

Energy Audit

Dr. Sanjay A. Khot
Certified Energy Auditor
Principal
SIT COE Yadrav.

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Outline

Energy Audit

Need for Energy Audit

The primary objective of Energy Audit

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A Guide for Conducting Energy Audit at a Glance

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Energy Audit

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**”.

Need for Energy Audit

In any industry, the three top operating expenses are often found to be

- ▶ Energy (both electrical and thermal)
- ▶ Labour
- ▶ Materials

The primary objective of Energy Audit

- ▶ To reduce energy consumption per unit of product output or to lower operating costs.
- ▶ 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.

Type of Energy Audit

The type of Energy Audit to be performed depends 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

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

Detailed Energy Audit Methodology

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

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Ten Step Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 1	<u>Phase I –Pre Audit Phase</u> <ul style="list-style-type: none">• Plan and organise• Walk through Audit• Informal Interview with Energy Manager, Production / Plant Manager	<ul style="list-style-type: none">• 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

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 2	<ul style="list-style-type: none">• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	<ul style="list-style-type: none">• Building up cooperation• Issue questionnaire for each department• Orientation, awareness creation

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 3	<u>Phase II –Audit Phase</u> <ul style="list-style-type: none">• Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	<ul style="list-style-type: none">• 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)

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 4	<ul style="list-style-type: none">Conduct survey and monitoring	<ul style="list-style-type: none">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.

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 5	<ul style="list-style-type: none">• Conduct of detailed trials /experiments for selected energy guzzlers	<ul style="list-style-type: none">• Trials/Experiments:<ul style="list-style-type: none">- 24 hours power monitoring (MD, PF, kWh etc.).- Load variations trends in pumps, fan compressors etc.

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step6	<ul style="list-style-type: none">• Analysis of energy use	<ul style="list-style-type: none">• Energy and Material balance & energy loss/waste analysis

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 7	<ul style="list-style-type: none">• Identification and development of Energy Conservation (ENCON) opportunities	<ul style="list-style-type: none">• 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

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step 8	<ul style="list-style-type: none">• Cost benefit analysis	<ul style="list-style-type: none">• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation• Select the most promising projects• Prioritise by low, medium, long term measures

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step9	<ul style="list-style-type: none">• Reporting & Presentation to the Top Management	<ul style="list-style-type: none">• Documentation, Report Presentation to the top Management.

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Step No	PLAN OF ACTION	PURPOSE / RESULTS
Step10	<u>Phase III –Post Audit phase</u> <ul style="list-style-type: none">• Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance <ul style="list-style-type: none">• Action plan, Schedule for implementation• Follow-up and periodic review

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.

The audit team should collect the following baseline data

- ▶ Technology, processes used and equipment details
- ▶ Capacity utilisation
- ▶ Amount & type of input materials used
- ▶ Water consumption
- ▶ Fuel Consumption
- ▶ Electrical energy consumption
- ▶ Steam consumption
- ▶ Other inputs such as compressed air, cooling water etc
- ▶ Quantity & type of wastes generated
- ▶ Percentage rejection / reprocessing
- ▶ Efficiencies / yield

Date Collection Hints

DATA COLLECTION HINTS

It is important to plan additional data gathering carefully. Here are 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
- measurement equipment can be inexpensive (flow rates using a bucket and stopwatch)
- the quality of the data must be such that the correct conclusions are drawn (what grade of product is on, is the production normal etc)
- define how frequent data collection should be to account for process variations.
- measurement exercises over abnormal workload periods (such as startup and shutdowns)
- design values can be taken where measurements are difficult (cooling water through heat exchanger)

DO NOT ESTIMATE WHEN YOU CAN CALCULATE

DO NOT CALCULATE WHEN YOU CAN MEASURE

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

Energy Audit Reporting Format

Report on

DETAILED ENERGY AUDIT

TABLE OF CONTENTS

i. Acknowledgement

ii. Executive Summary

Energy Audit Options at a glance & Recommendations

1.0 Introduction about the plant

1.1 General Plant details and descriptions

1.2 Energy Audit Team

1.3 Component of production cost (Raw materials, energy, chemicals,
manpower, overhead, others)

1.4 Major Energy use and Areas

Energy Audit Reporting Format

2.0 Production Process Description

- 2.1 Brief description of manufacturing process
- 2.2 Process flow diagram and Major Unit operations
- 2.3 Major Raw material Inputs, Quantity and Costs

3.0 Energy and Utility System Description

- 3.1 List of Utilities
- 3.2 Brief Description of each utility
 - 3.2.1 Electricity
 - 3.2.2 Steam
 - 3.2.3 Water
 - 3.2.4 Compressed air
 - 3.2.5 Chilled water
 - 3.2.6 Cooling water

Energy Audit Reporting Format

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

Energy Audit Reporting Format

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

Format for Energy Conservation Recommendation

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 m ³ /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 m ³ /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	=	$(3000 \times 4) / (5000 \times 8) = 30\%$
Capacity of DG Set cooling tower	=	240 m ³ /hr
Temp across the tower	=	5°C
Heat Load (240x1000 x 1x 5)	=	1200,000 K.Cal/hr

Format for Energy Conservation Recommendation

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	=	$(22 \times 2 + 7.5 \times 2) \times 0.80 = 47 \text{ kW}$
Additional power required for main cooling tower for additional water flow of $240 \text{ m}^3/\text{h}$ (66.67 l/s) with 6 kg/cm^2	=	$(66.67 \times 6) / (102 \times 0.55) = 7 \text{ kW}$
Net Energy savings	=	$47 - 7 = 40 \text{ kW}$
E: Cost Benefits		
<i>Annual Energy Saving Potential</i>	=	$40 \text{ kW} \times 8400 \text{ hr} = 3,36,000 \text{ Units/Year}$
<i>Annual Cost Savings</i>	=	$3,36,000 \times \text{Rs.}4.00 = \text{Rs.}13.4 \text{ Lakh per year}$
<i>Investment (Only cost of piping)</i>	=	Rs 1.5 Lakhs
<i>Simple Pay back Period</i>	=	Less than 2 months

Energy Saving Calculations

Old System

Type of fuel Firing

GCV

Avg. Thermal Efficiency

Heat Duty

Operating Hours

Annual Fuel Cost

: Furnace Oil fired heater

: 10,200 kCal/kg

: 82%

: 15 lakh kCal / hour

: 25 days x 12 month x 24 hours = 7,200 hrs.

: Rs.130 lakh (7200 x 1800 Rs./hr.)

Modified System

Type of fuel saving

GCV

Average Thermal Efficiency

Heat Duty

Annual Operating Cost

Annual Savings

Additional Auxiliary Power +

Manpower Cost

Net Annual Saving

Investment for New Coconut Fired heater

= Coconut chips fired Heater

= 4200 kCal/kg

= 72 %

= 15 lakh kCal / hour

= 7200 x 700 Rs./hr = 50 lakh

= 130 - 50 = Rs.80 lakh .

= Rs. 10 lakh

= Rs. 70 lakh

= Rs. 35 lakh

Simple pay back period

= 6 months

Key instruments for energy audit



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.

Key instruments for energy audit



Combustion analyzer:

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

Key instruments for energy audit



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.

Key instruments for energy audit



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 O₂ and CO₂ measurement.

Key instruments for energy audit



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.

Key instruments for energy audit



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.

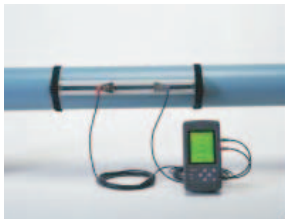
Key instruments for energy audit



Pitot Tube and manometer:

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

Key instruments for energy audit



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.

Key instruments for energy audit



Tachometer



Stroboscope

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.

Key instruments for energy audit



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.

Key instruments for energy audit



Lux meters:

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

Thank You !