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Energy Audit: A Case Study of an Academic Hostel, Delhi

Md Hasmat Ali Khan, Dr. Amit Shrivastava, Dr. Naveen Asati

M. Tech Scholar, Department of Power System, LNCTE Bhopal, M.P., India

Professor, Department of Electrical and Electronic Engineering, LNCT, Bhopal, India

Associate Professor, Department of Electrical and Electronic Engineering, LNCT, Bhopal, India

ABSTRACT: This paper presents a case study of an academic hostel energy audit exercise carried out at Shaheen Bagh, Delhi, to analyse the energy consumption patterns and to provide specific recommendations to improve energy consumption efficiency and reduce the energy bills. The audit was executed by data collection during an on-site survey, analysis of data obtained, and recommendations for improvement of performance. The energy audit showed that the academic hostel consumed an annual electrical energy of 7.2981 MWh and could save 2.6056 MWh of energy, a 35.7% electrical energy saving potential. To improve the electrical energy performance in the academic hostel, an enhanced level of awareness to reduce energy waste, the use of efficient equipment and control systems is found to be the most effective energy efficiency measure strategy to improve the lighting and electrical system efficiency in the academic hostel. The benefits of implementing the energy efficiency measures in the academic hostel are substantial, both in terms of energy savings and cost savings.

KEYWORDS: Energy Audit, Energy conservation, Payback period

I. INTRODUCTION

Energy audits apply energy analysis methods to evaluate energy consumption patterns and trends and identify efficiency opportunities in households, government agencies, and private commercial and industrial sectors. An energy audit is the first step in developing electrical energy efficiency measures (EEMs) within an organisation.
In 2023–24, India's commercial and domestic sectors consumed approximately 11% and 24% of the total electrical energy, respectively. The electricity consumption in the commercial sector has continued to increase at a faster rate compared to other sectors, with a compound annual growth rate (CAGR) of around 9% from 2014–15 to 2023–24. Therefore, energy conservation has become an even more critical issue.
There are well-known remedial measures to address energy inefficiency and to advise commercial and domestic consumers on the appropriate use of equipment and necessary adjustments to save both energy and costs on energy bills.

An energy audit is an evaluation of energy consumption in domestic, commercial, or other premises. It is generally used to determine where energy can be saved, conserved, or used more efficiently.
Energy audits are classified into:

- Preliminary Audit
- Detailed Audit

The Preliminary Energy Audit is a relatively quick exercise that estimates the potential for energy saving using existing or easily available data, helping to identify areas for a more detailed study.
The Detailed Energy Audit is conducted in three phases:

- Phase I – Pre-Audit Phase
- Phase II – Audit Phase
- Phase III – Post-Audit Phase

This is a comprehensive process that offers the most accurate estimate of energy savings and payback periods for recommended measures.
In the present study, the methodology of a Detailed Energy Audit was adopted. The paper highlights the energy-saving potential and the feasibility of achieving it in an existing academic hostel in Bhopal.

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II. OBJECTIVE OF THE WORK

The main objective of the work was to perform a lighting energy audit by taking a case study of the frequently used areas of an academic hostel. Depending on the audit findings, suggest ways to optimise energy consumption. Improvement in performance /Energy efficiency through energy audit covers the following areas: 1) Study of Lighting System. 2) Study of an electrical system

Phase I: Pre-Audit Phase

Step No.	Plan of Action	Purpose / Results
Step-I	Organise a walkthrough audit and conduct informal discussions with the owner.	Plan resources, set up the audit team, arrange instruments, and define the timeline. Collect preliminary data and observe current operations.
Step-II	Conduct a brief meeting (2-3 hours) with all stakeholders.	Encourage cooperation, distribute questionnaires, and create awareness about energy conservation.

Phase II: Audit Phase

Step No.	Plan of action	Purpose / Results
Step-III	Gather baseline data, including design specifications and operational schedules.	Analyse annual energy consumption patterns and energy bills.
Step-IV	Conduct a detailed survey using portable instruments to measure electricity consumption.	Verify actual operating data against design data for accuracy.
Step-V	Perform detailed tests and trials on major energy-consuming equipment.	Monitor power usage trends in devices such as fans, lighting systems, pumps, and other appliances.
Step-VI	Analyse energy consumption trends.	Identify areas of energy waste and inefficiencies.
Step-VII	Identify and propose Energy Conservation Opportunities (ECOs).	Develop ideas, review past recommendations, and explore new technology solutions.
Step-VIII	Conduct a cost-benefit analysis of the identified conservation measures.	Evaluate technical feasibility and economic benefits to prioritise implementation.
Step-IX	Prepare and present a report to top management.	Provide detailed audit findings and energy-saving recommendations.

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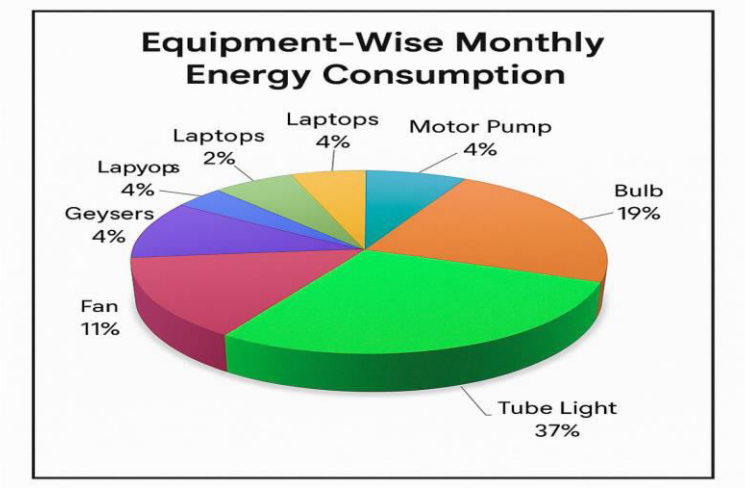
Phase III: Post-Audit Phase

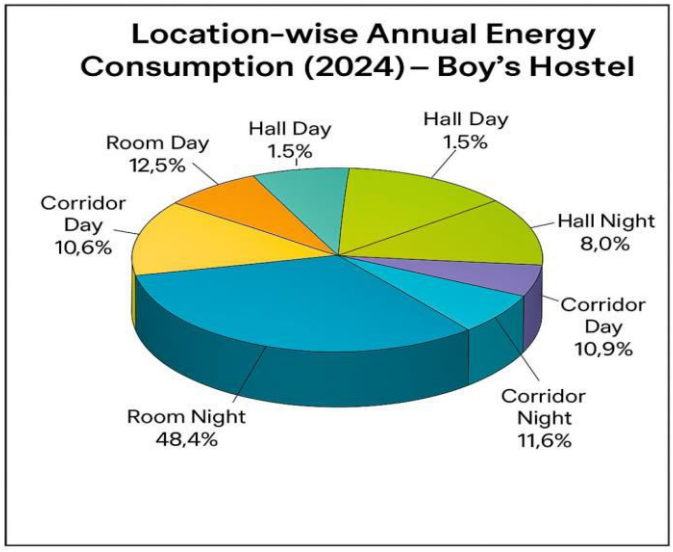
Step No.	Plan of Action	Purpose / Results
Step-X	Implement recommended energy-saving measures and follow up on progress.	Develop an action plan and ensure the successful execution of energy-saving initiatives.

IV. ANALYSIS

Equipment-wise, monthly energy consumption in the boys' hostel is shown in the table below. The table includes eight columns representing different electrical equipment used throughout the hostel. Monthly data has been collected from January to December. The table highlights how energy usage varies across seasons, depending on weather conditions and hostel needs. It also helps identify which appliances contribute most to the hostel's energy consumption annually.



Location-wise monthly energy consumption in the boys' hostel is shown in the table below. The table includes eight columns representing energy used across different areas of the hostel: rooms, halls, corridors, and toilets, divided into day and night consumption. This breakdown allows for the analysis of how each location contributes to overall power usage across the months.



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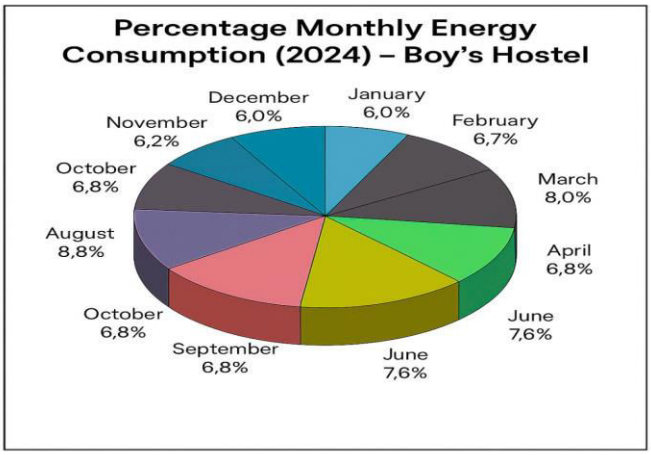
This section outlines a month-by-month comparison of energy consumption, energy supplied, and the resulting losses in the boy's hostel throughout the year 2024. The data indicates seasonal variations in energy usage influenced by environmental conditions and equipment needs. A significant rise in consumption can be observed during the summer months due to increased use of fans and water coolers. On the contrary, the lowest energy usage occurs in August, possibly due to reduced occupancy or academic breaks. Despite a consistent supply, minor losses were recorded each month due to common factors such as cable joints, minor leakages, and unaccounted small appliances like mobile chargers. Monitoring this data helps in identifying areas for improvement and ensuring efficient energy usage across the facility.



V. IMPLEMENTATION

1) Replacement of the resistance regulator of the fan by an electronic regulator: In the academic hostel, all fans are connected with a resistance regulator. Therefore, by replacing all resistance regulators with an electronic regulator, the average power saved for each fan is 9- 10W.

Analysis: -

□Total number of fan in an academic hostel = 18 □ Average Power saving by each fan = 9W
□ Total Power saving by all fan = 18*9 = 0.162KW
□ Total utilization of the fan in a year = 1805h
□ Total energy saved per year = 0.162* 1805 KWh =292.41KWh
□ Energy cost @Rs 8 per year = 292.41*8 = Rs 2339.28 per year
□ Cost of each electronic regulator = Rs 190
□ Total investment in electronic regulators =18*190 = Rs 3420
□ Payback period= (Total investment)/ (Energy cost) = (3420)/ (2339.28) = 1.461 years

2) Replacement of tube lights by White LED Bulb in the room and hall: In the academic hostel, there are 24 tube lights in the room and hall that can be replaced by white LED bulbs**.**

□ Power consumed by tube light =50W
□ Power consumed by White LED bulb = 13W □ Power saved by each White LED bulb = 50W-13W = 37W
□ Total number of White LED bulbs: 24
□Total power saved by white LED bulb =24*37 = 888W = 0.888KW
□ Total utilisation of white LED bulb in a year = 2192h
□Total energy saved per year = 2192*0.888=1928.96 KWh
□Energy cost @ Rs 8 per year = 1928.96*8= Rs 15431.68 per year
□ Cost of each White LED bulb = Rs 550 □ Total investment in White LED bulb = Rs 550*24 =Rs 13200
□ Payback Period= (Total Investment)/ (Energy cost) = (13200)/ (15431.68) =0.8553 year

3) Replacement of tube light by CFL in Toilet & Corridor: In the academic hostel, there are 11 tube lights in the toilet and corridor can be replaced by 9W CFL.

□ Power consumed by tube light = 50W
□Power Consumed by CFL 9W

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□ Power saving by each CFL=50W-9W=41W □ Total number of CFL= 11
□ Total power saved by CFL = 41*11W = 451W = 0.451KW
□Total utilisation of CFL in a year= 852h
□Total energy saved per year 0.451*852KWh=384.252KWh
□Energy cost @Rs 8 per year= 384.252*8= Rs 3074.016 per year
□Cost of each CFL= Rs 130
□Total investment in CFL bulb=Rs 130*11= Rs1430 □Payback period= (Total Investment)/ (Energy cost) = (1430)/ (3074.016) = 0.465 year

VI. SUMMARY OF COST ANALYSIS

This table shows a summary of recommendations. The third column shows the cost of recommending energy-efficient equipment. The fourth column shows energy saving by energy efficiency

S.No.	Recommendation	Cost of Recommendation	Energy Saving (kWh)	Payback period
1	Replacement of the resistance regulator with an electronic regulator of the ceiling fan	Rs 3800	411.48	1.154 year
2	Replacement of a tube light with a White LED bulb	Rs 11000	1375.92	0.999 year
3	Replacement of an incandescent bulb with a CFL	Rs 6000	1090.4	0.687 year

VII. OTHER ENERGY EFFICIENT EQUIPMENTS/ OPPORTUNITIES

- Use a solar water heater in place of geysers.
- Use an energy-efficient water cooler.
- Installation of servo voltage stabilizer ·
- Use a star rating for all new installations
- Minimize water wastage and ensure that the proper plumbing of the water cooler and water filter is done.
- Use a motion sensor in the toilet & corridor.

VIII. CONCLUSIONS

The total annual energy consumption in the boys' hostel, before any energy-saving measures were applied, was **13,908.954 kWh**. After using recommended energy-efficient solutions, such as LED bulbs, CFLs, and electronic regulators, the total energy consumption decreased. A total of **4,957.698 kWh** was saved, which is a **35.64%** reduction in energy use. The monthly data shows that energy consumption dropped each month after the improvements were made. The column chart also clearly shows the difference in energy use before and after the changes. These results highlight the importance of conducting regular energy audits and implementing Energy Efficiency Measures (EEMs). By following these steps, energy waste can be reduced, the hostel's operations can become more efficient, and sustainable energy practices can be adopted in academic hostels.

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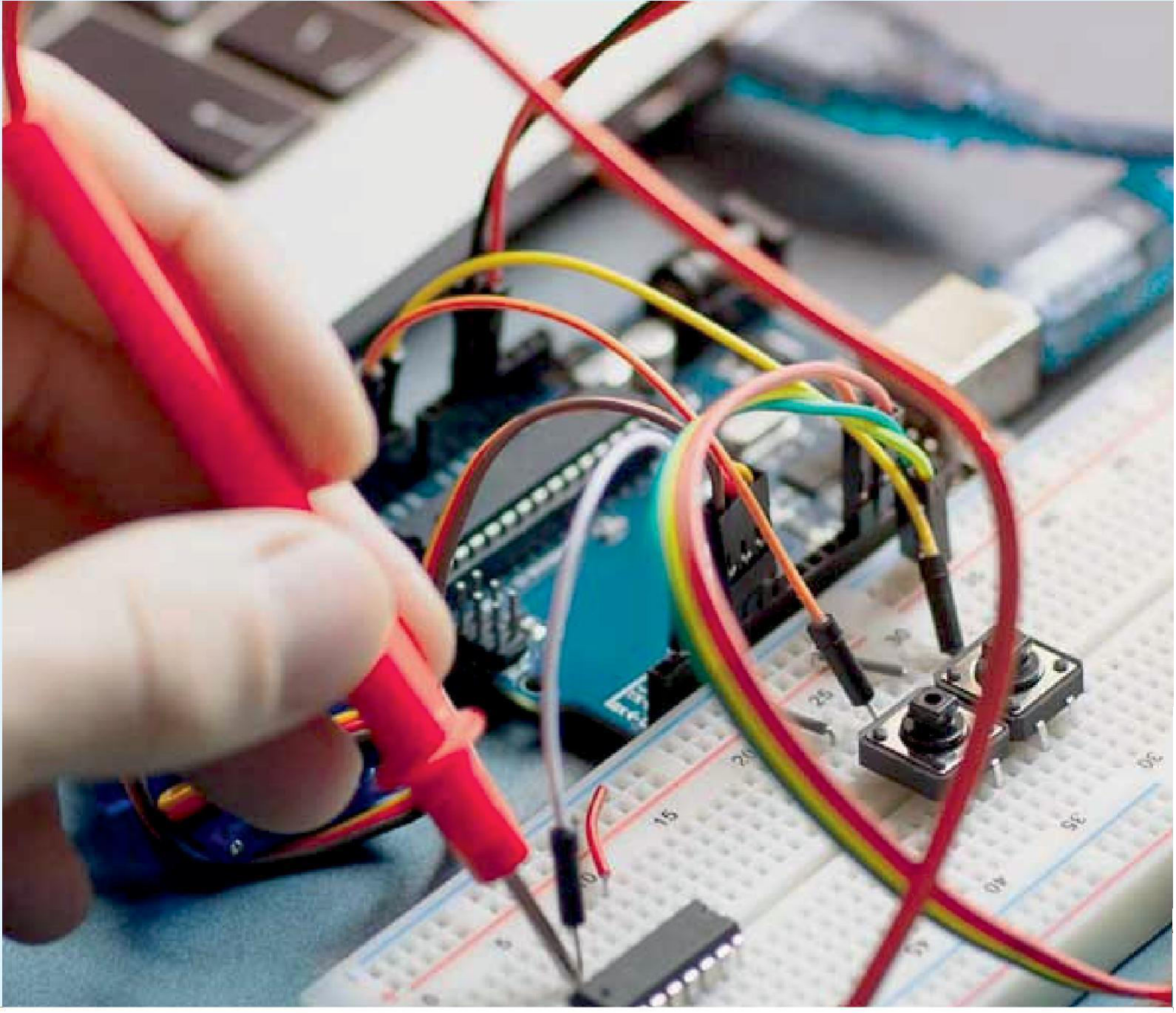

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