Energy audit: types, scope, methodology

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Abstract- The objective of this paper is to study about Energy auditing, need of energy auditing, scope and methods adopted during the energy audit. As energy play vital role in development of country all the nations focusing on saving the energy. The energy audit is an important parameter for all the developing and developed countries and they focus on energy efficiency, energy quality, and energy intensity. In the industrial, residential, and commercial sectors the top operating expense is found to be are material, machine, manpower, and energy. Implementation of an energy audit can enhance the efficiency, quality of power, reduce the tariff of bills, and reduces the wastage of energy. The need for energy audits, different types of energy audits, various types of software used were presented in this paper.an LED light example is presents in this paper to enhance need for energy auditing.

***Index Terms*—Energy auditing, Efficiency HVAC, LED light.**

I. INTRODUCTION

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 important point for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

An energy audit is the study of a plant or facility to determine how and where energy is used and identify methods for energy savings. There is now a universal recognition of the fact that new technologies and much greater use of some that already existed provide the most hopeful prospect for the future opportunities lie in the use of existing renewable energy technology, greater efforts at energy efficiency and the dissemination of these technologies and options. efficiency and would like to emphasize that an energy audit is a continuous process, in this regard the research list possible actions to conserve and efficiently utilize our scares resources and identify various savings Minor and major modifications process design of the plant will result in the dramatic improvement in the plant energy efficiency, the need for such modifications will be brought out by comparison specific energy consumption per unit product. The actual use of electrical energy has been calculated/measured at the output of electrical equipment in the preliminary audit, improving the efficiency of energy conversion process will result in lower loading levels in the electrical equipment and lower use of electrical energy. In examining the major low efficiency energy conversion processes and arrive at ways to reduce the energy consumption in those process. The possibility of using automatic controls in order to switch off electrical equipment when the process does not really need energy and to adjust the efficient operation of electrical equipment against varying process load levels should be critically examined. It is often possible to reset the process variables to new levels conducive for lower energy

consumption after a critical examination of the process. Todays, the world is suffering from Global warming that cause major harm to environment.

These problems are arising by generating energy from fossil fuel. The generation of energy is very expensive hence the conservation of energy is very important. The ultimate loads are lighting, heating, ventilation, and air conditioning (HVAC) system, fans, pump, computers, lightening system, blowers, compressor, and many other heavy machines are connected in this electrical system which perverts the performance and the efficiency due to the many reasons such as aging of the device, aging of the wires used, dust factor, humidity, and low quality of equipment's various other factors. This leads to loss of electrical energy and it is converted into heat energy which reduces the system efficiency and increases power consumption. It is possible to reduce the losses through energy auditing which helps to find the performance of the whole electrical system. If there are any leakages in energy they will be detected and rectified. Thus the Energy auditing activity will help the electrical and electronic devices increase their life span. An energy audit consists of various jobs that can be carried out, which depends on the type of energy audit and the purpose of the energy audit facility. The energy audit can start with a review of the electricity bill which shows energy consumption. The energy audit has been carried out by various researchers in different ways for the energy consumption has been presented in, and it states that energy audit in the Industries or residential house and provided recommendation for the energy can be used in proper utilization, which can also decrease the tariff in their energy bill. Now what exactly the energy audit is, it is an investigation of energy in a particular area or building. to decide from where and how the energy will be utilized and depends upon the utilization auditor makes different strategies for energy consumption. The whole investigation process will reduce energy consumption without affecting the work of his devices or its equipment and maintain the comfort level. Consumer behavior can be considered as vital factor that affecting energy consumption, in addition to the age of building and climate factor. Data gathered from the local weather station helps to design the model of the thermal power structure of the buildings, whether a large number of variables can affect the energy consumption whether increase and decrease. Good energy management starts with energy-saving; it would be done by using the adequate rating of devices, by using high-efficiency devices, and change of habits which cause huge wastages of energy audit. The energy audit is essential to reduce electrical billing and to decrease energy wastages. Governments must take some steps to make energy audits compulsory for industrial buildings at certain

Frequencies. In recommended that electrical energy is the most important part of private as well as in government. An energy audit is an effective tool to find out the energy consumption of a building and helps to obtain the best solution. Detailed auditing was carried out to find out the construction material, over all energy consumption, HVAC load, lightening system load, and thermal images to provide information about the temperature distribution and gives an idea about the heat or air leak from or into the building. Modifications can be done by using the payback method. Regular energy auditing will show the electrical energy consumption and wastage of electrical energy, it also helps in suggesting the new energy-saving opportunities and it is reviewed in reference. The reduction in electrical energy shows the reduction of carbon emission. In presents that India is the fifth largest producer of electrical energy in the world. Despite such accomplishments, the hole amongst requests and supply of electrical energy is expanding each year and power division is profoundly capital escalated. An energy audit is a compelling instrument for distinguishing and examining a complete energy administration program. This approach could be valuable for industry infighting fundamental energy cost and raps a few different advantages like enhanced creation, higher profit, better quality, and the most essential fulfillment of heading towards contributing to the world's energy-saving. Energy audit and planning for both existing and new-to-construct buildings have been of expanding enthusiasm amid the most recent years because of developing ecological concerns Energy audit finds out the energy-saving mechanisms and increases the responsiveness of energy conservation among society.

The remainder of this work is organized as follows: The description and need for energy audit have Been presented in Section 2. Section 3 presents the different types of energy audits. Software's used for Energy audit and the energy audit report structure have been

described in Sections 4 and 5. Finally, the Contributions with concluding remarks are described in Section 6.

2. ENERGY AUDIT

Energy has the highest potential for cost reduction, and thus the energy audit becomes a crucial exercise. An energy audit helps us to understand how the energy is used in the industry and helps in identifying areas where the waste of energy can occur and where the scope for improvement exists. The requirements that must be fulfilled for an energy audit are

- Measured up-to-date energy consumption data
- A detailed review of the energy consumption profile
- Provide life-cycle cost rather than the simple payback period

The audit should provide a clear picture of energy consumption and energy opportunities for improvements. The international standards ISO 50002:2014 specifies the process required for carrying out an energy audit. It specifies the principles, common process, and deliverables for an energy audit. European standards for energy audit BS EN 16247 deal with commercial, industrial, non-commercial, and public sector organizations, excluding individual private dwellings. According to the Bureau of Energy Efficiency (BEE), the consumer shall have its first energy audit conducted with the one and half year notification issued by the government. The time interval for conduct and completion of energy audit shall be 3 years with effect from the date of submission of the previous energy audit report by the energy auditors to the management of designated consumers.

2.1. Need for energy audit

The energy demand is increasing day-by-day. To fulfill this demand, we need to use more fossil fuels. Fossil fuel generates energy as well as pollution, which is harmful to mankind. The pollution and emission checking calculators are available on the internet and they are used to help in measuring the pollution level and emission level in the environment. An energy audit will reduce the environmental effect directly or indirectly. The functions of the energy audit are,

- an energy audit can reduce energy consumption
- an energy audit can reduce the energy bill and save the money
- an energy audit can reduce the carbon footprints
- an energy audit can reduce unnecessary waste and pollution

The energy audit is the great and most valuable step to save energy consumption and save money. It may seem that an organization's energy audit provides a point of reference for managing the consumption of energy and also it provides a better plan for the essential use of energy in an organization.

3. TYPES OF ENERGY AUDIT

The energy audit provides the best solution to reduce energy bills and energy consumption whether it is a commercial or non-commercial sector. The type of energy audit that needs to be performed depends on,

- to what extent the penetration and depth required for the final inspection are
- the industry used: its function and type
- the size of the audit and the desired amount reached.

There can be three types of energy audits, and they are walk-through energy audits, target energy audits, and detailed energy audits.

3.1. Walk through energy audit

The simplest and fastest type of energy audit is a walk-through energy audit. The Energy Auditor will come to your house and search for places where energy is being wasted. They will also inquire about your energy consumption.

3.2. Targeted energy audit

A target energy audit is more comprehensive than a walk-through energy audit. In addition to looking for areas where your home is losing energy, the Energy Auditor will also conduct tests to determine how much energy your home uses.

3.3. Detailed energy audit

A detailed energy audit is the most comprehensive type of energy audit. In addition to looking for areas where your home is losing energy and conducting tests to assess how much electricity your home consumes, the Energy Auditor will also offer suggestions for enhancing your home's energy efficiency.

4.0METHODOLOGY OF CARRYING OUT ENERGY AUDIT

4.1Pre-audit phase

A pre-audit phase is the first step of a comprehensive energy audit. In the pre-audit Phase, the energy auditor

organizes and plans for the energy audit. In this phase, a formal interview is Conducted with the plant manager, energy manager, and production Manager. In this phase, a brief meeting is also conducted with all the heads and the concerned person. During the pre-audit phase, the energy auditor to take the following measure:

-Obtains the site drawings such as a single line diagram of the electrical circuit, building layout, HVAC system

- Discusses with the site manager about the aim of the comprehensive energy audit
- Explains the meaning of the comprehensive energy audit and data needed during the audit phase
- Analyzes the major area of energy consumption

The outcomes of this phase should help to finalize the audit team, the expectation of the management from the comprehensive energy audit, and to plan the whole comprehensive energy audit within a period.

4.2 Audit phase

An audit phase is the second phase or second step of a comprehensive energy audit. The audit phase depends upon the nature and complexity of the site. In this phase, the audit can take days, weeks, or a month, as well as non-working hours and nights, are also included; to ensure that nothing is overlooked completely in the audit. The following information has been collected during the audit phase:

- Collect the information about the source of the energy supply
- Collect the energy bills to find out the tariff data and electrical energy cost
- Collect the load sector data
- Review of present energy management procedure and training program
- Energy flow diagram

The outcomes of the collected data are:

- Preparing process flow diagram and energy, and material balance.
- Identification of Energy Conservation opportunities.
- Energy conservation options and recommendations.
- Energy-saving and payback period.
- Technical and feasibility report.
- Implementation plan for energy-saving measures and projects for the third phase (post-audit phase).

4.3 . Post audit phase

For the evaluation of a capital budgeting decision, a set of procedures must require after the fact.

The plan of action for the post-audit phase is implementation and follow-up. The result is to assist and implement recommendation measures ad monitor the performance

5. ENERGY AUDIT TOOLS

An energy auditor utilizes a range of tools when performing an energy survey. Below are some commonly used tools, in no particular order:

1. Tape Measure

Energy auditors use it to measure the distance between two points or the dimensions of walls, ceilings, windows, and other parts of a property. Energy auditors may use more modern distance measuring tools such as laser measure.

2. Flow Meter

An energy auditor will use a flow meter to determine flow rates. Clamp-on flow meters may be used in conjunction with temperature measurements to measure thermal energy in hot water and chilled water. You'll be surprised how this is actually one of the most useful energy audit tools there is.

3. Infrared Thermometers

These tools monitor temperatures on HVAC, furnaces, and heaters to determine possible inefficiencies. Infrared thermometers and cameras (thermal imaging systems) can also be used to analyze a building's envelope for airtightness and insulation.

4. Temperature and Humidity loggers

Temperature and humidity loggers can be used to determine the effectiveness of an HVAC system. Temperature loggers can be used to monitor the status (on or off) of a wide range of energy-using equipment.

5. Combustion Analyzer

A combustion analyzer is a portable instrument that determines the combustion efficiency of boilers, furnaces, and machines that rely on fossil fuel. These are also used by service technicians to tune burners and boilers in order to maximize efficient operation.

6. Power Meter

Energy auditors use power and energy meters to determine the energy usage of individual items of

plant or equipment. They may also be used to build up a load profile of time-of-day power draw and energy usage.

7. Airflow Measurement Devices

Energy inspectors use these tools to measure the airflow from ventilating ducts, heating, and air conditioning. They can detect potential airflow problems. Typical airflow monitors include anemometers, velometers, pitot tubes, and airflow hoods.

8. Power Quality Analyzer

An electrical network analyzer is a portable device that can detect various electrical network parameters simultaneously. More advanced than an energy or power meter, they enable an analysis of power quality and can be used to determine the total harmonic distortion associated with an electrical load. Although quite expensive, we do recommend that you get this one as part of Energy Analyzer (also called a power meter) can locate, predict, prevent, and troubleshoot power quality problems in single-phase and three-phase power distribution systems, to help facilities reduce electrical power consumption and to improve the performance of electro-mechanical equipment. The analyzer measures voltage, current, dips, swells, interruptions, harmonics, power, energy, frequency, inrush, and power inverter efficiency. It calculates the monetary cost of poor power quality and helps to pinpoint the origin of energy waste in a system. The logger function, activated by a button, allows user-configurable, long-term recording of minimum, maximum, and average readings for up to 150 parameters on all three phases and neutral. The USB port and cable (included) transfers data to a PC for trend and waveform data analysis in Power Log software (included).

Figure 1. BASIC Energy Analyzer

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.

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.

6.0 Energy Audit Software Tools

Aside from various portable equipment, energy auditors also use several software tools to do their job more efficiently. These apps can perform complex energy-related calculations and create energy-efficient reports.

The following are some some examples of energy audit software tools:

1. EMAT Field Auditor

This software can collect audit data, generate reports, and improve lighting projects. They also offer audit services compliant with the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

EMAT Field Auditor is entirely cloud-based and offers customizable templates. You can also process load profiling, utility data, and even photo logs. The company also provides consulting services.

2. Weatherization Assistant

Oak Ridge National Laboratory developed this tool as part of the U.S. Department of Energy (DOE) Weather Assistance Program. This suite of energy audit tools can help identify and implement energy conservation measures (ECM).

Furthermore, this is one of the energy audit tools that is meant to assist users in weatherizing their facilities or properties. It also has a Health and Safety Audit program useful for properties undergoing energy-efficiency remodeling or retrofitting.

3. OptiMiser

Many energy auditors use this modular software to collect, exchange, and outline data. It prides itself as an advanced energy analysis tool with streamlined

workflow and accurate reports. It's business-friendly and is integrated with database systems like Oracle, MySQL, and Salesforce.

The software also features automated utility bill analysis and calibration. Moreover, it has intuitive worksheets and spreadsheet calculators. They mainly target residential and commercial energy users.

4. The Energy Analysis

The Energy Analysis Software comprises four independent modules: audit, modeling, budgeting, and benchmarking. However, the main downside of this product is the modules are sold separately. Nonetheless, it's a powerful and handy set of energy audit tools that will make your life as an energy auditor easier.

5. TREAT

Targeted Retrofit Energy Analysis Tool (TREAT) is a leading energy audit software with two versions – single and multifamily.

This software can help you build mathematically accurate models and generate energy-saving estimates. It also has various programs, such as a cooling efficiency calculator. Their main customers are from the housing and construction market.

6. ENERGY USAGE COMPARISON IN LIGHTING LOAD

LED (Light Emitting Diode) lights are the most energy efficient among the four types. LEDs use only about 20-25% of the energy consumed by an incandescent bulb to produce the same amount of light. CFL (Compact Fluorescent Lamp) lights use about 70% less energy than incandescent bulbs. They produce the same amount of light while using a fraction of the power. Halogen lights are more efficient than traditional incandescent, using about 20-30% less energy. However, they are still much less efficient than LEDs and CFLs. Incandescent bulbs are the least efficient, converting only 10% of electrical input into light. The rest is wasted as heat.

The table below summarizes the differences in power As seen above, LED and CFL bulbs produce far more light output per watt compared to incandescent and halogen.

Table :1

Light Type	Watts Used	Lumens Produced	Efficiency (lumens/watt)
Incandescent	60W	800 lm	13 lm/W
Halogen	55W	800 lm	14.5 lm/W
CFL	15W	800 lm	53.3 lm/W
LED	16W	800 lm	50 lm/W

6.1Lifespan Comparison

LED lights have by far the longest lifespan among the four types. The average LED bulb lasts 50,000 hours or more. CFL lifespan is 6,000-15,000 hours. Halogen bulbs last 2,000-4,000 hours. Incandescent only lasts 750-1,000 hours.

The extremely long life of LEDs means you won't have to replace them for years or even decades. This results in maintenance savings in addition to energy savings.

Light Type	Lifespan (Hours)	Upfront Cost	Lifetime Cost
Incandescent	1,000	Low	High
Halogen	3,000	Low	High
CFL	10,000	Medium	Low
LED	50,000	High	Low

Table:2

6.2Cost Comparison

Although LED lights have a higher upfront cost compared to incandescent and halogen bulbs, they save money in the long run. Their energy efficiency and long lifespan lead to savings that offset their higher initial price. At HitLigths we've got you covered. You can get quality LED strips and supplies at Factory Price by simply joining our professional partner program for free.

CFLs are relatively affordable upfront and provide great return on investment through energy savings over their lifetime. However, they are not a good choice when it comes to their environmental impact. Incandescents and halogens have low upfront cost but end up costing more in the long run due to frequent replacement and high energy use. Here is the combined table of the lifespan and cost:As shown, LED and CFL provide the lowest total cost of ownership despite higher initial price.

6.3 Environmental Impact

LEDs and CFLs have major environmental benefits compared to old incandescent and halogen

bulbs. Their energy efficiency means they result in lower greenhouse gas emissions from power plants. If everyone switched to efficient lighting, the pollution reduction would be significant. However, CFLs contain mercury. Incandescent release no mercury but their high energy use still causes more overall environmental harm. LED and CFL bulbs also last much longer, resulting in less electronic waste from replacements. LEDs in particular almost never need replacing.

In summary, LED lighting provides the maximum benefits across all areas - energy efficiency, cost savings, lifespan and environmental impact. They are the clear winner overall, although they have a higher upfront purchase price. CFLs are also a great option, offering many benefits at a lower initial cost than LEDs. They outperform halogen and incandescent bulbs across the board. Halogen lights are a step up from traditional incandescent but still lag far behind LED and CFL technology. Old-fashioned incandescent bulbs rank last in terms of energy savings, cost and environmental performance. Their use should be minimized whenever possible. Choose LED or CFL bulbs whenever replacing or installing new lights for maximum energy and cost savings while also helping the environment. The small upfront investment will pay off many times over through lower energy bills and reduced environmental footprint over the lifetime of the bulb.

7 CONCLUSION

This paper presents importance of energy auditing, various types, scopes, and methods that are required for the energy audit, software, Hardware tools, There are different strategies and methods from which one can save energy essentially. Alongside a given structure of such an audit, a few imperative undertakings are underlined to achieve a successful energy audit.

Various hardware & software and tools are used in energy auditing for measurement and diagnostics are also analyzed in this paper. To find out energy-consuming sectors is the prior attention to look for energy-saving potential and quality improvement. Implementation of an energy audit which can improve the efficiency, quality of the power, and reduces the tariff of bills, wastages of energy and also help to maintenance of clean environment.

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