IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Energy Conservation Through Audit Of JNTUK Engineering College Hostel Facilities

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Abstract: Academic hostel facilities consume significant amounts of electricity, contributing to rising operational costs and environmental impacts. This study presents an energy audit conducted at the hostel blocks of Jawaharlal Nehru Technological University, Kakinada (JNTUK), with the objective of reducing consumption through demand-side management and retrofitting. The baseline survey revealed that lighting and ceiling fans accounted for the majority of the hostel load, resulting in an annual electricity bill of approximately ₹35.2 lakhs. Retrofitting conventional appliances with 20 W LED lights and 28 W BLDC fans led to an annual energy saving of 207,216 kWh, representing a 35.25% reduction in electricity demand. The intervention achieved cost savings of ₹14.5 lakhs per year, with a simple payback period of 1.85 years. In addition, the audit-driven measures reduced carbon dioxide emissions by nearly 169,917 kg annually. The results demonstrate that a systematic energy audit combined with targeted retrofitting can yield substantial financial and environmental benefits, highlighting the importance of conservation measures in academic institutions.

I. INTRODUCTION

The rapid expansion of academic institutions in India has been accompanied by a substantial rise in energy demand, particularly in hostel facilities where thousands of students rely on electricity for essential needs such as lighting, ventilation, and indoor comfort. With the continuous rise in electricity tariffs and the ever-growing student population, energy consumption in these facilities has become a critical concern, placing a heavy financial burden on universities. In addition to economic implications, excessive energy usage also exacerbates environmental challenges by contributing to higher greenhouse gas emissions and increasing the institution's overall carbon footprint.

Energy audits have emerged as a highly effective and systematic tool to combat these challenges. By thoroughly assessing energy consumption patterns, identifying inefficiencies, and recommending targeted conservation measures, audits serve as the foundation for sustainable energy management. Hostel buildings in Indian campuses, including those at Jawaharlal Nehru Technological University, Kakinada (JNTUK), often rely on outdated electrical appliances such as fluorescent tube lights and induction motor-based ceiling fans. These devices, though widely used, are far less efficient compared to modern alternatives like LED lighting and brushless direct current (BLDC) ceiling fans. Their continued use leads to unnecessary electricity consumption, higher operational costs, and avoidable carbon emissions.

At JNTUK, the hostel facilities reported an annual electricity expenditure of approximately ₹35.2 lakhs, a figure largely driven by inefficient lighting and ventilation systems. Recognizing the potential for improvement, a comprehensive energy audit was undertaken to establish a baseline of energy use, pinpoint areas of inefficiency, and propose cost-effective retrofitting measures. The audit specifically examined the replacement of traditional appliances with energy-efficient alternatives, alongside an evaluation of their financial and environmental benefits.

The results of this study clearly demonstrate that adopting conservation strategies through appliance retrofitting can yield multiple advantages. The proposed measures not only reduce annual electricity demand but also lead to significant cost savings for the institution. The financial analysis indicated a simple payback period of less than two years, highlighting the economic viability of the interventions. Moreover, the reduction in electricity consumption translates directly into a measurable decrease in CO_2 emissions, thereby aligning with broader sustainability and climate change mitigation goals.

Overall, this research emphasizes the importance of audit-driven energy management in academic hostels, showcasing how targeted retrofitting measures can simultaneously reduce operating costs, enhance environmental performance, and set an example of sustainable campus operations. The findings are not only relevant to JNTUK but also offer replicable strategies for similar educational institutions across India that face rising energy demands and financial pressures.

II. LITERATURE REVIEW

Energy audits in educational institutions have been recognized as effective tools for reducing operating costs and promoting sustainability, with early works such as Edmund (2016) demonstrating that systematic audits can identify significant savings potential in lighting, ventilation, and hot water systems [1]. Studies on hostel buildings have consistently shown that lighting and ceiling fans dominate electricity consumption; Madhusudan et al. (2020) and Lonare et al. (2021) reported that replacing tube lights with LEDs and conventional fans with BLDC models reduced annual energy use by more than 30% with short payback periods [2], [4]. Similar results were observed by Velu et al. (2022), who combined retrofitting with occupant awareness programs to achieve nearly 30% savings [3], while Prabhu et al. (2023) and Chaudhary et al. confirmed typical hostel savings of 20–40% through targeted retrofits [5], [8]. Nakayama et al. (2024) advanced audit methodology by linking consumption analysis to decarbonization strategies and lifecycle impacts, strengthening the role of audits as planning tools for future clean energy integration [6]. Case studies from Nigeria and India further demonstrated that, despite differences in climate and occupancy, lighting and fan retrofits consistently provide the highest impact [7], [9]. Collectively, these studies highlight that hostel audits yield both economic and environmental benefits, though many remain limited to small samples or manual estimates, underscoring the need for larger campus-scale audits. Motivated by these findings, the present study investigates the hostel facilities of JNTUK, where an annual electricity bill of ₹35.2 lakhs necessitated a comprehensive audit and retrofitting program, with the goal of quantifying demand reduction, financial savings, and CO_2 mitigation.

III. METHODOLOGY

The energy audit was conducted on the hostel facilities of Jawaharlal Nehru Technological University, Kakinada (JNTUK) to establish baseline electricity consumption and identify opportunities for conservation through retrofitting. A detailed load survey was carried out in multiple hostel blocks, recording the type, number, power rating, and operating hours of appliances such as tube lights, ceiling fans, and geysers. The collected data were used to calculate daily, monthly, and annual energy consumption using standard formulas, with the pre-audit energy profile serving as the baseline. Inefficient appliances were identified, and retrofitting measures were proposed by replacing tube lights with 20 W LED fixtures and conventional ceiling fans with 28 W BLDC fans. The impact of these measures was assessed through spreadsheet-based calculations to estimate energy savings, percentage reduction, cost savings, investment cost, payback period, and CO_2 emission reduction using the grid emission factor of 0.82 kg/kWh. Financial analysis was performed by comparing the cost of retrofitting against the expected annual savings, while environmental benefits were quantified through avoided emissions. This systematic audit-based approach provided a reliable framework for evaluating both the economic and environmental potential of conservation in institutional hostel facilities.

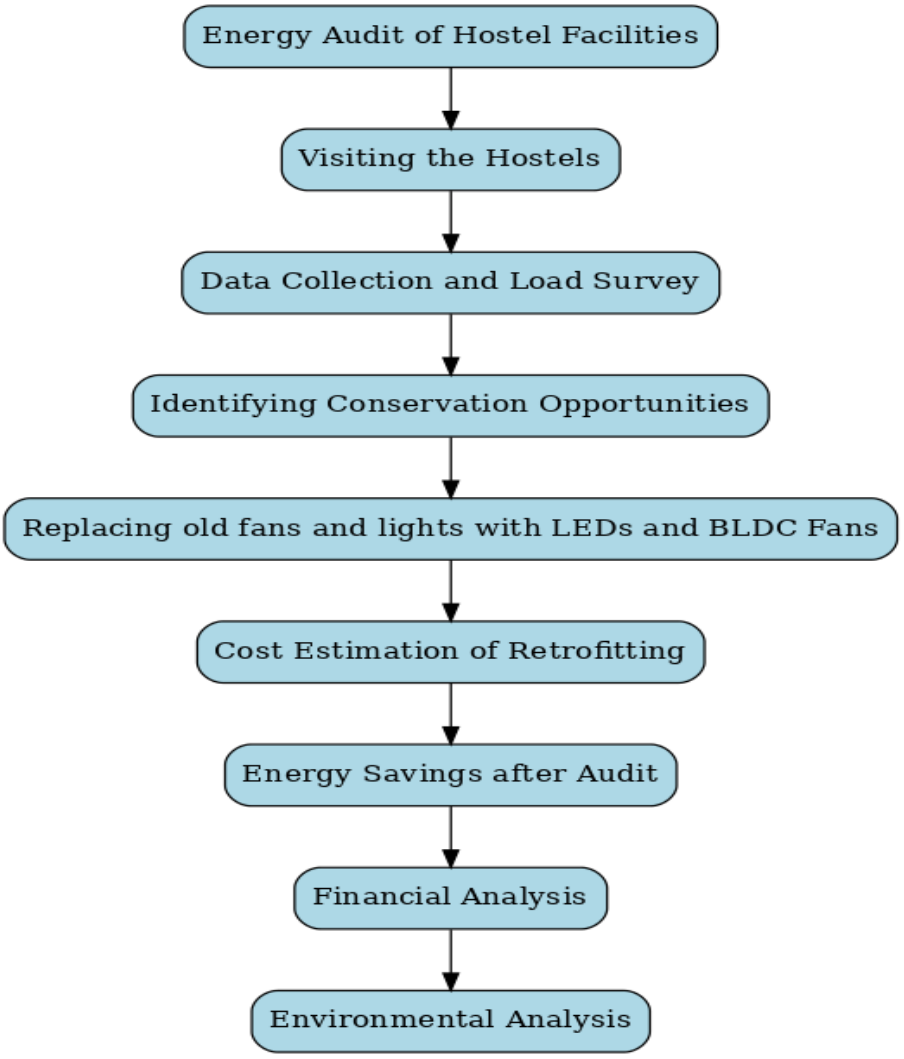

Figure 1 Complete Flowchart

3.1 Energy Audit

An energy audit serves as a diagnostic tool for understanding energy flow within a facility and identifying opportunities for energy conservation and efficiency improvements. In this project, a comprehensive audit was conducted on the hostel blocks of Jawaharlal Nehru Technological University, Kakinada (JNTUK), with a focus on optimizing electrical energy consumption across major load categories—lighting, fans, and geysers.

3.2 Load Survey and Baseline Energy Consumption

The initial phase involved conducting a detailed load inventory. All electrical appliances within the hostels were categorized by type—such as lights, ceiling fans, and geysers—and data was collected regarding their power ratings, quantity, and operating hours.

Formula Used:

1. Total Wattage of Appliance

Total Wattage (W) = Appliance Quantity × Wattage per Unit (W)

2. Daily Energy Consumption (kWh)

Daily Energy Consumption (kWh) = Total Wattage (W)×Average Operating Hours of Appliances (h) / 1000

3. Monthly Energy Consumption (kWh)

Monthly Energy Consumption (kWh) = Daily Consumption (kWh)×30

4. Annual Energy Consumption (kWh)

Annual Energy Consumption (kWh) = Daily Consumption (kWh)×365

5. Energy Savings (kWh)

Energy Savings (kWh) = Energy Before Audit (kWh)−Energy After Audit (kWh)

6. Percentage Reduction in Energy Usage (%)

Percentage Reduction (%) = (Before Audit−After Audit / Before Audit)×100

7. Cost Savings (₹)

Cost Savings (₹) = Energy Savings (kWh)×Cost per Unit (₹)

8. Total Investment Cost (₹)

Total Investment (₹) = (No. of LED lights×Cost per light)+(No. of BLDC fans×Cost per fan)

9. Simple Payback Period (Years)

Payback Period (Years) = Total Investment (₹) / Annual Cost Savings (₹)

10. CO_2 Emissions Reduction (kg/year)

CO_2 Reduction (kg/year) = Annual Energy Savings (kWh)×Emission Factor (kg CO_2/kWh)

The total daily, monthly, and annual energy consumption before audit implementation are summarized below:

Name of the Hostel	Type of Equipment	Quantity	Wattage per unit(W)	Total wattage(W)	Average daily operating hours(h)	Daily energy consumption(KWh)	Monthly energy consumption(KWh)	Annual energy consumption (KWh)
Narendra	Lights	109	20	2180	8	17.44	523.2	6278.4
	Fans	64	100	6400	10	64	1920	23040
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nataraj	Lights	242	20	4840	8	38.72	1161.6	13939.2
	Fans	108	28	3024	10	30.24	907.2	10886.4
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nalanda	Lights	128	20	2560	8	20.48	614.4	7372.8
	Fans	56	100	5600	10	56	1680	20160
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nagavalli	Lights	434	40	17360	8	138.8	4166.4	49996.8
	Fans	373	100	37300	10	373	11190	134280
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	2	1200	2400	6	14.4	432	5184
	Washing machines	6	410	2460	12	29.52	885.6	10627.2
	Systems	12	200	2400	6	14.4	432	5184
Nagavalli Extension	Lights	200	20	4000	8	32	960	11520
	Fans	84	100	8400	10	84	2520	30240
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	6	410	2460	12	29.52	885.6	10627.2
	Systems	12	200	2400	6	14.4	432	5184
Niveditha	Lights	294	20	5880	8	47.04	1411.2	16934.4
	Fans	126	100	12600	10	126	3780	45360
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	2	1200	2400	6	14.4	432	5184
	Washing machines	9	410	3690	12	44.28	1328.4	15940.8
	Systems	10	200	2000	6	12	360	4320
Total			16898	202354		1632.72	48981.6	587779.2

Table 1 Energy consumption before audit

3.3 Identification of Inefficiencies and Retrofitting Proposals

Analysis of the baseline data showed significant energy consumption from outdated appliances, particularly traditional fans and tube lights. Based on this, the following **retrofitting measures** were proposed:

- Replacement of 100 W fans with **28 W BLDC fans**
- Replacement of tube lights with **20 W LED fixtures**

3.4 daily, monthly, and annual energy consumption after audit

Table 2 Energy consumption after audit

Name of the Hostel	Type of Equipment	Quantity	Wattage per unit(W)	Total wattage(W)	Average daily operating hours(h)	Daily energy consumption(KWh)	Monthly energy consumption(KWh)	Annual energy consumption (KWh)
Narendra	Lights	109	20	2180	8	17.44	523.2	6278.4
	Fans	64	28	1792	10	17.92	537.6	6451.2
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nataraj	Lights	242	20	4840	8	38.72	1161.6	13939.2
	Fans	108	28	3024	10	30.24	907.2	10886.4
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nalanda	Lights	128	20	2560	8	20.48	614.4	7372.8
	Fans	56	28	1568	10	15.68	470.4	5644.8
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	0	0	0	0	0	0	0
	Systems	0	0	0	0	0	0	0
Nagavalli	Lights	434	20	8680	8	69.44	2083.2	49996.8
	Fans	373	28	10444	10	104.44	3133.2	134280
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	2	1200	2400	6	14.4	432	5184
	Washing machines	6	410	2460	12	29.52	885.6	10627.2
	Systems	12	200	2400	6	14.4	432	5184
Nagavalli Extension	Lights	200	20	4000	8	32	960	11520
	Fans	84	28	2352	10	23.52	705.6	30240
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	0	0	0	0	0	0	0
	Washing machines	6	410	2460	12	29.52	885.6	10627.2
	Systems	12	200	2400	6	14.4	432	5184
Niveditha	Lights	294	20	5880	8	47.04	1411.2	16934.4
	Fans	126	28	3528	10	35.28	1058.4	12700.8
	Geysers	6	2000	12000	6	72	2160	25920
	Ac	2	1200	2400	6	14.4	432	5184
	Washing machines	9	410	3690	12	44.28	1328.4	15940.8
	Systems	10	200	2000	6	12	360	4320
Total			16518	143058		1057.12	31713.6	380563.2

3.5 Energy savings , financial and environmental analysis

Table 3 Energy savings

Category	Before Audit	After Audit	Energy Savings(KWh)	Cost Per Unit(₹)	Cost Savings(₹)	Percentage Reduction in Energy Usage(%)
Daily Energy Consumption (KWh)	1632.72	1057.12	575.6	7	4029.2	35.25405458
Monthly Energy Consumption (KWh)	48981.6	31713.6	17268	7	120876	35.25405458
Annual Energy Consumption (KWh)	587779.2	380563.2	207216	7	1450512	35.25405458

- **Annual Energy Savings (kWh)**

Energy Savings (kWh) = Energy Before Audit (kWh)−Energy After Audit (kWh)
= 587779.2 – 380563.2
= 207216 kWh

- **Annual Percentage Reduction in Energy Usage (%)**

Percentage Reduction (%) = (Before Audit−After Audit / Before Audit)×100
= (207216 / 587779.2) × 100
= 35.25 %

- **Annual Cost Savings (₹)**

Cost Savings (₹) = Energy Savings (kWh)×Cost per Unit (₹)
= 207216 × 7
= 1450512 Rs

Table 4 Cost savings and payback period

Cost Of One 20W LED Light (₹)	150
Cost Of One 28W BLDC Fan (₹)	3729
Total available lights for retrofitting	434
Total available fans for retrofitting	703
Total cost of lights (₹)	65100
Total cost of fans (₹)	2621487
Payback period(Years)	1.852164615
Emission factor(Kg CO2/kWh)	0.82
CO2 Reduction(Kg/Year)	169917.12

- **Total Investment Cost (₹)**

Total Investment (₹) = (No. of LED lights×Cost per light)+(No. of BLDC fans×Cost per fan)
= (434 × 150) + (703 × 3729)
= 2686587 Rs

- **Simple Payback Period (Years)**

Payback Period (Years) = Total Investment (₹) / Annual Cost Savings (₹)
= 2686587 / 1450512
= 1.852164615
≈ **2 Years**

- **CO_2 Emissions Reduction (kg/year)**

CO_2 Reduction (kg/year) = Annual Energy Savings (kWh)×Emission Factor (kg CO_2/kWh)
= 207216 × 0.82
= 169917.12 Kg/Year

IV.RESULTS AND DISCUSSION

This chapter presents the results of an energy audit conducted on the hostel facilities of JNTUK, aimed at identifying inefficiencies and reducing electricity consumption through conservation measures. The audit focused primarily on lighting and ceiling fans, which accounted for the majority of hostel energy use and contributed to an annual electricity bill of ₹35.2 lakhs. By replacing conventional tube lights with energy-efficient LEDs and outdated ceiling fans with BLDC models, significant reductions in energy demand were achieved. The following section discusses the baseline energy profile, the impact of retrofitting, and the resulting financial and environmental benefits, demonstrating how systematic audits can serve as effective tools for improving efficiency in institutional hostels.

4.1 Energy Savings

Energy consumption in the hostels was assessed before and after implementing energy-saving measures, specifically retrofitting conventional lights with 20W LED lights and ceiling fans with 28W BLDC fans. The results reveal significant reductions across daily, monthly, and annual energy usage.

From the table (5), it demonstrates a dramatic decrease in overall energy consumption after the retrofitting project.

Table 5 energy consumption and savings

Category	**Before Audit (KWh)**	**After Audit (KWh)**	**Energy Savings (KWh)**	**Percentage Reduction (%)**
Daily	1,632.72	1,057.12	575.60	35.25
Monthly	48,981.60	31,713.60	17,268.00	35.25
Annual	587,779.20	380,563.20	207,216.00	35.25

- For each hostel, energy use was dominated by lights and fans, which were the primary targets for savings.
- Other equipment (geyser, ACs, washing machines, systems) either had negligible or no change, as retrofitting targeted mainly two device categories.
- The marked reductions in Nagavalli, Nagavalli Extension, and Niveditha are primarily due to the large number of eligible lights and fans.

4.1.2 Statistical and Financial Analysis

Table 6 cost and emission savings

Metric	**Value**
Cost per Unit (₹)	7.0
Annual Cost Savings (₹)	1,450,512.00
CO_2 Reduction (kg/year)	169,917.12
Payback Period (years)	1.85
Total Cost of Lights (₹)	65,100.00
Total Cost of Fans (₹)	2,621,487.00
Emission Factor (kg CO_2/kWh)	0.82

The energy audit and subsequent retrofitting measures across JNTUK hostels yielded remarkable outcomes in terms of both financial savings and environmental benefits. The intervention, which involved the replacement of 434 conventional lights with 20W LEDs and 703 traditional fans with 28W BLDC fans, resulted in annual cost savings of more than ₹1.4 million, allowing the investment to be recovered in less than two years.

Notably, the most significant reductions in energy consumption were observed in Nagavalli and Niveditha hostels, where a larger proportion of outdated, inefficient devices were replaced. The standardized adoption of efficient appliances not only improved energy performance but also ensured predictable and stable savings due to their lower power draw. Beyond monetary gains, the initiative also contributed to sustainability goals by reducing over 169,000 kg of CO_2 emissions annually, underscoring the dual impact of such retrofitting programs in promoting both economic and environmental efficiency.

V. CONCLUSION

The energy audit of JNTUK engineering college hostel facilities demonstrated that significant reductions in electricity consumption can be achieved through systematic assessment and targeted retrofitting. Analysis of the load profile revealed that lighting and ventilation were the major contributors to energy demand. By replacing conventional tube lights with 20 W LED fixtures and outdated ceiling fans with 28 W BLDC fans, electricity consumption was reduced by 35.25%, equivalent to annual savings of 207,216 kWh. This reduction translated into yearly cost savings of ₹1.45 million against an overall annual electricity bill of ₹3.52 million, resulting in a short payback period of 1.85 years. Additionally, the retrofit led to a decrease of 169,917 kg of CO_2 emissions per year, contributing directly to sustainability goals. These results clearly establish that energy auditing, when combined with appropriate conservation measures, is a cost-effective strategy for academic institutions. The study reinforces the importance of demand-side management as a prerequisite for long-term energy efficiency, financial savings, and environmental benefits in hostel facilities and other similar infrastructures. The energy audit and retrofitting have reduced hostel electricity demand and costs, but further scope exists in renewable integration. The lowered baseline demand now provides a better foundation for rooftop solar PV sizing and investment. In the future, solar-powered EV charging infrastructure can also be explored to extend clean energy use to mobility. Together, these steps can move the campus toward energy self-reliance and sustainability.

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