CHAPTER - 3

ENERGY AUDITING

OBJECTIVES

You will be able to:

- Define Energy audit & Explain the importance of Energy audit in industry.
- Explain the types of Energy audit and the outcomes of it.
- Explain the various measurements in Energy auditing.
- Write a short note on Energy audit instruments.
- Explain the steps in Energy audit report Generation.
- Enumarate the 10 step Methodology for Detailed Energy audit.
- Define Energy use profile and Describe the Energy audits required for constructing it.
- Explain the detailed Energy audit activities.
- Explain the different steps of presenting Energy audit results.
- Discuss the role of an Energy Management team.

3.1 Definition & 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 term Energy management means many things to many people. One definition of Energy management is

> ***"The judicious and effective use of Energy to maximize profits (minimize costs) and enhance competitive positions"***
>
> *(Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997)*

Another comprehensive definition is

> ***"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 objective of Energy Management is to achieve and maintain optimum Energy procurement and utilization, throughout the organization and:

- To minimize Energy costs / waste without affecting production & quality
- To minimize environmental effects.

3.2 Principles of Management

The Principles of management involve the following:

i. Procure all the energy needed at the lowest possible price(Examle:by from original sources, review the purchase terms)
ii. Manage energy use at the highest energy efficiency(Example::improve energy use efficiency at every stage of energy transport, distribution and use)
iii. Reusing and recycling energy by cascading(Example: waste heat recovery)
iv. Use most appropriate technology(select low investment technology to meet the present requirement and environmental pollution)
v. Reduce the available losses.(make use of wastes generated within the plant as a source of energy and reduce the component of purchased fuels and bills

3.3 Energy management strategy

Energy management should be seen as a continuous process. Strategies should be reviewed annually and reviewed as necessary. The activities (see the figure 3.3)

1. **Identify a strategic corporate approach**
   The starting point in energy management is to identify a strategic corporate approach to energy management. Clear accountability for energy management needs to be established, appropriate financial and staffing resources must be allocated, and reporting procedures initiated. an energy management program requires commitment from the whole organization in order to be successful.

2. **Appoint Energy Manager**
The energy manager, who should be senior staff member. Who will be responsible for the overall coordination of the program and well report directly to top management, energy manager need to have a technical background, need to be familiar with the organizations activities and have appropriate technical support.

3. **Set up an Energy Monitoring and Reporting system**
Successful energy management requires the establish of a system to collect,analyse and report on the organization energy cost and cionsumption.this will enable an overview of energy use and its related costs as well as the facilitating the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy use. as well as cost information from billing data, and be capable of producing summary reports on a regular basis .the information will provide the means by which trends can be analyzed and tariffs reviewed.

4. **Conduct Energy Audit**
An energy Audit establishes both where and how energy is being used, and the potential for energy savings. It includes a walk through survey, a review of energy using systems, analysis of energy use and preparation of energy budget, and provides a base line from which energy consumption can be compared over time. An Audit can be conducted by an employee of the organization who has appropriate expertise, or by a specialist energy Auditing firm. An energy Audit report also includes recommendations for actions, which will result in energy and cost savings. It should also indicate the costs and savings for each recommended action and a priority order for implementation.

5. **Formalize an energy Management policy statement**
A written energy management policy will guide efforts to improve energy efficiency, and represents a commitment to saving energy. It will also help to ensure that the success of the programme is not dependent on particular individual in the organization. An energy management policy statement includes a declaration of commitment from senior management, as well as general aims and specific targets relating to:
   - Energy consumption reduction (Electricity, fuel oil, gas, petrol.)
   - Energy cost reduction (by lowering consumption and negotiating lower unit rates)
   - Time tables'
   - Budgetary limits Energy
   - Cost centers
   - Organization of management resources.

6. **Prepare and undertake a detailed project implementation plan**
A Project implementation plan should be developed as part of the energy Audit and be enclosed by management. The path should include an implementation time table and state

any funding and budgetary requirements, Projects may range from establishing or changing operational procedures to ensure that plant and equipments use minimum energy, negotiating electricity supply arrangements etc to adopting asset acquisition programs that will reduce energy consumption. An Overall strategy should be introducing energy management projects, which will achieve maximum financial benefits at least cost to the organization.

7. **Implement a staff awareness and training program**

A key ingredient to the success of an awareness management program is maintaining a high level of awareness among staff. This can be achieved in a number of ways, including formal training, newsletters, posters and publications, and by incorporating energy management into existing training programs. It is important to communicate program planes and case studies that demonstrate savings, and to report results at least at 12-month intervals. Staff may need training from specialists on saving practices and equipment.

8. **Annual Review**

An energy management program will be more effective if its results are reviewed annually. Review of energy management policy and strategies will form the basis for developing an implementation plan for the next 12 months

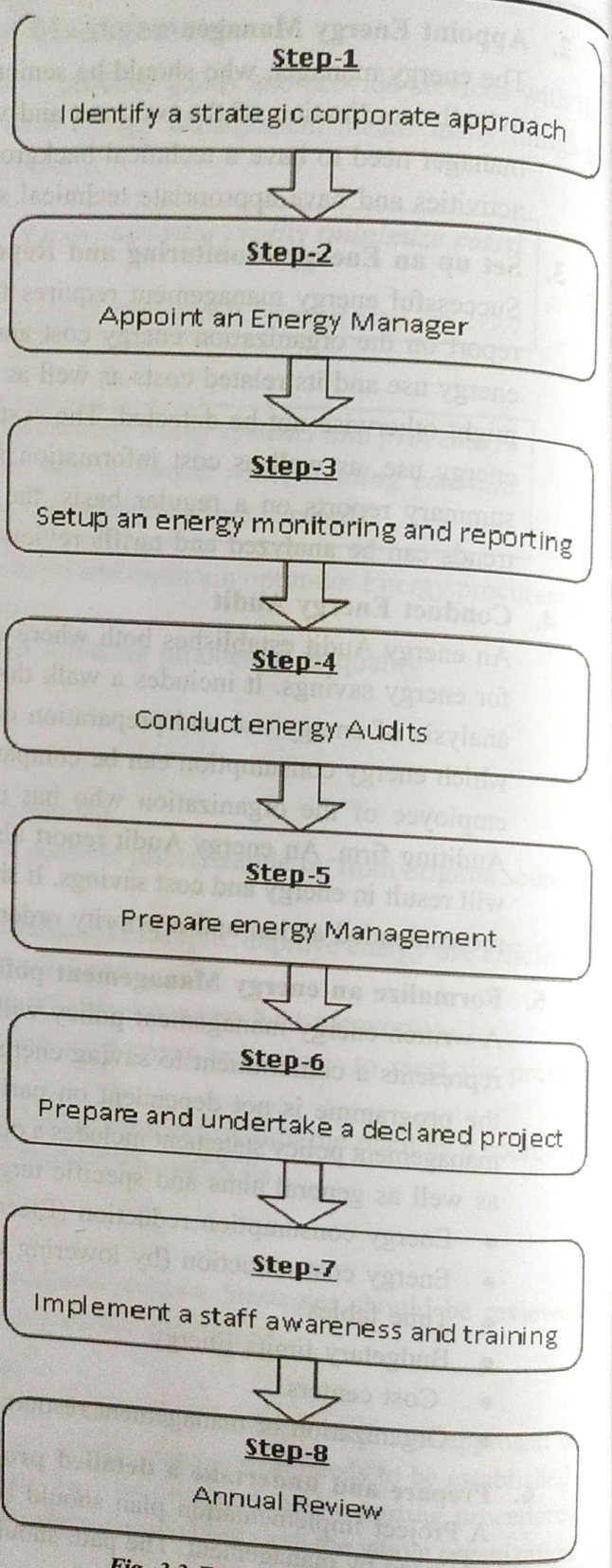


Fig. 3.3 Energy Management Steps

Samples of Energy Management Policy is given below :

Reliance
Industries Limited

Mukesh D. Ambani
[illegible]

[illegible]
Phones: [illegible]
Fax: [illegible]
E-mail: [illegible]

October 03, 2001

ENERGY MANAGEMENT POLICY

Reliance plays a lead role in the national economy by providing quality goods and services in the materials and energy value chains and in infrastructure.

Our mission is

- To be the lowest specific energy consumer in the industry we operate.
- To maximize the use of renewable fuels and low energy level fuels in our operations

This we plan to achieve by the following:

- Manage efficiently the utilization of energy resources, upgrade hardware and employ cleaner and more efficient technologies
- Train employees to make Reliance the pace setter in the area of energy conservation
- Carry out regular internal and external audits to identify areas for improvement
- Benchmark continuously our performance against the best in the world.
- Enrich our experience on energy conservation by exchange of ideas with other organizations.
- Promote awareness among all members of the large Reliance family.

(Mukesh D. Ambani)

Energy Policy Statement

We, at INDAL Hirakud are committed to continuously improve our energy performance in all our activities, products and services so as to make it environmentally sustainable for future generations.

To meet the above goals, we will strive for :

- Energy efficient power generation, aluminium smelting and casting.
- Nurturing energy efficient designs and technology for all future acquisitions, wherever practicable.
- Enhancing utilization of renewable energy resources, wherever feasible.
- Recognizing efforts of our employees and their family members in energy conservation initiatives.
- Going beyond standards, wherever economically viable.
- Yardsticks, which drive us to monitor and improve energy performance through periodic reviews and skill up-gradation of our employees.

As a part of our energy conservation and environmental strategy, our organisation is committed to reduce its specific energy consumption by a minimum of 2% from the present level by the year 2010.

The policy shall be made available to interested parties.

23/08/2002

23rd August 2002

Rabindra Misra
Chief Executive

INDIAN ALUMINIUM COMPANY LIMITED, HIRAKUD

3.4 Energy Audit: Types and Methodology

Energy Audit is the key to a systematic approach for decision-making in the area of Energy management. It attempts to balance the total Energy inputs with its use, and serves to identify all the Energy streams in a facility. It quantifies Energy usage according to its discrete functions. Industrial Energy audit is an Effective tool in defining and pursuing comprehensive Energy management programme.As per the Energy Conservation Act, 2001, Energy Audit is defined as **"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".**

3.4.1 Need for Energy Audit:

In any industry, the three top operating expenses are often found to be Energy (both electrical and thermal), Labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, Energy would invariably emerge as a top ranker, and thus Energy management Function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways Energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the Energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the 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 lending technically feasible solutions with economic and other organizational considerations within a specified time frame. The primary objective of Energy Audit is to determine ways to reduce Energy consumption per unit of product output or to lower operating costs. Energy Audit provides a "bench-mark"(Reference point) for managing Energy in the organization and also provides the basis for planning a more effective use of Energy throughout the organization.

3.4.2 Types of Energy Audit

The types of Energy Audit to be performed depend on:

- Function and type of industry
- Depth to which final Audit is needed, and
- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types.

1. Preliminary Audit
2. Detailed Audit

3.4.3 Preliminary Energy Audit Methodology:

Preliminary Energy audit is a relatively quick exercise to:

- Establish Energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary Energy audit uses existing, or easily obtained data

3.4.4 Detailed Energy Audit Methodology

A comprehensive audit provides a detailed Energy project implementation plan for a facility since it evaluates all major Energy using systems.

This type of audit offers the most accurate estimate of Energy savings and cost. It considers the interactive effects of all projects, accounts for the Energy use of all major equipment, and includes detailed Energy cost saving calculations and project cost. In a comprehensive audit, one of the key elements is the Energy balance. This is based on an inventory of Energy using systems, assumptions of current operating conditions and calculations of Energy use. This estimated use is then compared to utility bill charges.

Detailed Energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase
Phase II - Audit Phase
Phase III - Post Audit Phase

A Guide for Conducting Energy Audit at a Glance

Industry-to-industry, the methodology of Energy Audits needs to be flexible. A comprehensive ten-step methodology for conduct of Energy Audit at field level is presented below. Energy Manager and Energy Auditor may follow these steps to start with and add/change as per their needs and industry types.

3.5. Ten step methodology for Detailed Energy Audit:

Step No.	PLAN OF ACTION	PURPOSE / RESULTS
Step 1	<u>Phase I-Pre Audit Phase</u> • Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production/ Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices • Building up cooperation

Step No.	PLAN OF ACTION	PURPOSE / RESULTS
Step 2	• Conduct of brief meeting / awareness program with all divisional heads and persons concerned(2-3 Hrs)	• Issue questionnaire for each department • Orientation, awareness creation
Step 3	**Phase II-Audit Phase** • Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design operating data and schedule of operation • Annual Energy Bill and Energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements: Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data
Step 5	• Conduct of detailed trials / experiments for selected Energy guzzlers.	Trials/Experiments: • 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 experiments etc.
Step 6	• Analysis of Energy use	• Energy and Material balance & Energy loss/water analysis
Step7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by Energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
Step8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation. • Select the most promising projects • Priorities by low, medium long term measures
Step9	• Reporting & Presentation to the top Management	• Documentation Report Presentation to the top Management
step10	**Phase III-Audit Phase** Implementation and Follow-up	• Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

3.6 Phase I -Pre Audit Phase Activities

A structured methodology to carry out an Energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important. Initial Site Visit and Preparation Required for Detailed Auditing An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the Energy audit.

During the initial site visit the Energy Auditor/Engineer should carry out the following actions:

- Discuss with the site's senior management the aims of the Energy audit.
- Discuss economic guidelines associated with the recommendations of the audit.
- Analyses the major Energy consumption data with the relevant personnel.
- Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.
- Tour the site accompanied by engineering/production
- The main aims of this visit are: -
- To finalize Energy Audit team
- To identify the main Energy consuming areas/plant items to be surveyed during the audit.
- To identify any existing instrumentation/ additional metering required.
- To decide whether any meters will have to be installed prior to the audit eg. KWh, steam, oil or gas meters.
- To identify the instrumentation required for carrying out the audit.
- To plan with time frame
- To collect macro data on plant Energy resources, major Energy consuming centers
- To create awareness through meetings/ programme

3.7 Phase II- Detailed Energy Audit Activities

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, Energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked. The audit report will include a description of Energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of Energy, by department, by major items of process Equipment, by end Use
2. Material balance data (raw materials, intermediate and final products, recycled Materials, use of scrap or waste products, production of by-products for re-use in Other industries, etc.)
3. Energy cost and tariff data
4. Process and material flow diagrams
5. Generation and distribution of site services (eg.compressed air, steam).
6. Sources of Energy supply (e.g. electricity from the grid or self-generation)
7. Potential for fuel substitution, process modifications, and the use of co-generation Systems (combined heat and power generation).
8. Energy Management procedures and Energy awareness training programs within the establishment.

Existing base line information and reports are useful to get consumption patteren, production cost and productivity levels in terms of product for review material inputs. The audit term should collect the following base line data:

- Technology, processes used and equipment details
- Capacity utilization
- Amount and types of input materials used
- Water consumption
- Fuel consumption
- Electrical energy consumption
- Steam consumption
- Other inputs such as compressed air, cooling water etc
- Quantity and types of wastes generated
- Percentage rejection reprocessing
- Efficiency/yield.

Data Collection Hints:

It is important to plan additional data gathering carefully. here some basic tips to avoid wasting time and effort

- Measurement systems should be easy to use and provide the information to the accuracy that is needed, not the accuracy that is technically possible.
- Measurent equipment can be in expensive(flow rates using a bucket and stop watch)
- Define how frequent data collection should be to account for process variations.
- Measurent exercises over abnormal work load period (such as start up and shut down)
- Design values can be taken where measurements are difficult (cooling water through heat exchanger)

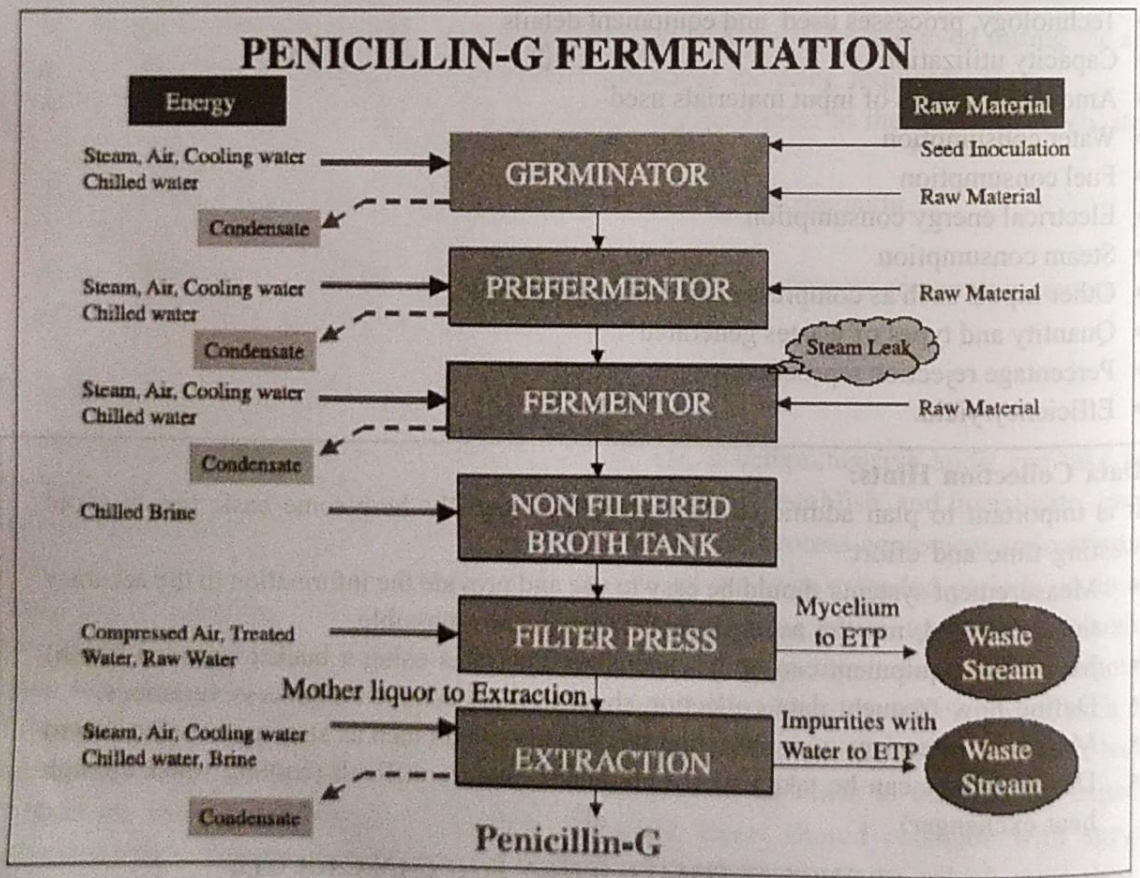
"DONOT ESTIMATE WHEN YOU CAN CALCUTE
DONOT CALCULATE WHEN YOU CAN MEASURE"

Draw process flow diagram and least process steps. Identify waste terms and obvious energy wastage

An overview of unit operations, important process steps, areas of material and energy use and sources of waste generation should be gathered and should be represented in a flow chart as shown in the figure below. Existing drawings, records and shop floor walk through will help in making this flow chart. Simultaneously the term should identify the various input and output terms at each process step.

Example: A flow chart of penicillin-G manufacturing is given in the figure below, Note that waste stream (Mycelium) and obvious energy wastes such as condensate Drained and steam leakages have been identified in the flow chart

The Audit focus area depends on several issues like consumption of input resources, energy efficiency potential, and impact of process step on entire process or intensity of waste generation/ energy consumption. In the above process, the unit test operations such as germinator, pre-ferment or, ferment or, and extraction are the major conservation potential areas identified



Identification of energy conservation Opportunities

Fuel substitution: Identifying the efficiency opportunities in energy conversion

Energy generation : Identifying Efficiency opportunities in energy conversion equipment/ utility such as captive power generation. Steam generation in boilers, thermic fluid heating, optimizing existing efficiencies, efficient energy conversion equipment, biomass gassifiers, cogeneration, and high efficiency DG sets.etc.

Energy distribution: Identifying efficiency opportunities network such as transformers, cables, switchgears and power factor improvement in electrical system and chilled water. Cooling water. Hot water, compressed air.etc

Energy use by progress: this is where the major opportunity for improvement and many of them are hidden. Process analysis is useful tool for process integration measures

Technical and Economic feasibility

The technical feasibility should address the following issues

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

The economic viability often becomes the key parameters for the management acceptance. The economic acceptance analysis can be conducted by using variety of methods. Example: payback method, internal rate of return method, Net present value method etc for low investments usually pay back period are usually sufficient. A simple worksheet for assessing economic feasibility is given below:

Sample work sheets for Economic feasibility

Name of the Energy Efficient Measures

1. Investment	2. Annual operating cost	3. Annual savings
• Equipments	• Cost of capital	• Thermal energy
• Civil works	• Maintenance	• Electrical energy
• Instrumentation	• Man power	• Raw material
• Auxiliaries	• Energy	• Water Disposal
	• Depreciation	

Net savings/year (Rs/Year)
= (Annual savings-annual operating cost)

Payback period in months
= (Investment/net savings/year) X 12

Classification of Energy Conservation Measures

Based on energy audit and analyses of the plant, a number of potential energy saving projects may be identified. These may be classified into three categories:

1. Low cost -High return
2. Medium cost-medium return
3. High cost -high return

Normally the low cost -high return projects receive priority. Other projects have to be analyzed, engineered and budgeted for implementation in a phased manner. Projects relating to energy cascading and process changes almost always involve high cost coupled with high returns and require carefully scrutiny before funds can be commited.these projects are generally complex and may be require long lead times before they can be implemented Refer table below project priority guide lines

PROJECT PRIORITY GUIDE LINES

Priority	Economical feasibility	Technical feasibility	Risk/Feasibility
A-Good	Well defined and attractive	Existing technology adequate	No risk/Highly feasible
B-May be good	Well defined and only marginally accepted	Existing technology may be updated lack of conformation	Minor operating risk/may be feasible
C-Held	Poorly defined and marginally accepted	Existing technology inadequate	Doubtful
D-No	Clearly not attractive	Need major break through	Not feasible

3.9 Role of energy management team:

The energy management team has to do the following roles

1) Compilation of energy audit data
2) Preparation of energy efficiency program and budget estimates.
3) Identification of energy loss and inefficient devices and equipments
4) Preparation of energy audit schedules
5) Initiation of energy conservation measures
6) Evaluation of energy savings and none for a saving
7) Spreading energy awareness

3.9 Energy Audit Reporting Format

After successfully carried out Energy audit Energy manager/Energy auditor should report to the top management for effective communication and implementation. A typical Energy audit reporting contents and format are given below. The following format is applicable for most of the industries. However the format can be suitably modified for specific requirement applicable for a particular type of industry.

Report on

DETAILED ENERGY AUDIT

TABLE OF CONTENTS

4.0 Detailed Process flow diagram and Energy& Material balance

4.1 Flow chart showing flow rate, temperature, pressures of all input-output streams

4.2 Water balance for entire industry

5.0 Energy efficiency in utility and process systems

5.1 Specific Energy consumption

5.2 Boiler efficiency assessment

5.3 Thermic Fluid Heater performance assessment

5.4 Furnace efficiency Analysis

5.5 Cooling water system performance assessment

5.6 DG set performance assessment

5.7 Refrigeration system performance

5.8 Compressed air system performance

5.9 Electric motor load analysis

5.10 Lighting system

6.0 Energy Conservation Options & Recommendations

6.1 List of options in terms of No cost/ Low Cost, Medium cost and high investment Cost, Annual Energy & Cost savings, and payback

6.2 Implementation plan for energy saving measures/Projects

ANNEXURE

A1. List of Energy Audit Worksheets

A2. List of instruments

A3. List of Vendors and Other Technical details

3.10 Understanding Energy Costs

Understanding energy vital factor for awareness creation and saving calculation. In many industries sufficient maters may not be available to measure all the energy used. In such case invoices for fuels and electricity will be useful. The annual company balance sheet will be other source where fuel cost and power are given with production related information.

Energy invoices can be used for the following purposes:

- They provide a record of energy purchased in a given year, which gives a base line for future reference
- Energy invoices may indicate the potential a for savings when related to production requirements or to air-conditioning requirements space heating etc
- When electricity is purchased on the basis of Maximum demand tariff
- They can suggest where savings are most likely to be made.
- In later years invoices can be used to quantify the energy and cost savings made through energy conservation measures

Fuel costs

A wide variety of fuels are available for thermal energy supply. few are listed below

- Fuel oil low sulphur heavy stock(LSHS)
- Light Diesel oil(LDO)
- Liquefied petroleum gas(LPG)
- Coal
- Lignite Wood etc.

Understanding fuel cost is fairly simple and it is purchased in tons or kiloliters availability, cost and quality are the main three factors that should be considered while purchasing.

The following factors should be taken into account during procurement of fuels for energy efficiency and economics.

- Price at source transport charge ,types of transport
- Quality of fuel(contamination ,Moisture etc)
- Energy content(calorific value)

Power cost

Electricity price in India not only varies from state to state but also city to city and consumer to consumer though it does some work every where. Many factors are involved deciding final cost of electricity such as:

- Maximum Demand charges KVA (i.e., how fast the electricity is used?)
- Energy charges KWh (i.e., how much electricity is consumed?)
- TOD Charges, Peak/nonpeak period (i.e., when electricity is utilized?)
- Power factor charge, P.F (i.e., Real power used varies apparent power use factor)
- Other incentives and Penalties applied from time to time

- High tension tariff and low tension tariff rate changes
- Slab rate cost and its variation
- Type of tariff clause and rate for various categories such as commercial industrial ,residential government ,agricultural etc
- Tariff rate for developed and undeveloped area/states
- Tax holiday for new projects

3.11 Energy use profiles:

The Energy audit process for a building emphasizes building envelops heating and ventilation, air conditioning plus lighting functions. For an industrial facility the Energy audit approach includes process flow consideration. Figures 3.8.1 through 3.8.4 Illustrates how Energy is used for a typical industrial plant. It is important to account for total consumption, cost, and how Energy is used for each commodity such as steam, water, air and natural gas. This procedure is required to develop the approximate Energy conservation strategy.

The following pie charts Illustrates how much Energy is used by fuel type and its relative percentage. How much of Energy is spent for each function such as lighting, process and building heating and ventilation. Pie chart should be made for each category such as air, steam, electricity, water and natural gas and amount spent for different Fuels. Pie chart presentation or nodal flow diagram can be very helpful in visualizing how Energy is being used.and for identifying Energy conservation potential

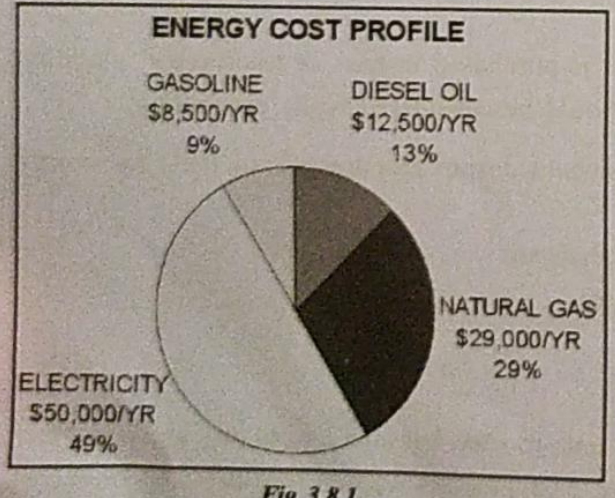


Fig 3.8.1

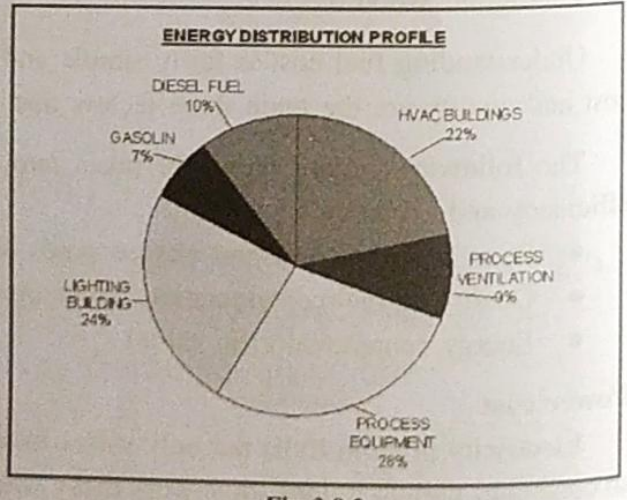


Fig 3.8.2

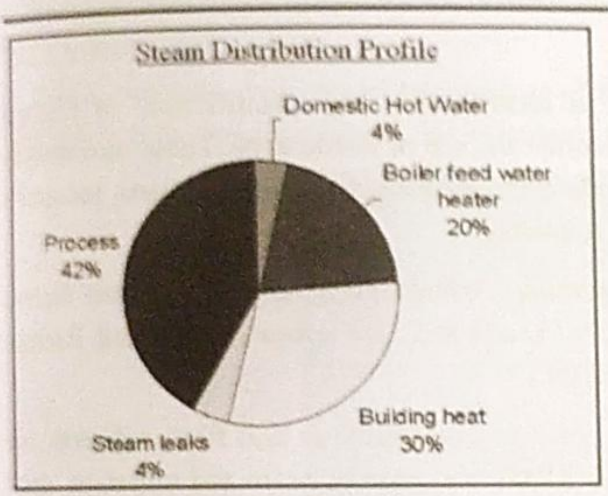


Fig 3.8.3

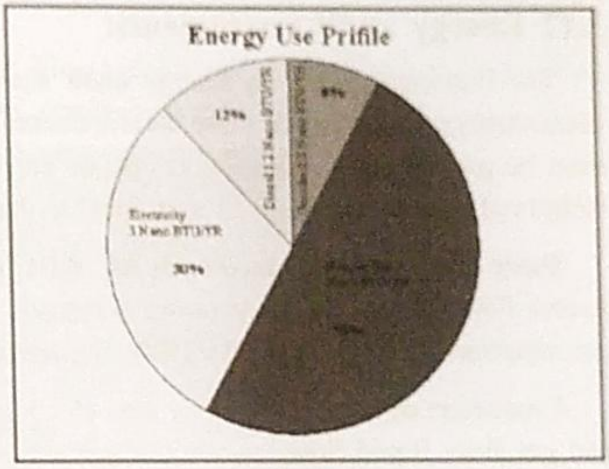


Fig 3.8.4

Figure 3.8 Illustrates Energy Use profiles

3.12 Audits are Required to construct the Energy use profiles:

3.11.1 Envelop audit:

This audit always surveys the building envelop for losses or gains due to leakes,building construction,doors,glass,lack of insulation,etc.

3.11.2 Functional audit:

This audit determines the amount of Energy required for a particular function and identifies Energy conservation opportunities.funtional audit include:

- Heating, ventilation and air conditioning
- Building
- Lighting
- Domestic hot water
- Air distribution

3.11.3 Process audit:

This audit determines the amount of Energy required for each process function and identifies Energy conservation opportunities. Process functional audit include:

- Process machinery
- Heating, ventilation and air conditioning process
- Heat treatment
- Furnaces

3.11.4 Transportation audit:

This audit determines the amount of Energy required for forklift, trucks, cars, vehicles,

3.11.5 Utility audit:

This audit analyses the monthly, daily or yearly Energy use for each utility.

3.12 Energy audit instruments:

The requirement for an Energy audit such as identification and quantification of Energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive. The parameters generally monitored during Energy audit may include the following:

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

Parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow, revolutions per minute (RPM), air velocity, noise and vibration, dust Concentration, Total Dissolved Solids (TDS), pH, moisture content, relative humidity, flue gas analysis - CO_2, O_2, CO, SO_x, NO_x, combustion efficiency etc.

3.12.1 Electrical Measuring Instruments:

These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hz, 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 as shown in fig-12 (a) &(b)

Figure 3.12 (a)

Figure 3.12 (b)

3.12.2 Combustion analyzer:

This instrument has in-built chemical cells which measure various gases such as O_2, CO, NO_X and SO_X.

Figure 3.12.2

3.12.3 Fuel Efficiency Monitor:

This measures oxygen and temperature of the Flue gas. Calorific values of Common fuels are fed into the microprocessor this calculates the combustion efficiency.

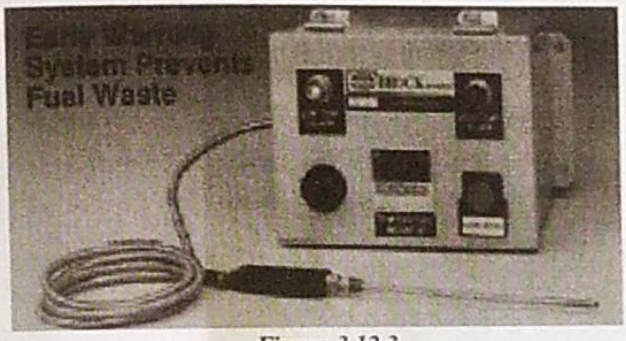


Figure 3.12.3

3.12.4 Fyrite:

A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for $O_2$and CO_2measurement.

Figure 3.12.4

3.12.5 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.

Figure 3.12.5

3.12.6 Infrared Thermometer:

This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.

Figure 3.12.6

3.12.7 Pitot Tube and manometer:

Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.

Figure 3.12.7

3.12.8 Water flow meter:

This non-contact flow measuring device using Doppler Effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

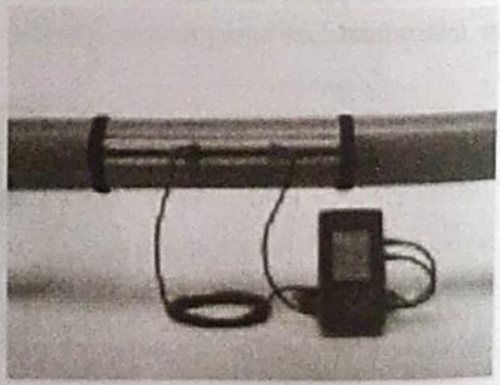


Figure 3.12.8

3.12.9 Speed Measurements:

In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading. 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.

Figure 3.12.9 (a) Tachometer

Figure 3.12.9 (b) Stroboscope

3.12.10 Leak Detectors:

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities.

Figure 3.12.10

3.12.11 Lux meters:

Illumination levels are measured with a luxmeter. It consists of a photo cell which senses the light output, converts to electrical impulses which are calibrated as lux.

Figure 3.12.11

REVIEW QUESTIONS

1. Define Energy audit. Explain the importance of Energy audit in industry.
2. Explain in brief the types of Energy audit and the outcome of the audit.
3. Explain the various measurements in Energy auditing.
4. Write a short note on Energy audit instruments.
5. Explain the steps in Energy audit report generation.
6. Give the 10 step methodology for detailed Energy audit and explain.
7. What is Energy use profile? What are the audits required for constructing the Energy use profile?
8. Explain the detailed Energy audit activities.
9. Explain the different steps of presenting Energy audit results.