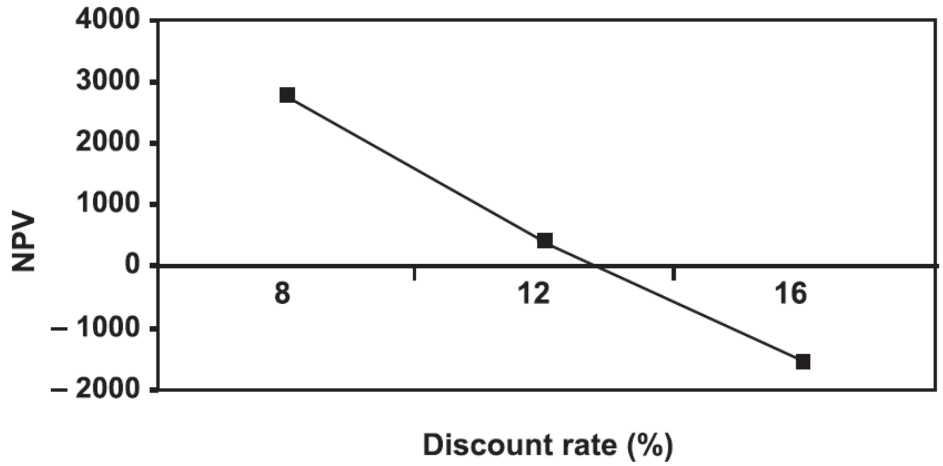


Figure 7.1 NPV versus Discount Rate

The Figure 7.1 shows the IRR for the project from graph is around 12 .88 %.

Comparison between *Net Present Value* and *Internal Rate of Return*

Although, they look similar, there is an important difference between the two methods.

In the net present value calculation, NPV of the project is determined by assuming that the discount rate (cost of capital) is known. In the internal rate of return calculation, we set the net present value equal to zero and determine the discount rate (internal rate of return), which satisfies this condition.

The *net present value* method is essentially a comparison tool which enables number of different projects to be compared while the *internal rate of return* method is designed to assess whether or not a single project will achieve a target rate of return.

Some of the strategies that can be used to meet future energy requirements include:

- Reducing energy requirements
    - Improving the efficiency of extraction of fossil fuels
    - Improving fuel efficiency of new coal-fired power plants by adopting new technology (i.e. super critical pulverized fuel fired boilers)
    - Adopting energy efficiency and demand side management
    - Promotion of public transport / mass transport (e.g. metro rail, light rail, monorail etc.) in urban areas
    - Developing renewable energy sources especially solar and wind
- Substituting imported oil/gas with domestic alternatives
    - Ethanol / Biodiesl as substitute for petrol / diesel
    - Biomass gasification for heat or power as alternative to gas / coal
    - Coal-to-oil technology as done in South Africa
- Diversifying energy supply sources
    - Mix of fuel comprising of coal, gas, nuclear, hydro and renewables with no dependence on any particular fuel
    - Sourcing oil / LNG from different countries
    - Importing gas through pipelines passing through countries who also benefit
- Expanding energy resource and developing alternative energy sources
    - Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR) for improving exploitation of reserves
    - Recovery of oil and gas from abandoned or marginal fields
    - In-situ coal gasification
    - Capturing Coal Bed Methane (CBM) which escapes from coal seams during mining
    - Conversion of coal to oil
    - Gas to Liquid (GTL)
    - Stepping up exploration to find new reserves (only one-third of oil bearing area explored so far)
    - Equity oil, gas, coal from other countries
    - Setting up energy intensive units (i.e. fertilizer plants) abroad
    - New domestic sources (nuclear –fast breeder reactor, thorium reactors, gas hydrates etc.)
    - Promoting Community Biogas Plants
    - Energy plantations