A Comprehensive Review on Optimization of Energy Audit in an Engineering Institute (2023)

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Abstract — An energy audit plays a crucial role in assessing energy consumption patterns and identifying opportunities for efficiency improvements in buildings. This abstract provides an overview of an energy audit conducted on a college building, aiming to evaluate its energy usage, identify areas of inefficiency, and propose sustainable measures for energy conservation. The audit encompassed a comprehensive analysis of the college building's energy systems, including lighting, electrical equipment, and insulation. Data collection methods employed comprised on-site measurements, equipment surveys, and analysis of utility bills and historical energy consumption data. Findings revealed several areas of energy wastage and inefficiency. Outdated lighting fixtures were identified as a significant contributor to excessive energy consumption, prompting recommendations for the implementation of energy-efficient technologies such as LED bulbs and occupancy sensors. The HVAC analysis highlighted inadequate insulation and air leaks, leading to significant heat loss and increased energy usage. Recommendations were made to improve insulation, seal air leaks, and optimize controls. Furthermore, the audit identified opportunities for energy conservation through behavioral changes and occupant engagement. Suggested measures included awareness campaigns and energy-saving guidelines to promote sustainable habits among students, faculty, and staff. Financial analyses were performed to evaluate the potential return on investment for implementing energy-efficient measures, considering factors such as energy cost savings, equipment lifespan, and available incentives and rebates. The audit report also emphasized the environmental benefits of energy conservation, including reduced greenhouse gas emissions and enhanced sustainability. In conclusion, the energy audit of the college building outlined numerous energy-saving opportunities and proposed practical recommendations to optimize energy consumption and reduce the institution's environmental footprint. By implementing the suggested measures, the college can achieve substantial energy savings, contribute to sustainability goals, and serve as an exemplar for other educational institutions striving for energy efficiency.

Keywords: Energy Audit, College Building, Energy Efficiency, Energy Conservation, Fume Exhaust System and Motor Efficiency

I. INTRODUCTION

Escalating Prices of Crude Oil is Worldwide have significant expenses in electricity generation .The industrial sector has prime prioritize energy management to ensure sufficient energy utilization and enhance effectively. The efficient use of energy is crucial across all sector of economy field.

Nowadays, Energy consumption in industrial sectors of developed countries around 30-40% of total energy demand ,energy is basic need required for industry and it is essential for development ,Industrial growth ,Automation Financial stability for industry, However, the global energy needs has raised to meet future energy requirements .It has been analyzed by researchers energy consumption will increase by near 30-40% from 2005-2025 worldwide.

Within college building, Home, Industries and Buildings Energy is consumed for various activities such as Lighting, Ventilation, Processing, Conditioning, Specifically 75% of energy used by industrial sector. With Natural gas, Coal, Petroleum around 28%, 27% & 6% respectively.

Energy cost are a significant controllable factor for any organization .There is impactful scope for reducing energy consumption. the benefits of energy efficiency initiatives are not only reflected & improved profitability for organization but also contribute to global environmental sustainability through energy conservation.

Energy Auditing Measure efficiency of energy utilization in manufacturing ,Lighting ,Ventilation ,Controlling processes focusing on energy performance directly associated with production it involves monitoring verification .analysis of energy consume along with improving energy efficiency ,cost analysis ,&plans for reduction of consumption .

Energy Audit aim to promote energy conservation within particular field & Identifying opportunities for improvement .They often benefits like maintainability ,reliability ,and reduced losses long term benefit achieved through the adoption of energy efficient equipment. Microsoft *Word* versions 6.0 or later. If you are reading a paper or PDF version

II. LITERATURE REVIEW

Anupama Gupta, Pallavi Verma, and Richa Priyadarshani [1] focused on the energy audit of a fume exhaust system blower used in a cold rolling mill. They observed that the previous system operated continuously at a constant speed, irrespective of the fume generation. They suggested a better approach by implementing an AC electronic speed variable drive, resulting in energy savings and increased motor lifespan. The implementation cost was Rs. 1,50,000, and the annual monetary saving was calculated to be Rs. 3,60,000.

Manoj Kumar Lamba and Abhishek Sanghi [2] conducted an energy audit on an academic building. They identified the highest energy consumers as lighting load (36%) and personal computers (44%). Their recommendations included replacing conventional ballast FTL with electronic ballast FTL, replacing CRT monitors with LCD monitors, installing solar water heating systems, and using motion sensors to control lights. By implementing these measures, they estimated a total energy saving of 311126.4 kWh per year, resulting in a monetary saving of Rs. 2,644,574.4 per year.

Ramya.L.N and M.A.Femina [3] conducted an energy audit of an educational institute, with a focus on conventional lighting load. They suggested replacing regular tube lights with CFL or LED lamps to conserve energy and reduce costs. By replacing the existing tube lights with CFL or LED lamps, they estimated monthly energy savings of 739.2 kWh and 308 kWh, respectively. The payback period for CFL was calculated as 5.2 months, and for LED, it was 8.1 months. Additional recommendations included insulating ceilings, switching off unnecessary electrical appliances, using timers for AC units, and optimizing computer brightness levels.

Sachin P. Parthe and Santosh Kompeli [4] conducted an energy audit on the "Kohler Power India" industry in Aurangabad. They suggested replacing sodium vapor lamps with LED lamps and using Variable Frequency Drives (VFD) to reduce power consumption in blowers. By implementing these changes, they estimated annual savings of Rs. 5832 per lamp and 4069 kWh per month, respectively. They also proposed converting conventional blowers to advanced breeze air blowers, resulting in monthly cost savings of Rs. 10653 and energy savings of 78 kWh units.

Gousia Sultana and Harsha.H.U [5] conducted an energy audit at Nandi Institute of Technology and Management Sciences (NIT&MS) in Bangalore. They aimed to reduce power consumption by 20% to 60%. Their recommendations included replacing conventional chokes with electronic chokes for Tubular Fluorescent Lamps (TFL), using motion sensors, avoiding idle usage of photocopier machines, replacing FTL with LED lights, changing laser printers to ink-jet printers, and replacing CRT monitors with LCD monitors. The total investment required for these measures was Rs. 2,42,062. The study projected a reduction of about 41.66% in energy consumption and 30.6% in cost reduction, with calculated payback periods for each appliance.

A recent report [6] the United Nations reveals that around 1.3 billion people worldwide don't have access to electricity. Many of these people live in 10 specific countries, including Pakistan in the Asia Pacific region. The report suggests that in the future, efforts to improve electricity availability will focus on smaller power systems and off-grid connections, with a focus on using renewable energy sources.

Although the Asia Pacific region was a leader in using renewable energy to generate electricity in 2010, it still accounted for a relatively small portion of the total electricity used in the region. The average amount of electricity used per person in homes in the region is also quite low compared to other parts of the world.

The report also points out that many people rely on solid fuels like wood or coal for cooking, which can cause indoor air pollution. This type of pollution can be harmful and even lead to premature deaths. It's important to find cleaner and safer cooking solutions for these communities.

This After reviewing the report [7] evident that tube lights are heavily utilized. To improve energy efficiency, it is recommended to replace tube lights with LED lights. LED lights come with a two-year warranty and consume fewer units compared to CFL and tube lights. By analyzing Fig. 3, it becomes clear that LED lights are highly effective in conserving electrical energy over the next five years.

Within the household, there is only one refrigerator with a 1000 W rating, which exhibits below 50% load test efficiency. It is advised to replace this refrigerator with a star-rated model. The current refrigerator consumes 1642.5 units annually, resulting in an expense of Rs 4927.50. However, by replacing it with a 3-star rated refrigerator, the annual power consumption will reduce to 636 units, amounting to an expense of Rs 1878. This replacement will save 1016.5 units per year, equivalent to Rs 3050 in savings. Furthermore, opting for a 5-star rated refrigerator will result in savings of Rs 3727.5 per year.

Similarly, the air conditioner in use is an outdated model that performed poorly in the load test analysis. It is advisable to replace it with a star-rated air conditioner. The current air conditioner consumes 20075 units annually, costing Rs 60225. By switching to a 5-star 1.5-ton split air conditioner, the annual power consumption will decrease to 13466.1 units, resulting in an expense of Rs 40398.30 per year. This replacement will save 6608.1 units per year, equivalent to Rs 19826.70 in savings.

Several studies[8] conducted in EU countries have examined the energy consumption of schools and identified significant opportunities for energy savings. For example, schools in southern Finland have the highest energy consumption, with primary schools and universities averaging 214 kWh·m-2 and 229 kWh·m-2 per year, respectively. In Slovenia, the average total final energy consumption for school buildings is 192 kWh·m-2 per year. Similarly, studies in the United Kingdom and Luxembourg have reported energy consumption figures for schools.

In Italy, there are around 51,000 educational buildings with an average yearly energy consumption of 130 kWh·m-2 for thermal energy and 20 kWh·m-2 for electricity. Energy audits play a crucial role in improving the energy efficiency of these buildings by identifying weaknesses and suggesting solutions.

Several methodologies have been developed for energy audits in educational buildings, including the use of standards such as EN 16247-2 and EN ISO 13790. These audits help assess energy performance and identify potential energy efficiency measures. Tools have also been developed to support administrators in assessing energy performance and identifying cost-effective measures.

The objective of this work is to present a new energy audit methodology that aligns with EN 16247-2 guidelines. This methodology aims to provide a detailed energy diagnosis, identify feasible and cost-effective solutions, and meet the requirements for nearly Zero-Energy Buildings (nZEBs). The approach involves creating a numerical model of the building, calibrating it, selecting energy efficiency measures, determining cost-optimal solutions, and ensuring compliance with nZEB requirements.

Overall, this research [9] aims to provide a practical and effective instrument for identifying energy weaknesses in schools and implementing cost-effective retrofit actions to transform them into The second level of energy auditing involves a comprehensive evaluation of the operating systems in a campus building to analyze its energy consumption. This includes assessing the building's operation, HVAC and lighting systems, working hours, and occupancy density. The audit begins by collecting relevant information and specifications from architectural plans and drawings. The energy usage patterns are analyzed to categorize data such as peak demand, climate conditions, and potential energy savings.

The analysis of a campus building in Rockhampton revealed that the HVAC system is the main energy consumer, accounting for 95% of the overall energy spending at the university. Other energy sources, such as natural gas and fuel, contribute 2.5% and 3.5%, respectively. Within the Rockhampton campus, the Academic Zone consumes 88% of the total electricity, making it the primary energy user.

The electrical energy demand in Rockhampton fluctuates throughout the year, with the HVAC system being the major contributor. There is a significant correlation between the mean air temperature and electrical energy consumption. The reference building load, representing the minimum energy used throughout the year, was determined to be approximately 57,000 kWh/month for the Rockhampton campus.

From 2014 to 2016, the electrical energy usage at CQ University increased by around 3% annually, while the Rockhampton campus's consumption bill increased by approximately 9%. The variations in energy usage are influenced by climatic conditions. Notably, energy usage is higher during the summer season and lower during the winter months.

The peak energy demand consistently occurred in March, while the lowest demand was observed in July. Total energy usage was higher in December due to additional sessions and decreased during holiday periods when classrooms were closed. The yearly electric energy consumption cost is estimated to be around 1,175,149 AUD.

The sustainable development [10] of modern society relies heavily on ensuring an adequate and efficient energy supply. As of February 2018, the total installed capacity of power stations in India stood at 334,146.31 MW. However, with India's energy consumption projected to grow by 4.2% per year until 2035, there is a pressing need to prioritize renewable energy sources. To address this demand and alleviate the burden on energy production, energy audits become crucial in reducing wastage and optimizing energy usage.

Energy conservation entails utilizing energy efficiently while minimizing waste. This paper focuses on an alternative approach to energy audits, specifically targeting the reduction of electricity bills by replacing existing devices with more energy-efficient alternatives. The methodology outlined in this paper aims to conserve energy effectively, with a primary focus on implementing solar water heaters and biogas systems.

Solar water heaters harness the power of the sun to heat water, reducing reliance on electricity or gas-powered water heaters. By adopting solar water heaters, households can significantly decrease their energy consumption and expenses. Similarly, biogas systems offer an environmentally friendly solution by generating biogas through the decomposition of organic waste. This biogas can be utilized as a renewable energy source for cooking or generating electricity.

This paper provides a comprehensive methodology for effectively conserving energy and highlights the benefits of implementing solar water heaters and biogas systems. Additionally, it addresses the economic and environmental advantages of these solutions while discussing potential challenges and considerations for their successful implementation.

[11] Understanding and managing energy consumption in buildings is crucial for effective energy control. Simply analyzing overall energy usage does not provide sufficient insight into energy efficiency. It is essential to evaluate the specific energy consumption patterns of each facility individually. At CQUniversity, the Department of Facilities Management is responsible for overseeing the building systems. Currently, maintenance profiles, energy consumption data, and systems efficiency reports are utilized to assess a building's performance and identify any irregularities in its operations. However, there are several opportunities to enhance energy efficiency within the buildings.

An energy audit conducted on the Rockhampton campus of CQUniversity revealed that the major energy-consuming equipment includes HVAC systems, lighting systems, and office and educational amenities. Lighting systems were found to account for approximately 30% of the total energy usage on the campus, based on a study conducted in 2012. Most rooms are equipped with fluorescent lights and power factor correctors. The primary purpose of the electric lighting system is to supplement daylight and provide adequate indoor illumination.

One notable issue discovered during the audit is that electric lighting in unoccupied rooms remains switched on at all times. Additionally, university facilities and offices are often utilized by students outside of normal working hours, resulting in lights being left on even after they have left. Furthermore, the outdoor lighting fixtures are poorly maintained, covered in dust, which affects their performance and leads to unnecessary energy waste due to unsatisfactory illuminance. The fluid-tilt installed in the car park operates from 5:00 pm to 5:30 am daily, suggesting the need to adjust its working hours based on seasonal variations between summer and winter.

HVAC systems, including chillers, air handling units (AHUs), and fan coil units (FCUs), were identified as the most significant energy consumers, responsible for an estimated 45-50% of the building's total energy usage. The HVAC system was found to operate under constant control strategies, without adjusting to the actual demand. Many FCUs were observed to be left on in unused spaces, and openings such as doors and windows were frequently left open in classrooms, laboratories, and offices. Similar to the lighting energy audit, academic staff, administrative staff, and students were allowed access to conditioned spaces after normal working hours, resulting in the HVAC system continuing to operate unnecessarily. Another significant finding was that all AHUs supplying conditioned air operated as constant air volume (CAV) suppliers, disregarding the indoor temperature.

To improve energy efficiency, several recommendations can be made based on the energy audit findings. Implementing occupancy sensors or timers for lighting control can help reduce energy waste in unoccupied areas. It is also important to prioritize the maintenance and cleaning of outdoor lighting fixtures to optimize their performance and minimize energy inefficiencies. Moreover, adopting stricter control strategies for the HVAC system, such as utilizing variable air volume (VAV) systems and incorporating temperature sensors for demand-based operation, can significantly reduce energy consumption. These measures will not only contribute to cost savings but also promote environmental sustainability by reducing the campus's carbon footprint.

[12] By conducting thorough energy audits and analysis on a facility-by-facility basis, the Department of Facilities Management can identify specific areas for improvement and implement targeted energy-saving measures. This proactive approach towards energy management will lead to enhanced energy efficiency, reduced operational costs, and a more sustainable campus environment.

The sustainable development of human society relies heavily on having access to adequate and appropriate forms of energy. As the demand for energy continues to rise, it is crucial that we take necessary steps to bridge the gap between energy supply and demand. This research paper focuses on conducting an energy audit in an academic institution, specifically the hostel and mess of Maharaja Surajmal Institute of Technology in Janakpuri, New Delhi. The objective is to identify areas where energy consumption can be optimized and suggest measures to make energy usage more economical.

By conducting a thorough analysis of energy consumption and wastage through various appliances, the study aims to raise awareness about energy use and promote energy conservation practices. The detailed study provides valuable insights into the patterns of energy consumption within the institution. It helps identify specific areas where energy conservation measures can be implemented, leading to cost mitigation, reduced environmental pollution, and better management of the demand-supply gap.

The findings of the research paper contribute to the overall understanding of energy conservation in the academic institution. They highlight the importance of energy awareness and emphasize the need for sustainable practices. The paper suggests practical measures that can be implemented to optimize energy usage and reduce energy waste. By implementing these measures, the institution can contribute to a more sustainable and environmentally friendly environment.

In conclusion, this research paper underscores the significance of energy conservation and the need for sustainable energy practices. The energy audit conducted in the hostel and mess of Maharaja Surajmal Institute of Technology sheds light on the energy consumption patterns and wastage within the institution. The suggested measures derived from the study provide valuable insights for cost mitigation, reduction of environmental pollution, and addressing the demand-supply gap. The paper aims to raise awareness and encourage the adoption of energy conservation practices, ultimately contributing to a more sustainable future.

Energy consumption is a critical factor in the operating costs of buildings. Modern buildings are now designed with a focus on energy performance and reducing carbon footprints. However, there is still room for improvement in existing older buildings through suitable retrofitting to lower energy consumption and carbon footprints. In a case study conducted in northern India, an energy audit of an academic institution revealed several opportunities for significant energy reduction.

[13] The case study specifically analyzes the National Institute of Technical Teachers Training & Research in Chandigarh, India, and proposes measures that can lead to a 35% reduction in energy consumption and a decrease of approximately 177 tons in carbon footprint. The recommendations put forward in the study are practical and involve moderate investments with reasonable payback periods.

One key aspect highlighted in the analysis is the utilization of the institute building's rooftops for installing solar photovoltaic (PV) power plants. Currently, the building meets 7% of its energy requirements through an existing solar PV power plant installed on its rooftop. By expanding the installation of solar power plants on all rooftops, it is estimated that up to 25% of the building's energy needs can be met through solar energy sources.

This integration of solar power generation, along with retrofitting measures, has the potential to significantly reduce energy consumption and carbon emissions. By harnessing renewable energy sources like solar power, the building can become more sustainable and environmentally friendly.

The findings of this case study emphasize the possibilities for energy and carbon footprint reduction in existing buildings through retrofitting measures and the adoption of solar power generation. These insights are valuable for building owners, managers, and policymakers seeking to promote energy efficiency and sustainable building practices.

[14] In the United Arab Emirates (UAE), the combination of a hot climate and rapid demographic and urban growth has resulted in a built environment where the emphasis has been on the quantity rather than the energy efficiency of construction. This situation has been further exacerbated by the slow development of energetic building codes and the subsidized cost of electricity. As a consequence, the UAE consistently ranks high on the list of countries with the largest environmental footprint, with a significant portion of emissions arising from the electricity production required for building cooling.

This study focuses on reviewing research primarily conducted in the UAE that investigates the effectiveness of passive building-envelope measures in reducing energy consumption. With increasing demands for energy regulations, various measures have been developed to address the specific challenges faced in the UAE. These measures encompass strategies for the building envelope during the planning phase as well as retrofitting options. They target radiative, convective, and conductive heat transfer through walls, windows, and roofs. Additionally, energy-efficient natural ventilation techniques have been explored.

The geographic scope of this review is limited to the UAE, as its unique economic growth pattern and specific legislation to promote energy efficiency give rise to distinct development challenges. The findings of this review underscore the significance of several factors in achieving energy-optimized structures. These factors include building orientation, thermal insulation (which has demonstrated energy savings of over 20% in residential contexts), appropriate selection and placement of glazing in highly glazed office buildings (with reported energy savings of up to 55%), management of excessive light levels and glare, and the utilization of natural ventilation. Natural ventilation techniques have proven to be particularly promising, with potential energy savings of up to 30% in villas and even up to 79% in high-rise office buildings employing mixed-mode ventilation.

By implementing these measures, the UAE can make substantial strides in reducing energy consumption and mitigating its environmental impact. The research stresses the importance of considering regional factors and developing tailored strategies to enhance energy efficiency within the unique context of the UAE. Through the adoption of energy-efficient practices and the incorporation of passive building-envelope measures, the UAE can work towards a more sustainable and environmentally conscious built environment.

[15] Energy audits are an effective and cost-efficient solution for addressing the gap between energy demand and supply. These audits help identify areas of energy loss and provide recommendations for improvement. In a recent study, a detailed analysis of building energy audits was conducted on several commercial buildings in Dhaka. The study also developed a tool called "EnergyWise" using Microsoft Visual Basic Application to facilitate the energy audit process.

The "EnergyWise" tool automates data processing, summarization, and transfer to Excel spreadsheets. By inputting data, users can quickly analyze and identify areas of electrical load consumption, represented as a percentage of the total load. This information is valuable for understanding energy usage patterns and prioritizing energy-saving measures.

The study findings reveal that commercial buildings in Dhaka exhibit inefficiencies in electrical energy consumption. However, by replacing existing equipment and lighting fixtures with more efficient components, significant energy reductions can be achieved. The study suggests that energy savings of 8%-15% in electrical equipment and 28%-45% in lighting are possible.

Implementing the recommended energy-saving measures based on the audit findings brings multiple benefits. Firstly, it helps bridge the gap between energy demand and supply by reducing overall energy consumption. Secondly, it leads to cost savings for building owners and occupants through reduced energy bills. Lastly, it contributes to environmental sustainability by lowering carbon emissions associated with energy production.

To sum up, energy audits and tools like "EnergyWise" are instrumental in addressing the energy demand-supply gap. By identifying energy loss areas and proposing energy-saving techniques, audits enable significant reductions in energy consumption, particularly in electrical equipment and lighting.

III. CONCLUSION

In conclusion, the energy audit conducted in the academic building has yielded valuable insights and recommendations for energy conservation and management. Serving as a preliminary study, this audit sets the foundation for the implementation of a campus-specific energy use database and a national energy management program. The comprehensive report compiled from the observations made during the audit has been submitted to the physical planning department of the university for further evaluation, including economic analysis and prefeasibility study.

The walk-through survey results have revealed that adjusting the motor drive speed during operating hours is the most effective technical approach to achieve significant energy savings in the building. This measure should be prioritized for implementation. Additionally, improving the building's envelope through enhanced insulation and increased sealing will optimize the utilization of air-conditioning systems within specified spaces and operating hours, resulting in substantial energy savings. These recommendations represent the second most cost-effective means of reducing the building's annual energy costs.

Furthermore, it is crucial to emphasize the implementation of the suggested lighting recommendations to enhance energy efficiency in the engineering block. Despite its high-energy use, the building has the potential to become a model of energy efficiency on campus through the adoption of these lighting strategies.

The findings from this energy audit underscore the importance of conducting such assessments to identify and capitalize on energy conservation opportunities. The proposed actions presented in this study provide a clear roadmap for energy management in academic buildings. By implementing these measures, the university can make significant strides in achieving improved energy efficiency, reducing operational costs, and advancing its sustainability goals on campus. conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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