

Energy Auditing Tools & Saving Gadgets

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Abstract— Energy audit is a practice developed to estimate the unnecessary usage of energy, control and also streamline processes leading to energy efficiency. Generally Industries give priority to Energy audit as its impact on a daily basis is precarious. Energy Conservation is one of the key in terms of saving excessive bills and building up of unnecessary usage. The world is an aspirant of energy efficient and it should be a forefront process to ensure the optimum usage and possible saving. This paper describes about the energy audit, techniques and tools for conservation of energy along with gadgets for energy saving. Since any developing economy like India becomes beneficent by saving considerable amount of unused energy and also recovering the waste energy.

Key words: Basics of Energy Audit, Audit Tools, Audit Process, Audit Analysis, Audit Report, Energy Saving Gadgets

I. INTRODUCTION

Energy audit's first and foremost application is to verify and find faults in energy systems, amount of possible savings in bills through minimum usage and procurement of devices to formulate energy flow. It is decisive in terms of mitigating excess cost in various loads like domestic, industrial and so on. Utility bills can be saved up to 15-20% if auditing is made a regular practice. Energy auditing is done in various ways which shall be responsible in effective energy management and conservation. Auditing seems scrutiny. Auditing can also be termed as energy survey or energy analysis and gives a consumer oriented result.

Energy audit evaluates efficiency of all processes that consumes energy. Auditing starts by allocating areas of energy sources, then it is quantified into discrete functions followed by efficiency analysis and finally by substantial energy saving and cost saving opportunities.

II. COMPONENTS IN AN ENERGY AUDIT

Energy auditing is a huge process and hence requires synchronization of lot of components to come together. The auditing procedure of certain processes can be defined in a conventional way. The audit process can be initiated by identifying the previous records of the facility's operations and utility bills, which can be used to assess and help in the selection of an appropriate technique.

III. ENERGY AUDIT TOOLS/ INSTRUMENTS

Tools and Instruments that are widely used for auditing are

- Lux meter: A lux meter is a device used to measure the brightness of a light. The accuracy of lux meter reading depends upon height, proportionality, daylight, shadows, and orientation of light source.
- Thermometers: Temperature is a key attribute as this enhances an auditor to determine efficiencies and to identify waste heat recovery scopes.

- Tape Measures: A tape measure or measuring tape is a flexible ruler consisting a ribbon of cloth, plastic, fiber glass, or metal strip with a linear-measurement markings. Its design allows for the measurement of great length which should be easily carried in pocket or toolkit that permits one to measure around curves or corners.
- Infrared Cameras: These are used to find the overheated electrical wires, connections, circuit breakers, transformers, motors and various electrical equipments. These are also used in finding out wet insulation, missing of insulation, cold spots and roof leaks. Mostly these are expensive but very essential in carrying out audit
- Voltmeter: A voltmeter is an instrument used for measuring electrical potential difference between two points in an electrical circuit.
- Combustion Analyzer: Emissions monitoring can be done accurately with analyzer in a product line of industrial portable emissions. The portable analyzers measures O₂, CO, NO_x (NO + NO₂), SO₂, H₂S, CO₂, and C_xH_y hydrocarbons provide emissions monitoring for boilers, engines, burners, and other combustion equipment.
- Blower Door Attachment: A blower door is a machine used to measure the airtightness of buildings. It can also be used to measure airflow between building zones, to test ductwork air tightness and to help physically locate air leakage sites in the building envelope
- Smoke generator: Also called as an air current tester. Smoke generators can be used either individually or in conjunction with the blower door to visually indicate sources of leaks or air infiltration. These are an excellent client education tool.
- Tonge tester: It measures AC/DC current up to 400 amps with 3.0 percent (VAC) accuracy without damaging the circuit. Also measures AC/DC voltage, resistance, frequency, capacitance and continuity.
- Safety Equipment: Auditing of certain necessary safety equipment like safety glasses, hearing protectors, electrical insulated gloves, breathing mask, safety shoes etc., becomes pretty tough.
- Data loggers: A data logger is a device that can be used to store data. Different data types include data acquisition devices such as plug-in boards or serial communication systems (using a computer as a real time data recording system). The advantage of data loggers is that they can be operated independently. Data loggers are available in various shapes and sizes.
- Anemometer: Anemometers are available for measuring airflow. The volume of air moving through an orifice can be determined by estimating the free

area of the opening (e.g., supply air register, exhaust hood face, etc.) and multiplying by the air speed. This result is approximate due to the difficulty in determining the average air speed and the free vent area.

IV. SAFETY CONSIDERATIONS

- Hearing: Usage of foam inert plugs when around loud machinery can reduce sound levels up to 30 decibels
- Respiratory: Wearing of full face respirator mask with proper filtration. Using activated carbon cartridges in low concentrated noxious gas environments, and changing on a regular basis.
- Electrical: Avoiding live currents, switching off the circuits on equipment.

V. AUDIT PROCESS

Initially an audit visit information is secured in which details like energy and utility bills, processes and current status is identified. In accordance with this audit equipment are finalized.

A. First Visit

An introductory visit can be made by meeting the facility manager or supervisor and discuss out the purpose of audit. If possible managers from various departments can be familiarized with the audit process and also point out the possible energy conservation technique.

B. Audit Sessions

Obtaining the appropriate and an adequate information is essential for audit as it will yield in giving methods to trap losses and save bills. Few steps during an initial visit

- 1) Meeting facility manager or plant manager for information on running data and past record.
- 2) Finance officers can provide with various bills like electricity, fuel and water.
- 3) Interacting with floor supervisor and operators to understand conditions.
- 4) Maintenance supervisor is always a key to retrieve information from.
- 5) An auditor must record down the important contacts for further record

1) Walk through Audit

A walk through audit is extremely necessary to get the initial feel and to recognize the prospective areas. This will help the auditor and the audit team to see the major operational equipment General information can be obtained and hence would yield to data acquisition.

2) Detailed Audit

Post walk through a detailed audit is extremely crucial to actually decide upon the factors involved in energy losses and potential areas for focusing.

C. Important Parameters to look for

- Lighting: A detailed inventory for lighting is required to be obtained. Data pertaining to number of lights and fixtures wattage, hours of operation. A lighting record should be maintained to. Using a light meter auditor should measure out the lux levels at various points as suitable.

- HVAC Equipment: HVAC equipment should be stocked. With the use of prepared data sheets size, model numbers, age, electrical specification, hours of operation are to be noted. The equipment is to be monitored to determine the condition of condenser coils, evaporators, air filters, and insulation on refrigeration lines.
- Electric Motors: All motors present in the industry to be taken into consideration. Audit the data sheet by highlighting the motor size, age, duration of work and other specifications. Other important factors like power factor, voltage levels, current are to be noted. Rewinding of motor is a common practice in industries, comparing the cost and performance of a rewound motor to a new motor are few areas of concern.
- Water Heaters: Relevant details like type, size, model number, and working duration are noted. Temperature of hot water should be noted.
- Waste Heat Sources: Majorly all industries have waste heat sources giving an opportunity to reuse that heat. Various waste heat sources are air conditioners, air compressors, heaters and boilers, ovens, furnace and so on. The main condition is temperature that determines the amount of heat that can recovered.
- Peak Load Equipment: Peak load equipment would generally mean the electrically powered machines that are either used intermittently or at a stretch. Peak load should be adjudged by surveying a load pattern and hence should be made to operate at intervals keeping in mind the time for maximum usage.

D. Post Audit Analysis

Data obtained should be examined, organized and reviewed for authentication. Missing data should be obtained from facility manager in case of discrepancy. There should be a proper channeling of the obtained value and conditions should yield a proper result. Cost effectiveness should be shouldered in mind as one of the major criteria is to cut down the expenses due to losses.

1) Energy Index (EI)

$$\text{Energy Index} = \frac{\text{The energy used}}{\text{The production output}}$$

2) Cost Index (CI)

$$\text{Cost Index} = \frac{\text{The energy cost}}{\text{The production output}}$$

These may be calculated weekly/monthly/yearly.

VI. ENERGY AUDIT REPORT FORMAT

A. Introduction of the plant

- General plant details and description
- Energy audit team
- Components of production cost (energy, raw material, manpower etc.)
- Major energy usage and areas

B. Production Process Description

- Description of manufacturing process
- Process flow diagram
- Major raw materials, Quantity and Cost

C. Energy and Utility System Description

- Lists of utilities
- Brief description of each utility
- Electricity
- Steam
- Water
- Compressed air
- Cooling water

D. Detailed process flow diagram and Material & Energy balance

- Flow chart showing flow rates, temperature, pressure of all input –output streams.
- Water balance of entire industry.

E. Energy efficiency in utility and process systems

- Specific energy consumption
- Boiler efficiency assessment
- Cooling water system performance
- DG set performance assessment
- Electric motor load analysis
- Compressed air system performance
- Lighting system

F. Energy conservation options and recommendations

- List of options in terms of No cost / low cost, medium cost and high investment cost, annual energy and cost saving, payback period
- Implementation plan for energy saving measures and projects

G. Energy Saving Gadgets

1) Smart Thermostats

Smart thermostats learn how and when your family uses the heating and air conditioning system and follows your patterns for the smartest energy savings. Since as much as 40 percent of your home overall energy bill from heating and cooling. This system is a great place to make huge differences with a little investment.

2) LED Lighting

Of all the energy-efficient lighting available, LED bulbs offer the brightest light for the least money. Halogen and

compact fluorescent haven't been well received among consumers for several reasons. Some people fear about the mercury present in fluorescent bulbs while others aren't satisfied with the quality of light emitted by halogen bulbs. LED is a good alternative, providing a consistent light for little money, and they are in safe.

3) Energy Management System

This system allows you to control your entire home electrical load via a remote control. You'll never have to worry about leaving lights on, or if you left the coffee maker on or the geyser to make hot water ready as soon as you reach for bathing and A/C on/off. The lights, heating and air system, appliances, stereo, and security system can all be controlled from your remote or with your smartphone.

4) Energy Star Appliances

If you have to buy a new microwave, toaster oven, refrigerator, ceiling fan or other appliance, shop for Energy Star certified products. These appliances offer significant savings in operation, often saving you enough money to pay for the appliance in just a few months. Washing machine technologies have come particularly far recently, and you can now get a machine that costs less than ₹ 480 per year to operate.

5) Charging Stations:

One common cause of energy waste around the home is phantom power. This results from electronics that are plugged in but not turned on, sucking as much as 8 % of power consumed by a home electrical load for nothing. Charging stations are available which are automatically turned off and stops phantom power leaks when phones or MP3 players are fully charged. Others shut off after a specific interval of time, such as after 4.5 hours. Most cell phones are fully charged in this time interval.

6) Smart Power Strips

Instead of having unplugged appliances and electronics around the house at every night, consider a smart power strip that cuts phantom power from anything plugged into it. This is ideal for hard to reach plugs on the floor, in the back of the kitchen counter, under the computer desk, and behind the TV. These gadgets vary in price, but all are able to save you enough money on the power bill to justify the purchase price. The energy consumption of different home appliances is described in the home load table.

Appliance Type	Considerations
Cookers	We have recommended ovens that have a 5 star energy rating as they are most efficient of all. A new 5 star rated electric oven will consume 40% less energy than a 3 star rated oven.
Microwave ovens	Microwave Ovens provide energy efficient way of cooking food rather than the electric oven. Because microwave oven uses energy directly to heat your food, whereas electric ovens also heats the air along with food inside the oven.
Dishwashers	Dishwashers can take up a significant chunk of your electricity bill, costing an average of ₹ 3500 a year to run. A new dishwasher costs around ₹ 800 less than an old inefficient machine of the same size, and it will use less water.
Fridges, freezers and fridge-freezers	These are switched on 24 hours a day, 7 days a week, so it's well worth finding models that are energy efficient. Choosing a 5 star rated fridge/freezer over a 3 star will save you about ₹ 1500 per annum in energy bill. However, as the energy rating is based upon classification by size, a smaller 3-star rated fridge could use less energy than a larger 5 star rated fridge. You can compare the total energy consumption of appliances by looking for their yearly energy consumption in kWh / annum displayed on the bottom right of the energy label.
Kettles	Kettles are one of the most commonly used appliances in the kitchen. ECO kettles that only boil the amount of water required can use 20 per cent less energy than a conventional electric kettle. On an average a household boils the kettle 1,500 times a year.
Washing machines	An energy efficient machine will save you money on your electricity bill.

Digital or DAB (Digital Audio Broadcasting) radios	Digital radios have been one of the biggest selling consumer electronic products for the last few years due to superior sound quality, a wide range of extra channels and rapidly falling prices. Digital radios generally consume more power than their analog equivalents.
Digital television recorders	Recording your favourite shows doesn't need to cost additional in energy bills. In most homes, entertainment equipment accounts for about 10% of your electricity bill.
Televisions	Televisions can be the most power-hungry entertainment appliances, particularly the larger ones. The larger a television is, the more energy it will consume, regardless of its energy rating. HD TVs have more pixels per square inch of screen area and therefore tend to consume more energy than SD (Standard Density) televisions. LED, LCD and plasma screen are the most common forms of flat-screen TVs on the market. LED and LCD TVs are not good for seeing the screen from sideward angles, but otherwise there is little difference between the picture quality of these and plasma screen TVs. However, plasma screen TVs tend not to come in smaller sizes, and generally use more energy than the similar sized LED or LCD TVs.
Desktop and laptop PCs	Laptops typically uses 85 per cent less electricity over an year than the desktop PCs. Choosing a laptop over a desktop and reducing the standby could save up to ₹2000 per year.

Table 1: Home load table

VII. CONCLUSION

Energy audit is an effective energy conservation technique. It is a methodical method and is technologically advanced procedure to find out energy consumption of an industry/plant/firm. The various instruments used for auditing and measurement devices are technically enhanced and is portable in various uses. The energy conservation methods implemented can sustain energy for future generations. The prior intention for usage is easiness in use and mobility as an auditor has to travel all around in pursuit of data collection.

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