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Unveiling the Path to Energy Efficiency: A Comprehensive Review of Energy Auditing Strategies and Best Practices

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ABSTRACT; Energy is the primary operating expense in industrial, commercial, and residential buildings. Advancements in electrical appliances offer significant energy-saving opportunities. Efficient energy conservation and management are crucial due to high energy demand surpassing production levels. Studies indicate that energy auditing can save 5-20% of energy in various sectors. Energy audit plays a vital role in identifying energy-saving opportunities and reducing electricity costs. It recommends system changes that result in reduced energy consumption without negative consequences. This paper emphasizes the significance of energy auditing and reviews previous research in the field.

KEYWORDS: energy audit, energy management, energy conservation, consumption.

I. INTRODUCTION

Energy is a critical driver of a country's economic growth, and its consumption is rising rapidly, straining available resources. India's current energy generation capacity is 379,130 MW as of 2021, but consumption keeps increasing. Coal-based thermal power plants contribute to approximately 50% of energy production. To address the escalating energy demand, energy conservation is the most effective solution. An energy audit involves surveying and analyzing energy flow within a system to identify opportunities for energy conservation. It provides recommendations for enhancing energy efficiency, including investment costs, cost-saving analysis, and an action plan for implementation.

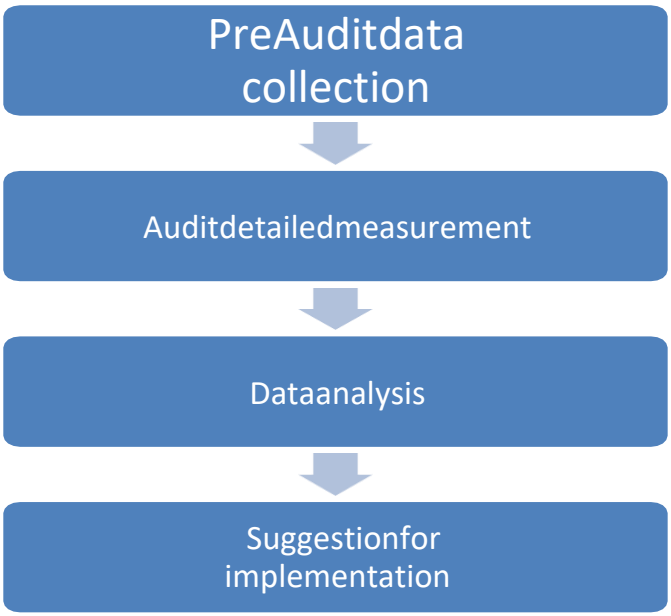

Fig.1-Process of energy audit

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II. NEED FOR ENERGY AUDIT

n any industry, the top operating requirements are found to be energy, labor and materials. If one were to seek out the likelihood of energy saving in any of the three domains, energy will show the foremost scope and thus energy management constitutes a strategic area for cost reduction. Energy Audit will help to know more about the ways energy and fuel are utilized in any industry. It will also help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would also provide a positive orientation to lower the energy cost, preventive maintenance and internal control programmes which are vital for production and utility activities. Such an audit program will help to stay specialize in variations which occur within the energy costs, availability and reliability of supply of energy, identify energy conservation technologies and retrofit for energy conservation equipment.
In general, Energy Audit is the formation of conservation ideas into realities, by applying feasible solutions which will help to lower the energy consumption in the organization without any negative output. Along with that it also lowers the energy consumption bills.

The primary objective of Energy Audit is to determine ways to reduce energy consumption or to lower operating costs. Energy Audit gives a "Reference point" for managing the use of energy. It also provides the basis for planning a more effective use of energy.

III-ENERGYAUDITMETHODOLOGY

The type of Energy Audit to be done depends upon:

- Type and function of industry
- Degree to which final audit is required
- Investment and Potential of cost reduction

Thus energy audit can be categorized into the following types.

1. Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively easy exercise to:

- Scout energy consumption in the organization
- Find the scope for saving
- Identify the most likely areas for attention
- Identify areas of improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study
- Preliminary energy audit makes use of existing or easily obtained data

2. Detailed Energy Audit Methodology

A detailed energy audit provides implementation plan for an organization, as it evaluates all major energy using systems.
This type of audit gives the most accurate result for energy savings. Detailed energy audit methodology takes into consideration the effects of all systems which accounts for the energy use of all major equipment, and includes energy saving recommendations with calculations.

In a detailed audit, one of the important aspects is the energy balance. This is based on energy using systems, assumptions of current operating situation and by calculations of energy use. This estimated use is then checked by comparing with utility bill charges.
Detailed energy auditing is carried out in the following phases:
Phase I - Pre Audit Phase
Phase II - Audit Phase

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Phase III - Post Audit Phase

IV. LITERATURE REVIEW

This review is based on the work done in Energy Audit in various sources. The literature shows the work done in the field of energy audit and management. The objective of this review is to identify the contribution of the researchers in the energy audit and their work done.

Jiskani, S. A., Shaikh, S. A., Memon, Q. A., Bhutto, M. A., Shaikh, M. F., & Kumar, M. [1] in their work have discussed about the During the assessment, it was discovered that the annual electric power consumption in Sector A was 461,411.85 kWh, with 75,490 kWh consumed in winter and 385,924 kWh in summer. By optimizing the use of air conditioners (ACs) and personal computers (PCs), significant energy savings were identified. By reducing usage time from 8 hours to 5 hours per day, a maximum energy saving of 274.44 kWh/day for ACs and 250.2 kWh/day for PCs could be achieved. This translates to annual energy savings of 52,143 kWh for ACs and 66,303 kWh for PCs, amounting to savings of Rs. 1,658,244 and a reduction in CO2 emissions of 73.8 metric tons per year. Additionally, implementing energy-saving measures such as utilizing natural daylight and installing sensor-based technology in offices to regulate lighting based on natural illumination conditions can further conserve energy. These combined efforts could result in a total annual power saving of 184,369 kWh and a reduction in CO2 emissions of 130.4 metric tons. It is recommended to increase natural illumination in classrooms and office spaces on the university campus, and deploy sensor-based technology for efficient lighting control based on ambient conditions.

Velu, V., Subramaniam, K., Sethu, D., & Khan, M. R. B [2] many individuals are unaware of the significance of energy in their daily lives until an audit is conducted. Energy plays a crucial role in various aspects of human life. Buildings such as universities, companies, and industries consume a substantial amount of energy and have the potential to make a significant impact on a country's energy consumption. While the energy consumption at Manipal International University hostel is not excessive, there is still room for further reduction through the collective efforts of students and staff. Taking initiative and fostering cooperation can lead to minimized energy consumption in the hostel.

Bahrami, A., Ameen, A., & Nkweto, H [3] in their paper the energy performance of buildings is significantly influenced by their envelopes and thermal bridges, which are responsible for a large portion of heat losses. To improve the energy efficiency of buildings, various Energy Saving Measures (ESMs) were examined and analyzed. These included adding thermal insulation, replacing windows, installing an Air Handling Unit (AHU), incorporating heat exchangers in showers, addressing thermal bridges, and modifying air discharge schedules. The implementation of these ESMs demonstrated a positive impact on the energy performance of the buildings. While all ESMs contributed to energy savings, their economic viability depended on factors such as investment costs and life cycle savings. The effectiveness of individual ESMs varied, with the combination of external insulation and temperature reduction showing the highest energy reduction. However, installing a new AHU had the greatest energy reduction among the individual ESMs, highlighting the importance of ventilation with a heat recovery system. Economically feasible ESMs included adding attic insulation, installing heat exchangers in showers, replacing lighting bulbs, and adjusting AHU control schedules. This study establishes a connection between ESMs, urban sustainable development, and building energy efficiency. By implementing ESMs, older buildings can be retrofitted to meet energy efficiency standards and contribute to urban sustainability.

Mbaye, A. [4] This paper provides a comprehensive review of the current benefits, challenges, and opportunities associated with energy audits, supported by extensive literature and case studies. It highlights that a well-defined and properly implemented energy audit can serve as a potent tool to achieve carbon neutrality or zero carbon emissions. The case studies presented in the paper demonstrate the significant savings that can be identified through regular energy audits Addressing barriers is crucial, and a gradual implementation of a unified policy worldwide is recommended to overcome existing differences between countries and continents Additionally, barriers such as training and certification in energy auditing have been identified and discussed. The paper also outlines a list of opportunities for enhancing energy audits, ranging from training initiatives to exploring water energy. These opportunities should be the focus of dedicated research efforts.

Chavan, V. ,Khardekar, V., Chavan, P., & Shinde, S. [5] in their work have discussed about the process equipment, specifically pumps, is responsible for 46% of MSPL's electricity usage, resulting in a daily cost of around Rs. 3.25

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lakhs. To address this, implementing a computerized energy management system would enable data-driven energy savings. Additionally, close monitoring, precise weighing, and periodic analysis can optimize coal consumption in the nine coal-based combustion centers, which currently consume Rs. 14 lakhs worth of coal each day. The plant's electrical infrastructure is stressed by the nonlinear plant load, causing harmonic currents. By implementing harmonic filters and improving reactive power compensation, losses can be reduced, and equipment damage prevented. Adjustments to combustion parameters are needed to improve the efficiency of coal combustion. The installation of automatic TDS-based blowdown systems can effectively reduce blowdown and result in significant coal savings. Heat recovery from hot air generators can enhance energy efficiency by preheating input air. Although exploration of heat pumps and solar water heating systems for hot water generation did not provide favorable payback periods, introducing a separate coal-based "Hot Water Generator" can achieve consistent and efficient performance, reducing coal consumption by 12 tons per day. Additional energy savings can be achieved by insulating hot water pipes. Furthermore, installing a rooftop PV solar power system with a capacity of up to 1.5 MWp has the potential to save approximately Rs. 25.2 lakhs annually, and implementing the ISO 50001 energy management standard can drive continual improvement in energy performance. It is important to note that the savings from solar PV and illumination improvements depend on the choices made by MSPL and are not included in the main table.

V. CONCLUSION

From the overall literature review, it is concluded thatareas of energy saving andmanagement can befoundout by implementing energy audit. Hence there is a needto prefer energy auditing in all the sectors once a year.Energy audit can lead to find energy saving potential andgives recommendation onhow exactly energy can be saved.Byimplementingenergyauditingwecanconserveenergy,whichinturnwillreducepowerdemand in ourcountry. The government can save a lot of moneyfrom utility bill of bus stand building by implementing energy saving procedures.

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