ENERGY AUDIT

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***Abstract*—: In this paper, the importance of energy auditing and process of energy auditing are presented in detail. A sincere attempt has been made to conduct the Energy Audit at Nandi Institute of Technology & Management Sciences, Bangalore, to estimate the Energy consumed in a day, week and month. Identification of areas of energy wastage and estimation of energy saving potential in the Canteen, all Departments and Institute Central Facilities has been made by walk-through energy Audit. Also, detailed analysis of data collected is done by suggesting cost- effective measures to improve the efficiency of energy use. Estimation of implementation costs and payback periods for each recommended action has been made. The results & vital information generated through these activities are documented. The Energy Auditing for a day is the index of the consumption which normalizes the situation of Energy crisis by providing the conservation schemes.**

***Index Terms*: Energy audit, Energy Consumption, Energy management, Estimation, energy conservation**

I. INTRODUCTION

Energy is one of the major factors for the development of any country as it decides the economic growth of the country. The energy consumption is increasing exponentially and to cope up with the requirement puts a tremendous load on the country's resources. The energy generation capacity of India, as of year 2021 is 379,130MW which is increasing every year but so does the consumption. Almost 50% of the energy produced is from thermal power plant by consumption of coal. Energy conservation can be the best solution to deal with this situation of increasing energy demand. An energy audit is a survey, analysis and inspection of the energy flow in the system to find the scope of energy conservation by implementing energy saving procedures without affecting the outputs of the system. It also includes submission of technical report containing recommendations for improving energy efficiency with investment cost required to execute the energy saving analysis and action plan to be implement. As society becomes more complex, there is an increased likelihood that unreliable information will be provided to decision makers. There are several reasons for this remoteness of information, voluminous data and the existence of complex exchange transactions. As a means of overcoming the problem of unreliable information, the decision maker must develop a method of assuring him that the information is sufficiently reliable for these decisions. In doing this, there must be a cost of obtaining more reliable information against the expected benefits.

A common way to obtain such reliable information is to have some type of verification (audit) performed by independent persons. The audited information is then used in the decision- making process on the assumption that it is reasonably complete, accurate and unbiased. VISSJ Government Polytechnic is a institute under the Department of Technical Education located in Bhadravathi. The energy consumption on campus is mainly in the form of electricity. The electricity bill comprises two parts: one related to the energy consumed (per kwh or per unit energy consumed) and the other is the maximum demand charge (per KVA of maximum demand during the month). There also exists a penalty for low power factor. Furthermore, the energy charge includes a component based on time of use.

1.1NEED FOR ENERGY AUDIT

In any Organization, the three top operating expenses are often found to be energy (both electrical and thermal), labor 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 programmed which are vital for production and utility activities. Such an audit programmed 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.

Eco-campus concept mainly focuses on the efficient use of energy and its conservation including savings opportunities in a sustainable manner. It also focuses on the reduction of contribution to carbon emissions, carbon footprint calculation, procurement of star rated equipment for a cost effective and secure supply of energy, encourage and enhance energy use conservation in all buildings, reduce the organization's energy consumption, reduce wastes to landfill, and integrate environmental considerations into all contracts and services considered to have significant environmental impacts. Auditing for Energy Management may be studied in terms of energy savings and opportunities. In general, energy cannot be seen, but we know it is there in wire, pipes and other non- living materials because we can see its effects in the forms of heat, light and power. This indicator addresses energy

consumption, energy sources, energy monitoring, lighting, vehicle movement, electrical and electronics appliances, and transportation. Energy use is clearly an important aspect of campus sustainability and thus requires no explanation for its inclusion in the assessment. However, energy saving and opportunities may be taken into consideration while energy is extensively used. An old incandescent (tungsten) bulb uses approximately 60W to 100W while an energy efficient light emitting diode (LED) uses only less than 10W which indicated the positive indication on energy savings. Energy auditing deals with the conservation and 3 methods to reduce its consumption related to environmental degradation. In addition, suggestions and recommendations might be given after auditing which in turn useful for energy savings. It is therefore essential that any environmentally responsible institution examine its energy use practices at least once in two years using internal and external auditors.

1.2AIMS AND OBJECTIVES OF AN ENERGY AUDIT

An energy audit is a useful tool for developing and implementing comprehensive energy management plans of an organization. The aim of an energy audit is to identify the energy efficiency, conservation and savings opportunities at the premises of the audit sites in a systematic manner. The audit process is carried out as per the following.

- Review of energy saving opportunities and measures implemented in the audit sites.
- Identification of additional various energy conservation measures and saving opportunities.
- Implementation of alternative energy resources for energy saving opportunities and decision making in the field of energy management.
- Providing a technical information on how to build an energy balance as well as guidance to be sought for particular applications.
- Detailed analysis on the calculation of energy consumption, analysis of latest electricity bill of the campus, understanding the tariff plan provided by the central and State Electricity Board.
- List ways that the use of energy in terms of electricity, electric stove, kettle, microwave, LPG, firewood, Petrol, diesel and others.
- Analysis of electricity bill amount for the last two to three years, amount paid for LPG cylinders for last one year and amount paid for water consumption for human beings and watering to the plants.
- Use of incandescent (tungsten) bulb and CFL bulbs, fans, air conditioners, cooling apparatus, heaters, computers, photo copiers, inverter, generators and laboratory equipment and instruments installed in the organization (for example- 60-watt bulb x 4hours x number of bulbs = kwh).
- Alternative energy sources / nonconventional energy sources are employed / installed in the organization (photovoltaic cells for solar energy, windmill, energy efficient stoves, Biogas, etc.).
- Creating awareness among the stakeholders on energy conservation and utilization.

2.BLOCK DIAGRAM

2.1GENERAL

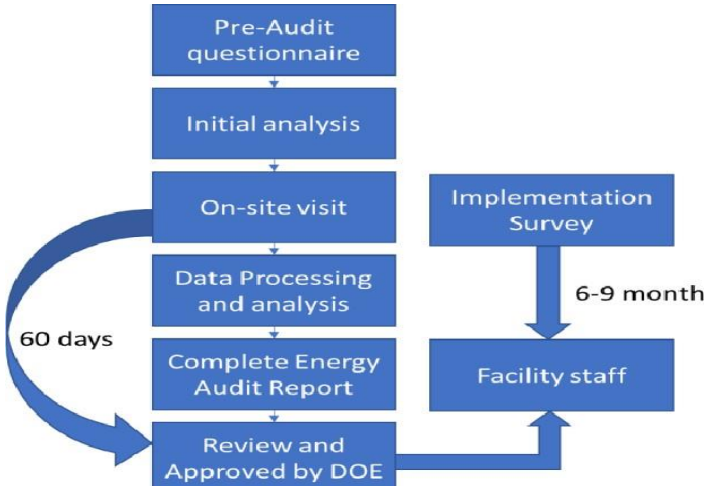


Fig 2.1 Block Diagram of Energy Audit Process

2.2 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. i) Preliminary Audit ii) Detailed Audit

2.2.1Preliminary 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.

2.2.2 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.METHODOLOGY

3.1PHASE 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.
- Analyze 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

3.2PHASE 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 lime, 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 pay-back on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be per-formed 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 (e.g., 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.

3.3 IDENTIFICATION OF ENERGY CONSERVATION OPPORTUNITIES

Fuel substitution: Identifying the appropriate fuel for efficient energy conversion Energy generation: Identifying Efficiency opportunities in energy conversion equipment/utility such as captive power generation, steam generation in boilers, thermic fluid heating, optimal loading of DG sets, minimum excess air combustion with boilers/thermic fluid heating, optimizing existing efficiencies, efficient energy conversion equipment, biomass gasifies, Cogeneration, high efficiency DG sets, etc. Energy distribution: Identifying Efficiency opportunities network such as transformers, cables, switchgears and power factor improvement in electrical systems and chilled water, cooling water, hot water, compressed air, Etc. Energy usage by processes: This is where the

major opportunity for improvement and many of them are hidden. Process analysis is useful tool for process integration measures.

Total Connected Load of Different Usage in kwh

Name of block	Ground floor	First floor	Second floor	Machine lab	Mechanical machine shop	Carpentry lab	Thermal lab	Fitting section	Foundry lab	Civil survey lab-1	Survey lab-2	Metallurgy lab	Language lab	Embedded lab	Office building
Lighting load	480	1050	940	400	400	200	400	400	400	400	400	200	200	200	400
Fan	365	445	225	1200	750	375	750	750	750	750	750	375	150	375	375
PC	1400	2870	75	-	-	-							1400	700	-
Machines	750			53614	34332	4476	4438	3730	7460	7460	3730	5968			

Total average Electrical Energy consumption per month

Total Sanctioned Load=146.21KW
Total power in watts= 139798 watts or 139.798 KW
Total energy consumption in kwh/month=power in watts*no of hours/month Total energy consumption in kwh= 3256.816 kWh/month
= 3256.81 units/month

i. When KPTCL shut down the power supply due to some extensive repair works during such periods the back-up power from diesel generator installed in the campus is utilized for running academic related essential requirements.
ii. Power is utilized from various UPS batteries installed in the campus.

4.RECOMMENDATION

4.1RECOMMENDATIONS FOR BETTER ENERGY EFFICIENCY

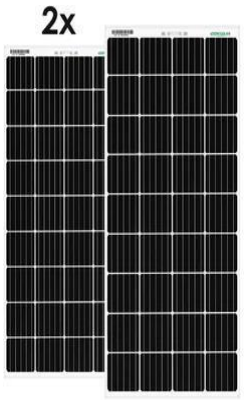
Recommended Measure	Energy Savings /year in KWh	Savings in Rs. /year	Capital Investment in Rs.	Pay-back Period (years)
Installation of solar power plant	4380	90000	100000	1.00
Replacing conventional choke of all FTL's by Electronics choke.	1209.6	6,894.72	26,250	3.8
Replacement of existing street lamp with LEDs	1752	6,000	9000	1.5
Replacing all FTL's by LED tube lights of equal similarities	5292.5	5840	29000	5.45
Replacement of existing old(without 5sar rating) fans with 5 star rated energy efficient fans	3000	80000	240000	3.00
Replacing CRT monitors of PC's with LCD monitors	383.25	42,000	90000	2.14
TOTAL	**14265.35**	**230734.72**	**404250**	**16.89**

4.2Monthly Electricity Bill Cost= 60000 Yearly Electricity Bill Cost= 720000

- Implementation of all the above measures can bring about a total saving of around Rs. 230734.72 per year that is 32.04 % of the present electricity bill. The total investment is Rs. 404250 for various appliances. The pay-back period for

each appliance varies as shown in above table.

4.3Solar Panel Description



5.	Weight	12 Kg
	Dimensions L x W x H	1495 x 670 x 35 mm

Loom solar 200 watt solar panel is made of A grade black silicon cells to generate electricity from sun. The cells are made of superior quality silicon which gives higher efficiency up to 20% and also performs better in low light. It is the latest panels in mono crystalline technology that comes with 5 bus bars 36 cells and 25 years performance warranty. IP 67 rated junction with MC4 connectors and 1 meter wire is given for outdoor use.

5.CONCLUSION:

Energy efficiency is the wave of the future. The world is quickly moving towards energy sustainability. At the same time, the mankind is trying to re-establish the connection it once had with nature. An energy efficient campus is a personal step toward the direction of renewable energy, environmental protection, and sustainable living. Having such a campus helps campus owners reduce their bills and provides an excellent investment. Furthermore, energy efficiency means healthier and more comfortable living that is in line with nature.

To understand exactly what you need to do to improve your campus efficiency, have a professional perform a campus energy audit. You may choose to conduct your own audit, but it will not be as precise. A good first step toward energy sustainability is generating your own energy. Solar panels are the most practical and cost-effective way of producing electricity and heat on your property. In addition, proper insulation and draught-proofing are essential to cutting the amount of wasted energy consumed by your household.

Making your campus energy efficient includes reducing electricity, water, and fuel usage. You can choose a more efficient water heater and install fixtures that conserve water. Changing your laundering and showering habits also helps to conserve water. Although lighting might not seem expensive, it is certainly a factor that contributes to your energy loss. Upgrading to LEDs and CFLs reduces energy loss. In addition, you should make more use of sunlight and natural daylight to lower your utility bill.

The Following Facts have emerged after the Detailed Energy Audit of said Campus

1. Energy saving per year is 14265.35 kWh
2. Total Cost reduction per year is 230734.72 rupees
3. Pay-back period of various appliances.

Acknowledgements:

1) **Anupama Gupta, Pallavi Verma, Richa Priyadarshan ‘‘A Review on Energy Management and Audit’’ International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering February, 2015.**
In their work have discussed about the need of energy audit and types of energy audit methodology with the example of conducting an audit of fume exhaust system blower used in cold rolling mill. The fume exhaust blower had a motor of rating 3 phase AC induction motor of 50 HP, 415 V working at 1460 rpm. The previous system used star delta starter for motor and belt pulley for power transmission to fan; due to which the blower fan kept working continuously at constant speed and at full speed regardless of the fumes generated or not. The author made a note of their observations and suggested a better way to use the energy flow. The present system has AC electronic speed variable drive and software designed according to the drive operation to optimize the power consumption during idling of mill. The new system after implementation has smooth start which increases

life of motor and energy saving due to speed/ voltage variation during idling mill. The monetary saving per year was calculated to be Rs. 3,60,000 with one time investment of Rs. 1,50,000.

2) **Manoj Kumar Lamba, Abhishek Sanghi ''Energy Audit on Academic Building'' International Journal of Engineering Research and General Science July August, 2015.**

They conducted an energy audit on academic building with the objective of inspection and analysis of energy flow in the said building. In their work they have discussed about possible ways to conserve energy by utilizing it effectively and potential of energy savings with importance of implementing energy saving methods. The methodology used for this audit consisted of- data collection, data analysis and recommendation. It was https://doi.org/10.46335/IJIES.2021.6.4.4 e-ISSN: 2456-3463 Vol. 6, No. 4, 2021, PP. 18 -21 International Journal of Innovations in Engineering and Science, www.ijies.net 20 found out that among all the electrical loads, lightning load and personal computer has the highest consumption consisting of 36% and 44% respectively. The energy saving calculations was done to find how much energy can be saved by replacing appliances with more energy efficient components. Investment cost and capital cost recovery time (payback period) was also calculated for each recommendations.

3) **Ramya.L.N, M.A.Femina ''Energy Auditing – A Walk Through Survey'' International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering April, 2014.**

They conducted energy audit on an industry named "Kohler Power India'' Aurangabad. The Kohler Company is a manufacturing company based in Kohler, Wisconsin founded in 1873. Even though the company is best known for its plumbing products, it also manufactures engines, furniture, tile, generators and cabinetry. In this paper, they have conducted preliminary energy audit of Kohler plant, Aurangabad and energy saving ideas was observed. The company was using 250 W sodium vapor lamps as flood lights in shop floor. Replacing the conventional lamps with LED lamps of equivalent illumination was suggested. Net saving per year per lamp was calculated to be Rs. 5832 with payback period of 1.4 year per lamp. The total power saving on 240 nos Sodium vapor lamp lightning lamps was found out to be 43.2 KW. The next energy saving opportunity was found in blowers. The use of VFD- Variable Frequency Drive was suggested to reduce electric power consumption. By implementing VFD, the company can save 4069 kWh units per month.

DISCUSSION:

From the overall literature review, it is concluded that areas of energy saving and management can be found out by implementing energy audit. Hence there is a need to prefer energy auditing in all the sectors once a year. Energy audit can lead to find energy saving potential and gives recommendation on how exactly energy can be saved. By implementing energy auditing we can conserve energy, which in turn will reduce power demand in our country. The government can save a lot of money from the utility bill of bus stand building by implementing energy saving procedures.

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